

**Application of Spatial Planning Strategies to Achieve
Sustainable Transport Systems in Rapidly Urbanizing Cities:
A Study of Abuja, Nigeria**

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DEDICATION

This thesis is dedicated with love and gratitude to my darling wife Sherifah, my children Hameedah Ahmad and Muhammad-Al Ameen; my parents Alhaji Abdulrazak Bello Oluokun and Alhaja Taibat Abdulrazak Oluokun; and my siblings Abdulwaheed, Lola, Tunde, Bukola, Teslim and Muhydeen for their relentless prayers, encouragement and supports towards the successful completion of this study.

DECLARATION

This thesis is submitted under the University of Salford rules and regulations for the award of a PhD degree by Research. During the research process, some findings were published in refereed conference papers prior to the submission (refer to Appendix I)

I declare that this work or any part has not previously been presented in any form to the University or any other body whether for the purpose of assessment for the award of any degree or certificate. I confirm that the intellectual contents of the work are the results of my efforts and no other person.

Signature ----- Date -----

Sherif Yinka Razak

LIST OF ABBREVIATIONS

AGIS	Abuja Geographic Information System
ANPR	Automatic Number Plate Recognition
ASIF	Activity, Structure, Intensity, Fuel mix
AUMTCO	Abuja Urban Mass Transport Company Limited
BRT	Bus Rapid Transit
CAGR	Compound Annual Growth Rate
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
DRTS	Directorate of Road Traffic Services
FAR	Floor Area Ratio
FCC	Federal Capital City
FCDA	Federal Capital Development Authority
FCT	Federal Capital Territory
FME	Federal Ministry of Environment
FRSC	Federal Road Safety Corps
FCT SURE-P	Federal Capital Territory Subsidy Reinvestment and Empowerment- Programme
HDI	Human Development Index
IEA	International Energy Agency
ITDP	Institute for Transport and Development Policy
IPCC	Inter-governmental Panel on Climate Change
LAMATA	Lagos Metropolitan Area Transportation Authority
LRT	Light Rail Transit
NITP	The Nigerian Institute of Town Planners
NIMET	Nigeria Meteorological Agency
NNPC	Nigerian National Petroleum Corporation
NURTW	National Union of Road Transport Workers
ONEX	Outer Northern Expressway
OSEX	Outer Southern Expressway
PPG	Planning Policy Guidance
SECDA	Self Employed Commercial Drivers Association, Abuja
SCCU	Special Climate Change Unit
STDA	Satellite Towns Development Agency
TDM	Transport Demand Management
TOD	Transit Oriented Development
URP	Urban and Regional Planning
UNCRD	United Nations Centre for Regional Development
UNFPA	United Nations Funds for Population Activities
UNFCCC	United Nation Framework Convention on Climate Change
UNHSP	United Nations Human Settlement Programmes (UN-Habitat)
UNEP	United Nations Environmental Programme
UNCED	United Nations Conference on the Environment and Development
UNDP	United Nations Development Programme
VKT	Vehicle Kilometre Travelled
WBCSD	World Business Council for Sustainable Development
WCED	World Commission for Environment and Development

DEFINITION OF TERMS

Sustainability is here used to refer to the capacity of the city to create harmony across policies and strategies in order to achieve optimal outcomes and reduced level of externalities in the city's spatial development and transport fabric while making efficient use of resources. These involve ensuring that social, economic, environmental dimensions of intervention in cities are geared towards the enhancement of the livelihood of city residents without undermining the development of future generation.

Master Plan Approach is used to refer to the planning system that stem from the Post-World War II Modernist Planning approach. It focuses on preparation of blueprint plan that provide broad overall long-term guidance to planning development of a city. This plan is majorly premised on landuse planning with zoning of different uses to create spatial and functional differentiation of uses across the urban space. The numerous trend pattern generated across the uses are usually addressed via the predict and provide solution of continuous building and expansion of roadways in cities.

Spatial Planning Strategies is used here to various array of deliberate urban planning intervention that can be initiated towards optimizing the use of space, and related activities to in part achieve convenience for the people and partly create a balance across socio-economic, political and environmental interests. Importantly, it contributes to spatial planning and sustainability objectives.

Spatial Planning Approach is here used to refer to the strategic urban planning approach that demonstrate the capacity for efficient landuse allocation and management by permitting sectoral integration, proactive rather than reactionary process; outcome focused plans, stakeholders engagement, the elimination of restrictive bureaucratic practices, and joining-up of governments for realizing sustainable place making and situation-specific urban planning objectives.

Core-city is used to refer to that part of the city which is the primary hub and consist of the city centre with the highest order of services and facilities including employment areas. This character of primary and mono-centric form generates numerous levels of trips into the core-city from its surrounding settlements.

Institutional Reform is used here to refer to the creation of a shift in existing institutional settings of urban planning organization to bring about enabling environment backed by relevant enabling legislation to realize sectoral integration, stakeholder engagement, eradicate restrictive bureaucratic practices in the functions of planning organization. These described changes are to be reflected in the structural outlook and operation of urban planning organization, the goal is to ensure that the functions of the organization are discharged more efficiently toward realizing optimized outcomes.

Commuters are used here to refer to city residents who routinely travel from the suburban areas to work in the core-city through mini-bus or private car mode.

Automobile Dependence is used here to refer to a mobility pattern in a city which indicates great emphasis on private car oriented transportation with relatively inefficient and fragmented public transport system. In this situation, car usage remains the superior alternative to reach service and activities in a short time. This mobility pattern is known to be favoured by sprawling extensive spatial form in a city, and it's a trend ravaging most rapidly urbanizing cities with sprawling spatial form. The impacts from this mobility pattern is usually characterized by traffic congestion and related externalities as loss of productive time, fuel loss, and transport-related CO₂ emission.

Modernist Planning is here used to refer to the urban planning paradigm that stem from the Post-World War II (1945) era and tagged the new town planning system with it predict and provide approach that is permissive to motorization of cities globally. The Master Plan and landuse focus of this planning paradigm that has been transmitted to global south cities through international consultancies and knowledge transfer has shaped and continue to shape global south cities.

Global South Cities is used here to refer to cities located in the global south region which include Africa, Latin America, developing Asia and the Middle East. These cities are classified as institutionally weak cities with rapid urban population and low level of infrastructural developments.

Suburban Areas is used here to refer to that part of the city located outside of the primary hub, these are areas that generate travel and traffic into the core-city and located within such distance of between 15– 40km. These areas are predominantly residential areas with very few formal employment, and more informal activities. At best, these are dormitory settlements providing cheap accommodation to the populace working in the core-city.

Suburbanization is here used to refer to the growth of areas on a fringe of cities, and characterized by predominantly unregulated and unplanned development with overly extensive sprawling spatial configuration. The inhabitants in these areas are predominantly low middle income spectrum of city residents who cannot afford the cost of accommodation in the core-city.

Smart Growth is used here to refer to approach, strategies, and urban planning principle adopted in cities with deliberate effort to transit communities that emphasizes the location of housing, shop, schools and jobs in walk-able compact setting and in proximity to public transport corridors.

Transit Oriented Development is here used to refer to a spatial planning strategies that focuses on the creation of transit communities characterized by diverse mixed use high density development located in proximity to an efficient transit corridor e.g. BRT. The communities small compact walk-able urban setting with reduced need for private car usage and contribute to efficient usage of land in view of its high density character.

Bus Rapid Transit is used here to refer to bus-based mass transit system characterized by convenient, comfortable and cost-effective service to commuters. With an exclusive bus lane, it deliver fast commuting, less travel time that mimic the efficiency of rail transit services.

Increasingly, it is serving as viable alternative adopted by cities to reform fragmented and unreliable public transport infrastructure in cities.

Congestion Pricing is here used to refer to a Transport Demand Mechanism adopted by cities to provide cost disincentive for private car usage. It is characterized by a Traffic Restricted Zone (TRZ) defined as cordon that circumscribes a portion of the city (usually the city centre) with real-time cameras placed at designated points on this cordon, motorist are charged (congestion charge) for driving car into the core-city.

ABSTRACT

It has become increasingly clear that the level of road traffic in cities has created high levels of congestion with implications on man-hour, fuel loss and growing transport-related greenhouse gas emissions. Earlier studies have attributed these impacts to the legacy of the Modernist Planning/Master Planning paradigm which prevails in rapidly urbanizing cities in the global south region. While this strategic instrument is considered relevant and dominates the centre-stage of physical planning in most global south cities, earlier studies argue that it may have created the extensive spatial pattern which continues to produce unsustainable transport-related problems such as increases in commuter trips and greater distances between core-city employment areas and suburban residential areas. Implicit in the Modernist Planning approach is “predict and provide” engineering solutions which skew investments in transportation towards the building and expansion of roads for addressing traffic congestion challenges. It is widely argued that this situation creates incentives that permit the ownership and use of private automobile vehicles at the expense of public transportation.

This research investigates the contention that the prevailing Master Planning system in expanding cities of the global south region has fueled the growth of suburbia and car-dependent mobility patterns resulting in inefficiencies such as traffic congestion, the waste of human time and fuel, and emission of greenhouse gases (GHG). The study offers an alternative model that provides solutions to traffic-related and suburban sprawl impacts in expanding cities of the global south region. This alternative is based on a framework for the combination of spatial planning strategies of Bus Rapid Transit (BRT), Transit Oriented Development (TOD), and congestion pricing to overcome the shortcomings of inefficient strategic planning tools and improve sustainable outcomes for global south cities.

CHAPTER 1: INTRODUCTION

1.1 Contextual Background

The prevailing strategic planning system and planning institutions in cities in the global south region (Africa, Latin America, and developing Asia including the Middle East) have been characterized by the vestiges of Modernist Planning (UNHSP, 2009, p.12) paradigm and this has shaped planning policies in cities in this region for decades. This strategic tool and its Master Plan approach has provide the framework for spatial and functional differentiation of uses and it is known to have ensured compatibility in the location of land uses in some of these cities through physical plans. However, earlier studies have argued that the top-down, technocratic and expert-driven philosophy that characterizes this Modernist Planning and its Master Planning approach has not permitted the effective implementation of planning objectives as typified by the growing trend of sprawling suburbanization and motorization in these cities (UNHSP, 2009, p. 29//; UNHSP 2013, p.5).

As noted in earlier studies, the application of the Modernist Planning model in global south cities appear to have concentrated planning efforts, infrastructure and services in the core-city area with less attention being paid to shaping the growth and development of suburban areas. The suburban areas have therefore, emerged as settlements characterized by an extensive sprawling spatial pattern with unplanned, unregulated and spontaneous development occurring at the periphery of the core-city (UNHSP, 2009 p.31; Chin 2002, p. 2). With this growing bias and with the deficits in infrastructure, services and employment within the suburban areas, these suburban settlements have evolved as simply dormitory towns with a strong reliance on the core-city for employment and services. This sustained bias and the emerging extensive spatial character permitted by this growth pattern appear to have also impacted on the volume and mode of daily travel between the suburban areas and the core-city and, therefore, have shaped the overall transport fabric of these cities such as Cebu (Philippines), Izmir (Turkey), La Paz (Bolivia), Casablanca (Morocco), Dar el Salam (Tanzania) and Abuja (Nigeria) etc.

The slow ineffectual response of the present planning system and the present planning institutions to anticipate, and appropriately respond to, the above described trends and pattern of urban development in these cities may have provided the recipe for the sprawling extensive suburban spatial growth and the informal public transportation system. In view of the weak level of coverage of enforcement of planning regulations, the spatial development resulting from informal low income housing in these suburban areas evade detection by the planning authority. The suburban areas, therefore, grow and

they are growing extensively further away from the core-city at a fast rate far beyond the level with which the institutional capacities of these cities can cope.

The current transport fabric is characterized by huge daily motorized trips in fragmented, unreliable, informal public transport. Polluting mini-buses and the proliferation of private cars that characterizes daily motorized trips may have emerged as a response to the growing demand for mobility which stems from the urban growth pattern and the increasing distance between the core-city and the suburban areas. This mobility pattern culminates in a large number of vehicles running in mixed traffic which repeatedly clogs the roadways and increases travel time.

It is not surprising that urban developments in this region are characterized by this type of situation. This is because, in this 21st century, the urban planning systems and institutions in this region have been shaped and continue to be shaped by the relics of the off-the-shelf Modernist Planning paradigm which provided the blueprint for urban development in Britain and North America in the 20th Century (UNHSP 2009, p.59f, and 77). This planning model is a technocratic, top-down model and is characterized majorly by single use zoning, with its transport sector intervention emphasizing the predict and provide engineering solution of the building and expansion of highways (Jacobs, 1961, UNHSP 2009, p.15 and 154; Kenworthy 2000, p.3).

With an increasing need for effective response to the trend of sub-optimal urban planning outcomes, and to mainstream sustainable urban development agenda in global south cities, these current urban planning tools may no longer be relevant. Therefore, there is the need for in-depth research into the current planning systems and on the related institutional dimensions in cities in this region. This is to identify potential reforms that have capacity to transform the current urban planning system and institutional capacities towards a pathway that permits efficient, sustainable spatial growth and passenger mobility.

This research will help in setting an urban planning and transport policy agenda for transforming sprawling spatial forms, in reducing the huge dependence on automobile-centered mobility and permit enabling environment for developing an efficient transit-dependent transport fabric in cities in the global south region.

1.2 Research Problem Definition

Historical accounts of the development of cities have shown that solution to urban planning problems emerge as a result of prevailing challenges in cities (Rydin 1993, p. 1; Benevolo 1980, cited in Dutton 2000, p. 15). Accordingly, the Modernist Planning paradigm evolved to address the challenges that

faced European cities in the late 19th century. However, the challenges facing cities today are different, diverse and more complex than what was prevalent in the 19th Century. Regardless of the complexity of the recent challenges facing cities, cities in the global south region have remained stuck to the relics of the Modernist Planning approach; this inappropriateness/mis-match may, therefore, explain why the application of this approach has been ineffectual. It may therefore be opined that the application of Modernist Planning in cities in today's context is not an appropriate urban planning tool; it is less relevant than it once was and is not in-tune with the present challenges in global south cities.

On the one hand, earlier studies show that the current planning systems in cities (especially in the global south region) have been characterized by the predict and provide engineering solution of road building and expansion to address traffic congestion challenges (Litman 1998, Newman and Kenworthy 2000, p.23; Newman and Kenworthy 1989). The enabling environment created by this trend has further fuelled the growth of private car usage which, in turn, continues to fuel the extensive sprawling spatial pattern of development (Salingaros 2006, p.1). On the other hand, earlier studies have shown that the implicit car-dependent mobility pattern and ensuing sprawling spatial pattern of growth in cities has continued to expand extensively to eat-up arable lands (Azocar et. al. 2007, p.200; Chen et. al. 2008, p.29). This trend has continued permitting the emergence of suburban settlements located further away from the core-city and using land inefficiently. This, therefore, results in the daily distant commuting between the core-city and these suburban areas by the residents as seen in many global south cities including Abuja, Nigeria. This daily commuting pattern has been characterized by the proliferation of cars and informal mini-bus public transport struggling to cope with daily movement of commuters. This fleet of cars and mini-bus public transport generally features second-hand vehicles with deteriorating emission levels and a huge pollution footprint (Kutzbach 2009, cited in UNHSP 2011, p.41; Penalosa 2004, p. 8). This growing expansion in the amount of vehicular travel has continued to be fueled by continued road expansion and commuters' social aspirations to own and use cars for commuting (Penalosa 2004, p.8).

The traffic congestion challenge implicit in the high level of motorization in cities in the global south region has culminated in a lack of efficient passenger mobility, as commuters are forced to sit in traffic jams for many unproductive hours. In these cities, private car usage has exceeded its tipping point and the resulting traffic congestion negates the primary advantage of automobile transport (Freund and Martin 1996, p. 27) which is to guarantee speed and time-savings in travel. This situation therefore renders the use of cars to be almost pointless due to their slow speeds. Thus, daily commuting in these cities continues to culminate into intolerable levels of traffic congestion, loss of economically

productive hours, and air pollution, also, vehicles spend more time in operation due to longer travel times and fuel is wasted due to frequent acceleration and deceleration in traffic jams. The implications of this mobility pattern show that large numbers of productive hours are lost and fuel wastage occurs which culminates in an economic loss with implications on GDP.

Similarly, public transport usage in these cities has not been favoured because, firstly, the existing public transport services are operated by informal unregulated operators, with services characterized by inefficiency in terms of unreliable waiting times, unscheduled bus services and a lack of passenger comfort in small-sized buses (Cervero 2000, p.7f; Penalosa 2004, p.8); secondly, there is a perception of public transport as a mode of transport for the poor spectrum of society due to limited choices, as current riders use public transport because they have to, and not because they are choice riders. This spectrum of people has high aspirations to own and use cars because car usage is perceived as symbol of affluence and leverage on social credential. Lastly, government investments in the transport sector have focused mostly on road expansion in order to ease traffic congestion, in actual fact, this serves as an incentive and impetus for the proliferation of cars. In this situation, minimal efforts are being made to expand investments in public transport as seen in these global south cities including Abuja, Nigeria. These factors interplay with each other to continually shape the existing mobility patterns in these cities and to dwarf any efficiency in passenger mobility.

Further, research evidence has shown that, with the predicted and continuing rise in urban population growth, the corresponding rise in the demand for mobility is also predicted to continue to rise on average by 1.8% per year between 2003 and 2050 in the global south region (Schaefer and Victor 1997, p. 59ff; WBCSD 2004, p. 36; IEA, 2006; WRI, 2007 cited in Schipper et al., 2007, p. 1711). This increasing demand for mobility and the rises in per capita income is leading to greater private car ownership and usage (Molina et al., 2004, p.5; Schipper, 2003, p.12). By 2030, the total number of vehicles in the global south region will surpass the number of vehicles in countries within the Organization for Economic and Development (OECD) (Wright and Fulton, 2005, p. 692).

The above stated predicted rise in car ownership and usage due to a rising demand for mobility has implications on certain matters such as air pollution and transport-related GHG emissions (Molina et al. 2005 p.6, and Schipper et al. 2006, p.6). While available research evidence shows that the historical and present contributions of cities in the global south region to GHG is minimal in both relative and comparative terms (Klein 2007 p.4; UNHSP, 2011), the potential for population growth in the cities in this region is notably high and has implications on the trend of GHG emissions (Jenks 2000, p. 2f; Moser and Satterthwaite 2008, p. 1; Satterthwaite 2007, p.viii). This tendency of increasing transport-

related air pollution deserves attention partly because cities in the global south region are evolving as emerging economies with a predicted rise in per capita income which is likely to propel a huge proportion of the populace to become car owners; also, partly because mostly single-occupant vehicles are used for daily commuting and the proliferation of these low occupancy cars results in a high level of per-capita fuel usage, with increased consequences on air pollution and GHG emissions.

With the evidence discussed above which show that the current urban planning and transport policy agenda has been largely permissive to the current challenges, it may suffice to posit that the current Modernist Planning paradigm may not be relevant enough to realize efficient spatial growth and passenger mobility in these cities in the face of the prevailing complex challenges. While the age-long Modernist Planning and its Master Plan approach have been useful in providing the overall framework for physical development in these cities, it has however not been able to effectively address the complex challenges of traffic congestion and suburban sprawl as seen in most global south cities including Abuja-Nigeria where the researcher works and live. This may therefore necessitate the need for an alternative approach/paradigm. Therefore, what may be required is an approach that is proactive rather than reactionary, context-specific, and relevant to the situated experience of the complex challenges in global south cities. This approach should on one hand permit smart spatial growth that uses land efficiently (and retrofit the trend of suburban sprawl), and on the other hand, emphasize transit-dependent mobility pattern in order to reverse the rising trend and the various impacts of car proliferation in these cities. This reform should ensure efficient passenger mobility.

1.3 Aim

The aim of this research is to develop a framework for spatial planning strategies to transform urban sprawl and car-dependent mobility patterns to address traffic congestion and its related challenges with a view to achieving sustainable transport systems in cities in the global south region.

1.4 Objectives

The objectives are to:

- i. examine the rate of urbanization, suburbanization, highway expansion and the growth of highly motorized mobility patterns in global south cities.
- ii. examine the character and role of existing Modernist Planning in creating and enabling an environment that permits the existence of numerous motorized mobility patterns in global south cities.

- iii. assess the impact of automobile-dependent mobility patterns on traffic congestion and, man-hour losses, fuel wastages and transport-related CO₂ emissions in global south cities.
- iv. evaluate the existing level of collaboration between the relevant sectors and the existing urban planning system in evolving and implementing spatial plans and urban infrastructure plans in global south cities.
- v. develop a framework for spatial planning strategies to achieving sustainable transportation systems and the spatial development of global south cities based on the findings of the research.
- vi. evaluate the relevance and effectiveness of the developed framework for spatial planning strategies to address the challenges of traffic congestion and suburban sprawl in global south cities.

1.5 Research Questions

The following three research questions are being investigated by this research.

- i. How has the existing urban planning approach in global south cities created an enabling environment for suburbanization and road expansion which has permitted high level of traffic congestion and the related challenges of man-hour losses, fuel wastages and CO₂ emissions?
- ii. Why has the present urban planning approach permitted a weak level of sectoral integration amongst the urban planning sector, and other relevant sectors with regards to evolving and implementing spatial plans and urban infrastructure plans in global south cities?
- iii. How can an effective alternative framework for spatial planning strategies be developed in order to achieve sustainable transportation systems in the global south cities?

1.6 Scope of the Study

The city of Abuja features prominently in this thesis, this is because it was chosen as the indicator case city used to contextualize the research problems and the developed solution within the realm of global south cities. However, several other rapidly urbanizing medium-sized global south cities that could have been considered as candidate case city include Cebu (Philippines), Izmir (Turkey), La Paz (Bolivia), Casablanca (Morocco), Dar el Salam (Tanzania). The justification for choosing Abuja is

mostly because many of its features strongly depict the major character of rapidly urbanizing medium-sized cities in the global south region. These defining features include, presence of Modernist Planning approach, rapid urban population growth, ineffective public transport system, increasing level of private car proliferation, and sprawling spatial pattern of suburban settlements. While these features are also common to these global south cities mentioned above, the features are strongly typified by the city of Abuja-Nigeria where the researcher works and lives, hence, its selection as the case city. The detail discussion on the process and criteria for selecting the case city Abuja is explained in Chapter 3 Section 3.6. The definition of scope for this study is explained using such indices as geographic coverage (geographic location) and thematic coverage (urban planning systems, urban population growth, public transport sector, private car usage levels, presence of sprawling spatial patterns of suburban growth and spatial planning strategies).

I. Geographic Scope

In terms of geographic coverage, the study focuses on medium-sized global south cities with population ranging between 500,000 – 3million, as earlier studies and predictions (UNHSP, 2008, 2009) reveal that these cities (and not mega cities) will be zones of major urban transition in terms of population growth and because they offer opportunity to shape present and future urban development trends.

The city of Abuja is the new administrative capital of Nigeria and is located in the central part of Nigeria. Nigeria is located within West Africa (in sub-Saharan Africa) and has a population of over 170 million (National Population Commission, 2012). Therefore, in geographic terms, Abuja is located in the global south region. The population of Abuja stands at 3 million in 2014 with annual population growth of 9.3% which is predicted to continue for the next 15 years (UNFPA, 2012). In terms of population, Abuja stands out as a candidate city because of its medium-sized population and especially because its rate of population growth remains the highest across the entire continent of Africa (See Figure 3.1 below). Abuja's high population growth provides backing to the predictions that most urban population growth from 2008 through to 2050 will take place in small and medium-sized institutionally weak cities in the global south region (UNHSP 2009, p.205).

In view of these geographic characteristics, the geographic scope of this study therefore focuses on Abuja as the illustrative case study for this research as the study's findings will be relevant to understanding and addressing the research problems in global south cities.

II. Thematic Scope

In terms of thematic coverage, the scope of this study focuses on investigating the factors that created the enabling environment for the present level of motorization and growing sprawling suburban settlement. This include an analysis of the trend of sprawl by identifying the annual rate of landuse/land cover and the growth of motorized trips in order to explain how high motorization levels in cities contribute to, or necessitate, sprawling suburban growth. The analysis also focused on the rising motorization levels and consequent traffic congestion; loss of productive time, fuel wastage, and implication of these on the economy of the city. Additionally, the study focused on the transport-related GHG emissions from the present rising motorization level. The study also focused on investigating the deficiencies within planning systems and institutions in shaping spatial development and transport systems in global south cities. In sum, the study focuses on exploring what alternative spatial planning strategies approach exist with the capacity to efficiently address the research problems especially, innovative approach which have not been implemented before now. Here, the major focus is on the relevance of the unique conceptual strategies to addressing the existing challenges and the situated experiences of global south cities. The study focuses on these themes because they involve mass population movements and GHG emissions which have global dimensions beyond a single city level, and because they are relevant cross-cutting indices which will ensure that the research findings can be compared with, and reproduced by similar studies across cities in this region.

The study excludes focus on the implications of implementation of the resulting conceptual strategies, and the analyses of other impacts such as traffic accidents and local particulate matter air pollution. This is not because their impacts may not be important but because these impacts are subject to factors that are affected by city/regional variability, and, as issues relating to local land ownership, deficit of funding, corruption may influence the implementation of these strategies. Local weather/climate conditions such as precipitation, humidity, temperature and other external variations greatly influence the level of atmospheric content of particulate matters at any point in time (Liu et al., 2008, p.5). In terms of traffic accidents, such events are affected by local factors such as road alignment, weather conditions, drivers' attitude, and enforcement of traffic regulations. The city-scale variations of these indices and the resulting local impact may inhibit the effective comparison of research findings across cities in the global south region.

Hence, this study is focus on central novel ideas and strategic conception that underlies the developed solution with implications on the spatial impact of suburban sprawl and on the economic and

environmental impacts of mobility patterns. This should make the research findings relevant across global south cities as comparisons can be easily made.

1.7 Knowledge Gap and Research Justification

The current challenges facing these global south cities appear to defy the solutions and capacity proffered by current planning systems, not only because they may be contextually irrelevant, but also because the ramifications of these challenges are wide, complex and dynamic. As illustrated by earlier studies, the current single application of spatial planning strategies such as (TOD, BRT and TDM) as solutions put forward to address the research problem may have been over-simplified, fragmented, ad-hoc, and inefficient. This may therefore, indicate why the existing urban planning tool and institutional capacities may have been sub-optimal at moving these cities to the required pathway that will guarantee sustainable urban development. This study therefore seeks to fill this gap in knowledge in terms of the deficit of integrated spatial planning strategies to address the research problems.

Further, although many research studies have focused on spatial form and mobility patterns in the global north region (North America, Western Europe, Developed part of East Asia and Australia) (Newman and Kenworthy, 1989, 1992; Litman, 1998; Cervero, 1996; Neuman, 2005), research efforts on how these themes are shaped by the application of spatial planning strategies, prevailing planning systems, and institutional capacities in cities in the global south region are limited. The prevalence of the increasing trend of sprawl and motorization in global south cities makes the study particularly relevant.

This research is unique because earlier researches in this subject area have focused on the cities on the global north region; this research, therefore, fills the gap on coverage of cities in the global south region.

Some of the expected benefits to come from the study's recommendations include:

- ▶ Commuting time for passengers is reduced and this, in turn, increases productivity with a corresponding increase in GDP (Gross Domestic Product).
- ▶ Fuel wastage is reduced which, thus, contributes to economic savings.
- ▶ The transit-dependent transportation pattern put forward will provide increased accessibility for a large spectrum of the populace instead of the facilitation of mobility for private automobile vehicles.
- ▶ A transit-dependent transport system will lead to a reduction in the level of transport-related

CO₂ emissions (and thus a lowering of their contribution to climate change) due to the reduced number of motorized trips. Importantly, a transit-dependent mobility system in cities will emerge as a climate change mitigation strategy for reducing the CO₂ footprint from automobile-dependent cities.

- ▶ The emerging network of nodes will bring about the transformation of present and future spatial developments pattern towards an intensive form of development that uses land efficiently and balances population and their activities between the suburbs and the core-city.

1.8 Contributions to Knowledge

The contributions to knowledge in this thesis is explained under two themes, these are in terms of theoretical (spatial planning strategies) and methodological contributions.

In terms of theoretical contribution, this research posits a new and novel prescription of the combination of spatial planning and Travel Demand Management (TDM) strategies for addressing the challenges of traffic congestion and suburban sprawl in global south cities.

Prior to this study, there has not been any study on the application of the combination of these spatial planning strategies anywhere in the world. As reported by earlier studies, the single application of these strategies have recorded some level of success but have not been sufficient to solve all the complex deep-rooted ills of traffic congestion and suburban sprawl.

It is therefore argued by this study, that the innovative combination of these strategies can provide optimization of urban planning outcomes. The unique strategic combination of these spatial planning and Travel Demand Management (TDM) strategies is therefore the central theme of the unique contributions of this thesis to knowledge, and this is hoped to provide co-benefits to both policy and practice in the fields of urban and regional planning, and sustainable urban development.

In terms of methodological contributions, this study has demonstrated that the Design Science research methodology can be adopted as innovative research methodology in the built environment. This study shows how the structured compartmentalized nature of the Design Science research methodology framework can structure the process of an empirical investigation into a simple ordered systematic sequence from problem explication, developing solutions, through evaluation and validation of the developed solution. In addition, the study helped to show that the Design Science research methodology provides a premise to investigate real-life problem (as is the case in this study) and develop real-life solution.

Importantly, this therefore indicate co-benefit to both research and practice by contributing to producing theoretical knowledge in the built environment, and also applying this knowledge to create

artefacts targeted at real life problems to improve practice. Indeed, this provides a premise to bridge the gap between research and practice/industry.

1.9 Structure of the thesis

This thesis is organized into nine (9) chapters. The structure of this thesis follows the compartmentalized framework of the Design Science research methodology (See Section 2.4 and Chapter 6). Aside from Chapter 1 and 2 which focus on the Introduction to the thesis and the Theoretical Clarifications which underpins this study, the structure explained below is set out in line with the stages of Design Science research framework. These stages are the Explication of Problem, Define the Requirements, Design and Develop Artefact, Demonstrate Artefact, and the Evaluate Artefact stage.

Chapter one is the introductory chapter which consists of a brief background on the subjects in this thesis, and therefore sets the tone for the subsequent chapters. The justification for the research and its expected contributions are highlighted.

Chapter two focuses on two main topics. Firstly, the theoretical framework within which to position the research subject in order to provide understanding and explanation for the planning ideologies that influences urban planning system and institutions in cities. Secondly, it provide insight into the underlying concepts that underpins and shapes the capacities of planning system and institution in responding to spatial growth and mobility pattern in rapidly urbanizing global south cities. The chapter concludes with a brief introduction of the Design Science research strategy adopted in the thesis.

Chapter three consists of review of literature evidence and inherent gaps in earlier studies on the various themes relevant to the research problems which include sprawling suburban development, unprecedented huge population growth, private car usage for daily commute, intractable traffic congestion levels, weak public transport systems which struggles to cope with daily movement of commuters. The chapter also consists of the detailed explanation of the selection process and criteria of an indicator city to contextualize the research problems within the realm of a typical global south city. This chapter represents the Explication of Problem phase of this study, and uses primary and secondary data to elucidate on the different dimension of the research problems in the case city, Abuja.

Chapter four deals with a review of literature and empirical cases to identify the various array of spatial planning strategies that have proven performance capabilities to address the challenges of sprawling spatial pattern of suburban development, car-dependent mobility pattern and traffic congestion in cities. This chapter represents Defining the Requirement phase of this study, and specifies the

performance capabilities required from the various identified strategies to effectively address the research problems.

Chapter five focuses on analyses that lead to developing the artefact which in part satisfies the defined requirements and partly demonstrates the capacity to efficiently address the explicated problem. This chapter represent the Design and Develop Artefact phase of Design Science research structure and focuses on the actual design/development of the solution to the research problems (of traffic congestion and suburban sprawl). The design and development of this solution is predicated upon the performance capabilities specified in the defining the requirements phase in chapter four. These include analysis of the illustration of the outcomes in terms of spatial pattern and travel pattern in cities that have implemented some of the strategies. The developed artefact/intervention is therefore the combined application of BRT, TOD, and TDM strategies as a hybrid in order to produce optimal outcomes. The chapter concludes with the recognition of the need to contextualize the developed artefact and its related strategies within the realm of a typical global south city.

Chapter six focuses on the overall research strategy which reflect the philosophical leaning and research process conducted in this thesis. Firstly, the chosen research approach, strategy and methods, and the justification for the choices were discussed. Secondly, the various data sources (quantitative and qualitative) that were collected, the techniques on how they were collected were explained. Finally, the data analysis method for the data sets was discussed.

Chapter seven is an extension of chapter five and consists majorly of contextualizing the identified spatial planning strategies with the selected indicator city of Abuja in order to demonstrate the applicability of these strategies to the situated experience of global south cities. This consists of the use of metrics (on the level of land usage, mode shift, travel time) to illustrate the performance capability of the developed spatial planning strategies (artefact). This chapter represents the Demonstrate Artefact phase of the Design Science research strategy. It provides a platform for making comparison between the existing situation (with present planning system and without the new artefact) and the proposed situation (with a different planning system and with the new artefact). The comparison focuses on reduction in land usage, reduction in travel time and related economic and environmental impacts, and reduction in land usage.

Chapter eight consists of the sections on data analysis and results, and represents the Evaluation phase of the Design Science research strategy adopted in this thesis. The results discussed in the analysis were obtained from the indicator city (Abuja-Nigeria) and consist of interview and focus group

sessions with relevant experienced practitioners such as urban planning practitioners in government establishments, private consulting firms, the academia, and transport operator association. The focus here is to validate the artefact through an iterative process by analyzing the expert opinion on the relevance and applicability of the developed solution (artefact) and the demonstrated performance capabilities as a credible alternative for addressing the challenges of traffic congestion and suburban sprawl, and to reform the present Master Plan approach. In addition, users perception surveys were also used to provide another layer of validation to the performance level specified for this solution (artefact).

Chapter nine focuses on the main conclusions that are drawn from the findings in this research. The conclusions were drawn in view of the findings relevant to the respective objectives and research questions. The implications on the planning policy agenda are discussed. The recommendations arising from this research and, for areas of further research are presented.

CHAPTER 2: THEORETICAL CLARIFICATIONS

2.1 Introduction

This section focuses on the exploration of the trajectories of urban planning ideation and thoughts, and the related debates and contradictions, this is to elucidate on how this trends has shaped urban planning practice and city development globally. Importantly, the focus included theoretical clarifications of the relevant urban planning theories which include Institutional Theory and Network City Theory.

This trajectories and theoretical clarification are necessary at this stage in this study in order to provide a general perspective and definition of the theories that shapes the phenomenon under investigation in this study. These therefore provide the premise for understanding the range of themes to be covered in the investigation in this study.

The last section of this chapter focuses on brief introduction of the research methodology adopted for this study and shows how the chosen Design Science research methodology framework has provided the guide for structuring the entire thesis. The detail discussions and explanation of all the range of the relevant research methodology strategies open to selection by the researcher and the selection of Design Science research strategy are contained in Chapter 6.

2.2 Conceptual Background and Theoretical Framework

Increasingly, there has been consensus on the unsustainability of the present unprecedented level of automobile usage in cities because of its inherent challenges such as traffic congestion, particulate matter air pollution, GHG emissions and traffic accidents. This existing situation has been linked to the weaknesses of the existing Classical Modernist Planning paradigm (Master Plan) (Williams, 2006, UNHSP, 2009). This existing paradigm is characterized by the *“Predict and Provide” engineering solutions of road building and expansion, low-density development, dispersed urban forms, expert-driven technocratic activities, single-use zoning, and rigid standards/regulations*. This paradigm has permitted a sprawling extensive pattern of suburbanization which has continually increased the distance between suburban areas and the core-city of cities in the global south region. This distance has generated a mobility demand and huge daily commuting volumes into and out of the core-city. This mobility pattern has continually overwhelmed the available roadways with traffic congestion which keeps people sitting in the traffic for many unproductive hours and also results in local air pollution and transport-related GHG emissions.

In view of the approach of *predict and provide engineering solutions* that characterizes the Modernist Planning system in these global south cities, roads are continually built and expanded to address traffic

congestion challenges and this fuels the trend of a sprawling pattern of suburbanization (UNHSP 2009, p. 154; Salingaros 2006, p. 1). Earlier studies have shown that traffic does not behave like liquid that retain its volume in a given space but is rather like gas that expands over any given space that is provided (Litman 1998 cited in Newman and Kenworthy 2000, p. 23; ITDP and EMBARQ 2012, p.5). As such, this engineering solution which skews transportation investments towards building more roads largely induces more traffic and, soon after the expansion phase, the traffic challenges that ensue are similar to the earlier challenges that the expansion phase was attempting to deal with. According to Newman and Kenworthy (2000. p.23), automobile dependence is inevitable in this unsustainable scenario of traffic engineering as it sets in motion the vicious cycle of a self-fulfilling prophecy of congestion and more road building.

These challenges have remained deeply rooted in the fabric of cities globally because this form of planning spread to all corners of the world in the 20th century through the processes of *colonialism, market expansion, international planning consultancies and the intellectual exchange of planning values peculiar to solving the challenges of European cities* (UNHSP, 2009, p.206). This explains the influence and diffusion of Modernist Planning ideas into most cities in the global south region including sub-Saharan Africa. Many master plans and zoning schemes in Nigerian cities today (including Abuja) maintain geographic density distinctions which are devoid of density mix, and single-use areas devoid of functional mix. In addition, the current enabling environment for automobile-dependent mobility (created by the building and expansion of roads), and suburbanization leads to overly extensive spatial configuration with low-income groups settling on marginal and environmentally vulnerable lands (Mabogunje, 2001; Okon, 2008 p.2; Ball, 2002 and Jinadu, 2004). Planning Laws and Zoning Ordinances in many global south cities in this 21st century are an exact replica of those used in Europe and UK in the early 20th century and they are still enforced in the face of new changing complex challenges in these cities.

Notwithstanding the changing 21st century complex challenges in the global south cities, the Modernist Planning paradigm and its Master Plan approach (landuse and zoning regulations) appear to have provided benefits in realizing orderly spatial development mostly in the core-city portion of cities in this region. The sustained trend of building and expansion of highway that characterize transport policies under the Master Plan system may have also contributed to road infrastructure development and prosperity of these cities. The absence of democratic urban planning culture in this region may have also made the Master Plan approach appear suited and still relevant in these cities. In the face of complex challenges facing cities today and the need for inclusive development, it may be imperative to reform the existing planning system in response to the present realities in these cities.

2.2.1 The Trajectories of Urban Planning Views and Ideas

It is important to analyze the range of planning views and ideology in order to evolve an appropriate theoretical underpinning to the current planning system in cities with a view to understanding spatial growth and mobility pattern in global south cities. Whilst exploring the range of planning views and ideas, Faludi (1973, pp.3-8) identified two broad categories of theories; procedural theories (process oriented) and substantive theories (focusing on urban activities). In Faludi's opinion, the procedural theories better reflect the essence of planning theories. His stance has undoubtedly generated debate along the existing polarized line of ideological differentiation (Campbell and Feinstein, 2003, p.12).

In essence, planning theories have oscillated severally across different views and ideological leanings. Broadly speaking, two discernible shifts can be noted here (Rydin, 1993, Hall 1996); from the *plan/blueprint* to the *rational systematic approaches*, and from the *systematic approach* to the *broad combination of the systematic and political views* embodied in the collaborative planning and sustainable development which guide the present ideology and practice.

2.2.1.1 Plan /Blueprint and the Classical Modernist Planning View

The emergence of planning philosophies occurred as a corrective intervention out of the need to address and reshape prevailing challenges in the built and natural environment at a set time and place (Rydin 1993, p. 1; Benevolo 1980, cited in Dutton 2000, p. 15). At the beginning of 20th century, the quest for developing a modern society generated ideological differentiation in the urban planning field and huge debates took place which was polarized along pre-existing ideological leaning. This debate shaped the emergence of planning ideologies and practice through until today. According to Taylor (1998, p.5-17), the pioneering ideas by Ebenezer Howard, Frank Lloyd Wright and Le Corbusier can be described as being overly utopian, expert-driven and anti-urban. The Pre-World War II planning in Britain largely concentrated on a plan-led design with a strong emphasis on physical and detailed blueprint Master Plans. In the same way, visionary plans illustrating a spatial configuration of an ideal city often dominate planning theories (Taylor 1998, p.5-17).

Consequently, these plan-led Modernist Planning ideas have shaped the development of major cities in the global north region and have also been exported to the global south region through colonialism, intellectual exchange, international consultancies, etc. In the global north, these ideologies have guided planning theory and practice through to the middle of the 20th century (UNHSP 2009, p.206).

Notwithstanding the highlighted weaknesses of the Modernist Planning paradigm, its Master Plan approach and the implicit simplification of the role of planning to landuse and zoning regulation, and the approval and rejection of development permit, some of the benefits of the Master Planning

approach include landuse regulation that has fostered spatial and functional differentiation of location of uses. This appears to have ensured orderly spatial development of landuse in the core-city portion of most global south cities. These include the focus of transport policy on building and expansion of highway which is perceived in some quarters as contribution to infrastructure development and prosperity of the city.

The mid-20th century witnessed the criticism of this planning theory and the approach of having a Master Plan for urban forms on the grounds that it over-emphasizes the physical elements of a city and because the resulting plans are not situation-specific (Nadin and Shaw, 1998, Faludi, 2003, Shaw and Sykes, 2003). Put simply, Taylor (1998, p.55) opined that “what planners lacked, and what planning theory had failed to provide, was an adequate empirical understanding of the world they were seeking to manipulate”. Hence, planning practice was skewed towards being concerned with urban form with little or no attention being paid to the social interactions that shape a city.

To sum up, the blueprint approach paid little or no attention to the important factors of the environment and the social networks/interactions that create the dynamism in a city system. It is self-evident that the static blueprint and end-state documents may be inappropriate for addressing the complex challenges and the dynamic nature of cities today.

2.2.1.2 Systematic Rational View

In recognition of the deficiencies in the blueprint view of using static documents (Master Plan Approach) to guide a dynamic phenomenon such as a city, systematic rational analysis evolved in order to address the intricacies, complexities and dynamism of a city system. As a result, planning evolved as a continuous process of rational action that focuses on the uncertainty of the future. The rational view of planning placed more emphasis on method of planning (Chadwick 1971, and Faludi, 1973 cited in Du 2010, p.22). Indeed, the procedural planning theory provides a framework for a strategic approach to planning; it was, however, criticized on the grounds of abstraction.

According to Taylor (1998, pp.95-109), the rational view lost credence on the grounds that using this viewpoint, planning failed to recognize the importance of the political-economic context in cities and in determining the effectiveness of planning activities. In addition, emphasis was laid on disaggregating planning into an exclusive chain process at the expense of planning and policy implementation issues. Indeed, it is pertinent that planning should not end with the preparation of a plan but with the consideration of implementation issues and the socio-political context.

Consequently, gradually planning shifted towards reflecting substantive issues related to a city, with a renewed approach that was problem-centered. Gradually, the planning paradigm became problem-centered research and also focused on issues of institutional change and communicative approaches as the major drivers of plan-making and implementation.

2.2.2 Collaborative and Institutional Views

In recognition of the relevance of the socio-political context of planning, there is an increasing consensus for planning to emerge as a collaborative process that involves and incorporates relevant stakeholders. In order to achieve the goal of a spatial plan, it has been noted that interaction between relevant stakeholders is critical in ensuring that planning evolves as a collaborative process that reforms urban planning from “building places” to building the institutional capacity in communities for on-going “place-making” activities (Healey, 1998). By this process, spatial development plans and urban infrastructure plans emerge as a product of the interaction between relevant stakeholders and this ensures that the emerging solutions are situation-specific and relevant to their context. Healey (1997 p.65) called for increasing recognition of the current complex multi-cultural world, noting that planning is an interactive process that takes place within a complex diverse context. Accordingly, planning is characterized by a strategic policy-driven approach with social, economic and environmental objectives. Indeed, this particular feature of planning may be what is required to mainstream a sustainable development agenda within urban planning.

Collaborative planning has also been criticized on the grounds of theoretical and practical deficiencies (Feinstein, 2000; Huxley and Yiftached 2000; Lauria 2000; McGuirk 2001; Mergerum 2002, Brand and Gaffikin cited in Du 2010 p.26). However, notwithstanding the reported challenges or deficit of inter-discursive and inter-personal communication skills, reduced attention to mobilization of resources and expertise, communicative or collaborative ideology has continued to emerge as a tool of immense utility and offers useful insights for planning systems in order to achieve urban planning goals.

2.2.3 Fusing Sustainable Development and Planning

Globally, cities have emerged as a critical engine of socio-economic growth with huge environmental consequences within and beyond their immediate boundaries (Newman and Jennings, 2008, p.3; IEA 2009; ITDP, 2013). The environmental challenges created by cities have become increasingly relevant because of international concerns about the global environmental problems; these concerns result in part from the World Commission on Environment and Development (WCED) in 1987 and in part from the Rio Earth summit in 1992 which focused on sustainable development. In line with the outcomes reported from these meetings, sustainable development is defined as “a process of change in

which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspiration” (WCED, 1987, p.46).

Urban planning ideas and practice have increasingly been influenced by the concept of sustainable development since the 1990s. Consequently, the task of mainstreaming ideas of sustainable development into planning practices in cities remains widely debated (Hall, 1996, p.412). In recognition of the imperatives of the sustainable development agenda, Taylor (1998 pp.130-153) opined that it is pertinent for planning practice to promote and emphasize knowledge-based, communicative, public participative and action-oriented philosophy.

While the Modernist Planning paradigm and its Master Planning approach may not appear to provide the requisite platform for communicative and participative capacity required for engagement under the sustainable urban development regime, it can still offer some usefulness. This is because the sustained application of the Master Plan approach under the current (Non-participatory) autocratic urban planning culture and the evidence of spatial and functional differentiation of uses resulting from landuse planning in the core-city of most global south cities may provide indication that the Master Plan approach can contribute to some facet of the sustainable urban development agenda. With this, the realization of the goal of sustainable urban development may still be achieved to some extent under the Master Plan approach in the global south cities. Even though, a robust platform for inclusive development may be lacking.

To sum up, the above mentioned planning views are seen as relevant in different contexts and should be viewed not as mutually exclusive but as complimentary to each other. By focusing on physical form and design at a local level, optimal planning outcomes may be achieved, while at a strategic level, the concept of system and a rational process becomes imperative. According to Hall (1996, p. 332), it is imperative to achieve a shift towards an approach that emphasizes broad, and incremental solutions. Accordingly, it is imperative that planning theorists re-tune their approach to recognize that intervention in planning is often based on “disjointed and incremental” approaches. Hence, new planning tools and mechanisms are required to focus on consensus building amongst all the relevant stakeholders and engender negotiation in order to build relevant and broad-based consensus. Therefore, with sustainable development in view, sectoral integration is imperative in achieving sustainable spatial development in cities. By this, urban planning becomes an open, collaborative and integrated realm.

2.3 Theoretical Framework

Notwithstanding some of the reported benefits of the Modernist Planning approach which prevail in most global south cities, earlier studies have argued that the prevailing Modernist Planning paradigm and its Master Plan approach may have permitted the trend of sprawling spatial pattern and automobile-dependent mobility pattern (UNHSP, 2009). In view of the impact and externalities implicit to this trend in most global south cities, the capacity of governance in these cities is known to have been stressed. These kinds of challenges have been described as a *transformative stressor* that compels institutional change (Matthews, 2011). Accordingly, the existing planning paradigm may require reforms not only to make urban planning institutions responsive to these stressors but also to appropriately anticipate and address them timely and efficiently.

The relevant theoretical knowledge pertinent to this reform includes institutional theory (Institutional Analysis), the Transit Oriented Development model and the Network City Theory (Spatial Analysis).

2.3.1 Institutional Theory

Earlier studies have posited that existing urban planning systems and inherent weak institutions may have contributed to the existence of unsustainable pathways in cities globally, especially in global south cities (UNHSP, 2009). These institutional deficiencies are expressed in the increasing trends of the extensive spatial pattern of suburbanization, automobile-dependent mobility and the attendant externalities of traffic congestion, air pollution and transport-related GHG emissions. In view of this situation in global south cities, the spatial planning paradigm whose features include being situation-specific, outcome-focused, avoid of restrictive bureaucratic practices and engender the joining-up of government sectors to achieve sectoral integration (vertical and horizontal) may become desirable.

Since urban planning systems, through their dispensing organizations aim at creating social order via social and spatial interactions, it becomes imperative to leverage these organizations with respect to the reforms required for the optimization of the organization. Institutional theory offers the basis for carrying out institutional analysis on these organizations with the aim of reforming them and re-creating them as new 'norm'. Rydin (1998) defined institutional theory as a channel for examining the character and strength of institutions which include the organizations' social norms and habits as well as the influence of larger social, economic and political structures.

This assertion illustrates that institutions are shaped by the strengths and weaknesses posed by the social structure internal to them, and by opportunities and threats posed by the economic and political structure external to them. The deficiencies in the existing planning organizations are evidenced in the challenges of sprawling suburban growth and inefficient passenger mobility caused by automobile-

dependent mobility. Further, this strains the already weak institutional capacities in global south cities and therefore, necessitates institutional change in order to achieve sustainable urban planning outcomes. This institutional change should adequately equip urban planning organizations/institutions with the required capacities beyond the existing urban planning paradigm to effectively cope with the emerging complex challenges so that urban planning outcomes are optimized.

Thus, planning organizations need to become institutionalized with a new set of codified rules that can reflect the recognition of the new order of sustainable development (social, economic and environment) into urban planning practice. Scott (1987 p. 496) noted that “...institutionalization involves the process by which social processes, obligations or activities come to take on a rule-like status in social thought and action”. Geels (2004, p. 916) also observed that institutionalization is used to conceptualize the dynamic interplay between actors and structures and to address issues of change from one system to another.

A review of Scott’s perspective of the forms of institutional explanations, the *Acquisition of organizational structure* and the *Incorporation of organizational structure* is relevant. Scott opined that institutional explanations are not all of a piece (Scott 1987 p. 501, 2004, p.21). These two identified forms permit a choice of a model(s) that is appropriate for organizational actors to be able to scale-up organizational capacities in order to deal more effectively with strategic issues via a broad array of adaptive mechanisms. The present urban planning organizations should therefore be analyzed with a view to institutionalizing a new order to address the inadequacies of the present settings. The analysis is expected to reveal a pathway for strengthening capacities to cope with, and address, the emerging stress caused by present suburban sprawl, the automobile-dependent mobility pattern and related externalities. The new paradigm therefore, requires to be institutionalized in order to achieve the required shift from the current urban planning system in order to not only achieve a strong and virile urban planning institution but also to achieve sustainable urban development.

By this, with the relevant actors and structures equipped with the requisite capacities, changing from one system to another are insulated from economic/political influence. These are the pre-requisites for transforming existing urban planning organizations to strong efficient institutions that are characterized by the ideals of a new order.

2.3.2 The Network City Theory

There has been increased recognition of the concern relating to the emerging extensive spatial pattern of development that characterizes the increasing trend of suburban sprawl in global south cities, and its

attendant challenges of increasing commuting distances to the core–city employment area. In addition, an automobile-dependent mobility pattern has emerged as this is deemed to be the fastest means of commuting between the core-city and suburban areas due to the permissive factor created by the building and expansion of roads.

The increasing potential to moderate travel demands through changes in the built environment has been the subject of recent empirical studies (Ewing and Cervero, 2007). These studies are in response to the sprawling spatial pattern of development and the ravaging automobile-dependent mobility pattern and its related externalities that has plagued city systems. These research studies show that transit network and land-use are being integrated by focusing spatial development around transit stations. The assumptions here are premised upon the notion of precincts designed for high-density residential development strongly coupled with high-intensity commercial development within a high-quality pedestrian environment, and within the proximity of efficient transit system (Curtis 2008, p. 287). Indeed, the rationale for this approach is to achieve a substantial reduction in car-based travel by providing the opportunities for both local and regional trips via the transit system.

With these emerging connected transit node(s) and hub(s), a pattern of networks of sub-centres emerges, creating a polycentric outlook on the landscape of the city (Volchenkov 2008, p. 332; Borgatti and Halgin, 2011, p. 2). Camagni and Capello (2008, p. 526), in their study, refer to this network pattern as intentional city strategies, both at the level of the single centre and at the level of the entire city-system with centres having the capacity to develop high-order functions without increasing in size. Lehman adopted the *Network City Theory* to explain the emerging networks in the city. He regarded the core-city as the primary node (or hub) with different networks connecting the secondary and tertiary nodes (Lehmann 2012, p. 6; Newman and Kenworthy, 2006). The Network City Theory explains how sprawling spatial configuration and the implicit automobile-dependent mobility pattern can be transformed around a city's central hub and network of nodes characterized by intensive rich, diverse, functional and density-mixed smart development along the transit corridors.

Premised upon this described ideology of the Network City Theory, extensive spatial configurations of suburban development can be transformed by the identification of potential areas within suburban areas and along routes to suburban areas to serve as nodes for intensive spatial development. By designating multiple secondary nodes inter-linked by public transport corridors while still maintaining linkage with the core–city hub (primary node), a polycentric spatial form can emerge. Consequently, this polycentric spatial configuration can de-leverage the huge commuting volume into the core-city employment area, grows the suburban area and creates a balance of activities and development.

This spatial development pattern is envisaged not only to firm up the existing extensive spatial pattern by increased densification and intensive rich diverse, functional and density-mixed development, but also to generate ridership that can support the optimal operation of the transit and also justify investment in the transit infrastructure. By shifting cities toward polycentric spatial configuration, Network City Theory illustrate how the overly extensive low density sprawling spatial configuration and automobile-dependent mobility pattern in cities can shift towards being a transit metropolis and contribute to the reduction of inherent externalities.

To sum up, the institutional theory provide a premise for explanation of how present planning organizations can be leveraged in order to institutionalize a new order to help mainstream the indicators of sustainable development into urban planning. As a result, this paradigm should provide the required framework for integration amongst sectors relevant to achieving sustainability in cities' transportation systems. The Network City Theory demonstrate the capacity to aid the explanation of how the overly extensive spatial pattern of suburbanization and the implicit car-dependent transportation pattern can be transformed by the resulting transit-dependent mobility pattern.

2.4 Research Methodology Overview

This section provides an overview of the research methodology developed for this study. The research methodology is premised upon the research design which is derived from a matrix that consist of the research problems, research objectives, research questions and data sources (see Table 2-1).

Table 2-1: Summary of the Research Objectives, the Research Questions and the Research Methods/Data Sources

Objectives	Research Questions	Data Sources					
		A	B	C	D	E	F
<p>Objective 1: Examine the rate of urbanization, suburbanization, highway expansion and automobile dependence in global south cities.</p> <p>Objective 2: Examine the character and role of the existing Modernist Planning in creating an enabling environment that permits the existing motorized mobility pattern in global south cities.</p>	<p>Research Question 1: How has the existing urban planning approach in the global south cities created an enabling environment for suburbanization, road expansion, which has permitted the level of traffic congestion and related challenges of man-hour loss, fuel wastages and CO₂ emissions?</p>	X	X	X	X		
<p>Objective 3: Assess the impact of automobile-dependent mobility patterns on traffic congestion and transport-related CO₂ emissions in global south cities.</p> <p>Objective 4: Evaluate the existing level of collaboration between relevant sectors and the existing urban planning system, in evolving and implementing spatial plans and urban infrastructure plans in global south cities.</p>	<p>Research Question 2: Why has the present urban planning approach permitted a weak level of sectoral integration amongst urban planning, and other sectors with regards relevant to evolving and implementing spatial plans and urban infrastructure plans in global south cities?</p>	X	X	X	X	X	
<p>Objective 5: Develop a framework for spatial planning strategies to achieving sustainable transportation system and spatial development of global south cities based on the findings of the research.</p> <p>Objective 6: Evaluate the relevance and capabilities of the developed framework for spatial planning strategies to address the challenges of traffic congestion and suburban sprawl in global south cities.</p>	<p>Research Question 3: How can an effective shift towards new alternative spatial planning strategies be develop in order to achieve sustainable transportation systems in global south cities.</p> <p>Hypothesis: There is no significant relationship between desire of motorists to leave their car at home to ride on the BRT and the introduction of BRT system, TOD and congestion pricing in Abuja.</p>	X		X	X	X	
					X	X	X

Source: Author's Analysis, 2013.

Note: **A**-Document Review; **B**-Direct Observation; **C**-Archival Records; **D**-Interviews (Structured/Semi-Structured); **E**-Focus Group Discussion; **F**-Users Perception Survey

By this, the research design therefore shows a linkage between the research problems, the objectives and data sources; hence, the relevance of the data sources to the research problem and reliability of the research findings. The data sources include document review, direct observation, archival records, interview (structured/semi-structured), Focus Group Discussion (FGD) Session and users' perception surveys.

In view of the research problems as a practical real-life problem that exist (with subjective respondents as research participants), and the solution (artefact) resulting from the study which is not necessarily implemented (nor observed while in practical use as in Case Study), the Design Science research methodology strategy has been adopted as the research methodology strategy appropriate to this study.

The detail discussions and explanation of the range of the relevant research methodology strategies open to selection for the research, and the selection of Design Science research strategy is contained in chapter six. The defining character of the Design Science research strategy is the ability for structured compartmentalized frameworks that helps shape and structures the processes of an empirical investigation into a simple ordered systematic sequence.

Notably, the Design Science research strategy has the capacity to integrate various data sources as required by the research design in this study in order to realize the research objectives. The framework of the Design Science research strategy consist of five (5) compartmentalized structure which consist of the Explication of Problem phase, Defining the Requirement phase, Design and Develop Artefact phase, Demonstrate Artefact phase, and Evaluate Artefact phase. This framework therefore provides the premise for structuring the chapters in this thesis (See Table 2.2).

Table 2-2: Structure and Chapterization of Thesis (in line with the Design Science Research Framework)

S/N	Generic Structure of a Design Science Research (Johanneson and Perjons, 2012)	Chapterization of Thesis	Summary of Contents of Chapter in the Thesis
1	-	Chapter 1: Introduction	General introduction, brief introduction and contextualization of research problem, aim, objectives, research questions, justification, scope of study, contributions to knowledge, structure of thesis.
2	-	Chapter 2: Theoretical Clarifications	Review of the trajectories of urban planning ideologies in order to evolve an appropriate underpinning to the current spatial development, transport fabric and capacities of urban planning organizations in cities. This include identifying theoretical knowledge relevant to making reforms in cities (global south) and urban planning organizations. This include a brief overview of the Research Methodology and how it framework structures the thesis.
3	Phase 1: Explication of Problem	Chapter 3: Challenges of Traffic Congestion and Suburban Sprawl in Cities	Review and detailed explication of the research problem in global context, while also explaining all debates and controversies on the themes and concepts relating to the research problem. Detail explanation of research problem within the context of the case city using datasets extracted from the case city.
4	Phase 2: Define Requirement	Chapter 4: Guide for Developing Solution to the Explicated Problems	Establishing the features that the solution/artefact requires in order to effectively address the explicated problem. Here, various alternative concepts and solution on how to overcome the research problem are highlighted. These include rapid transit infrastructure, physical planning measures and travel demand management strategies.
5	Phase 3: Design and Develop Artefact	Chapter 5: Spatial planning strategies and related spatial planning framework	Present and illustrate the solution(s) selected from the various alternative concepts/solution identified in the earlier phase. In this case, the developed solution as the artefact is explained and presented. The reason for selecting these particular strategies is explained. These include detailed explanation of the process for the selection of the case city to contextualize the developed artefact.
6	Phase 4: Demonstrate Artefact	Chapter 6: Research Methodology	Research methodology framework, ontology, epistemology, research approach, research strategy, research method, data sources, sampling procedure, and data collection procedure in the case city, including explanation of how Design Science framework structures the thesis. These empirical investigations provide the premise for the Demonstrate and Evaluate Artefact chapters.
		Chapter 7: Contextualizing the spatial planning strategies to the case-city	The focus here is documenting the extrapolated outcomes from the application of the developed solution to the case city. This is expressed in terms of reduced travel time, reduction in car usage, reduction in sprawl, and reduction in economic losses associated with the developed solution. These include detailed explanation on how the developed solution can solve the explicated problem in the case city.
7	Phase 5: Evaluate Artefact	Chapter 8: Results, Discussions And Findings	The result of the performance of the artefact derived from the extrapolated outcomes attributable to the application of the artefact to the case city, and the graphical illustration resulting from the demonstration phase is presented to selected expert groups (urban planning practitioners in government agencies, private consulting firm, and the academia) in semi-structured interviews, and Focus Group Discussion Sessions for feedback. This iterative process of validating or invalidating the demonstrated results of performance level of the artefact to address the explicated problem provides the premise for feedback to modify the artefact in order to improve its performance. This include Users Perception Survey of selected sample of commuters, the result from this analysis also elucidate on the relevance of the artefact to addressing the explicated problem. The explanation of how and why the respondents are selected is also presented.
8		Chapter 9: Conclusion and Recommendations	Conclusions emerging from the findings and the Recommendations drawn therefrom.

Source: Hevner et al, 2004; Vaishnavi and Kuechler, 2008; Johanneson and Perjons, 2012; Author's Analysis, 2013.

The adoption of the Design Science framework for structuring this study is therefore explained below:

The Explication of Problem phase (Chapter 3) represents the extensive exploration of the research problem within the context of existing literature and empirical cases from earlier studies to elucidate on all the themes that relates to the research problem and gaps in earlier studies. The Defining Requirement phase (Chapter 4) represent the establishment of the performance capabilities required to address the identified research problem, these requirement serves as specifications for the required artefact as seen in diverse cases. The Develop and Design Artefact phase (Chapter 5) represent the analyses and selection of an appropriate solution to the explicated problem based on the defined requirement and specification of the range of alternative solution, this shows how the developed solution is the appropriate artefact/intervention required to solve the problem in the case area. In line with the Design Science framework illustrated above, the phase that follows is the Demonstrate Artefact phase and the Evaluate Artefact phase, and these phases requires contact with the selected case-city and empirically-based investigation. On the one hand, to extrapolate the outcomes from the application of the artefact to the case-city, while on the other hand, to investigate the relevance and capabilities of the developed artefact to address the explicated problems. The Research Methodology chapter (Chapter 6) which sets out the Research Methodology framework and makes detail explanation of all the empirical investigations therefore precedes the Demonstrate Artefact and Evaluate Artefact chapters.

The Demonstrate Artefact phase (Chapter 7) focuses on showing that the developed artefact can solve the explicated problem in one illustrative or real-life case. It is essentially the application of the artefact to a chosen case; these include documenting the extrapolated outcomes from the application of the artefact to the chosen case. The documented metrics from the extrapolated performance capabilities of the artefact therefore demonstrate the capacity of the artefact to address the explicated problem. This outcome is compared to the existing situation and specification seen in the literature and empirical cases. The Demonstrate Artefact phase functions as a proof-of-concept showing that the artefact could actually be used as intended, and therefore provides an adequate test-bed for the artefact.

The Evaluate Artefact phase (Chapter 8) represents the collection and collation of feedback by relevant expert groups from the evaluation of the relevance and capacity of the developed solution/artefact to solve the explicated problem in the case area. This evaluation consists of presentation of graphical illustration of the artefact and the results from the extrapolated outcomes before selected expert groups in interviews and FGD session. By analyzing and applying expert feedback on why and how the artefact can produce optimal outcome, an iterative process ensues. The ensuing iterative process of refining the artefact based on feedback from expert provides the premise for rigour in the research process and indicates the process of how the resulting artefact is developed.

The empirically-based investigation from interview and FGD sessions serves as platform for validating the performance capability of the artefact in the case area. The user perception survey provides another layer of validation to the feedback from practitioners. These therefore provide the premise for the conclusions and recommendations in this study.

The detail discussion on the philosophical leaning, research approach/reasoning, the Design Science research strategy and each of its phases, and research methods is contained in Chapter 6. These also include the justification for the choice of the Design Science as the chosen research strategy.

2.5 Summary

This chapter discussed the various ideological leanings that have shaped the growth and development of cities and provided a framework within which to position the subjects being investigated in this thesis. Modernist Planning has been identified to be responsible for currently shaping urban spatial form and urban planning in most global south cities. Notwithstanding some of its reported benefits, it has been argued to be sub-optimal, not only because it is blueprint-oriented and based on standards operational in European cities, but also because emerging complex challenges have arisen and the need to mainstream sustainable development agenda into urban planning has become increasingly relevant.

The Master Plan tool of the Modernist Planning (characterized by the “predict and provide” engineering solution of the building and expansion of roads, low density development, dispersed urban forms, expert-driven technocratic activities, single-use zoning, and rigid standards and regulations) has been found to permit suburbanization and automobile-dependent transport systems in cities. This situation appear to have generated externalities which compound the challenges of passenger mobility efficiency, economic losses, local air pollution and transport-related GHG emissions in cities and these factors are emerging as a transformative stressor that compel institutional change.

There has been a development of planning ideation through the Blueprint view, the Systematic Rational view, the Collaborative and Institutional views, and the Fusing of sustainable development and urban planning and therefore, it may be desirable to shift urban planning pathway from the present Master Planning system towards a new order. In order to transform the overly extensive spatial development pattern in cities’ suburban expansion and mobility patterns, the Network City Theory has been identified as a basis to explain how network of nodes can be evolved as sub-centres and as rich diverse, density and functionally-mixed development communities inter-linked by transit routes (metro, Light Rail Transit, or Bus Rapid Transit). Further, Institutional theory has been adopted to explain how an innovative reform can be institutionalized so that the present weak capacity of urban planning organizations can be leveraged to address the emerging complex challenges in cities. The chapter concludes by setting out an overview of the research methodology adopted for this study, and consists of explanation of how the thesis is structured in line with the compartmentalized framework of Design Science research strategy adopted for this thesis.

The next chapter represents the Explication of Problem phase in this study, and serves to elucidate on the various ramifications of the research problems in cities. The chapter consist of review of relevant literatures on the various themes relevant to the research problems which include rapid urban population growth, mobility demand, proliferation of car usage for daily commute, intractable traffic congestion level, weak public transport system which struggles to cope with daily movement of commuters, sprawling suburban development and weak institutional capacity of urban planning organization. These problems were also contextualized within a typical global south city using the case city of Abuja.

CHAPTER 3: CHALLENGES OF TRAFFIC CONGESTION AND SUBURBAN SPRAWL IN CITIES

3.1 Introduction

This chapter represents the explication of problem phase of the design science research framework and focuses on the review of literatures relevant to the research problems. This is in line with the structure of the Design Science research framework discussed in (the last section of Chapter 2) section 2.4. This chapter elucidates on earlier works regarding the various themes which relates to the research problems. These themes include, rapid urban population growth, sprawling pattern of spatial development in rapidly urbanizing cities, demand for mobility, car-dependent mobility pattern (private car proliferation), and impacts of this situation on traffic congestion in terms of social, economic and environmental consequences. The chapter concludes by using primary data set extracted from the case city (Abuja) to corroborate and illustrate evidence from earlier studies on the research problem within the context of a global south city. This case city contextualization should provide a clearer understanding of the situated experience of these challenges in a typical global south city, and also provide answer to research objectives 1-4, and research questions 1-2.

3.2 Trends of Urban Population Growth, Urbanization and Suburbanization

3.2.1 Urban Population Growth

People live in a rapidly urbanizing world. According to current projections, by 2030 all developing regions, including Asia and Africa, will have more people living in urban areas than in rural areas (UNHSP 2008, p. 5). This is a huge departure from the pattern of a more balanced split between urban and rural areas that existed between 1950 and 1975.

For the first time, in 2008, half of the human populace lived in cities and it is predicted to rise to 70% by 2050, when the global north region will have 86% of its population as urban residents and the global south region will have 67% urban dwellers. Furthermore, within the global south region, the increase is expected to be 61.8% and 66.2% in Africa and Asia respectively (UNHSP, 2008, p. 5 and 13). As a further illustration of the huge magnitude and consequences of this movement, it has been reported that *“the world would have to build one city of 1 million people every five days for the next 42 years to accommodate the massive rural-to-city migration and the natural population increase that follows”* (Cohen cited in Pierce & Johnson 2008, p. 30). It is predicted that, by 2025, 26 mega cities holding more than 10 million people will emerge and 22 of these mega cities will be located in developing countries (UNFPA, 1999 p.26). It has been further conjectured that the bulk of the new urban growth will occur in smaller, and often institutionally weak, settlements of 100,000-250,000 people.

Similarly, projected data by UNEP (2010, p. 54) indicate that, in absolute terms, Kinshasa will be the fastest growing city with 12.7 million inhabitants by 2020 (a 46% increase on its 2010 population of 8.7 million). Furthermore, Lagos ranks second with a projected 33.8% increase and, remarkably, Dar el

Salam, Nairobi, Ouagadougou, Cairo, Abidjan, Kano and Addis Ababa will all see their population increase by more than one million before 2020. In addition, data on the tremendous growth of the 10 proportional fastest growing cities in Africa puts the increase at 51%, with Abuja, Bamako, Luanda, Niamey, Kampala, Dar el Salam, and Nairobi projected to grow at the rate of between 47-57% over the current decade (UNEP 2010, p.55; UNEP, 2011a, p.11 (see Figure 3-1).

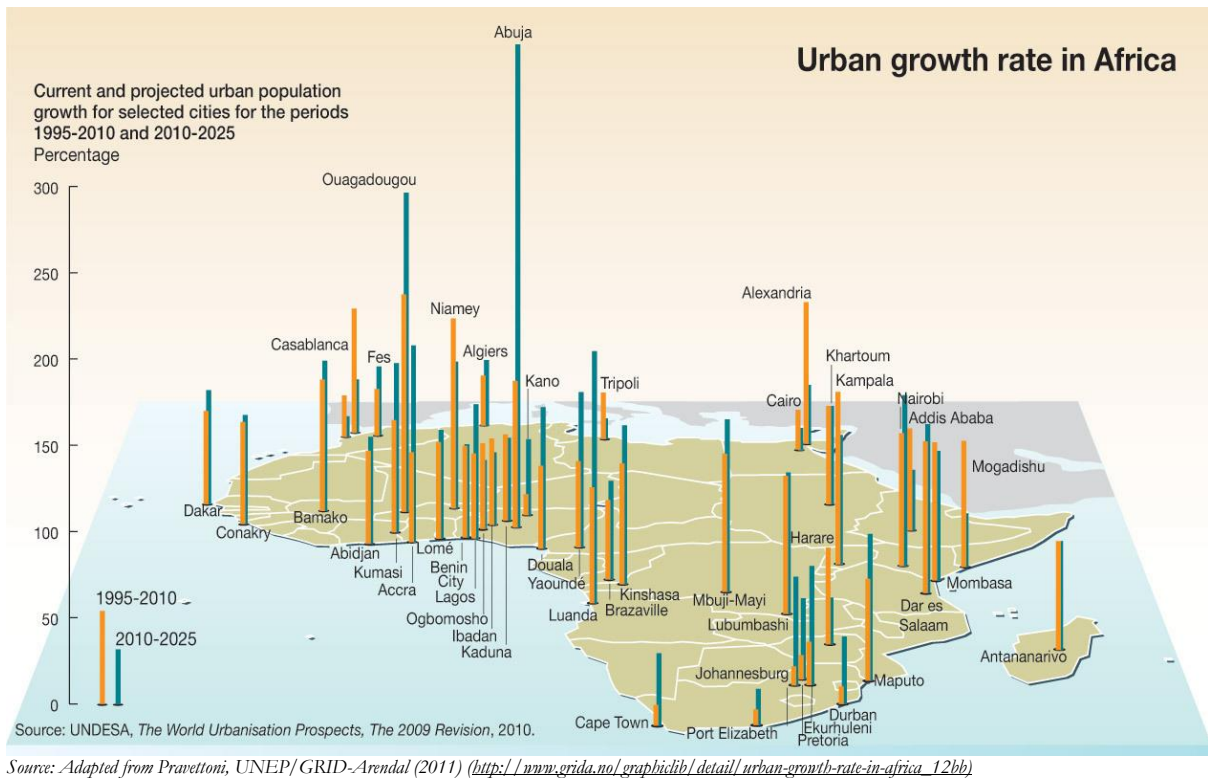


Figure 3-1: Urban Growth Rate in Africa.

Evidently, Abuja is a city with one of the fastest growing urban population rates in Africa and, may be faced (if not already being faced) with the challenges of urbanization because of the weak institutional capacities in the global south. As most predictions have indicated, most of African urban population growth will take place in small and medium-sized cities and these will be the domain of major urban transition in Africa. All these cities, including Abuja, may indeed experience this phenomenal growth and would increasingly need public investments and the leveraging of existing weak institutional capacities to cater for this phenomenal growth. Without this leverage, these cities may be ill-equipped to address potential challenges implicit in urban population growth and urbanization which are expressed in unsuitable housing; a lack of access to basic services, and the spontaneous unplanned, unregulated and unprecedented peri-urban suburbanized development in this region.

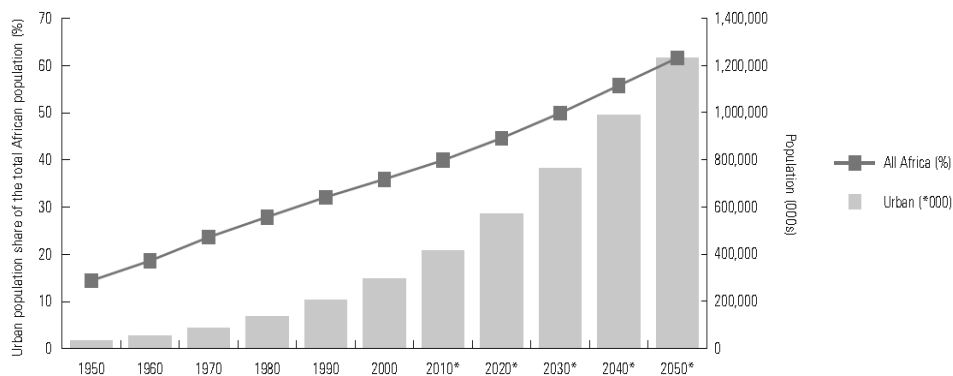
3.3 Urban Spatial Configurations (Urbanization and Suburbanization)

The work of Chin (2002, p. 7) examined the debate on urban growth, paying cognizance to the UN Report which focused on “urban transition” and reported the first phase termed **urbanization** which permits the fastest growth in the city-core; on a second phase termed **suburbanization** which has the

fastest growth just outside the city-core; on a third phase termed **counter-urbanization** (a term coined by Berry in 1976) whereby the population in the core and suburbs move out to more clearly distinct rural areas, and on the fourth phase termed **re-urbanization** with an increase in the population in the core of the city (United Nations 1998 cited in Chin 2002, p.7). In line with this analysis, the second and third phase of the transition characterizes suburban sprawl.

3.3.1 Urbanization

Today, Africa is the least urbanized continent in the world but, with the prevailing urban growth rate of 3.4%, this trend is expected to reverse and cause its predominantly rural populace to become mostly urban dwellers by 2030 (Mabogunje 1968; UNEP, 2010). Presently, the net effect of all the contributing factors (growth, migration and re-classification) is a very high average rate of 3.4% per annum of urbanization in Africa (despite regional differences that occur that may skew this percentage) (World Bank, 2009). Consequent upon this unprecedented rate of urbanization, Africa is moving from an urbanization rate of 35% in 1950 to 48% in 2030 and 60% in 2050 (UN-Habitat, 2009) (See Figure 3-2).



* Projections
 Source: WUP 2009
 Source: WUP 2009, cited in UNEP (2010, p.1).

Figure 3-2: African Urban Population Trend 1950-2050.

Figure 3-2 indicates the African urban population trend between 1950 and 2050 evidently shows a gradual exodus of population from rural areas to urban areas over a century. Researchers have variously expressed pessimism on the implications of this trend, recognizing that cities in this region are already overwhelmed by slums and that the phenomenal tripling (if not quadrupling) of urban population could further exacerbate the challenges unless appropriate policies are put in place now.

A dominant characteristic in city growth in the sub-Saharan African region is “urban primacy” rising from 2.8% in 1950 to 6.3% in 2000 (Africapolis, 2008, p. 7). Primate cities are therefore the largest cities in a country which are fuelled by a huge concentration of investment, resources, people and

activities at the expense of relatively smaller cities. Single mono-centric polarized growth patterns are perceived to encourage primacy at the expense of other regions and produce un-balanced economic and spatial configurations that are not sustainable. Implicit in this extensive spatial form of cities is the tendency to allow the sprawling of low density development permitted by the forward and backward movements to work places in the core-city by suburban residents (core-periphery movements) (Breheny 1992, Holden and Norland 2005, p. 2163, Satterthwaite, 2007, UNHSP, 2008, p. viii). This scenario has the potential to contribute to the challenges of suburbanization, urban sprawl, and transportation congestion and environment-related challenges. In the absence of good anticipation and understanding of the complexities caused by this growth pattern, and appropriate sustainable urban development policies; this expected urban growth in the global south region may largely overwhelm the already weak institutional capacities.

3.3.2 Suburbanization

It was reported in the UNHSP study (2008, p. xi and 10f) that the spatial expansion of cities has been triggered by several factors including: residents' preference for a suburban lifestyle, land regulations' crises, weak planning control over land sub-divisions in suburban areas, improved or expanded road networks and technologies/services, and greater population mobility. Critical to permitting the spread of sprawl is the urban population growth, private car usage and a corresponding growth in highways (Miezekavski and Mills, 1993 cited in Brueckner 2000, p. 162, Salingeros, 2006, p.2, Chin 2002, p.10). The U.S. typifies this factor best because of its permissive disposition to automobile use. The spatial expression of all these issues/factors is in the form of "*peripherization*" (informal settlements) "*suburban sprawl*" (residential zones of high and middle-income groups). Suburbanization may therefore generate negative socio-economic and environmental externalities.

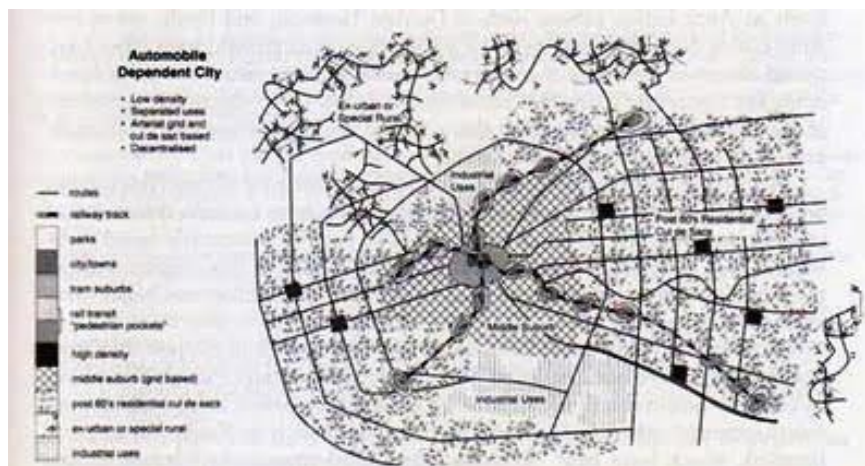
With increasing population growth in Nigerian cities, major administrative, economic and commercial urban functions are concentrated in the central business districts. The suburban areas, therefore, cope with the rising demand for providing informal housing characterized by sprawling spatial development for the low income spectrum which cannot pay for the high costs of having homes within the core-city (Oyesiku 2004, Onibokun 1992, Davies and Rakodi 1993, Mabogunje 1996, Jiriko 1998, Agbola 2004). The city of Abuja, Nigeria, is also an example of growing peri-urban settlements and suburbanization (Ujoh et al. 2010, p.106). Hence, a growing trend of suburbanization in Nigerian cities.

In general, urban sprawl is reputed to contribute to an increase in; the cost of public infrastructures and residential developments, traffic congestion, poor accessibility to services due to overwhelming car-dependence and the inefficiencies of transportation resulting in high energy consumption. In addition, in many places, urban sprawl causes significant losses in prime farmland as new sprawling city developments absorb vast stretches of arable land (Chin, 2002, p. 2; Alig et al. 2003; Pauchard et al. 2005, p. 275; Azocar et al. 2007, p.200; Chen et al. 2008, p. 29; Yuen 2008; Van Grusven 2000 cited

in UNHSP 2009, p. 30; McElfish 2007, cited UNHSP, 2008, p. 11). Even though the consequences of sprawl remains hotly debated within academia, some researchers argued that sprawl is a “*perceived negative phenomenon*”. As a result, Bourne (1992, p. 513) opined that even if the economic benefits of dispersal can be proved, which he noted as doubtful, it may amount to advocating and “... contributing to the evolution of urban forms that are increasingly inefficient and socially inequitable”. This indicate support for the assertion that the protagonists of dispersal will only end up creating urban configurations that will foster social un-inclusiveness, energy inefficiencies and the potential for increased CO₂ emission from the huge volume of private car use.

3.4 Role of Modernist Planning in creating enabling Environment for Car Proliferation and Traffic Congestion

The sustained application of this 20th century planning system in the 21st century in global south cities may explain why the inherent challenges of traffic congestion and suburban sprawl inhibit the efficiency of the overall transport fabric and the functional efficiency of city systems. The Modernist Planning paradigm and the advent of the private automobile during Post-World-War II era permitted the rise of motorization within the city and led to the emergence of the automobile-dependent city form (Newman and Kenworthy, 1999, Nobin and Lem 2001 cited in UNHSP, 2009, p.126). The meteoric rise of motorization reportedly created an enabling environment for large scale urban population growth in areas outside of the core-city (suburbs) with the pattern of development in these new settlements characterized by reduced densities (see Figure 3-3).



Source: Adapted from Newman and Kenworthy (1999 cited in Scheurer 2001, p. 146).
Figure 3-3: The Automobile Dependent City (1950 – 2000).

As can be seen in Figure 3-3, all areas outside the core-city have a reduced density that reflects the character of sprawl. Also dominant are the highways which crisscross/traverse the city and, therefore, fuel the growth of automobile-dependent mobility patterns. The sprawl that is thus created needs cars in order for people to move around (Salingaros, 2006). The externalities stemming from an extensive low density urban form are at the core of many serious critiques. This is because cities with extensive sprawling spatial forms are classified as automobile cities and feature huge environmental impacts and

sustainability deficits (Jacobs, 1961, Bank of America 1994; Kunstler 1993; Gillham 2002; Newman and Kenworthy 1999 cited in Kenworthy 2006 p. 70).

Planning for automobile growth by modeling traffic demand based on expected land-use growth largely preoccupied the post-World War II urban planning paradigm in global north cities and was subsequently transmitted to most global south cities as currently evident in most of these cities (UNHSP, 2009). Urban planning and transport planning initiatives within this setting involved essentially matching the supply of urban transportation infrastructure to meet projected traffic growth. This traditional approach to urban transportation lost sight of the inherent complexities and implications for “induced traffic” whereby new highways (or the expansion of existing ones) generate completely different trips that were never predicted rather than freeing up the road system for the existing traffic (ITDP and EMBARQ, 2012, p. 5).

Evidence from earlier studies have shown that if highways are built or roads are expanded because of traffic congestion, the benefits are quite marginal, in that, soon after the expansion phase, congestion rapidly sets in because of further induced traffic. It has been observed that traffic does not behave like liquid that retains its volume in a given space, but rather like gas that expands over any given space provided (Litman 1998, Newman and Kenworthy 2000). Unavoidably, this trend of road expansion in cities sets in motion a self-fulfilling prophecy of a vicious circle of congestion and more road building. Therefore, in this scenario of traffic engineering, automobile-dependent mobility patterns and their related externalities is inevitable (Newman and Kenworthy 2000 p. 23). Furthermore, there is clear evidence that, with the removal of road capacity, a high proportion of traffic disappears; this “*traffic evaporation*” or “*traffic re-generation*” may presents a viable mechanism for cities to address present and future mobility challenges (Goodwin 1994, cited in Newman and Kenworthy 2000 p.23; ITDP and EMBARQ, 2012, p. 5).

The absence of a strategic transport plan in cities, especially in the global south region, may be contributing to the rising level of private car ownership and use. *Wright and Fulton (2005, p. 693) reported that, in 2011, there were nearly 1.2 billion passenger’s vehicles worldwide. This figure is predicted to reach 2.6 billion by 2050, the majority of which will be found in developing countries.* The World Bank has cited the typical examples of China and India whose automobile ownership often exceeds a 10% annual increase (World Bank 1996, cited in Lagan and McKenzie 2004 p. 1).

A study by the Land Transport Academy (2011) reported on the mode share in major cities. In line with the findings of this study, private car mode accounts for as high as 67% and 77% of the total mode share in North America and Australia respectively. Reportedly, this has been permitted by planning policies in favour of subsidies for automobile ownership and for suburban housing, with less emphasis being made in these cities on transit, walking and cycling.

The motorization trend and automobile-dependence in cities is exceeding the capabilities of existing infrastructure and, therefore, culminates in traffic congestion (see Figure 3-4 – 3-5) and the consumption of huge amounts of fossil fuels with consequent negative externalities on the environment expressed in particulate matter (PM) air pollution and CO₂ emissions (GHG) (Al-Mofleh et al., 2010; Fulton 2004; Molina et al., 2004; Schipper et al. 2000; Schipper 2004; Dhakal and Schipper, 2005; IEA, 2009; Doering, 2002; World Bank, 2002).



Source: Adapted from Thomas (2011).

Figure 3-4: Traffic Jam in Houston, Texas, USA.



Source: Adapted from Suberu and Ayinla (2012).

Figure 3-5: Traffic Congestion in Lagos

In this scenario, traffic variously grinds to a halt in the inner-city and on many of the roadways to suburban areas, as the phenomenal growth of cars continue to overwhelm and defy any intervention to reduce traffic congestion and related externalities (Schipper et al. 2002; Penalosa 2004; Salingaros, 2006). The reduction of car use does not appear as a priority item on the agenda of most global south cities and this may explain why the growth of traffic in most cities appears rather intractable.

Evidence of traffic congestion from cities with an automobile-centered transport system reveals an exceeding of the “tipping point” beyond which the volume of automobile use dwarfs or negates the efficiency which automobile transportation should achieve (Freund and Martin 1996, p. 27). Freund and Martin’s findings on the costs of traffic congestion in Los Angeles in 1991 put the costs of time

delays plus fuel at US\$1000 per vehicle. This compelled them to draw conclusions that, with the phenomenal automobile proliferation of today and the attendant challenges in cities, automobile use is fast negating itself because of its exceedingly high overuse and misuse. In view of the predicted rise in the trend of motorization in the global south region, without any future cultural shift, car-dependent mobility patterns may impact significantly on sprawl, traffic congestion, loss of productive time, air pollution and CO₂ emission levels in cities.

In sum, the current trend of motorization and related traffic congestion challenges in cities shows indication that the prevailing planning system, sprawling extensive spatial form, incentives to private car usage and motorway infrastructure may be the permissive factors to this trend.

3.5 Impacts of Car-dependent Mobility Pattern on Traffic Congestion and, Transport-related CO₂ Emission, Man-hour losses, and Fuel Wastages in Cities

Researchers argue that with the predicted population growth, per capita rise in income, rise in mobility demand and the growing proliferation of private car usage especially in global south cities, traffic congestion and impacts such as time delays, fuel loss, transport-related CO₂ emission, and air pollution attributable to car-dependent mobility pattern may continue to rise (Al-Mofleh et al., 2010; Molina et al., 2004; Schipper et al. 2000; Schipper 2004; Dhakal and Schipper, 2005; Penalosa 2004). A study by Fulton shows that, because of the proliferation of private automobiles in cities, the transport sector has accounted for nearly all growth in oil use over the past 30 years and this trend is expected to continue (Fulton 2004, p. 4). It may therefore be safe to posit that, without a cultural shift from this trend, car proliferation may continue to impact significantly on traffic congestion, loss of productive time, air pollution and CO₂ emission levels in cities.

This section makes highlights of the different arrays of impacts and the methods for measuring these impacts.

3.5.1 Impact of Proliferation of Private Cars on CO₂ Emission and Global Warming

The study by Pachauri (2008, p.111) reported in 2008 that “eleven of the last twelve years have been the hottest in recorded history”, a huge pointer to the effects of global warming invariably caused by the production of wealth (industrial production processes, transportation, land-use change, agriculture, etc.) by both cities in the global north and cities in the emerging economies in the global south. The combustion of fossil fuels is a major global energy source and GHG emissions. Globally, transportation is responsible for about 23% of total energy-related GHG emissions and 13% of global GHG emissions (Barker et al., 2007 p. 40).

A study by Romm (2006, p. 2609) reported that about 97% of all energy consumed by automobiles and airplanes are fossil fuel based. He further noted in this study of the US that, in the 1990s, the transportation sector accounted for the fastest growth in CO₂ emissions beyond any other sector, and

that this sector is forecasted to generate approximately half of the projected 40% rise in the US CO₂ emissions by 2025 (IEA, 2004 cited in Romm 2006, p. 2609; Duduta and Bishins 2010, p. 1). Motoda and Taniguchi's study of Japan revealed that the transport sector accounts for 20% of CO₂ emissions in Japan, while road transportation is responsible for 88% of the transport sector-related emissions. They observed an increasing trend notably with a 16% rise in emissions between 1990 and 1995 (Motoda and Taniguchi, 2003 p. 1335). For Nigeria, the disaggregated GHG emission profile is reported by the study of Dayo et al (2009 cited in Federal Ministry of Environment 2009, p.41). Reportedly, the major GHG emission sources in Nigeria are landuse change, forestry, agriculture, fugitive emission and the transportation sector.

At the global level, the scenario is also challenging. As observed by the Head of the IEA in 2004 *"in the absence of strong government policies, we project that the world wide use of oil in transportation will nearly double between 2000 to 2030 leading to a similar increase in GHG emission"* (IEA, 2004 cited in Romm 2006, p. 2609). Kutzbach (2009, cited in UNHSP, 2011, p. 41) equally observed that the predicted GHG emissions from increasingly high private vehicle usage are further exacerbated by the nature of the stock of second-hand energy inefficient vehicles that are being acquired in global south cities. Therefore, these studies indicate evidence that the transportation sector can contribute to increase or decrease of CO₂ emission levels in cities.

3.5.1.1 Measuring CO₂ Emissions from Automobiles Vehicles in Cities

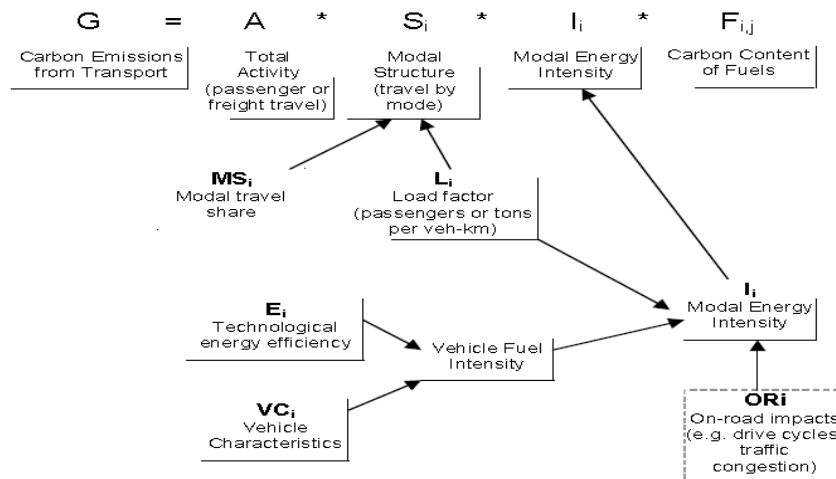
The study of Mickunaitis et al. (2007, p. 160) observed a linear dependence between fuel consumption and the CO₂ emission of a motor car (regardless of the fuel). Their findings showed that average fuel consumption of, and the CO₂ emission from, automobiles using diesel oil is lower than that of the level of cars using petrol by 26% and 17% respectively. But, when burnt, one litre of diesel oil releases 2.7kg of CO₂ while one litre of petrol produces 2.4kg of CO₂. It can therefore be inferred from this study that an increase in fuel consumption increases the level of CO₂ emission; thus increasing car proliferation and usage in extensive urban spatial configurations with higher VKT will increase the level of CO₂ emissions.

Other studies have attempted to evolve a methodology for computing and auditing carbon emissions from transportation on a city scale, these include the ASIF Methodology, and Methodologies from the Insurgentes (Mexico City), Transmileneo (Bogota), and Bently Technology Precinct (Perth) projects.

A. The ASIF Methodology

The Activity, Structure, Intensity, Fuel mix (ASIF) equation was developed by IEA to cover the effect of transport in a general and complete way. The ASIF methodology is widely used in assessing and estimating transportation-related emission in both situations with and without interventions.

According to Schipper et al. (2000, p. 10f), Schipper et al. (2007, p.1713), emissions (G) in the transportation sector are dependent on the level of travel activity (A) in passenger kilometres (or ton-km for freight) across all modes; the mode structures (S); the fuel intensity of each mode (I) in litres per passenger kilometre; and the carbon content of the fuel or emission factors (F) in grams of carbon or pollutant per litre of fuel consumed (see Figure 3-6).



Source: Adapted from (Schipper et al. 2000, p. 10f).
Figure 3-6: The ASIF Estimation in Two Dimensions (CO₂ case).

They noted that while the CO₂ emission factor (F) can be calculated using the carbon content of the fuel and the standard IPCC coefficient to convert the fuel (or electricity) used back to carbon emission. The emission factor of other pollutants can be measured in a laboratory in a test station, or can be test tracked by using on-board/remote sensing equipment to examine vehicles while in real traffic.

3.5.1.2 Emission Estimation Methodologies from Empirical Cases of Insurgentes (Mexico City), Transmileneo (Bogota) Project and the Bently Technology Precinct (Perth) Projects

The studies on the Insurgentes, Transmileneo and the Bently Technology Precinct Projects illustrate examples of methodologies that are relevant for the estimation of CO₂ emissions from existing transport settings and new interventions in cities.

I. Insurgentes

Estimation of emissions in the study on Insurgentes focused on how the changes caused by switching vehicle types (mini buses being replaced by BRT Metrobus) can be estimated by projecting how much fuel mini-buses would have required in order to carry the same number of BRT passengers over a future year (Rogers 2006; Rogers and Schipper 2005; INE 2006, cited in Schipper et al. 2007, p. 1716). The counting of traffic flows were used to estimate the emission level. Here, the BRT' corridor along

Mexico City's central Insurgentes street entailed the replacement of 262 minibuses and 90 buses by 27 buses with the holding capacity of 160 passengers.

The findings of Rogers reportedly revealed that the large buses used less than 40% as much fuel as the smaller ones for the same numbers of passengers hauled and the new system was capable of saving 46,500 tons of CO₂ per year, with nearly 40% of the emissions reduction coming from changes in buses, nearly 40% for changes in vehicles in the affected corridor, and nearly 30% of the reduction due to a modal shift.

II. Transmileneo

The estimation of emission from Transmileneo is largely based on the work of Grutter (2006). His work reportedly applied an elaborate technique to the Bogota BRT system, whereby he defined the unit of savings as the trip. Further, he compared the number of trips taken by travellers in a BRT system similar to that in Bogota (as a reference case) with trips they would have taken previously, whether on smaller mini-buses or in cars. He carried out surveys of passengers (travellers) to determine how the trips would have been taken and provided an indication of the fuel usage level of the cars left behind (Grutter, 2006 p. 7f).

Reportedly, Grutter's (2006) findings noted the interference with other traffic, induced traffic, etc. as a minor consideration but he was careful to include terms to represent them and he also suggested the estimation of changes in load factors of buses and taxis that might lose passengers to the new BRT. Schipper et al. (2007 p. 1717) opined that Grutter's (2006) method is the first and only methodology approved for certifying CO₂ savings in BRT projects to date.

III. Bently Technology Precinct (BTP)

An estimation of emissions, based on a study of Tiwari et al. (2011, p. 401), indicated the following parameters in computing the emission profile of the car-oriented (auto-dependent) Bently Technology Precinct (BTP), Perth, Western Australia. The list below indicates some of the key assumptions adopted in the study:

- i. Emission of Carbon Dioxide (CO₂) per kilometre travelled by each individual car is 240g (Schipper, Unpublished work).
- ii. Emission of Carbon Dioxide (CO₂) per kilometre from a bus is estimated as 86% less than the CO₂ emitted from 25 cars ($240 \times 25 \times 86\% = 840\text{g}$) (The Greens, 2008, p. 14).
- iii. Car occupancies are assumed to be 1.36% per car (Department of Planning, Unpublished work).
- iv. Bus occupancies are assumed to be 8.1% per bus (Department of Planning, Unpublished work) under business as usual conditions.
- v. Bus occupancies are assumed to be 20 per bus in a transit oriented development (Schipper, 2009, Unpublished work).

Table 3-1: The Greens (2008, p. 14) state that 1 bus with 25 people produces 86% less Greenhouse Gas emission as compared to 25 individuals in cars.

Bus Emission Workings	
86% off this value	
Emission for 25 cars	600g
Emission per car (CO ₂ per kilometre)	240g
Number of people working	25
Total: Emission for one bus	840g

Source: Adapted from Tivari et al., (2011, p. 404).

Evidently, the volume of cars and kilometres travelled over a highway can be used to compute a CO₂ emission pattern and volume of an area. However, when these are aggregated over the various highways under consideration, CO₂ emission from a city can be computed.

IV. Hybrid Methodology

In view of the deficit of data in most global south cities, it may be desirable to evolve a hybrid from the array of methodologies highlighted above in order to estimate the impact of transport-related CO₂ emission. Holding constant the scenario that these passengers will have to commute (home-work-home daily) the present volume of trips on mini-buses and private cars can be computed. Accordingly, the existing volume of passengers riding on the existing mini buses and private cars can be computed using a component of the ASIF methodology for the per capita (passenger/km) kilometres travelled in vehicles (mini-buses and private cars).

By computing the per capita emission of the passenger trips on the mini-buses and private cars in the existing situation, the existing CO₂ emission over a specific time-period (e.g. week, month or year) can be computed. However, by computing per capita emission of passengers in a situation with different mode share and transit system, the CO₂ emission level can be computed. The difference between the CO₂ emission levels in existing and new mode share and transit system reveals the savings of CO₂ emission. Importantly, when the data on the yearly rate of increase of fleets of mini-buses and private cars (and related CO₂ emission levels) are projected, the future emission profile from the mini-buses and private cars can be computed.

Estimation of CO₂ emissions from the usage of mini-buses and private cars can be computed by using the unit index of 240g of CO₂ emission per km travelled by computing the product of the value of per capita emission of trips in mini-buses and private cars and the volume of trips (in mini-buses and private cars) along a specified route. The daily CO₂ emission volume from these trips can be computed and when this is aggregated and projected, present and future CO₂ emissions for trips in the existing mini-buses and private cars can be computed and reported.

3.5.2 Estimating Economic Impacts of the Proliferation of Private Car Vehicles in Cities

As illustrated earlier, the impacts from the proliferation of private car usage in cities have varying implications which, aside from transport-related local air pollution and GHG emissions, also include increased travel times and the increasing trend of sprawling suburban areas.

3.5.2.1 Impacts on Increased Travel Time

Proliferation of cars in cities usually culminates in the congestion of roadways and, therefore, increases travel time. This increased travel time keeps passengers sitting in traffic during time that could have been channeled into productive activities. The increased travel time caused by traffic congestion leads to a loss of productive hours for both passengers in buses and cars, in such situations, the lost time incurred travelling in this traffic, therefore, amounts to economic loss. In addition, the frequent acceleration and deceleration of vehicles in traffic jams leads to fuel wastages by these vehicles; this, therefore, constitute economic loss with implication on GDP. The study by EMBARQ (2013, p. 10f) attempts to analyze the implications of this time loss on the economy.

A. Measuring the economic implications of man-hour loss and fuel loss due to increased travel time

By identifying the income level of the commuters (EMBARQ, 2013, p. 12f) travelling in the buses and private cars and the average time loss (in hours) in the home-work-home journey, the per capita cost/value of time loss in terms of wages can be computed and analyzed (EMBARQ, 2013, p. 14ff). This calculation therefore infers the per capita cost/value of wages lost if the time losses were spent working. By taking the difference between the expected travel time and the present travel time, the actual time loss is established; therefore, by computing the product of time loss by wage for a time period, for example, a month, the monthly loss of income from the increased travel time is established.

The impact may be less in an economy where the employees are paid based on input into production/service. However, where the employment structure is full time (as in most cities in the global south region), the employers bear the brunt. Either way, GDP is impacted negatively based on the time loss undergone due to traffic congestion. It may, therefore, be safe to suggest that increased travel time also leads to increased vehicle activities and increased fuel usage.

The litre of fuel per passenger per kilometre measurement can be computed by dividing the total passengers in the vehicle by the quantity of fuel used by the vehicle in either a congestion or non-congestion period. By computing the difference between per capita fuel usage of passengers in buses and private cars during non-congestion travel periods, and during traffic congestion periods, the level of fuel loss due to traffic congestion can be identified. Furthermore, by computing the product of the cost of this volume of fuel loss over a specific period (for example, on monthly basis), the monetary value of this fuel loss can be identified. Indeed, it is important to note that due to low passenger

occupancy levels in private cars the level of per capita fuel loss in private cars (Single-Occupant Vehicle) is usually higher than in high capacity public transport vehicles such as buses.

3.5.2.2 Impact on Sprawl and Usage of Land

Earlier studies as well as empirical evidence has shown that the fast mobility facilitated by private cars has served as a recipe for the growth of sprawl (Dutton, 2000, p.19). With most cities addressing transport challenges by highway expansions, this sub-optimal remedy has served to enable more cars and the growth in the extensive spatial pattern of sprawl in cities. Therefore, by measuring trends in private car ownership and usage, and the spatial growth of sprawling settlements, this would elicit a measurement of the extent of the impact of car proliferation on sprawl and usage of land.

A. Measuring the growth of private cars, sprawl and usage of land

By analyzing the trend of the annual growth of cars from available archival records or survey data, it is, therefore, possible to establish a pattern of growth or decline. Using the data set that covers a set of period, the Compound Annual Growth Rate (CAGR) formula can be used to compute the annual growth rate.

Further, the structure of transport sector investments may largely determine the enabling environment for private car mobility patterns which may, in turn, create an enabling environment for the sprawling spatial pattern of development (Dutton 2000, p. 19; Hidalgo et al. 2011, cited in EMBARQ 2013, p. 94). Therefore, archival data on yearly expenditure on the transport sector can be analyzed to reveal which facets of the transport sector receive more funding. An instance where expenditure is aligned toward public transport would indicate a less-enabling environment for automobile-centered sprawl; conversely, where expenditure is aligned towards an emphasis on building and the expansion of roadways would indicate an enabling environment for the proliferation of cars and the creation of automobile-centered sprawl.

By analyzing the data set on the annual rate of spatial land-use/land cover (urban sprawl) via Spatial and Temporal Analysis using computer-based GIS software (Suzuki et al. 2013, p.27f), the trends of the spatial growth of sprawl can be identified. By comparing the data sets on the trend of growth in the number of cars and sprawl, this can help illustrate the assertion that an enabling environment for the growth in the number of private cars also permits the growth of sprawl.

From the foregoing, a global context of the deep-rooted ills of traffic congestion and suburban sprawl can be discerned; however, it is imperative to contextualize the various realms of the research problems in a case-city. Such contextualization within a global south city will elicit clearer and in-depth understanding of the peculiarities related to the research problems in a realm that seldom exist in the existing body of literature. Consequently, the process and procedure for the selection of the case city to contextualize the research problems is explained below.

3.6 Selection of the Indicator Case City

In order to select the case-city, the researcher took due cognizance of the class of cities defined in earlier studies as medium-sized institutionally-weak global south cities with rapidly growing population witnessing the challenges of traffic congestion and suburban sprawl, and also cities having the potential to be transformed using innovative solutions. As reported in earlier research, medium-sized institutionally-weak global south cities with population of 500,000 – 3million (and not mega-cities) will be the zone of major urban transition between 2010 – 2050, and also offer opportunities/potentials for innovative solutions (UNHSP, 2009). This provided guide to the checklist for selecting the case city.

Accordingly, cities in the global south region are the focus of this study, and a case city was selected from a range of global south cities in order to contextualize both the problems and the developed artefact/solutions and provide the basis for generalization. While investigation across several case cities may provide richer and diverse research findings, in practical terms the key defining character of these global south cities and features in the checklist are similar, therefore, making generalization on these features and across these cities may be appropriate and not mis-leading. It is important to note that, by focusing on a single case city, substantial depth, intensity and rigour on the themes being investigated can be achieved and the richness of the findings enhanced.

The identified six (6) cities open to selection as case city include: Cebu – Philippines (South East Asia), Izmir – Turkey (Euro-Asia), La Paz – Bolivia (South/Latin America), Abuja – Nigeria (West Africa), Casablanca – Morocco (North Africa), Dar-el- Salem – Tanzania (East Africa). These identified cities to a great extent show representation of the geographic regions in the global south. The checklist for selecting the case city have been identified to include: medium-sized population of the city, rapid urban population growth (annual growth rate), city facing private car proliferation and traffic congestion challenges, city with public transport system struggling to move majority of the population (mini-buses/informal public transport), city with evidence of urban primacy and sprawling suburban development, city without the application of any three of the strategies being investigated (see Table 3-2).

Table 3-2: Checklist/Matrix for the Selection of the Case City

S/N	City	Medium-sized Population	Rapid Population Growth (Annual Growth rate)	Private car Proliferation and Traffic Congestion	Struggling public transport system	Evidence of urban primacy and sprawl	Application of any of three strategies (BRT, TOD and Congestion Pricing)	Rank
1	Cebu, Philippines (South East Asia)	2.3 million	4.8%	Yes	Mini-buses by private operator	Yes	Nil	6
2	Izmir, Turkey (Euro-Asia)	4.0 million	4.6%	Yes	Medium-sized buses by private operator	Yes	Nil	3
3	La Paz, Bolivia (Latin America)	1.7 million	4.2%	Yes	Mini-buses by private operator	Yes	Nil	5
4	Abuja, Nigeria (West Africa)	3.0 million	9.3%	Yes	Mini-buses by private operator	Yes	Nil	1
5	Casablanca, Morocco (North Africa)	3.3 million	3.9%	Yes	Mini-buses by private operator	Yes	Nil	4
6	Dar-el-Salam, Tanzania (East Africa)	4.3 million	5.6%	Yes	Mini-buses by private operator	Yes	Nil	4

Source: UNFPA 2012, World Bank 2013, unstat.un.org 2011, emphasis added by Author 2013.

It is evident from Table 3-2 above that all the listed cities share common features in the six criteria on the checklists. In specific terms, the factors in checklist 3 – 6 are common to the 6 cities; however, there exist variation in terms of checklists 1 and 2. The variation evident in the indices in checklist 1 and 2 across the cities, therefore, impact on the result of the ranking. The result of the ranking in column 9 of Table 3-2 therefore provides explanation for the selection of Abuja as the case-city. The case city Abuja therefore forms the premise to contextualize the research problem, demonstrate and evaluate the artefact/solution in this study. It is hoped that this should provide the premise for deeper understanding of the solution developed in this study within the situated experience of a global south city.

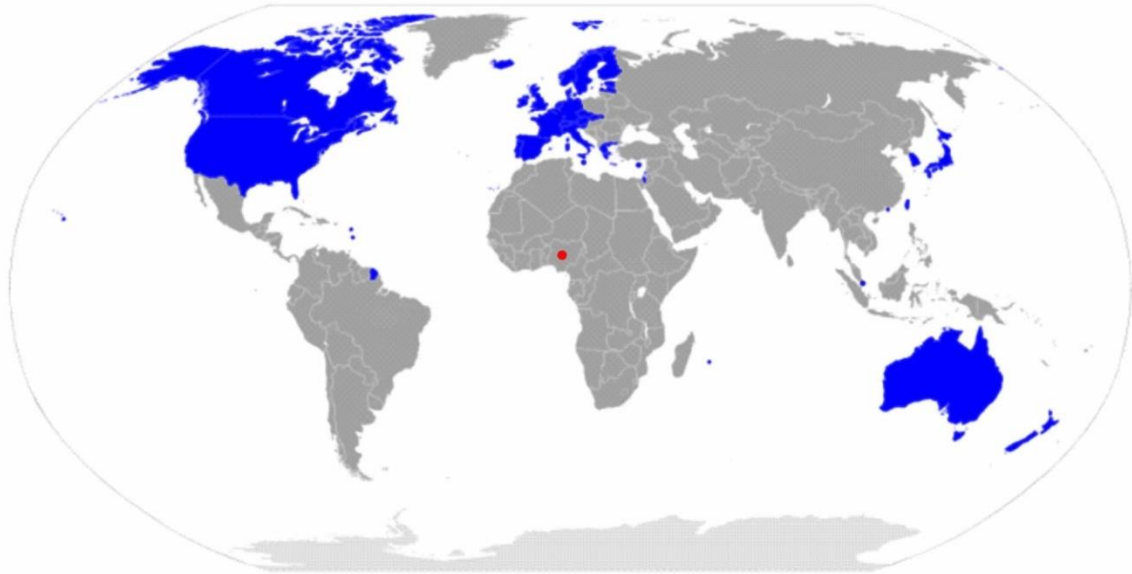
3.7 Explication of Research Problem within the Context of a Global South City

Sequel to the global review of the research problem, this section provides the contextualization of the various themes relating to the research problem within the realm of a typical global south city. Since the focus of the study is on global south cities, a more incisive and contextualized perspective of the highlighted problems should ensure better understanding of the research problems in this study. As remarked earlier, the city of Abuja would feature prominently in this thesis, accordingly, the city of Abuja has been selected for the purpose of the contextualization not as an exemplar, but as a case city that exhibit the defining character of most global south cities. The detailed explanation of the checklists and process of the selection of the case city is made in the last part of Chapter five.

In this section, some primary data set were extracted from reviews and content analyses of documents such as the Abuja Master Plan, the Abuja Transportation Master Plan, the Abuja Regional Development Plan and the Metropolitan Public Transport Concept Plan; archival records on the volumetric counts of vehicles and passengers on the routes under consideration (AYA, Kubwa-Bwari and Airport Road); photo recordings of observation of traffic congestion situations; patterns of development in the suburban areas of Nyanya-Karu, Kubwa-Bwari, Kuje-Gwagwalada axes. The data included structured interview with urban planning practitioners in government establishments, private consulting firm and the academia with focus on the assessment of the capacities of current urban planning organizations. This also include structured interview with transport users (commuters in mini-buses and private cars) along the 3 routes under consideration and transport operator association. These were used to corroborate literature evidence on the nature of the research problems and to establish the existence of the explicated problem of traffic congestion and suburban sprawl in the case-city Abuja. The evidence on the existence of these problems in Abuja are explained under the following themes below: existing urban planning approach, evidence of urban primacy, rate of urban population growth, pattern and trends of suburbanization, commuting pattern to bus stops, trends of sprawl, structure of transport sector investments, and private car proliferation, traffic congestion and related impacts, and the capacity of urban planning institutions. This section of the thesis also provides answer to the research questions 1 and 2 in this study.

3.7.1 Location of Case Study Area (Abuja)

Abuja is the capital city of Nigeria, a country located in the western part of sub-Saharan Africa. With its inception in 1976, Abuja has assumed the status of the new administrative capital of Nigeria. Abuja is located between latitude 8° 25" and 9° 25" north of the Equator, and between longitude 6° 45" and 7° 45" east of the Greenwich (See Figure 3-7).

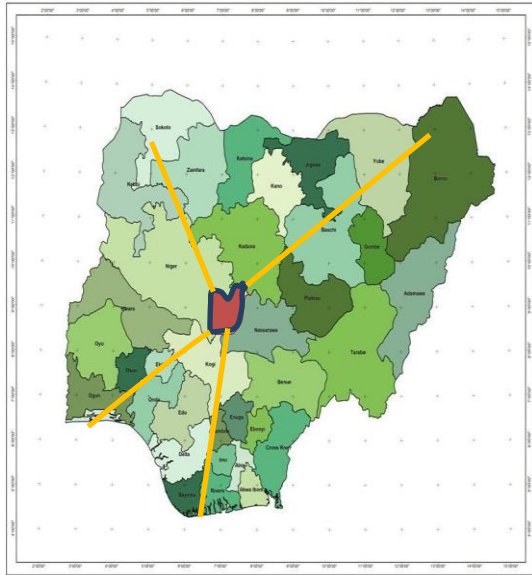


■ Global North Region ■ Global South Region ■ Abuja-Nigeria

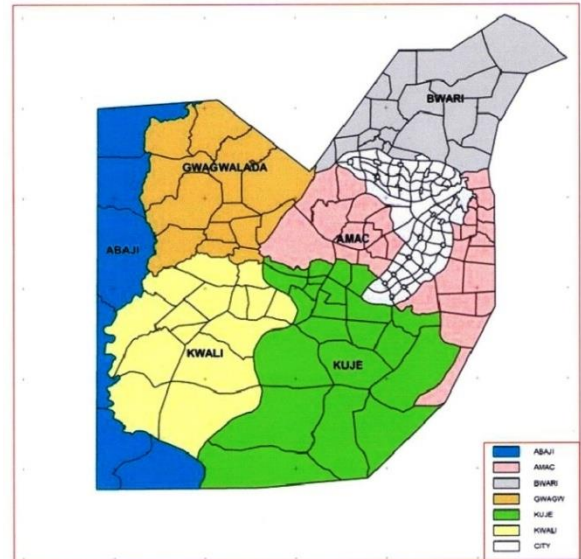
Source: International Monetary Fund, (2008), emphasis added by Author (2014).

Figure 3-7: Abuja within the global context

Figure 3-7 show Abuja within the global context, and therefore show that Abuja is located within global south region. In general, as the seat of the National Government, Abuja serves as an impetus which continues to propel a growing agglomeration. It is bordered to the north by Kaduna state, to the east by Nassarawa state, to the south by Kogi state and to the west by Niger state. It is situated at the geographic centre of Nigeria; approximately 800km from all corners of the country (see Figure 3-8).



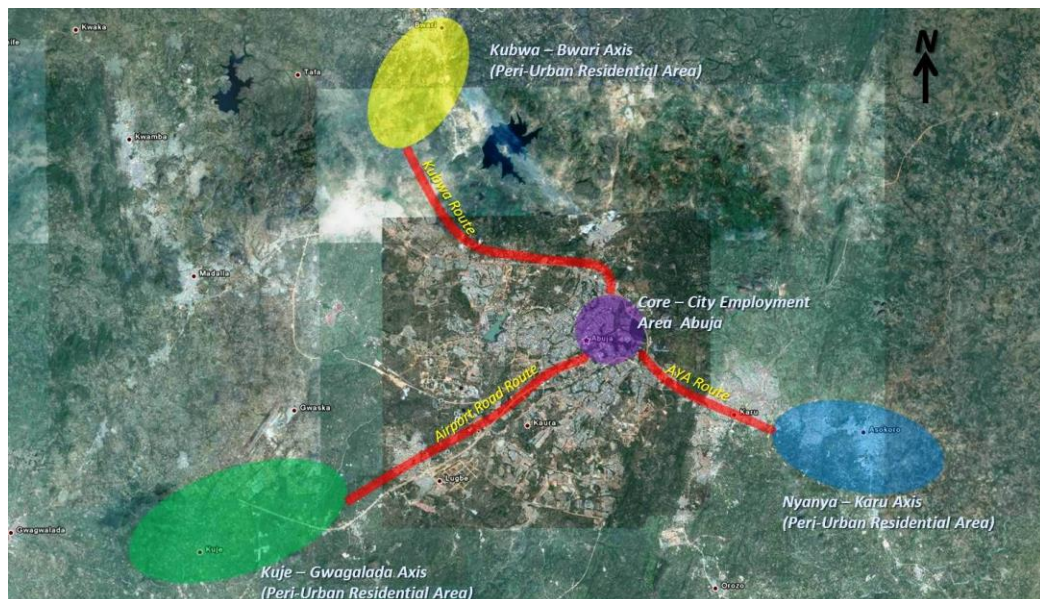
Source: Abuja Geographic Information Systems (AGIS) (2011).
Figure 3-8: Abuja in the National Context



Source: Abuja Geographic Information Systems (AGIS) (2011).
Figure 3-9: The Core-city Abuja and its Area Councils

Abuja-the Federal Capital Territory (FCT) is growing rapidly as a result of infrastructural development (roads and highways, sewers, water and electricity) appearing concentrated in the core-city of Abuja (the Federal Capital City-FCC) at the expense of the suburban areas located in the area councils. The core-city of Abuja is located in the northeastern part of the entire Abuja territory (FCT) with the territory divided into six area councils (see Figure 3-9) (FCDA, 1979, p. 2-5).

The core-city of Abuja and its employment/hubs area remains the dominant focal point for all the three major axes namely Kubwa-Bwari located to the north, Nyanya-Karu located to the south-east and Kuje-Gwagwalada located to the south-west part of the FCC (see Figure 3-10).



Source: Author's Analysis (2013).
Figure 3-10: Commuting Pattern between the Core-city and the Peri-urban Areas of Abuja.

It is suggested by this study that these major suburban areas provide residence for majority of the city's populace who routinely commute along the major routes linking the suburban areas to the core-city to get to employment areas and to access services.

3.7.2 Existing urban planning system, suburban development and mobility patterns in Abuja

The analysis in this section focuses on the enabling environment created by the existing urban planning system for suburban development, road expansion and the current car-dependent mobility pattern and, its related challenges. The analysis in this section provides answer to research objectives 1 – 4 and research questions 1-2. In view of the various data sources identified as relevant to addressing these research objective and research question in Table 2-1 Section 2.4, document review, archival record and observation data sources have been adopted in this section in order to home-in on data set relevant to addressing these research questions and objectives.

Firstly, in terms of documentary sources, data taken from documents take many forms and cover a variety of issues (Yin, 2009, p.103; and Descombe, 2007, p.12), and can help corroborate and augment information from other sources as a basis to understand and assess an existing tool/approach which in this case is the present Master Planning system in global south cities.

This study identified relevant official documents and formal study reports that provided relevant data/information on the existing Master Planning approach, traffic congestion and suburban development in global south cities including Abuja. These documents include the Abuja Master Plan, the Abuja Regional Plan, the Transportation Master Plan and the Urban and Regional Planning Law. Based on the submission of the Participant Invitation Form to the FCDA Urban and Regional Planning Department of Abuja (which was identified to be the Department in charge of the implementation of the city's Master Plan) and upon the researcher's receipt of the Department's written acceptance to participate and provide the relevant information to support the research, these documents were made available to the researcher.

Secondly, with regards to archival records, these include organizational records on budgets or personnel, maps, satellite imageries, charts of the geographical characteristics of a place and survey data about a site, employees or residents (Yin, 2009, p.105). The strength of archival records lies in their characteristics which include preciseness (they can be reviewed repeatedly), their contents could span over long periods, and their unobtrusiveness. However, some of the deficiencies in using archival records may include the difficulty of retrieval because of privacy issues and the possibility of unavoidable reporting of unknown bias by the author when the record was created.

The archival records retrieved in this study include maps and satellite imageries in order to analyze the scale and dimension of spatial development and the suburbanization trend of Abuja. The satellite imageries were obtained from the Google Earth computer application. The available records of the

volumetric count of passengers and vehicles on the routes under consideration were also obtained from the FCT Transport Secretariat (the establishment responsible for the Transport Sector in the city). Also, records on statutory budgetary expenditure on the transportation sector in Abuja for a 10 years' period was obtained and analyzed. This information were gained after a submission of the Participant Invitation Form to the FCT Transport Secretariat and Budget Division of the Abuja-FCT Treasury Department, and with the provision of written consent to participate in the study, the representative of the Department provided the records to the researcher. Generally, the retrieval of records on statutory budget is considered classified in Nigeria, however, upon persistent follow-up, the respondent obliged and requested that the records be used for academic purposes only.

Lastly, in terms of observational evidence, it is often useful in providing additional concrete evidence about the research problem being studied (Yin, 2009, p.110; Descombe, 2007, p.12), this may include taking photographs or video recording in order to document and reveal important characteristics of the phenomenon being studied. This data source is relevant to this study because it provided a premise for access to photographic evidence of the traffic congestion challenges of motorized trips on the routes under consideration (AYA, Kubwa-Bwari and Kuje-Gwagwalada routes), and the pattern and density of the spatial development in the suburban areas (Nyanya-Karu, Kubwa-Bwari and Kuje-Gwagwalada axes) under consideration in Abuja. These resulting data sets are therefore relevant because they are able to provide answer to research questions 1 and 2 and toward achieving the establishment of the research problem (Explicate Problem phase) in this study.

3.7.2.1 Character of the existing Master Planning approach in Abuja

In order to understand how the existing framework and procedure for urban planning in the case area (Abuja) may have created the enabling environment for the existing car-dependent mobility pattern, and traffic congestion and suburban sprawl, relevant documentary evidence mentioned above were analyzed to elucidate on the historical evolution of urban planning at the national scale in Nigeria.

Prior to the 1992 Urban and Regional Planning Law, the 1946 Town and Country Planning Act modeled after the British 1936 Town and Country Planning Law (Mabogunje 1968) continued to shape town planning practice especially in major cities as Kaduna, Lagos, Kano, Port-Harcourt, Ilorin amongst others. The procedure at this time did not encourage participatory decision making process on physical planning matters, as no objections or public participation is accommodated. The urban planning departments in these major cities pioneered the preparation of Master Plans. Further, the plan preparation procedure remained technocratic and non-participatory, with the objectives of the plans formulated by top government functionaries with little or no inputs from the public.

The preparation of Master Plans are usually outsourced to urban planning consulting firms in Europe and North America (UNHSP, 2009), as such, community engagement is usually minimal. The fancy layout and zoning plan resulting from the Master Plan often remain on the shelves awaiting

implementation, this may have been because of low level of priorities accorded to these Master Plans by politicians, disconnect amongst sectors relevant to implementation of the proposals, and also the challenges of restrictive bureaucratic practices that inhibit the effective and timely implementation of plans. In several instances, this Master Plan has provided blueprint/framework for urban development, with fairly orderly landuse development and infrastructural facilities and services evident in mostly the core-city. This shows some good outcomes from the Master Plan approach except for its limitation in terms of coverage which focuses on the core-city. These challenges may be because the planning departments have shortage of skilled personnel (Professional Town Planners), the task of effective monitoring and coverage of physical development outside of major cities is weak. Hence, physical developments in areas outside of major cities remain undetected, and lead to the growth of unplanned and unregulated development. These therefore illustrate the features that characterize the plan making procedure in these cities (including Abuja); this illustrated situation is consistent with the characteristics of the Master Planning system and institutionally weak global south cities described in the studies by Cervero (2000), Pachauri (2008), Satterthwaite (2008), and UNHSP (2009).

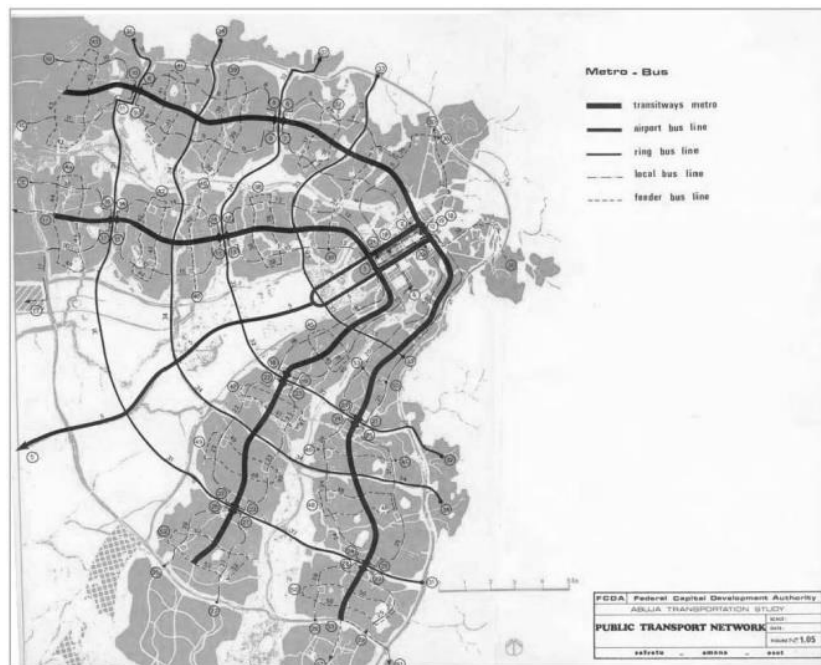
In sum, this described situation of the sustained application of the ideals of 20th century modernist planning approach applicable in Britain to address the challenges of complex, dynamic rapidly urbanizing cities in the 21st century reveals a gap. Such important contemporary issue relating to climate change and sustainable development did not find mention in the Abuja Master Plan, nor have they become institutionalized in the urban planning of Abuja. The evident sectoral disconnect may also lead to duplication of duties amongst related sectors and wastage of resources.

It may therefore suffice to argue that the present Master Planning system and its features described above may not be able to cope with the complex challenges of the current mobility demand in rapidly urbanizing global south cities and therefore present the enabling environment for car-dependent mobility pattern, suburban sprawl and related traffic congestion challenges.

3.7.2.2 Evidence of Urban Primacy in Abuja

The contents of the Abuja Master Plan, the Transportation Master Plan, the Regional Development Plan and the Metropolitan Public Transport Concept documents were analyzed in order to reveal evidence that may suggest urban primacy from provisions of the plans regarding public transport/transit infrastructure linkages between the core-city and the suburban areas.

The review of these documents reveal that linkages of the suburban areas via any planned transit infrastructure was overly absent in the plan documents. Mostly, the provisions of the Abuja Master Plan (1979) and the Abuja Transportation Master Plan (1981), in terms of transit, was a planned transit infrastructure designated to run through and cover all parts of, the FCC (core-city) and not beyond (see Figure 3-11).



Source: FCDA/Sofreth, Amana, Osot, 1981.

Figure 3-11: Abuja Transportation Master Plan showing Transit Network within the Core-City (FCC)

The proposal for transit infrastructure fundamentally focused on the core-city at this time with no concern for any linkage to the suburban areas. This situation in Abuja corroborate findings from earlier studies which argue that in most global south cities, major services and infrastructure are concentrated in the core-city at the expense of the suburban area.

In recognition of the travel demand that could arise from regional linkages, the Abuja Regional Development Plan stated that *“within the frame of the present study, only general policy and suggestions are made concerning the overall transportation network system. Implementation presupposes a special transportation study”*- (FCDA 1983, p.Dox-Nig_A138, Appendix vi.6). However, because of a lack of implementation of this provision of the Regional Development Plan, the recommended transportation study was not conducted. Consequently, the concentration of development efforts in the core-city was sustained overtime and may have created the polarization between the growing suburban areas and the core-city of Abuja.

This pattern of urban primacy where a single core-city serves as the hub for most infrastructure development, employment areas and services with attendant huge daily demand for travel is consistent with the findings made by UNHSP (2009) about the characters of most global south cities.

In this vein, transportation linkages to the suburban areas in Abuja were left to evolve organically as informal bus services, hence public transport has been largely fragmented, unregulated and unreliable. With a population of 3 million in Abuja, the deficit of a planned development of transit to connect the core-city with the suburban areas, the growth of the suburban areas has generated a huge demand for

mobility. This is expressed in the high level of private car trips, all contributing to the huge daily number of motorized trips resulting in incessant traffic congestion (See Figures 3-12 and 3-13).



Source: Author's Field Survey, 2013.

Figure 3-12: Images of public transport and mini-buses moving in mixed traffic



Source: Author's Field Survey, 2013.

Figure 3-13: Images of private cars and mini-buses moving in mixed traffic

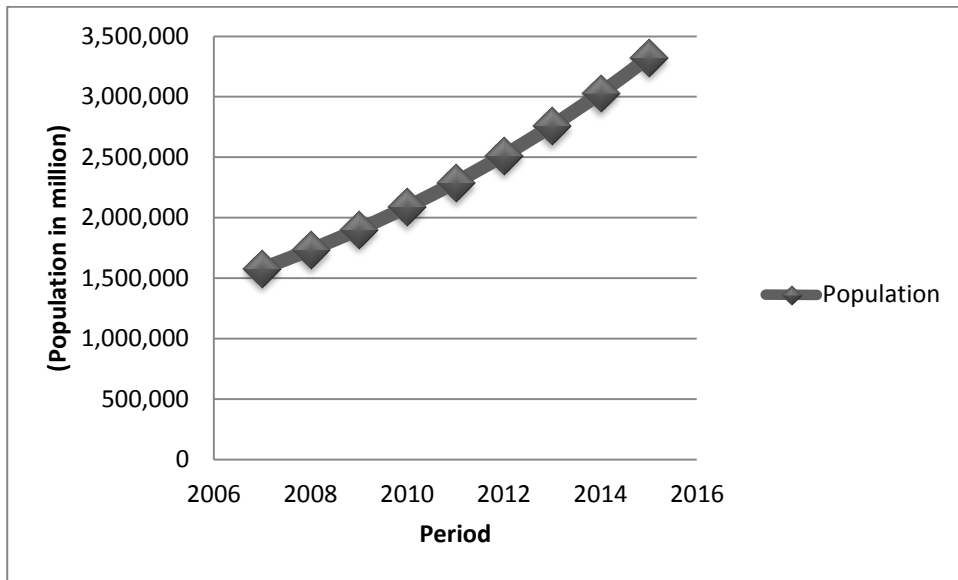
The continuous aspiration to own and drive a private car has rather continued to exacerbate and shape the mobility pattern in Abuja. This described characterization of informality in public transport system is consistent with the findings of the studies by Cervero (2000), and therefore show that this situation in Abuja typifies the situation of the same problem faced by other global south cities. In the same light, it also shows that the existing planning system may have created the enabling environment for this situation and may not be effective at permitting efficient passenger commuting experience in these cities including Abuja.

3.7.2.3 Character and Pattern of Existing Suburban Development

In this section, relevant archival records and observational evidence were collected and analyzed to show the rate of urban population growth, trends of suburbanization in Abuja, commuting pattern between residences and bus stops along public transport corridors, and the trends of sprawl in Abuja. The goal of the analyses is to in part identify if these trends are consistent with the findings of earlier studies about the challenges and characteristics of suburban development in global south cities, and partly to identify the enabling environment created by the existing Master Plan approach and this pattern of suburban development for the present mobility pattern in Abuja.

3.7.2.4 Unprecedented rate of urban population growth

The data on the rate of urban population growth in Abuja reveals an exceedingly high rate of growth. The UNFPA in 2011 put the rate at 9.3% annually and this rise is predicted to continue for the next 15 years. The population of Abuja in year 2014 was put at 3,028,807 (see Figure 3-14).



Source: UNFPA, 2014.

Figure 3-14: Urban Population Growth in Abuja

Indeed, if this prediction holds sway, as appears to be the case, the population growth of Abuja may continue to spur on demand for housing, especially cheap housing offered by the suburban areas of the Gwagwalada-Kuje, Nyanya-Karu, and Kubwa-Bwari axes. This trend of population growth in Abuja is consistent with evidence in earlier studies (UNHSP, 2008, UNHSP, 2009).

Linked to this, huge demands for mobility are also generated between the suburban areas (which are mostly dormitory settlements) and the core-city employment areas of Abuja. As seen in most global south cities, the huge volume of daily motorized trips further serves as a permissive factor for growing suburbanization, automobile dependence and CO₂ emissions resulting from traffic congestion UNHSP (2008), UNHSP (2009), WBCSD (2004), and Wright and Fulton (2005).

3.7.2.5 Pattern and Trends of Suburbanization in Abuja

As highlighted in Section 3.7.2.4, the majority of the population growth in Abuja is seemingly taking place more in the suburban areas. As a result, migrants, who are mostly low income workers, seek cheap accommodation and therefore find a residence in the major suburban areas of the Kubwa-Bwari, Nyanya-Karu and the Kuje-Gwagwalada axes. These suburban areas provide cheap housing accommodation because the housing development within them is characterized by unplanned, unregulated, spontaneously developed tenement buildings and bungalows with a high room occupancy ratio in the region of 500 - 1000 persons per hectare (Director, Department of Urban and Regional Planning, FCDA) (see Figure 3-15 – 3-17).



Source: Google Earth, 2013.

Figure 3-15: Satellite image of a portion of the Kuje-Gwagwalada axis showing the typical character of sprawl in suburban areas of the FCT



Source: Author's Field Survey, 2013.

Figure 3-16: A Typical view of planned development with bungalow housing in suburban area



Source: Author's Field Survey, 2013.

Figure 3-17: A typical view of unplanned development with bungalow housing type in suburban area

The analysis of the archival record of satellite image and observational evidence of picture recording appears to show the character of suburban areas in the case city as predominantly unplanned extensive pattern of development. With this extensive and dispersed spatial pattern in the suburban areas, majority of suburban residents may not live in proximity of walk-able distance to the existing public transport corridor. The various modes that characterize the ceaseless last mile commute to and from existing bus stops on the public transport corridors are illustrated in the figures 3-18 and 3-19 below.



Source: Author's Field Survey, 2013.

Figure 3-18: Last mile commuting via Commercial motor cycle in Kubwa, Abuja



Source: Author's Field Survey, 2013.

Figure 3-19: Last mile commuting via Commercial motor cycle in Kubwa, Abuja

This commute pattern captured in photo recording of the case area may therefore provide indications of the mobility impact on commuters which is implicit to the existing extensive pattern of suburban development in the case city.

3.7.2.6 Perception of Respondents on Commute Patterns from Residences to Bus stops on Public Transport corridors

In order to understand how the present extensive spatial pattern of the suburban development impact on last mile commuting pattern, the responses of the commuters was investigated in structured interview sessions. This is in line with the data sources identified earlier in Table 2.1, Section 2.4 as relevant to addressing research objectives 1-4, and research questions 1-2. Structured interview is characterized by a tightly controlled format of questions and answers as is the case with questionnaires (Descombe, 2007, p.179). This limited response allows for the standardization of response and ease of analysis of the ensuing quantitative data. This study has identified respondents in the structured interview to be commuters who reside in the suburban areas and commute daily (usually in traffic congestion) in mini-buses and private cars along the three routes under investigation to work in the core-city. The respondents also include urban planning practitioners in government establishments, private consulting firm in the case-city and in the academia.

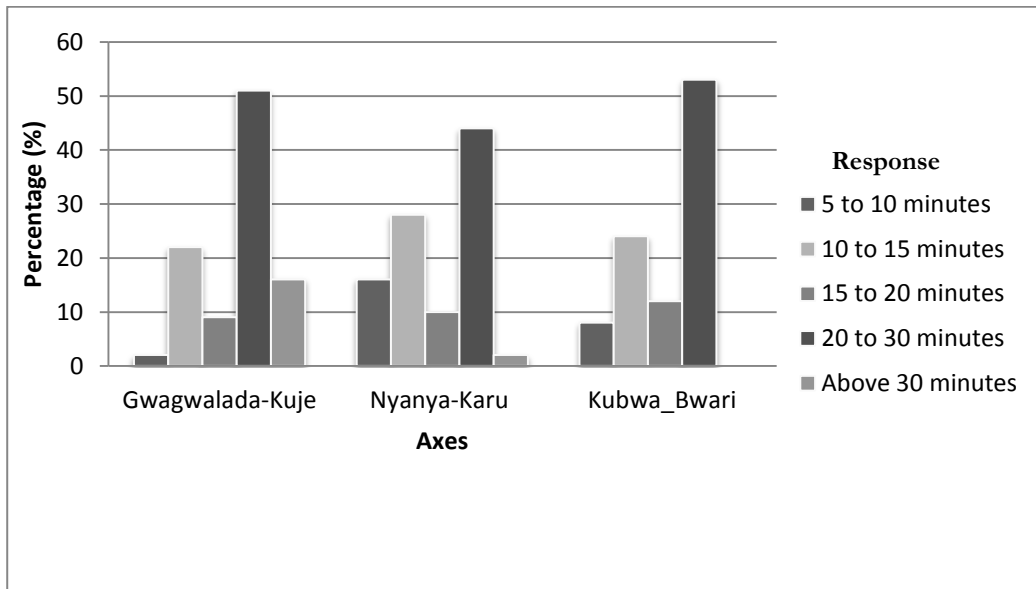
In this section, the respondents are commuters selected as participants because they possess lived experience of traffic congestion challenges along the routes under consideration and are able to make informed contributions that elucidate on research question 1-2. In order to collect structured interview data from the commuters on the mini-buses, the interviewer rode as commuter on the existing mini-buses along these three routes and conducted 5 interviews on each route with the commuters as respondents. Upon a brief introduction of the purpose of the interview to the 17-passengers typical capacity of a mini-bus, a sample of 5 respondents were purposively selected to participate in the interview based on their indication of interest to respond to the interview questions. The interviews

were conducted on each of the 5 work days (Monday through Friday). This therefore makes a total of 25 interviews on each route and 75 interviews along the three routes.

Similarly, twenty four (24) interviews was conducted with purposively selected private car drivers who commute to work by driving private cars on each of the three routes under investigation. This therefore makes a total of seventy two (72) interviews along the three routes. Two vehicle parking pools were selected, namely the Federal Secretariat within the Central Area District, and the Garki District Centre within Garki I District (both located within the core-city). This choice of the two parking facilities was made in order to capture the broad occupational spectrum of respondents, this is because the Federal Secretariat Complex consisted of civil servants employed by the government while the Garki District Centre consisted of persons employed in the private sector and self-employed persons. At the parking facilities located at the Federal Secretariat Complex in the Central Area District, 24 respondents were interviewed (with 8 respondents from each of the 3 routes). At the parking facility located at the Garki District Centre, 24 respondents from employees in the private sector (with 8 respondents from each of the three routes), and 24 respondents from self-employed persons (with 8 respondents from each of the three routes) were interviewed.

As these private car drivers parked their car within the parking facilities between the hours of 8:am-10:30am, and upon a brief introduction of the purpose of the interview, they were purposively selected as respondents based on the criteria that they live in the suburban areas and drive on either of the three routes for home-to-work commute. With this criteria satisfied, their consent was sought as participants in the structured interview session, with each session lasting for less than 5 minutes. The total number of structured interviews conducted with private car drivers equaled seventy two (72) interviews. The interviews were conducted on work days (Tuesday-Thursday). To sum up, a total of 147 structured interviews were conducted with this commuter group. Some of the questions which the commuters in mini-buses responded to in the structured interview include; type of occupation, purpose of trip, journey time during congestion and non-congestion situation, how much time is lost in traffic congestion, distance between residence and bus stops, and transport fare cost. In the case of commuters in private cars, the questions include; type of occupation, purpose of trip, journey time during congestion and non-congestion situation, vehicle brand and model, how much time is lost in traffic congestion (See Appendix V for sample of interview guide). The responses to these questions were relevant for establishing the impacts of the present traffic congestion situation on passengers travel time and related impacts of economic loss (man-hour), fuel loss, and transport-related Greenhouse Gases (GHG) emissions. Hence, the contributions to metric on establishing the commute pattern and the existence of the research problem in the explicate problem phase in this study.

The structured interview in this section involved asking questions on how much time it takes to walk (walking distance) from places of residences in the suburban areas to the bus stops on public transport corridors (see Figures 3-20).



Source: Author's Analysis, 2013.

Figure 3-20: Walking distance by commuters who travel in mini-buses from their residence to the existing bus stops

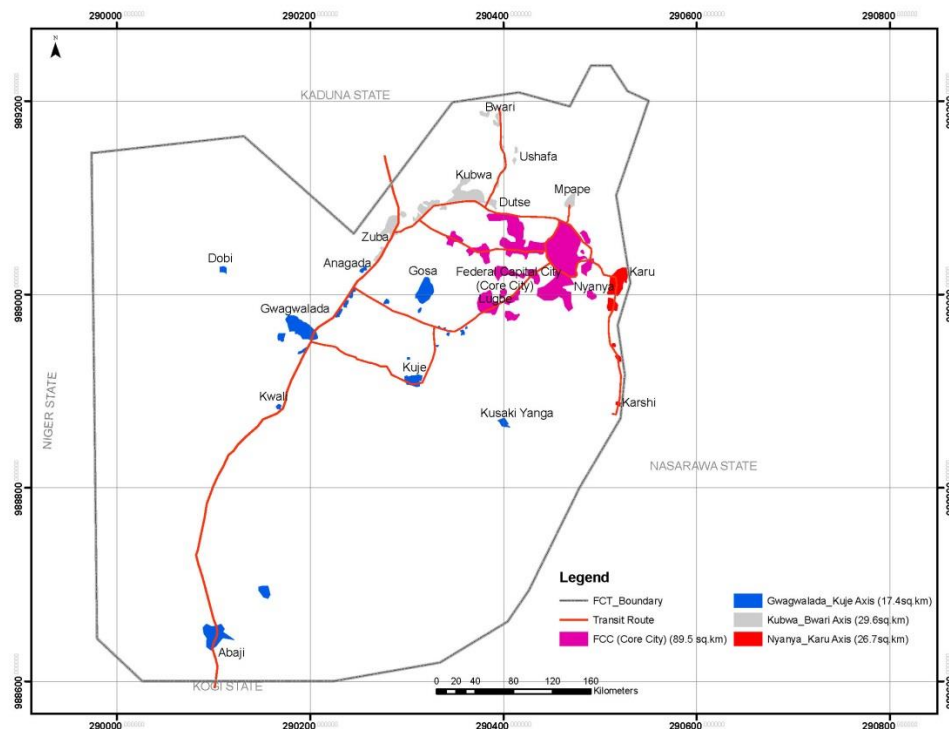
These responses indicate that more than half of these respondents walk beyond the recommended minimum walking distances to existing bus stations, with about one-quarter of the respondents walking for the recommended walking distance of 5 – 10 minutes to bus stops. This reveals the existence of a challenge in terms of the distances to existing bus stops across suburban areas and shows that a large spectrum of the residents are not efficiently served by the existing public transport system.

These findings is consistent with the study by Cervero (2000) which argued that public transport system in global south cities are predominantly fragmented and devoid of modal integration that can permit the convenience of commuters. Additional information provided by the respondents in the face-to-face structured interviews revealed that residents whose houses are located 20 – 30 minutes' walking distance to the bus stops (who are the largest spectrum) responded that they actually do not walk over this distance but rather ride on commercial motorcycles to get to the bus stops.. This, therefore, increase the portion of income spent on transport by these commuters from the suburban areas. Further, with the evidence of motorized trips in the form of commercial motorcycle being predominant in last mile commute, it may corroborate earlier assertion that the spatial pattern of suburban development are extensive and therefore necessitate the long distance commute.

This extensive spatial form contributes to increasing distances between the core-city and the suburban areas and, therefore, increases the travel distances and VKT. This finding in Abuja is consistent with the findings of UNHSP (2009) which posit that, this challenges result in most global south cities due to institutionally weak urban planning organizations, and may therefore illustrate the challenges and inhibitions inherent in the Master Plan approach.

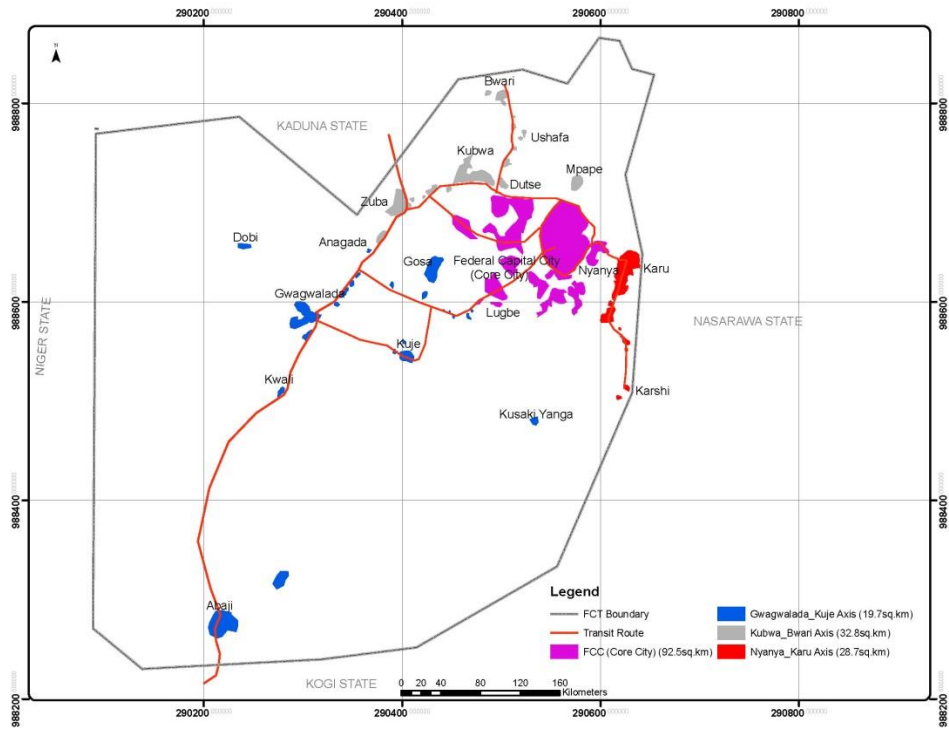
3.7.2.7 Trends of Sprawl in Abuja

Since evidence in earlier section suggest that most of the population growth in Abuja is taking place in these suburban areas, it is imperative to identify the trend of this growth; this trend of sprawl is pertinent to examining the impact of the growing population on spatial development and the demand for mobility. The archival record of satellite imageries used for this study's analyses cover a period of seven years between 2006 and 2012. Using GIS computer-based software GIS 9.3, the satellite imageries were, therefore, analyzed, looking at land cover for the periods of 2006, 2009 and 2012. The outputs are presented in Figures 3-21 – 3-23 and Table 3-3.

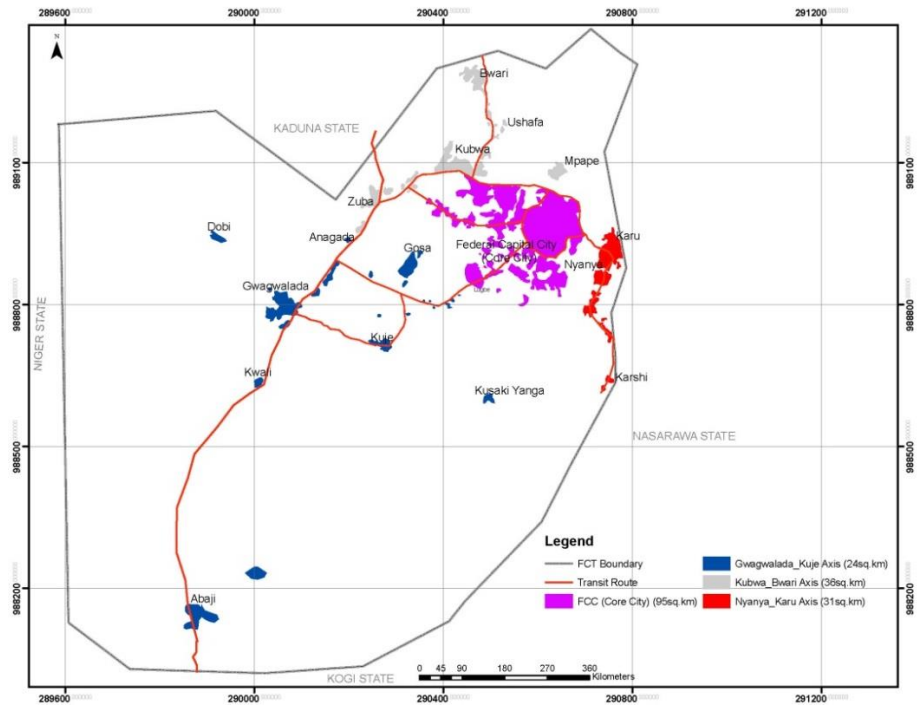


Source: Author's Analysis, 2013.

Figure 3-21: Trend of sprawl in the FCT- Abuja (as at 2006).



Source: Author's Analysis, 2013.
Figure 3-22: Trend of sprawl in the FCT- Abuja (as at 2009).



Source: Author's Analysis, 2013.
Figure 3-23: Trend of sprawl in the FCT- Abuja (as at 2012)

Table 3-3: Trend of sprawl in the suburban areas and the core – city of Abuja

Year	Axis in the Suburban Area			Suburban Areas (Total) (sq.km)	Core city (sq.km)
	Kubwa – Bwari (sq.km)	Nyanya – Karu (sq.km)	Kuje – Gwagwalada (sq.km)		
2006	28.0	22.11	23.58	73.7	89.5
2009	33.29	31.67	16.24	81.2	92.5
2012	32.76	31.85	26.39	91.0	95.0

Source: Author's Analysis, 2013.

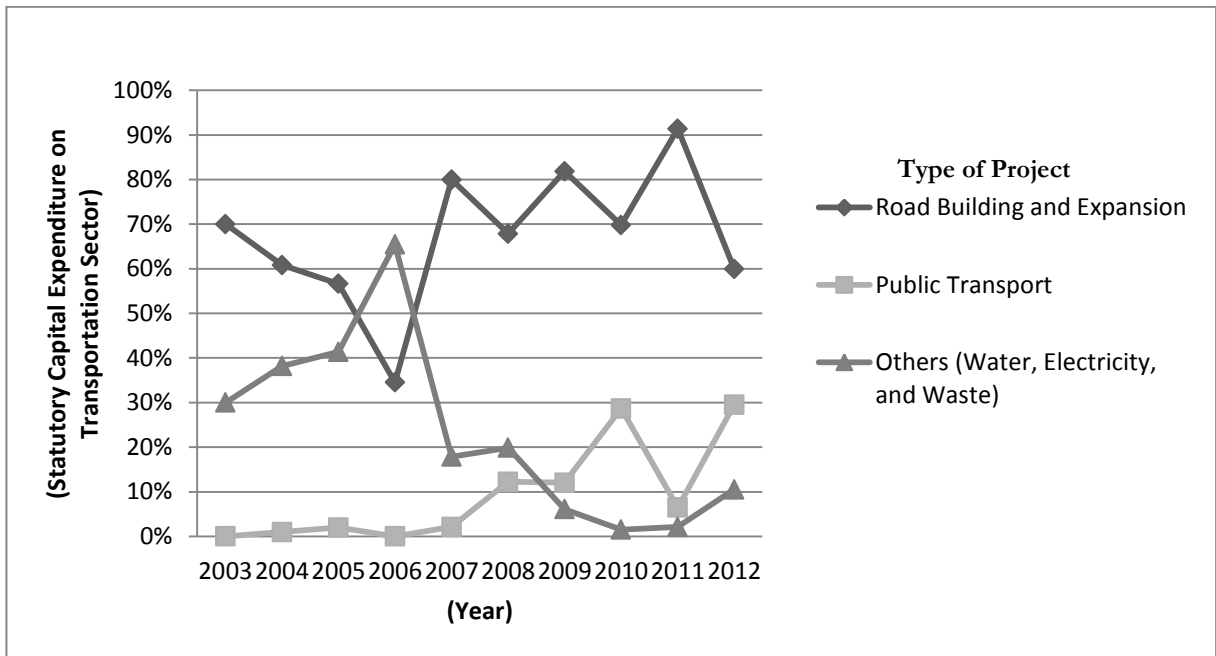
While the land cover in the core-city was 89.5 km² in 2006, it grew to 92.5 km² in 2009 and to 95 km² in 2012. This shows an average annual growth rate of 0.98%. Similarly, the land cover in the suburban areas was 73.7 km² in 2006, it grew to 81.2 km² in 2009 and 91 km² in 2012 and this shows an average annual growth rate of 3.54% (See Appendix II). This analysis shows that the rate of sprawl in the suburban areas is higher than that for the core-city which indicates that most of the population growth and its spatial expression are taking place mostly in the suburban areas.

With the core-city remaining the focus of attraction for employment and major services, the increase in the inefficient extensive use of land that characterizes this spatial pattern of development and the increasing distance may culminate in increasing mobility demands and increasing daily motorized trips on the three routes linking the suburban areas and the core-city of Abuja. This assertion is consistent with the findings by Chin (2002), Cohen (2006), and UNHSP (2009). This study further posited that the current modernist planning approach currently in use in most global south cities may not be efficient at responding to the increasing urban population growth and the related trends of sprawling spatial development.

3.7.2.8 Structure of Transport Sector Investments in Abuja

Earlier studies have often argue that the engineering solution of the 'predict and provide' philosophy of the building and expansion of roads to address traffic congestion challenges has dominated transport policies for a long time in most cities and it encourages sprawl and motorized car travel over long distances (Litman, 1998). In this situation, investments in transport infrastructure appear skewed towards building roadways to facilitate auto-mobility. In this section, documentary evidence sourced from the Budget Division of the Abuja-FCT Treasury Department was analyzed; the analysis revealed that the road transportation infrastructure in the Abuja Master Plan is usually implemented through government statutory capital expenditure. The provision of these road transport infrastructure is premised on the traditional demand forecasting that emphasize the prioritization of building and expansion of roads based on trend and growth of traffic and landuse activities.

By analysing the contents of the Statutory Budget Documents, the categorization of the nature of transport sector expenditure into *road building and expansion*, *public transport* and *other road-related infrastructure* projects between the years 2003 to 2012, in Abuja, was made and is illustrated in Figure 3-24 below.



Source: Department of Treasury, FCTA / The National Assembly, Abuja (2003-2012).

Figure 3-24: FCT-Abuja Statutory Capital Expenditure in the Transportation Sector (2003 - 2012).

The review of the Abuja statutory capital expenditure documents show that that the FCDA Department of Engineering Services, FCDA Department of Satellite Towns Infrastructure (Now Satellite Towns Development Agency), and the FCT Transport Secretariat are all charged with the responsibility of the transportation sector in the FCT. An analysis of capital expenditure of these departments in Abuja in Figure 3-24 shows that road building and road expansion account for a high of 91.40% and a low of 34.54% (with a mean of 67.29%); public transport accounts for a high of 29.51% and a low of 0% (with a mean of 9.40%) while others categories (water, electricity and waste) account for a high of 65.46% and a low of 1.53% (with a mean of 23.31%) through the 10 years' period (2003 – 2012). An analysis of these records on statutory capital expenditure on transportation in Abuja indicate that funds for the building and expansion of roads have been given priority and have been sustained, while funding for public transport has been abysmally low.

Hence, this clearly illustrates that the philosophy of the *predict and provide engineering solution* is evident in the existing urban planning system in Abuja, and this structure of transport sector expenditure may serve as permissive factors for the automobile-dependent mobility pattern in Abuja. However, when viewed differently, the trend of building and expansion of roads/highways as evident in the Master Plan approach in Abuja may represent a city's prosperity and contribution to infrastructure development that enhances car mobility for motorists. This trend may, therefore, help to explain the continued growth of the suburban areas of Abuja. Indeed, by leaving this existing situation unabated, the challenges associated with this trend may continue and further worsen current traffic congestion challenges and exacerbate the trend of sprawling spatial form in the suburban areas of Abuja.

3.7.2.9 Evidence of Car Proliferation in Abuja

In order to illustrate the growing demand for mobility and the trend of motorization, archival records on the volume of passengers and vehicles were collected from the FCT Transport Secretariat from a survey undertaken by them in 2008, and also from a survey conducted by the author in 2011. As illustrated in Section 2.4 and Table 2.1, archival records is identified as one of the data sources for addressing research objectives 1– 3 and research question 1. It is imperative to point out that the analysis in this section focuses mostly on the daily motorized trips in mini-buses and private cars on the routes under consideration, in that, these two commuting modes of vehicles accounted for 92% of the daily motorized trips. The structure of the two dominant modes is reflected in Table 3-4 below.

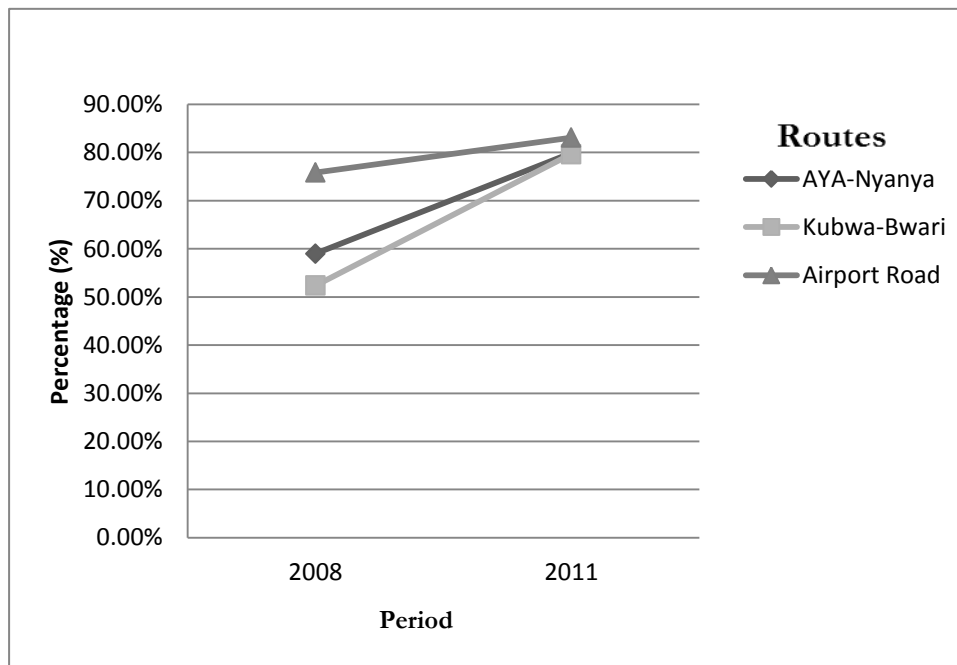
Table 3-4: The structure of the two dominant mode of transport in Abuja

Mode	Volume of Trips		Volume of Vehicles	
	No.	%	No.	%
Cars	142,076	39.05	71,038	85.23
Mini-buses	221,760	60.95	12,320	14.77
Total	363,836	100	83,358	100

Source: Author's Analysis, 2013.

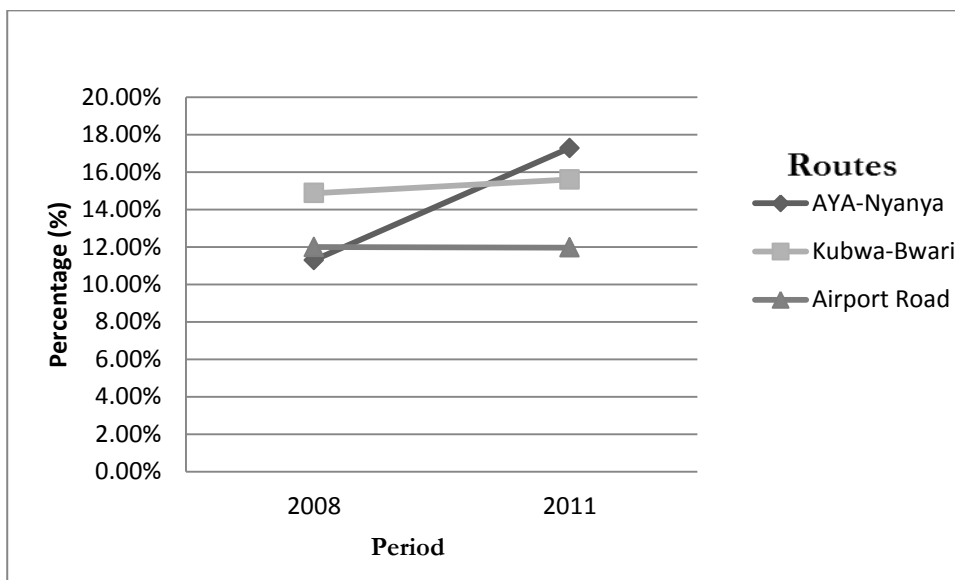
The structure of mode share shown in Table 3-4 illustrates how the present mini-buses struggle to cope with the daily movement of majority of the commuters. Notwithstanding, the huge number of private cars on the road, less than 40% of commuter are moved through the 85% daily volume of vehicular traffic. The explanation may be that the majority of the cars are single occupant vehicles. Therefore, the huge number of cars running in mixed traffic with mini-buses in the case area may explain the daily traffic congestion challenges.

Further, the archival records, on the volume of vehicular traffic (mini-buses and private cars) was analyzed to show the trend of increase in the volume of vehicular traffic between 2008 – 2011 on the three routes under consideration (Kubwa-Bwari, AYA and Airport Road) (See Figure 3-25 – 3-26).



Source: FCT Transport Secretariat, 2008 and Author, 2011.

Figure 3-25: Trend of growth of vehicular traffic: private cars (2008 – 2011)



Source: FCT Transport Secretariat, 2008 and Author, 2011.

Figure 3-26: Trend of growth of vehicular traffic: mini-buses (2008 – 2011)

The analyses presented in the figures above show that the volume of vehicular traffic (mini-buses and private cars) grew on average at an annual rate of 9.1%. This annual rate of growth closely mimics the annual rate of the urban population growth of Abuja which is put at 9.3%. The implication of this trend of increasing daily motorized trips indicates an increasing demand for mobility. Evidence show that this huge demand is being met mostly by a fragmented, unreliable and polluting, informal public transport system and private cars running/operating in mixed traffic with related challenges of traffic congestion.

3.7.2.10 Assessment of the Impacts of the Existing Mobility Pattern in Abuja

As illustrated in Section 2.4 and Table 2.1, observational evidence is identified as one of the data sources for addressing research objectives 1-3, and research question 1, this is because observational evidence can reveal important characteristics of the phenomenon being investigated. In this section, the traffic congestion created as a result of the present automobile-dependent mobility pattern and the numerous daily motorized trips along the three routes under consideration (AYA, Kubwa-Bwari and Airport Road) were photo-recorded during traffic peaks and in the off peak period. The peak period (6am – 10am, and 4pm – 7pm) is illustrated by the slow movement of vehicles with travel speeds oscillating between 10 – 20 km/h and can even reach “*dead-slow*” at certain points/times (see Figures 3-27 and 3-28).



Source: Author's Field Survey, 2013.

Figure 3-27: Traffic Jam on AYA route, Abuja



Source: Author's Field Survey, 2013.

Figure 3-28: Traffic Jam on Kubwa-Bwari route, Abuja

This traffic congestion prolongs commuting time beyond an ideal travel time. The responses from the structured interviews with commuters shows that 93% of the respondents agree strongly to the assertion that the growth in daily motorized trips in Abuja is huge and, if left unabated, passenger mobility may become dysfunctional.

3.7.3 Commuters' Perceptions on the Challenges of the Existing Mobility Pattern

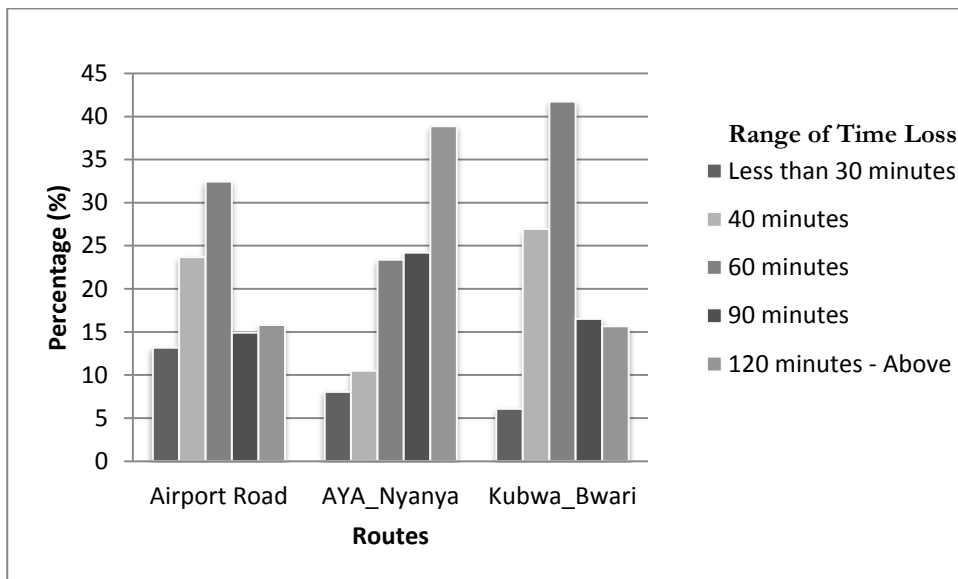
The responses from the structured interview with commuters in mini-buses and private cars explained earlier in Section 3.7.2.6 were analyzed in order to reveal the perception of the transport users of the challenges implicit in the existing mobility pattern. This is reported on further in the section below.

3.7.3.1 Costs of the existing mobility pattern

In this section, the responses from the structured interview of commuters' perceptions consisted of the perception of commuters in mini-buses and in private cars on the different challenges stemming from the existing mobility pattern. These include; time loss during journey to work, fuel loss during journeys to work, and CO₂ emissions resulting from the huge volume of daily motorized trips to work. This therefore addresses research objective 3, and research question 1. The findings are analyzed and reported in this section (See Figures 3-29– 3-30 below).

I. Time loss during journey to work

The time loss during journeys to work on the three routes was investigated in order to elicit the extent of the loss during the daily home-work trips. The results concerning time loss from the journeys are reported in Figures 3-29 and 3-30 below.



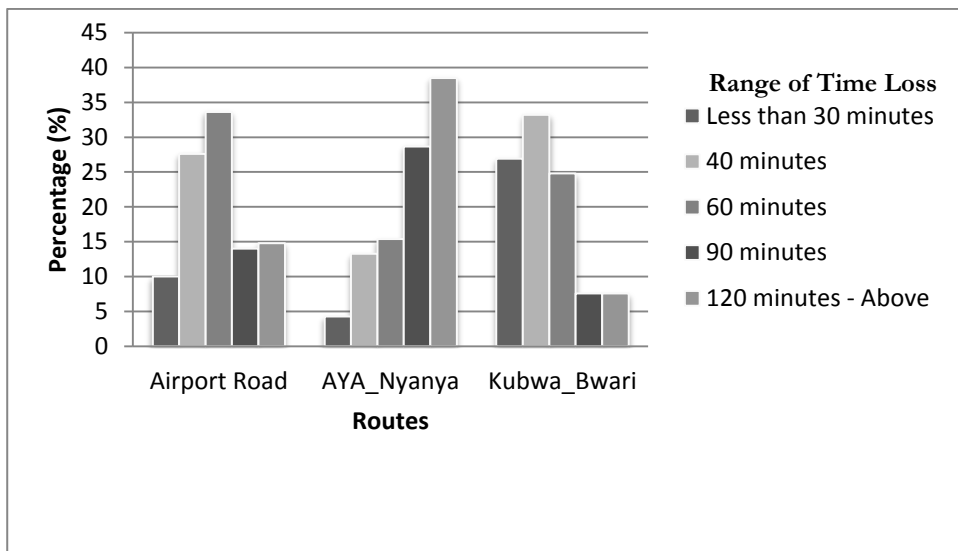
Source: Author's Analysis, 2013.

Figure 3-29: Time lost by commuters in mini-buses during journeys to work due to traffic congestion

As evident from the analysis in Figure 3-29, 38.87% of commuters on AYA route lose 120 minutes and above; also, 15.79% and 15.65% of commuters on the Airport Road and the Kubwa-Bwari route

respectively lose 120 minutes and above during their commute to work due to traffic congestion. Furthermore, 56.14% and 68.7% of commuters lose 40 - 60 minutes on the Airport Road and the Kubwa-Bwari route respectively. Also, 47.58% of commuters lose 60 - 90 minutes on the AYA route.

To sum up, the majority of time losses by commuters on the AYA route fall between 60 – 120 minutes (an average of 90 minutes) while on the Airport Road and the Kubwa-Bwari route they fall between 40 – 60 minutes (an average of 50 minutes). The markedly high level of time loss on the AYA route is undoubtedly connected to the fact that the AYA route has the highest number of daily motorized trips, public transport operates in mixed traffic on this road and the numbers of lanes on the carriageway are comparatively lesser than those on the Airport Road and the Kubwa – Bwari route. This indicates that more time loss is experienced on the AYA route. In aggregate, the majority of time losses by commuters in mini-buses on the Airport Road and the AYA and Kubwa-Bwari routes fall between 50 – 90 minutes (an average 70 minutes).



Source: Author's Analysis, 2013.

Figure 3-30: Time lost by commuters in private cars during journeys to work due to traffic congestion.

With regard to the analysis of time loss by commuters in private cars, Figure 3-30 shows that 38.46% of private cars on the AYA route lose 120 minutes and above; also, 14.8% and 7.56% of the commuters on the Airport Road and the Kubwa-Bwari route respectively lose 120 minutes and above during journeys to work due to traffic congestion. In addition, 61.2% and 57.98% of the commuters lose 40 - 60 minutes on the Airport Road and the Kubwa-Bwari route respectively. Also, 44.01% of the commuters lose 60 - 90 minutes on the AYA route.

Thus, on the average, the time lost by commuters in private cars on the AYA route falls between 60 – 120 minutes (an average of 90 minutes) whilst on the Airport Road and the Kubwa-Bwari route it falls between 40 – 60 minutes (an average of 50 minutes). Evidently, the AYA route records a relatively higher level of time loss. This is connected to the fact that the AYA route has the highest number of

daily motorized trips and the number of the lanes on the carriageway is comparatively less than those on the Airport Road and the Kubwa – Bwari route. As was illustrated also for the commuters in mini-buses, it is indicative that more time loss is experienced on the AYA route. In aggregate, the average time lost by commuters in private cars on the Airport Road and the AYA and Kubwa-Bwari routes is put at between 50 – 90 minutes (an average of 70 minutes).

To sum up, these opinions by the respondents shows that time loss is experienced on these routes due to delayed travel. Indeed, delayed travel leads to man-hour losses and the consequent economic losses with impact on GDP. In addition, the frequent acceleration, deceleration, and prolong travel time may lead to such consequences of fuel loss and transport-related CO₂ emissions. The evidence presented from earlier studies by Molina et al (2005) Schipper et al. (2006) Wright and Fulton (2005); illustrate that a mobility pattern skewed towards numerous daily motorized trips is a recipe for soaring level of transport-related CO₂ emissions.

To summarize, the present inherent traffic jams that characterize the mobility challenge in Abuja suggest that there are man-hour losses as a result of delays in commute time. Equally, the numerous daily motorized trips and the increased time undertaken by commuting trips also lead to fuel wastage and increased transport-related CO₂ emissions. It is, however, critical to note that if this trend of suburbanization, increasing distances between the core-city and suburban areas as a result of sprawl and the numerous daily motorised trips continue unabated, the challenges implicit in traffic congestion (which include man-hour losses, fuel wastage and transport-related CO₂ emission) may continue and impede efficient and sustainable passenger transportation in Abuja.

3.7.4 Profile of Man-hour Losses, Fuel Wastage and Transport-related CO₂ Emissions from the existing mobility pattern

The array of data used for the extrapolation in this section were sourced from archival records of vehicle traffic counts, structured interviews with members of the transport operators association, commuters in mini-buses and in private cars along the three routes. The extrapolation with these data sets revealed information on the level of CO₂ emissions, fuel wastage and man-hour losses that stem from the present mobility pattern and therefore addresses research objective 3, and research objective 1. The analysis on these identified issues is reported in in this section (see Tables 3-5, 3-6, and 3-7).

1. Profile of CO₂ Emission Levels

The data from the computed per capita fuel usage was used in the extrapolation of the level of CO₂ emissions against the volume of trips by commuters in mini-buses and private cars. The indices of 2.4kg CO₂ per litre of petrol fuel burnt by an automobile vehicle were used in this extrapolation (See Appendix III).

Table 3-5: Profile of transport-related CO₂ emissions on the three routes^a.

Route	Mini-Buses		Private Automobile		Total Yearly CO ₂ Emission (tons)
	Volume of Vehicles	Yearly CO ₂ Emission (tons)	Volume of Vehicles	Yearly CO ₂ Emission (tons)	
Airport Road	3385	15,892.085	23,476	69,532.985	85,425.069
AYA	4297	20,282.512	23,874	70,711.811	90,994.324
Kubwa-Bwari	4638	21,892.085	23,688	70,160.902	92,052.987
Total	12,320	58,066.632	71,038	210,405.698	268,472.330

Source: Author's Analysis, 2013.

^aSee detail computation in Appendix III.

The aggregation of CO₂ emission levels across the three routes from trips in mini-buses and private car is put at 268,472.330 tons. With the disaggregation of this present emission level by mode, the mini-buses and private cars account for 58,066.632 and 210,405.698 tons respectively. This situation indicates that private cars contribute a significant percentage (78.37%) of the total CO₂ footprint of the present mobility pattern due to the huge number of private car trips and, importantly, because occupancy rates are low (1-2 passengers) with high per capita emission levels. Therefore, the achievement of a significant reduction in CO₂ emission levels from the present mobility pattern largely depends on achieving a reduction in the level of private car usage.

II. Profile of Fuel Usage Levels

In order to accurately extrapolate the level of fuel wastage from the present mobility pattern, interview data from members of the transport operator association and private car users on passenger capacity and fuel usage per km during both congestion (peak period) and non-congestion (off-peak) periods was obtained. By dis-aggregating peak and off-peak period commuting, it helped to measure per capita fuel usage in different situations. The result was used against the volume of trips to compute fuel usage for trips during congestion and non-congestion periods. This, therefore, helped to establish the profile of fuel usage in the present mobility pattern. While per capita fuel usage for commuters in mini-buses during congestion and non-congestion periods is put at 0.243 litres and 0.194 litres respectively, per capita fuel usage for commuters in private cars during congestion and non-congestion periods is put at 1.285 litres and 0.644 litres respectively. Evidently, the amount of fuel usage for commuters in private cars is higher because these vehicles are usually single occupant vehicles (SOV). See Appendix VII.

Table 3-6: Profile of Fuel Usage Levels on the three routes^a

Route	Bus System		Private Automobile		Total Yearly Fuel Usage (litres)
	Volume of Vehicles	Yearly Fuel Usage (litres)	Volume of Vehicles	Yearly Fuel Usage (litres)	
Airport Road	3385	6,657,387.366	23,476	28,233,709.335	34,891,096.701
AYA	4297	8,451,046.8288	23,874	29,463,254.6724	37,914,301.5012
Kubwa-Bwari	4638	9,121,702.395	23,688	29,233,709.335	38,355,411.73
Total	12,320	24,230,136.5898	71,038	86,930,673.3624	111,160,809.932

Source: Author's Field Work, 2013.

^aSee detail computation in Appendix III.

The findings from the analysis in Table 3-6 shows that the total aggregated volume of fuel usage level across the three routes from trips in mini-buses and private car is extrapolate as 111,160,809.932 litres of petrol fuel. However, when this present fuel usage level is examined by mode type, the mini-buses and private cars account for 24,230,136.5898 litres and 86,930,673.3624 litres respectively. The private cars experience a relatively higher level of fuel usage to the tune of about 78.20% of the total fuel usage from the present mobility pattern due to the huge level of per capita usage of fuel in private car trips.

III. Profile of Man-hour Losses

In order to accurately extrapolate the economic implications of the time lost in traffic jams on the three routes, the face-to-face structured interviews with the commuters on mini-buses and in private cars provided data on the disaggregation of the income level/occupation. The status of the passengers contained in a typical mini-bus and private car is analyzed.

This data was used to extrapolate the economic cost of the time loss by applying the ratio of the occupational composition structure of a typical mini-bus or car across the total passenger trips (See Appendix III).

Table 3-7: Profile of Man-hour Losses' level on the three routes^a

Route	Bus System		Private Automobile		Total Yearly Man-hour losses
	Volume of Vehicles	Yearly Man-hour losses	Volume of Vehicles	Yearly Man-hour losses	
Airport Road	3,385	4,760,962.35 hours (₦ 468,713,260.055)	23,476	4,888,954.30 hours (₦ 1,018,532,164.76)	9,649,916.651 hours (₦1,487,245,424.82)
AYA	4,297	6,043,680 hours (₦ 594,995,828.2)	23,874	4,971,840 hours (₦ 1,035,799,834)	11,015,520 hours (₦1,630,795,662.2)
Kubwa-Bwari	4,638	6,523,292 hours (₦ 642,213,323.526)	23,688	4,933,104 hours (₦ 1,027,730,018.7)	11,456,396 hours (₦1,669,943,342.2)
Total	12,320	11,327,934.35 hours (₦ 1,705,922,411.781)	71,038	14,793,898.3 hours (₦ 3,082,062,017.46)	32,121,832.651 hours (₦4,787,984,429.22)

Source: Author's Analysis, 2013.

^aSee detail computation in Appendix III.

The information presented in the Table 3-7 above reveals the level of man-hour losses stemming from the traffic congestion that characterizes the present mobility pattern in Abuja. Accordingly, the total volume of man-hour losses (expressed in hours and wage equivalents) across the three routes from trips in mini-buses and private cars is extrapolate as 32,121,832 hours (~~₦~~4,787,984,429.22).

The analysis shows that trips in mini-buses and private cars account for man-hour losses to the tune of 11,327,934.35 hours (~~₦~~1,705,922,411.781) and 14,793,898.3 hours (~~₦~~3,082,062,017.46) respectively. An illustration of the relevant man hour losses from travel in mini-buses and private cars reveals that trips in private cars contribute significantly higher to man-hour losses to the tune of 46.05%. As a recap, the metrics presented in this section on the impacts of the existing mobility pattern and traffic

congestion on the three routes under consideration shows that the level of related CO₂ emissions, fuel wastages, and man-hour loss may grow in response to increasing motorization level, and therefore needs to be addressed.

3.7.5 Character of Existing Institutional Settings/Arrangement

The review of the planning documents revealed the provisions of the plans regarding the planning organization responsible for implementing the provisions of the physical plan and urban infrastructure plans in Abuja. The findings revealed that, upon the inception of the Abuja Master Plan document (1979), the Federal Capital Development Authority (FCDA) was created and charged with the responsibilities of developing the city. However, in 2004, the FCT Transport Secretariat was created and charged with the responsibility of providing integrated transportation for the entire territory (FCT). The FCDA Urban and Regional Planning Department is charged with the planning, design and regulation of landuse in the FCT. The Satellite Towns Development Agency (STDA) has also been recently created and charged with the transformation of the designated satellite towns and to address the infrastructural shortfalls that abound in the suburban areas (satellite towns).

In order to examine how effectively these organizations carry out the function of physical planning and development of related infrastructure in the city in view of the organizational structure and procedures produced by the existing Master Planning approach in Abuja, the opinions of the relevant practitioners were therefore investigated in structured interview.

In view of the structured interview explained earlier in Section 3.7.2.6, in this section, the investigation involved asking question on a checklist of factors with a view to assess the capacities of the current urban planning organization in the case city-Abuja (See Table 3-8). The checklist consists of seven (7) factors identified as crucial to the efficiency of a planning system and organization. The factors include government bureaucracy, sectoral integration and collaboration, a scheduled implementation of plans, achievement of planning goals, organizational capacity; relevance of planning documents, and political interference. These factors were therefore rated by the respondents as 'strong' when the existence of the factor is perceived as strong (evident/deep rooted); rated 'weak' when the existence of the factor is perceived as weak (not very evident not deep rooted); and non-existence when the factor does not exist.

The respondents are urban planning practitioners in government establishments, private consulting firm, and the academia purposively selected as participants because they have rich actual experience of urban planning issues, and are able to make informed contribution that elucidate on research questions 1-3. These structured interviews provide the premise to establish the level of sectoral integration and the capacities of the current urban planning organization to address the current challenges. Therefore, 30 structured interviews were conducted with these purposively selected urban planning practitioners

in government establishments, transport operator association, private consulting firm and the academia.

3.7.5.1 Analysis of Institutional Deficiencies

With cognizance to the organizational structure and operational procedures produced by the existing Master Planning system, the opinions of practitioners in the relevant organizations as FCDA, STDA and the FCT Transport Secretariat, urban planning consulting firms and the academia were investigated. A summary of the survey of responses to the pre-determined checklist for the institutional analysis is presented in Table 3-8.

Table 3-8: Evaluating the capacities of the existing planning system/organization.

S/N	Checklist	Rating			Total
		Strong (%)	Weak (%)	Non-Existence	
1	Government Bureaucracy: Current restrictive bureaucratic practice	70	30	-	100
2	Sectoral Integration and Collaboration: Current framework for sectoral integration and collaboration during planning and implementation	20	80	-	100
3	Implementation of Plan: Adherence to schedule of implementation	33	67	-	100
4	Planning Goal and Objectives: Current long range plan and long term technocratic-driven objectives	57	43	-	100
5	Organizational Capacity: Trained human capacity is available and adequate	40	60	-	100
6	Relevance of Planning Document: Current Planning document is up-to-date and relevant to existing realities	53	47	-	100
7	Political Interference: Current level of political interference in plans and implementation process	100	-	-	100

Source: Author's Analysis, 2013.

(I) Government Bureaucracy

Government restrictive bureaucratic practice is used here to refer to the creation of a procedural chain of activities that lengthen the completion time for processes and actions within government organizations. An analysis of the responses by the practitioners reveals that 70% and 30% of the respondents rated the current bureaucratic practice as strong and weak respectively. Thus, decisions on spatial plans and urban infrastructure plans take a long time to be accomplished, and therefore may inhibit the prompt realization of planning goals in Abuja.

(II) Sectoral Integration

In the planning and implementation of physical plans and urban infrastructure plans, it is imperative to have effective integration between, and collaboration with, relevant sectors to ensure that the economic, social and environmental dimensions of the plans are considered and addressed. An analysis of the responses of the practitioners showed that 20% and 80% of the respondents rated the current sectoral integration as 'strong' and 'weak' respectively. From this, it can be seen that planning and implementation of physical plans in Abuja generally lack effective sectoral integration, hence the sub-optimal level of the realization of the objectives of physical plans and urban infrastructure plans.

(III) Implementation of Plans

Physical plans and urban infrastructure plans are usually prepared and guided by schedules of implementation which are time-bound. Since most plans are part of a larger plan, it is imperative to ensure that the provisions of a plan is implemented according to schedule in order to ensure the achievement of the larger vision plan for the city. An analysis of the responses from the practitioners revealed that 33% and 67% of the respondents rated adherence to a schedule of implementation of plans as 'strong' and 'weak' respectively. These responses are an indication that compliance with the schedule of implementation of plans in Abuja is weak. Because of this fact, delays in the implementation of the larger vision plan for the city occur, consequently, unguided and unregulated development results.

(IV) Planning Goals and Objectives

The preparation of long-range physical plans and urban infrastructure plans with short-range stakeholder-driven objectives and outcomes are imperative to the efficient and timely realization of planning goals. By this, the objectives of the plan which are bottom-up are realized incrementally and the relevance of the plans is sustained. An analysis of the responses from the practitioners showed that 57% and 43% of the respondents chose the rating 'strong' and 'weak' respectively on the statement that the current planning system is characterized with long range plans and long term technocratic-driven objectives. This is an indication that more than half of the practitioners evaluated the existing planning system in Abuja as being characterized by long range plans and long term technocratic-driven objectives. This does not indicate consensus that the existing planning system has the requisite capacity to achieve short term stakeholder-driven objectives within long-range plans.

(V) Organizational Capacity

Trained abilities and capacities are required to prepare and implement physical plans and urban infrastructure plans using efficient methodologies. Such abilities can make the outcomes of the plans relevant to existing realities, ensure the efficient use of resources and achieve optimal results from the

plan. Planning organizations and institutions requires well-trained human capabilities to function optimally and to achieve set goals efficiently. An analysis of the response from the practitioners shows that 40% and 60% of the respondents rated the current availability and adequacy of trained human capacity in the existing planning organizations as 'strong' and 'weak' respectively. This shows that decision about planning and the implementation of physical plans and urban infrastructure plans may lack the capabilities for informed decisions required to achieve a level of efficiency that can ensure optimum realization of planning goals.

(VI) Relevance of Planning Documents

Physical planning documents provide the frameworks for the realization of the vision plan for the city, and this broad vision is implemented using physical plans and urban infrastructure plans. The planning documents are required to be up-to-date in order to ensure that the provisions are relevant to the current trends and realities. An analysis of the responses from the practitioners showed that 53% and 47% of the respondents chose the rating 'strong' and 'weak' respectively when asked if the current planning documents were up-to-date and relevant to existing realities.

It is not surprising that the responses from the practitioners indicated that the planning documents are up-to-date and relevant. This may be partly due to the circumstances that the majority of the practitioners in the government institutions considered are not being regularly trained. With adequate training and capacity building on current trends and knowledge as observed with practitioners in the academia, the responses from the perception of these practitioners in the government establishments on the relevance of the current planning document may become weak, especially recognizing that the existing planning documents does not contain any mention of sustainable urban development, climate change and low carbon development issues. The present nature of response by the respondents may also be partly due to the evidence from the finding by earlier studies (UNHSP, 2009) which argues that the planning system and practitioners in the global south region hold on to the vestiges of the Modernist Planning system and this continue to shape planning with the related sub-optimal outcomes of planning objectives.

(VII) Political Interference

Political interference is used here to refer to the process of subjective interference by elected political office holders in making and implementing physical plans and urban infrastructure plans. It is a factor that not only deters the scheduled implementation of plans but also contributes to sidetracking from the vision plan. Such occurrences result from the differentiation in the priorities of politicians and the desire to have unique individual attribution of a regime's achievements from policies and programmes, thus less attention is paid to the general larger vision. An analysis of the perception of the practitioners revealed that 100% of the respondents rated the presence of political interference in the planning and

implementation of physical plans and urban infrastructure plans as strong. Therefore, it is imperative to recognize political interference as a critical factor that inhibits the efficient planning, timely and scheduled implementation of physical plans and urban infrastructure plans in Abuja.

As a recap, it can be seen that the issues contained in the checklist for this analysis have elucidated on the challenges inhibiting optimal outcomes in the existing planning system and organizations. These challenges, therefore, point to the need for reform of the existing system in order to achieve the capacity required to realize set planning goals. It is pertinent to recognize that the highlighted issues require that there is a strong emphasis placed on organizational reform. By this, the institutional reform should engender a platform that integrates reform to all these of deficit.

To summarize, the novelty of this study lies in part in the creation of new knowledge which can be viewed from the methodological approach adopted to focus the study on real-life case in global south city context. The mixed method research approach and the Design Science research strategy explained in Section 2.4 has been adopted to focus the investigation of the explicated problems on global south city context. Data sources which include the review and content analysis of literature and planning documents were used to understand the peculiarity of the research problems within the context of global south cities and, the inherent gap in literature. Further, a matrix consisting of several indices and list of some global south cities was used to analyze the characteristics of the listed global south cities vis-à-vis the explicated problems. The analysis of the matrix provided the premise to focus the investigation in this study on a selected global south city as the case-city to contextualize the explicated problems.

This case-city was chosen especially because it appears to substantially exemplify the explicated problems. The evidence of the explicated problems in the case-city were gathered using the Design Science research strategy explained in Section 2.4, the data sources used include document reviews and content analyses of Abuja Transportation Master Plan, the Abuja Regional Development Plan and the Metropolitan Public Transport Concept Plan. These include Archival records on the volumetric counts of vehicles and passengers on the three routes under consideration (AYA, Kubwa-Bwari and Airport Road), and structured interviews of practitioners and expert groups. These also include structured interviews of commuters who reside in the suburban areas and commute daily (usually in traffic congestion) in mini-buses and private cars along the three routes under investigation. The content analysis of documents reviewed and the analysis of responses of structured interviews of expert group on institutional deficiency within the context of the case-city revealed that the situation in the case-city present extra barrier/challenges which include rapid population growth, private car proliferation and traffic congestion, struggling public transport system, evidence of urban primacy and sprawl in the case-city. Also, the barriers to the implementation of urban planning intervention include government restrictive bureaucratic practices, lack of sectoral integration and collaboration, weak

implementation of plan, long range and technocratic driven planning goal and objectives, weak organizational capacity, obsolete planning documents, and political interference in the implementation of urban plans. These barrier/challenges appear to have inhibited urban planning intervention that can lead to realization of optimal outcome from urban planning goal and objectives. The peculiarity of the extra barriers/challenges evident in the case-city which seldom exist elsewhere therefore present the opportunity to contemplate an innovative strategic response that will be developed in this study to address the explicated problems in terms of intervention to curb the challenges of traffic congestion and suburban sprawl, and in terms of mitigating the institutional barriers to implementation of the intervention.

3.8 Summary

This chapter represents the explication of the research problem as outlined by the Design Science research strategy adopted in this study. It draws from literature evidence and other data sources to provide the premise for establishing that the challenges of the increasing trend of traffic congestion and suburban sprawl exist in cities. The chapter also recognizes and states the need to contextualize the research problems within the context of a global south city in order to have clear and in-depth understanding of the peculiarities of the research problems. Consequently, the process and procedure for the selection of the case-city to contextualize the research problems was explained.

Evidence discussed show that there is growing trend of global urban population, with majority of the growths taken place in small and medium-sized (500,000 – 3million population) institutionally weak global south cities. This includes evidence of growing mobility demand, traffic congestion and sprawling spatial pattern of suburban development globally and in the case city-Abuja. The structure of transport sector investment in the case city is noted to emphasize road building and expansion, and this is consistent with the predict and provide engineering solution to traffic problem which characterizes the Master Plan system and transport policies in most cases. It is therefore suggested by this study that the ineffectual response by the existing planning system and institution may account for these trends by creating enabling environment for the increasing trend of traffic congestion faced by commuters in daily commuting between the core-city and the suburban areas. The analyses of these impacts indicated that averagely commuters in mini-bus and private car lose 21.66 and 20.84 days respectively every year by being in traffic jam during home-work-home commute along the three routes under investigation in the case city. Put differently, this involve around loses in tune of 11,160,809.932 litres of fuel, 32,121,832.651 hours, and CO₂ emission in the tune of 268,472.330 tons.

These impacts include the extensive pattern of suburban sprawl which continues to increase commuting distances. The analysis of the impacts here show that annually the land cover in the suburban area grew at a rate of 3.54% (with unplanned extensive spatial pattern of development) while

the core-city grew at a rate of 0.98%, this shows that the suburban areas in the case city are growing faster than the core-city.

The prevailing Master Plan approach may have provided the framework for the city growth, and provided distinct location for land use and ensures compatibility in the location and functioning of the various uses. It has not been quick and efficient at responding to the trends of increasing population growth in mobility demand, prevailing urban primacy and its impacts on sprawling suburban development and traffic congestion challenges.

Evidence discussed show that with public transport struggling to cope with moving the large volume of commuters daily in mini-buses and single-occupant private cars in Abuja (as is the case in most global south cities), traffic congestion in daily commuting is imminent. The resulting impacts evident from structured interviews of commuters include loss of productive time and fuel wastages due to time-delays, and increased vehicle activities, these impacts also include transport-related greenhouse gases emission.

The assessment of the existing urban planning system and capacity of existing urban planning suggest the existence of deficient institutional capacities that do not appear to cope with the complex challenges of traffic congestion and suburban sprawl in global south cities, provided corroborative evidence. This analysis therefore illustrates the existence of character of these challenges within the context of a typical global south city. This may therefore show that the solution developed in this study for addressing these challenges may present viable and valid alternative which may be pursued by other similar medium-sized global south cities.

The next chapter represents defining the requirement phase of this study, and specifies the performance capabilities required from relevant strategies to effectively address the research problems of traffic congestion and suburban sprawl in cities. The chapter relies on literature evidence of good practice and specifications for solving the research problem in terms of efficient spatial pattern and travel pattern in cities.

CHAPTER 4: GUIDE FOR DEVELOPING SOLUTION TO THE EXPLICATED PROBLEMS

4.1 Introduction

This chapter focuses on a review of literatures of good practice that relates to strategies for addressing the explicated problems. The goal is to provide the premise to identify and outline the artefact/solutions that demonstrate the capabilities to address the explicated problem of traffic congestion and suburban sprawl. This chapter represents the Define Requirement phase of the Design Science research strategy adopted for this study. In essence, the defined requirements serve as specifications imperative to the design and developing of the artefact/solution. These defined requirements have evolved in recognition of the peculiarities of the explicated problem.

Some examples of the requirements include reduced volume of motorized trips and traffic congestion, reduced length of travel time, moving more commuters in less vehicles, reduced level of transport-related impacts of time loss, fuel loss, CO₂ emission, reduced level of sprawl, reduced need to travel by car and making more people live in smart communities near public transport corridor; and disincentives to deter the proliferation of car usage. These requirements therefore provide the premise for identifying broad array of solutions that have the capabilities for addressing the explicated problems.

The characteristics of the explicated problem provided a premise to making a choice on what artefact is appropriate for addressing the explicated problem. The artefact could be a method, model or concept. As stated earlier, the goal of this research relates to developing framework for spatial planning strategies, by this, the artefact is therefore classified as a model that should encapsulate the set of strategies required to address the explicated problems of traffic congestion and suburban sprawl. In sum, the output from this chapter is the outline of an artefact and the related set of requirements which it can realize.

4.2 Reducing Urban Sprawl and the need to Travel by Car through Physical Planning Measures

The role of urban planning has been a subject of debate and discourse, and has led to suggestion by several studies indicating that reforms to the present sprawling spatial form in cities is imperative. This is not only because of the inextricable link between sprawling spatial form and proliferation of car (usage with related challenges of traffic congestion), but the wider ramifications that appear to inhibit sustainable urban development in cities (Calthorpe 1993; Beimborn and Rabinowitz 1991; Bernick and Cervero 1997; Williams, Burton and Jenks 2000 cited in Kenworthy 2006 p. 70; Williams et al., 2000; Breheny 1995; Rickaby 1987; Feitelson and Verhoef, 2001 cited in Williams, 2005, p. 2).

In the realm of policy initiatives, the compact city approach is gaining recognition as illustrated by the acceptance of the argument that low density sprawling cities promote an excessive use of energy by the

1992 United Nations Conference on the Environment and Development (UNCED) held in Rio de Janeiro (Brazil). The European Green Paper of 1990 equally promoted the idea of compact cities (Mindali et al. 2004 cited in UNHSP 2009, p. 158). Some countries like South Africa and cities such as Curitiba in Brazil are known to have started the process of mainstreaming compact city policy into their urban planning systems. As reported by Breheny (1995 p. 84), two major UK government initiatives - The UK Strategy for Sustainable Development (Department of Environment, 1993) and the Planning Policy Guidance Note PPG13 (Department of Environment, 1994) - are effective tools which have evolved as a range of urban planning measures to reduce the need to travel.

In an attempt to define the relationship between city form, density and feasibility for a transport infrastructure, Bertaud (2004) noted that sprawling cities with a reduced level of density present technical and financial feasibility challenges for the provision of an efficient public transport system. The study by Bertaud (2004, p.17f) further illustrates the relationship between density and access to public transport in a densely populated city and also provides a comparison to a sprawling city. Table 4-1 shows the effect of densities on access to public transport in the case of sprawling Atlanta (U. S.) and the denser Barcelona (Spain).

Table 4-1 Density and Public Transport Access: Comparing Atlanta (US) and Barcelona (Spain)

	Atlanta	Barcelona
Area (km ²)	137	37
Population (millions, 1990)	2.5	2.8
Density (people per hectare)	6	171
Population close to metro	4% within 800m	60% within 600m
Trips undertaken by public transport	4.5%	30%

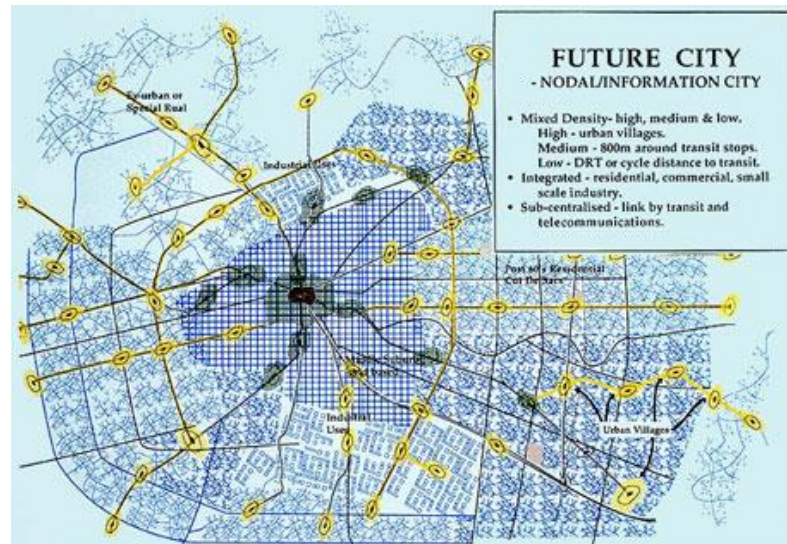
Source: Adapted from Bertaud (2004, p. 16f).

The proximity of high density residences along, or close to, transit nodes/public transport corridors (transit communities) in the city of Barcelona has permitted 30% of trips to be undertaken via transit as compared to the 4.5% trips undertaken via transit in the sprawling low-density city of Atlanta. Indeed, to illustrate the savings and benefits in this situation, it can be said in relative terms that Barcelona has more than 600% the number of trips made via transit than Atlanta, and so will this impact savings in car usage level, fuel use, consequent pollution and transport-related CO₂ emission levels.

However, there exists a group of analysts who believe that the claimed benefits of compact cities are overly exaggerated. This group argue that urban compaction is neither politically feasible nor desirable, and that fostering a containment policy is likely to push up land costs and also encourage development beyond the restricted zones (Chen et al. 2008 cited in UNHSP 2009, p. 158f). In response to this criticism, Newman and Kenworthy (1992) have noted that economic determinants (price and incomes) are not tools that politicians consider effective over landuse measures put forward as effective means of reducing urban energy consumption. They concluded that physical planning that leads to a

sustainable urban spatial configuration with a reduced need to drive car is key to achieving a less automobile-dependent urban future (Newman and Kenworthy 1992, cited in Breheny 1995 p. 84, Litman, 2012).

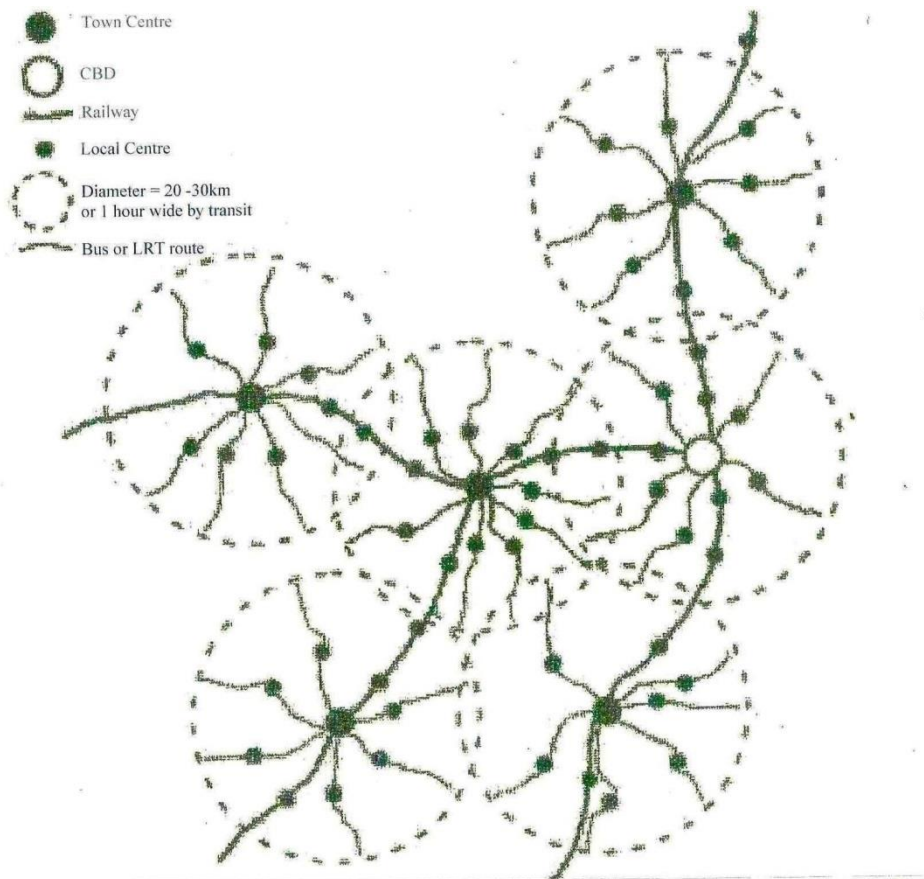
The studies by Newman and Kenworthy (1999) and Scheurer (2001), posited that reforming city's spatial form to realize a shift from automobile dependence in order to address the ills of traffic congestion in cities has become unequivocal. It was therefore opined that the future city form is, arguably, *the transit metropolis* (Cervero, 1998) (see Figure 4-1).



Source: Adapted from Newman and Kenworthy (1999 cited in Scheurer 2001, p. 146).

Figure 4-1: The Future City (2000 – Future)

The transit metropolis is characterized by a strategic visioning of the city linked by a network of efficient rapid transit systems with nodal development of compact mixed-use communities. In a similar light, the study by Newman and Kenworthy (2006) suggested a physical planning design model for transforming sprawl and automobile dependence in cities by creating sub-centres and nodes interlinked by transit routes (metro, Light Rail Transit and Bus Rapid Transit) (Newman and Kenworthy, 2006, p. 47) (see Figure 4-2).



Source: Adapted from Newman and Kenworthy, 2006 p.47

Figure 4-2: A Conceptual Plan for Reconstructing an Automobile City

In order to illustrate the benefits of reforms towards the above described compact spatial form, Kenworthy (2006, p.69) explained the findings from his study which suggested that, when urban density is correlated with private car use, urban density explains 84% of the variance in car travel. Simply put, the lower the density of spatial form of a city the higher the level of car use and vice versa. In essence, cities which are aligned towards a compact, smart, higher density urban form with a rich diversity of functional and density mixes are smart and efficient, as a result of their reduced commute volume and distances.

In view of the polarization of the debates on an efficient city form, what may be required is a hybrid plan comprising of an inter-mix of elements that reflect decentralized concentration rather than a rigid application of either extremes of compaction or decentralization. Breheny (1996), observed that the works of Blowers (1993), Breheny and Rookwood (1993), Hooper (1994) and Lock (1991; 1995) fostered the middle-ground position and revealed the role of intermixing the merits of compaction and decentralization views in the development of sustainable cities in the face of present realities and challenges.

This described spatial form and the implicit nodal development is consistent with the suggestion by Cervero (1998) and Newman and Kenworthy (2006) which is characterized by rich, diverse, high-density mixed-use communities built around transit stations at the metropolis scale. In this situation, most people live near transit stations, commute via transit and have a reduced need to travel via private cars vehicles.

It may therefore be safe to suggest that making reforms to sprawling spatial form in cities can contribute to reduced need to travel by cars. Based on the evidence from these studies by Cervero (1998), and Newman and Kenworthy (2006), this solution and strategy on reforming spatial form may therefore demonstrate the capability to fulfill the requirements for a solution that can contribute to reduced level of sprawl, reduced need to travel and reduced car usage in cities. This include capabilities to address the challenges attributed to the European legacy of un-mixing of density and spatial differentiation of uses created by Modernist Planning Approach (Master Plan and Landuse Zoning Regulation) in global south cities.

4.3 Encourage Efficient Transit System, Transit Usage and Reduced Commuter Travel Time

With the increasing clamour for reforms to the current proliferation of car usage in most global south cities, the requirements of an intervention should not only reflect capacity to reduce commuter travel time, reduce the proliferation of cars and motorized trips as explained above but to also reform existing fragmented unreliable public transport in order to attract choice riders from car usage to transit usage. This shift and recalibration of mode share towards efficient transit-dependent mobility pattern is opined to be ingredients to sustainable transport in cities (Sakamoto et al. 2010, World Bank 1996, cited in Lagan and McKenzie 2004 p. 2).

Even the groups of antagonists to compact cities are in consensus that the spatial configuration of urban compaction provides an enabling environment and better conditions for public transport. This is by providing a potential for huge ridership that can justify and sustain investment in transit, and also provide a sufficient demand to make local facilities and services viable. However, the antagonists are quick to point that, even with good functional transit such as in the case of Japan, rising car ownership and usage are not deterred and that people's choices and preferences are pertinent to the frequency and distance of their commute (Breheny 2001; Burton 2002 cited in Chen et al. 2008, p. 29). This rising ownership in, and the use of private automobiles despite the availability of good and functional transit has created complexities that impede the statistical proof of the benefits of compaction (correlating high density with less volume and frequency of trip/ travel); hence, the benefits of compaction are more equivocal than expected and statistically weak (UNHSP, 2009 p. 159). Therefore, encouraging transit usage by commuters may require not just the provision of efficient transit, but ensuring that residences, employment areas are functionally linked to the transit network.

The World Bank also defines what it refers to as the three pillars of sustainable transport: **Economic and Financial Sustainability** - “ensuring that transport is cost-effective and continuously responsive to changing demands.”; **Environmental Sustainability** - “...emphasis on better planning of landuse and stricter management of demand, including the use of pollution and congestion charges to incentivize public transport.”; **Social Sustainability** - “designing transport strategies to provide social inclusivity with improved accessibility to employment, education, and health services” (World Bank 1996, cited in Lagan and McKenzie 2004, p. 2).

Sakamoto et al. (2010, p. 7) also summarized the key characteristics of sustainable and unsustainable transportation as given in Table 4-2 below.

Table 4-2: Key characteristics of unsustainable and sustainable transport

	Unsustainable transport	Sustainable transport
Transport volume	Requires a high level of numbers of trips and trip distances, due to sprawled urban development and inefficient logistical networks	The demand for travel is minimized and journeys are short, owing to compact urban development, mixed land use and optimized logistical chains.
Transport modes	Reliance on private motorized transport for passengers, and heavy goods vehicles for freight.	Most passenger trips are made by public or non-motorized transport, and freight is carried by rail and other low-carbon modes.
Transport technologies	Vehicles rely on inefficient, fossil-fuel engines.	Low carbon vehicle technologies are mainstreamed, including highly efficient engines, hybrids, plug-in hybrids and electric vehicles.
	The transport network is inefficiently managed.	New technologies such as “Intelligent Transport Systems” and “Smart Logistics” help manage transport systems in highly efficient ways.
Transport pricing	The price paid by users for vehicles, fuel, parking and road space do not cover the full external costs to society, encouraging motorized vehicle use at the expense of more sustainable choices.	The price paid by transport users fully ‘internalizes’ the true costs, managing growth in motorized vehicle use and encouraging environmentally friendly alternatives.
Resilience to climatic change	Transport systems are highly vulnerable to changes in the climate.	Transport assets are screened against vulnerability criteria, and are developed in a way that is resilient towards changes in climate.

Source: Adapted from Sakamoto et al. (2010, p. 7).

A synthesis of the above described characteristics and requirements for sustainable transport indicates that it is pertinent for cities to pursue compact urban development and mixed landuse in order to achieve a reduction in travel demand and to allow short travel within the city where it is unavoidable. Furthermore, most passenger trips should be made by the public or non-motorized transport mode and low carbon vehicle technologies should be pursued which reduces the emphasis and reliance on inefficient fossil fuel engines.

It therefore, suffices to note that implementing these described requirements for sustainable transport can serve to ensure the realization of efficiencies in passenger mobility and efficient use of land through more compact development. These reforms are, therefore, likely to be more relevant in institutionally weak cities in the global south region which are in dire need of reform to their existing transport systems in view of the current public transport inefficiencies and the predicted rise in mobility demand.

4.3.1 Transit Infrastructure

In terms of the requirements for an efficient transit network, earlier studies have shown that the classic illustration of efficient mass transit intervention (metro, LRT or BRT) is via an assessment of “cost-effectiveness” which shows considerable reductions in travel time and in the expenditure of transit riders in a project area (Weinstock et al. 2011. p.5). These include reduction in per capita fuel usage and CO₂ emission per passenger trip. This described intervention also consists of providing evidence that the system has attracted new choice riders from other modes and is effective in achieving strategic public transportation objectives which integrates sustainable urban development agenda. In some cities such as Vienna, Berlin and Barcelona in Europe, Guangzhou, Osaka and Singapore in Asia, and Curitiba and Bogota in Latin America, with a remarkable investment in public transportation, modal share is largely skewed towards public transport and non-motorized modes as expressed in the mode share of these cities. Therefore, an important requirement is having transport investment structure skewed towards emphasis on development of transit infrastructure.

As stated in the study by ITDP, what may be required for transit infrastructure intervention is the innovation presented by the Bus Rapid Transit (BRT) system which integrates the exemplary efficiencies and quality of metros with the flexibility and relative low cost of buses, while offering significant environmental benefits. Notably, the transit option of BRT systems achieve marked levels of efficiency in terms of speed, capacity, passenger comfort and convenience which are comparable to rail-based systems and, remarkably, can be built at a fraction of the cost and time in construction terms (ITDP, 2011). Indeed, BRT provides opportunities for cities that seek to provide efficient and affordable transit solutions that meet the needs of increasing urban growth.

4.3.2 Non-Motorized Mode

The integration of non-motorized modes within transit network can ensure that, commuting over short trips can be made via cycling and walking, and contributes to a reduction in the level of motorized trips. Such a mode has zero impact on CO₂ emissions and gasoline consumption, thus creating huge savings in socio-economic and environmental terms (per capita fuel usage and CO₂ emission) (Hughes and Zhu 2011, Guzman and Shaheen, 2011). Earlier studies have shown that urban development projects, infrastructure and sectors have benefited from raising revenue by trading units of carbon saved by the development of projects with proven and certified capacities for the reduction of GHGs (EMBARQ, 2013). Therefore, urban development infrastructure should have such requirement and capacity to contribute to reduction in GHG emission.

Thus, if the walking and cycling infrastructures are made safer and associated with quality service, new riders of choice could be attracted to this mode and, therefore, could place cities on the “green” pathway for a low carbon future (see Figures 4-3 and 4-4).



Source: Author's Field Survey (2011).

Figure 4-3 Road profile showing safe segregated cycling lane in Groningen, The Netherlands



Source: Author's Field Survey (2011).

Figure 4-4 Road profile showing Bus Transit and safe segregated cycling lane in Groningen, The Netherlands.

From the study of non-motorized modes in cities globally by ITDP (2011), it was noted that increasing the use of bicycles and putting in place a permissive safe walking infrastructure is one of the most affordable and practical ways to reduce transport-related air pollution and CO₂ emissions, while at the same time enhancing access to employment areas and services for users.

It may therefore be safe to suggest that making reforms to mobility pattern to reflect mode share skewed in favour of transit and non-motorized trips/mode can contribute to reduce level of traffic congestion and related impacts of travel time, fuel usage and CO₂ emissions. Based on the findings from the studies by ITDP (2012), and EMBARQ (2013), this solution and strategy that encourage transit usage may therefore demonstrate the capability to fulfill the requirements for a solution that can contribute to enhance transit usage, reduced commuter travel time, reduces the proliferation of cars and motorized trips in cities.

Indeed, aligning cities' spatial form towards a more compact, richly diverse, people-scale, walk-able spatial form that integrates the increased usage of transit and non-motorized transport modes, and with reduced emphasis on an enabling environment for car use, may help reduce proliferation of cars and motorized trips, and reduce travel time in cities. This may therefore, assist in aiding the efficient passenger commuting in cities.

4.4 Establishing Disincentive Mechanism to deter Car Proliferation and Traffic Congestion

Earlier studies have suggested that a reform that focuses on addressing traffic congestion challenges by implementing efficient transit infrastructure without a regime of disincentive directed at imposing additional cost on private car usage to deter excessive car usage/proliferation do not produce optimal outcomes in reduction of traffic congestion (Penalosa, 2004). This is because in this situation car proliferation appear to persist. This situation may be explained further by the conclusion drawn by

Kennedy (2003) that “if a finite resource is free, human beings tends to use it all up, regardless of the consequences. If it has a cost, they tend to use it more rationally”. Hence, without such disincentive in form of additional cost to car usage, the trend of car proliferation in cities may continue.

Therefore, an important requirement for the effective reduction of car usage in cities may require a regime of such deterrent mechanism as metered-parking or congestion fine to motorists in order to impose additional cost on car usage to stem car proliferation. This suggestion is supported by the study of Sakamoto et al. (2010, p. 7) which summarized the need to ensure that the prices paid by users for vehicles, fuel, parking and road space fully internalizes the true costs. This would help to manage the growth in motorized traffic and traffic congestion by deterring car proliferation and encouraging transit usage (See Table 4-2 above). It is suggested that this is one of the critical ingredients to realizing sustainable transport.

Similarly, Kamal-Chaoui et al. (2009 p. 76) observed good examples of municipal policy tools being implemented in cities which have led to significant reductions in transport-related CO₂ emissions. These include: *congestion pricing* (Singapore and Stockholm), *dense and integrated landuse* (Barcelona and Sao Paulo) and *provisions of good public transit* (Zurich, Curitiba and Bogota). As a result of these policy initiatives, these cities are witnessing, and continue to witness, reductions in GHG emissions. Indeed, the urban infrastructure and policies put in place by city governments influence life style choices which, in turn, impact on urban GHG emissions.

Evidently, by creating policy-related disincentives, private car use can be reduced. In addition, aside from parking strategies and road pricing, workplace car parking space taxation can be adopted as mechanisms to dis-incentivize car ownership, and to reward those who use transit, bikes, and walk. It may therefore be safe to suggest that making reforms that dis-incentivizes car proliferation to realize mode share skewed in favour of transit trips/mode can contribute to reduced level of traffic congestion and related impacts of travel time, fuel usage and CO₂ emissions. Based on the evidence from the studies by Sakamoto et al. (2010), and Kennedy (2003), this solution and strategy that focuses on disincentive to car usage may therefore demonstrate the capability to fulfill the requirements for a solution that can contribute to reduced need to travel and reduced car usage in cities.

4.5 Spatial Planning Approach and related Framework

The defined requirements highlighted above for the various outlined strategies and reform (smart spatial form, efficient transit infrastructure, and car usage disincentive mechanism) may also require reform to the current planning system in order to create a platform to permit engagement and collaboration amongst sectors required for realizing the strategies. The regulative and zoning tool of the current Master Planning approach may have been criticized on several grounds, it appear to suit

the situation in most global south cities where democratic ethos to urban planning is poorly developed. In the global south cities, the Master Planning approach has served to shape and direct development in the core-city where landuse zoning fosters functional and spatial differentiation of use to ensure orderly development. The gap in the Master Plan approach may be evident in the rapid suburban development, if urban planning institutions are made more proactive, the Master Plan approach may become relevant, and responsive to the complex challenges facing cities today, even though the described proactive feature is an integral part of spatial planning approach.

Several studies have indicated that the paradigm required to reverse the prevailing spatially prescriptive Master Plan approach should emphasize the creation of strategic visions. This implies the development of strategic planning capacity and a shift in the planning approach to a stakeholders-driven planning process on the basis of a collective definition of the action to be taken and the sharing of interests, aims, and relevant knowledge (Shaw and Sykes, 2003, Albrechts, 2004, p. 743, Nadin, 2007, Allmedinger and Haughton, 2010). In line with this call for culture change in urban planning, “spatial planning” has been suggested as the concrete theme for the reforms (ODPM, 2004, Nadin 2007, Shaw and Lord, 2007).

Spatial planning emphasizes the “coordination or integration of the spatial dimension of sectoral policies through a territorial based strategy” by establishing better coordination of territorial impacts “horizontally across different sectors, vertically among different levels of jurisdiction, and geographically across administrative boundaries” (Shaw and Sykes, 2003, Cullingworth and Nadin 2006 p. 91; RTPI 2007, p.11, Shaw and Lord, 2009). This paradigm goes beyond traditional land-use planning; it allows for situation-specific broad range approaches which are capable of addressing the challenges created in cities globally as a result of international borrowings of the “*off-the-shelf*” Modernist Planning system (RTPI 2007, p.47; Nadin 2006, p. 17; Morphet, 2011, p. 176) (See Table 4-3).

Table 4-3: Comparison between Master Planning and Spatial Planning

Elements	Master Planning	Spatial Planning
Purpose	Regulating landuse and development through designation of areas of development and protection, and application of performance criteria.	Shaping spatial development through the coordination of the spatial impacts of sector policy and decisions.
Form	Schedule of policies and decision rules to regulate landuse for administrative areas. Mapping and designation of areas and sites for development purposes and protection.	Strategy identifying critical spatial development issues and defining clear desired outcomes across functional areas. Visualization of spatial goals, and key areas of change. Principles and objectives that will guide coordinated action.
Process	Discrete process leading to adoption of final blueprint plan. Confrontational process, instigated through consultation on draft plans and political negotiation. Stakeholders using the process to protect and promote their interests.	Continuous process of plan review and adjustment. Mutual learning and information sharing, driven by debate on alternatives in collaborative political process. Stakeholders using the process to achieve their own and mutual goals.
Ownership and policy community	A document of the planning authority providing guidance to other professional planners promoting and regulating development.	A corporate document of the local authority in shared ownership with communities and other stakeholders, partnerships and NGOs.
Procedural safeguards	Final plan determined through adversarial inquiry on parts of plan subject to objections.	Final plan determined by inquisitorial examination of the soundness and coherence of the whole plan.
Methods	Mapping of constraints and collection of sectoral policy demands. Bargaining and negotiation with objectors and other stakeholders, informed by broad planning principles. Checking of proposals through sustainability appraisal/strategic environmental assessment.	Building understanding of critical spatial development trends and drivers, market demands and needs, and the social, economic and environmental impacts of development. Analysis of options through visioning and strategic choice approaches. Generation of alternatives and options assisted by sustainability appraisal/strategic environmental assessment.
Delivery and implementation	Seeks to direct change and control investment activity in landuse through prescriptive regulation, whilst mitigating local externalities through conditions and planning agreements.	Seeks to influence decisions in other sectors by building joint ownership of strategy and a range of incentives and other mechanisms including landuse regulation and planning agreements.
Monitoring and review	Measures conformance of the plan's policies and proposal with planning control outcomes. Data provides portrait of plan area as general context for implementation of proposals. Periodic but infrequent review of whole plan.	Measures performance of the plan in influencing sector policy and decision making. Data informs understanding of spatial development and the application of the strategy. Regular adjustment of components of plan around a consistent vision.

Source: Adapted from Nadin (2006) (2007), emphasis added by Author (2014).

Spatial planning is not merely a regulator of landuse and zoning but is a proactive and strategic coordinator of all policy actions that influence spatial development in order to achieve sustainable development goals (Nadin, 2006, p. 3, Lord and Shaw, 2009). Put more succinctly, this new order of spatial planning seeks to change urban planning from the existing situation of restrictive bureaucratic

practices that constrains development to a more pro-development scenario where the urban planning system will be proactive rather than reactive. The adoption of spatial planning is known to guarantee the realization of strategic solutions such as viable TOD and integrated public transportation (BRT or LRT) (RTPI, 2007, p.27 and 83, Hoornweg et al., 2011, p. 3 and 12). This approach may produce remarkable results in addressing the challenges of traffic congestion and transport-related challenges implicit in the automobile-centered mobility pattern in cities and also serves as a viable climate change action at the urban level (Rydin, 2011, p.33; UNHSP, 2011). Spatial planning can therefore, put cities on the pathway of sustainable development and achieve enhanced coordination of the spatial impacts of sectoral policies across suburban spatial growth and mobility patterns.

In order to illustrate the capacity of the application of spatial planning in transforming mobility patterns in cities, RTPI reported on the case study of city centre planning in Sheffield (RTPI, 2007, P.27). As reported by RTPI, spatial planning was adopted to direct the regeneration of the city centre by considering related spatial and landuse issues. The key components of the regeneration centered on transport, in order to encourage the use of public transport and related alternatives to private cars and to also stem traffic congestion. An Action Area plan was prepared to deliver these objectives. Further, a local area forum comprising business representatives and residents assisted with the consultation on the project. The effectiveness of spatial planning was seen in its capacity to integrate all the relevant stakeholders, to define the city centre's role locally and sub-regionally, integrate an approach for transport infrastructure, and options to dis-incentivize people's travel behaviour and preferences, and to integrate the city centre with the rest of the city.

In a similar vein, the RTPI reported the case study of Sheffield's local transportation plan, where the key public transport corridor were designated as the main component of infrastructure investment. According to this plan, the networks of key routes (corridors) were being used as locations for new housing and other developments including public facilities (TOD and diverse mixed uses). This was coupled with the integration of a walking and cycling infrastructure within the corridor and a park and ride facility to permit the use of transit and long stay in city centre (RTPI, 2007, p.83). Largely, this case study focused on using spatial planning to effectively support the provision of transit services, reduce private automobile usage, create smart compact transit-oriented development and make the city more efficient in terms of passenger mobility and spatial growth.

Further, earlier studies have illustrated examples of the application of spatial planning framework and the Planning Policy Guidance notes (PPG 13) in the UK as the delivery vehicle to drive urban planning reform (Breheny, 1995, Plymouth City Council, 2014). As illustrated by these studies, the application of the spatial planning strategies was directed at reforming the modal split towards a significant reduction in the use of cars in favour of the increased use of transit and non-motorize modes. This was achieved by using such spatial planning strategies as *Transit Oriented Development*

(TOD), Transit and mobility infrastructures such as LRT, BRT and Non-Motorized modes and Regulatory mechanisms such as metered-parking and Congestion Pricing.

The effectiveness of the application of spatial planning framework and related strategies is seen in its capacity for sectoral integration in implementing the strategies. These strategies effectively supports the provision of transit services, reduces private car usage and enhances smart compact transit-oriented development (RTPI, 2007, p.27 and 83; Cervero 1998, p. 292f; Breheny 1995, p. 86f; Whitelegg 2007, p. 7f; Rabinowitch and Leitman 1993 p.21; Penalosa, 2004, p.11; Hughes and Zhu, 2011, p. 2f; Beevers and Carslaw, 2004, p.5; Shaw and Lord, 2009; Hashemi and Jalali cited in ITDP 2012, p. 12f). In view of the exemplary features of spatial planning elicited above, it can therefore be argued that the existing urban planning approach in most global south cities characterized by Modernist Planning requires to be leveraged in order to reflect the features of spatial planning by implementing reforms that permit the institutionalization of spatial planning and related strategies in these cities.

Given the highly varied nature of urban societies globally, it becomes imperative that urban planning systems and paradigms should avoid the option of transplanting ideologies from one context to another but focus on situation-specific broad range solutions to the challenges caused by international borrowing of urban planning systems (UNHSP, 2009, p.59). Hence, it is important to ensure that the new paradigm stems from ideas generated from “situated” experiences that are relevant to the prevailing specific issues, challenges and opportunities. These include mainstreaming this reform into the institutional culture and the norms of the contexts for which they are evolved so as to prevent counter-productive results.

4.6 Summary

This chapter has focused on identifying and defining the requirements for the artefact/solution to the explicated problem of traffic congestion and suburban sprawl in global south cities. The defining requirements represent the 2nd Phase of Design Science research strategy and serve as the prelude to design and develop the artefact/solution to the explicated problem. The requirements for the artefact/solution have been derived from best practices of spatial planning strategies that integrate several inter-related strategies which demonstrate the capabilities for addressing the explicated problem. Further, the detail requirements which the artefact/solution should satisfy in order to sufficiently address the explicated problem were illustrated. The summary of the requirements defined for the Artefact, the list of all potential solutions as component of the artefact, and the decision about the selected requirements and solutions is presented below in Table 4-4.

Table 4-4: Summary of Decision on Acceptance and Rejection of Potential Solution as Component of the Artefact

S/N	Component of the Research Problem	List of Requirement for the Artefact	List of all Potential Solution as Component of the Artefact	Decision		Reason for Decision
				Rejection of Potential Solution as part of the Artefact	Acceptance of Potential Solution as part of the Artefact	
a.	Huge volume of daily motorized trips traffic congestion and increased travel time for commuters	i. Reduced volume of motorized trips	i. Engineering solution of road building and expansion to address traffic congestion	√		i. Engineering solution of road expansion to solve traffic problems has not worked, hence the need for alternative strategies of efficient rapid transit system
		ii. Reduced level of traffic congestion	i. Restructure modal share in favour of transit trips		√	i. BRT was chosen as the rapid transit system because of its comparative efficiency gains in terms of travel speed, ridership capacity, convenience, less cost of infrastructure, and less time of implementation
		iii. Reduced length of travel time	i. Application of Rapid Transit System of BRT to reduce travel time and encourage more transit trips		√	
		iv. Deter the proliferation of car usage	i. Metred-parking	√		i. Since the focus in this study is on traffic congestion on routes linking suburban areas to the core-city, metred-parking may be less appropriate
i. Application of Congestion Pricing System to deter proliferation of car usage			√			
b.	Increasing trend of transport-related challenges such as time loss, fuel loss and CO ₂ emission	i. Reduced level of transport-related impacts (time loss, fuel loss, CO ₂ emission)	i. Application of Congestion Pricing System to deter proliferation of car usage		√	i. In the absence of TDM measure that imposes additional cost as deterrent on motorist, car proliferation and related impacts is imminent ii. Congestion Pricing as TDM strategy that impact significantly on cost of car usage can deter excessive car usage and proliferation, and also spur choice riders from car commuting to transit trips
c.	Ineffective public transport characterized by mini-buses which struggles to move commuters daily	i. Moving more commuters in less number of motorized vehicles	i. Application of Rapid Transit System of BRT with high capacity 160-250 articulated and bi-articulated buses		√	i. BRT was chosen as the rapid transit system because of its comparative efficiency gains in terms of travel speed, ridership capacity, convenience, less cost of infrastructure, and less time of implementation. ii. The cost of BRT system is in the region of 1/10 the cost of LRT and metro rapid transit system.
			ii. Metro rapid transit system	√		
			iii. LRT rapid transit system	√		
d.	Increasing trend of	i. Transform suburban	i. Urban renewal initiative	√		i. Urban renewal intervention can improve living

	suburban sprawl and inefficient use of land evident in extensive spatial pattern of development make people live further away from core-city, and increases commuting distances	development into smart compact spatial pattern in order to reduced sprawl ii. Diverse mixed use community that make more people live near transit iii. Reduced need to travel by car	ii. Application of TOD strategy to achieve diverse mixed use commuting with reduced need for long travels, and located along transit corridor to ensure access to rapid transit for long trips (intra-city)		√	condition of an area but would require green field development. However, TOD strategy has the triple benefit of improving living condition, using land efficiently and enhancing convenience of commuters due to proximity to transit corridor which therefore enhance and optimizes transit operation
e.	Ineffective planning system and weak institutional capacities of current urban planning organization which cannot cope with the complex challenges of traffic congestion and suburban sprawl in global south cities	i. Appropriate and responsive urban planning system that can address complex challenges ii. Strong institution that can timely and effectively respond to complex urban planning challenges	i. Master Plan and landuse zoning approach ii. Framework for combined application of spatial planning strategies iii. Institutionalization of spatial planning framework to reform the existing urban planning organization and the related planning procedures	√	√	i. The spatial planning framework and combined application of TOD, BRT and Congestion Pricing strategies indicates the capacity to efficiently address the challenges of traffic congestion and suburban sprawl ii. The planning procedures implicit in the spatial planning approach indicate capacity for sectoral integration, stakeholder and inclusive engagement, and avoidance of restrictive bureaucratic practices, these features are imperative to realizing timely and efficient urban planning outcomes.

Source: Author's Analysis, 2013.

The stated requirements represented technical specification which is predicated upon literature and empirical evidence from earlier studies on what detail reforms are required to address the challenges of traffic congestion and suburban sprawl in cities. Some of the accepted requirements and solutions include urban planning strategies that reduces sprawl and uses land efficiently, with high density/mixed use residences located in proximity of transit; efficient transit system that contribute to reduced need for private car, reduced volume of daily motorized trips and traffic congestion, reduced travel time, reduced per capita fuel usage, and reduced per capita CO₂ emission; this include disincentive for private car ownership and usage; and spatial planning framework required to deliver the accepted strategies.

The next chapter focuses on Design and Develop solution/artefact that fulfills the defined requirement and show substantial capacity to address the explicated problem. In line with the requirements defined for the artefact/solution in Chapter 4, this chapter develops an artefact which has capabilities to fulfill the requirements which include being a spatial planning solution, reduction in volume of daily motorized trip, reduced travel time, reduced sprawl, reduced fuel usage and CO₂ emission, encourage use of transit, high density/mixed use residences located in proximity of transit, and the urban planning approach required to drive the reforms.

CHAPTER 5: SPATIAL PLANNING STRATEGIES AND RELATED SPATIAL PLANNING FRAMEWORK

5.1 Introduction

This chapter focuses on identifying various strategies that have the capabilities to fulfill the defined requirement, this is followed by design and developing the solution/artefact which has the capabilities to address the explicated problem of traffic congestion and suburban sprawl in global south cities. This chapter represents the 3rd phase of Design Science research strategy adopted in this study.

There are several arrays of strategies that can be adopted as components of the artefact to fulfill the defined requirements of spatial reform to the city's sprawling form, rapid transit infrastructure and disincentive to car proliferation to solve the explicated problem. In specific terms, these strategies may include metro rail, Light Rail Transit (LRT) or Bus Rapid Transit (BRT) infrastructure to realize rapid transit in the city's public transport system, these include, urban renewal or Transit Oriented Development (TOD) strategies to reform the city's spatial form. These include metred-parking or the different forms of Congestion Pricing (Cordon Pricing, Area License Pricing, Priced Lanes or Corridors) directed at dis-incentivizing car usage and proliferation. These competing alternative strategies are discussed in the next section below.

In line with the structure of Design Science research strategy, the design and develop artefact phase is predicated upon knowledge from research literature, other written sources and existing artefact used in practice as shown in Chapter 4. The purpose is to produce prescriptive knowledge by creating an artefact.

In essence, this is a search process through relevant solution space that consists of array of alternatives. According to Design Science literature, this phase involves a combination of revising and adopting components from existing solutions, inventing new components and combining them in an innovative way.

In this chapter, the suggested alternatives were therefore analyzed and prioritized in order to select the most relevant/useful ones. The analyses include stating reasons and justification behind design decision, alternative decisions considered and arguments leading to the decision. Further, the chapter clearly describes and justifies each component of the artefact to be developed, this include the purpose of the artefact and which requirements it addresses. These includes the description of how the artefact and its components are to be used in its intended practice to address the explicated problems.

This chapter therefore provides answer to objectives 5 and Research question 3 set out earlier on how to develop an alternative solution to the explicated research problems.

5.2 Competing Alternative Strategies related to the Defined Requirements and Solution to the Explicated Problem

Even though plans and proposition are made for rail development due to its capacity for speed, they have remained a mirage in most global south cities due to the implicit high costs. However, the increasing adoption of implementation of the BRT system by cities has been widely illustrated in

various studies by ITDP (2014), Hughes and Zhu (2011), Suzuki et al. (2013), UNHSP, (2013), amongst others because of its efficiency level that mimics the efficiency achieved by an LRT at a fraction of cost, and implementation period (See Sections 5.3.2 and 5.4 for detail explanation). The analysis of this comparison therefore provides the justification that may suggest the choice of BRT system as the candidate transit infrastructure solution in recognition of evidence from several studies that indicates the efficiency of the BRT system as rapid transit infrastructure.

With regards to making reforms to the spatial pattern of the suburban areas, these areas can be regenerated by the adoption of urban renewal strategy to improve housing conditions; and the standard of living of residents. With this strategy, new green field development would be required to accommodate the balance of persons currently cramped in unplanned suburban houses, this would imply placing people/residents further away from the transit corridor and exacerbate spatial disconnection, reduced level of accessibility and more road building and expansion to access new areas. While the additional housing type that would result from the urban renewal scheme could be in line with the existing bungalow-type housing, and not expected to face rejection by residents, this pattern of land usage may not be optimal in view of the existing overly extensive spatial pattern of development. In this situation, with less people living near transit corridor, car usage and proliferation is likely to be encouraged, while the investments in transit infrastructure (e.g. rail system) is not likely to be justified, because the ridership that can ensure optimization of operation of the transit infrastructure may not be realized.

However, what the adoption of TOD may do differently is that the existing area within the 800m sphere of influence of the rapid transit station can be redeveloped into high density mixed use transit communities (Calthorpe 1993, Delhi Development Authority 2012, Pushkarev and Zopan, 1977, Dunphy et al., 2003, Dittmar and Ohland 2007 p.38, Guerra and Cervero, 2011, Cervero, 2013, ITDP, 2014) (See Sections 5.3.1 and 5.4.1 for detailed explanation). Due to vertical densification, the character of the spatial pattern of these communities can have the capacity to accommodate present residents, as well as new residents without new Greenfield developments. This can therefore lead to the optimization of land usage, while also improving the standard of living of the residents and creating investment opportunities for economic development in these areas.

Importantly, this is corroborated by the study of (Cervero, 1998, 2013) which posits that the density and spatial pattern of development in proximity of transit infrastructure/system improves the convenience and living standard of residents in these communities and generate ridership that is able to support the optimal operation of the transit system and also justify the huge investment. These may therefore suggest the choice of the TOD strategy as an appropriate potential strategy to be adopted for reforms to the sprawling city's spatial pattern.

It is recognized that several disincentive mechanisms exist to deter private car usage in cities which include metred parking, car purchase tax, and congestion pricing amongst others (Litman, 2011, Beever and Carslaw, 2004). Vehicle purchase tax can be a viable mechanism directed at reducing car proliferation and the resulting traffic congestion as it deters car ownership at the point of purchase. However, while this may serve as viable solution, such tax policy are not quickly embraced or do not find the support of politicians. Even where it is adopted, institutionally weak cities in global south may face the challenge of smuggling which lead to loss of revenue for the government. While these appear as an efficient mechanism, it requires huge political backing and strong institutional capacities to prevent leakages of government revenue.

Metred parking is known to contribute to increase in car usage cost and can serve to deter car usage, especially where fee charged are relatively high, it can therefore lead to the reduction in reduce traffic congestion in an area of the city. In the context of this study, the concern is private car usage by commuters, which leads to traffic congestion on routes linking the core-city and the suburban areas. This may therefore suggest that the application of congestion pricing (See details in Section 5.3.3 and 5.4.3) may be appropriate for reducing private car usage along these linkage routes between the core-city and the suburban areas, as these are the routes under consideration in this study.

The application of congestion pricing system may be elaborate as it requires database management to prevent leakages, yet it may be achieved, as it is been implemented in some global south cities (e.g. Tehran-Iran), as illustrated in the studies by Hashemi and Jalali (2012); Allen (2013), Behrooz et al. (2013); and Shoar (2008). It is important to note that the initial inertia and skepticism by motorists is expected with the implementation of Congestion Pricing system as seen in London and Copenhagen (Litman 2011; Beever and Carslaw 2004; and Eliasson 2008). The skepticism does ease with time, as the improvement in travel time is experienced by commuters. Congestion pricing may therefore be more relevant and effective than metred parking in the context of this study, because metred parking within the core-city can only deter car usage in some areas within the core-city, but may not succeed in deterring traffic congestion on the linkage routes. By this, if Congestion Pricing is not adopted, most private cars may constitute traffic congestion on both linkage routes and within the core-city, in that, some cars may avoid metred parking within the core-city while they have added to the fleet causing traffic congestion on both the linkage routes and the core-city.

As a recap, the analysis of the various spatial planning strategies in this section therefore provided the premise for suggestion on the possible choice of BRT, TOD and congestion pricing strategies as the candidate solutions appropriate to the defined requirements and solution to the explicated problems. The detailed explanation of the characteristics and capabilities of these strategies are contained in the section below.

5.3 Relevant Spatial Planning Strategies

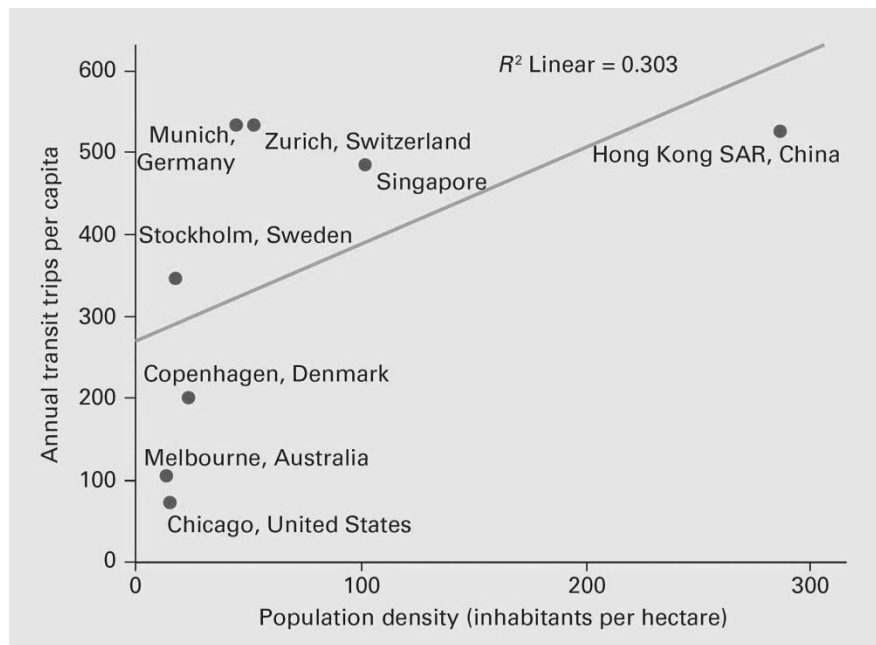
Sequel to the review and analyses of the various competing alternative strategies to fulfill the defined requirements and to address the explicated problems of traffic congestion and sprawling spatial form in cities, the identified relevant strategies include Transit Oriented Development (TOD), rapid transit infrastructure of Bus Rapid Transit (BRT) and transport demand management strategy of (congestion pricing). It is suggested that these spatial planning strategies can be directed at reducing the need to travel, reducing the level of private car proliferation, reduced travel time, and reduced level of urban sprawl. The application of the TOD, BRT and Congestion Pricing strategies as spatial planning related-solutions have been exemplified in several case studies which include Insurgentes in New Mexico, Bogota in Columbia, Ahmadabad in India, Jakarta in Indonesia, Rajkot in India, Curitiba in Brazil, Stockholm in Sweden, Singapore, Johannesburg in South Africa, Guangzhou in China, and Lagos in Nigeria.

5.3.1 Transit Oriented Development (TOD) Strategy

Transit Oriented Development strategy is premised on the idea of creating an initiative that concentrates a mix of pedestrian-oriented development around public transport nodes, with opportunities for residents to use a train or bus for out-of-neighbourhood trips (Calthorpe 1993 p. 35ff; Bermick and Cervero 1997, cited in UNHSP, 2013, p.93). The integration of residential and commercial development within the public transport corridors is known to generate the ridership to support the optimization of transit operation, improvement in accessibility to public transport, major reduction in private car usage; the co-benefits include transforming a city's extensive spatial form into smart compact development.

It has become increasingly evident from earlier studies that, by adopting TOD and shifting cities away from extensive spatial form characterized by single-use zoning and car-dependent mobility patterns, a remarkable reduction in the cost of extending public services, local roads, utilities, municipal services and, in commuting distance, and the share of income spent by households on long journeys can be realized (Jacobs, 1961, Calthorpe 2011; Burdell 2005 and Osman et al., 2008 cited in UNHSP 2013, p.76). In addition, a series of studies by UNHSP illustrate the consensus of evidence that by reforming a city's spatial form and reducing travel demands, the consequent reductions in traffic congestion culminate in a reduction in transport-related CO₂ emissions and traffic accidents (UNHSP, 2013, p.52f).

The characteristics of density permitted by TOD helps to support the optimization of transit operations. The positive association between population density and transit ridership is illustrated in Figure 5-1.



Source: Adapted from Suzuki et al. (2013, p. 51).

Figure 5-1: Population density and transit ridership in selected global cities.

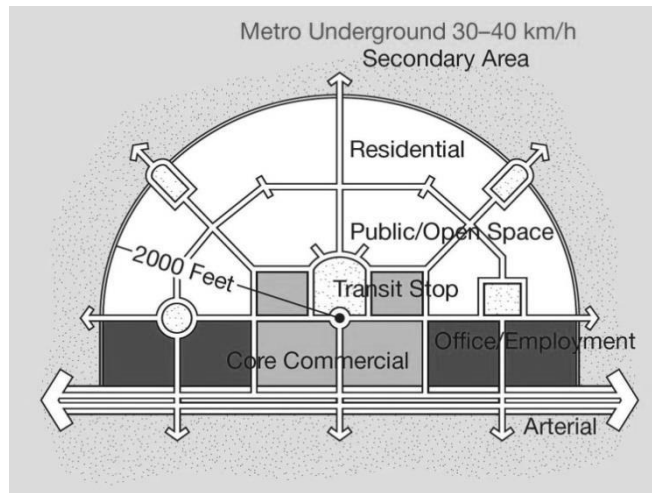
Evidently, the high density cities of Asia (Hong Kong, Singapore) and Europe (Zurich, Munich and Stockholm) have illustrated the positive correlation between densification and transit ridership. In Suzuki et al.'s analysis, compact patterns of development are usually a prerequisite for a successful transit system when measured on the basis of per capita transit ridership (Suzuki et al., 2013, p. 50).

Dunphy et al. (2003, p.5) noted that, while a richly diverse and integrated TOD coupled with functional transit cannot solve all the deep rooted ills of sprawl, it presents viable steps towards offering people convenient travel options that can transform, the city's spatial configuration and lower excessive motorization levels in cities. Therefore, the adoption of TOD has the co-benefits of transforming the extensive spatial form of cities towards a compact smart form and of transforming passenger mobility towards transit-dependent mobility patterns.

TODs are built on the corridors of high capacity public transport systems such as Metro, LRT and, recently, BRT. Examples of TODs around BRT stations include Curitiba (Brazil), Santiago (Chile), Guatemala City, Kooshing, Qingdao and Jiaxing (China) and Kuala Lumpur (Malaysia) (UNSHP, 2013, p.94).

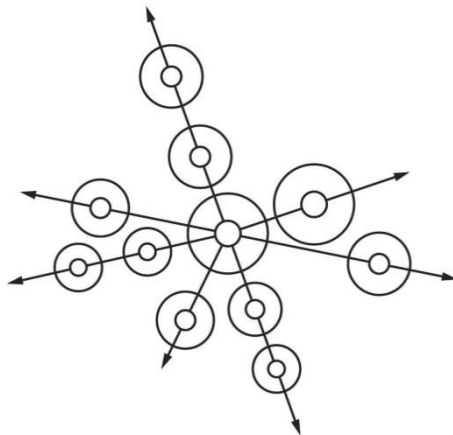
5.3.1.1 Visioning and Conceptualization in TOD

The process of adopting the concept of TOD starts with the strategic visioning of the conceptual image of the future of the city at the city-region or metropolis level, as expressed in the example of Newman and Kenworthy's Conceptual Plan for Reconstructing an Automobile City (Newman and Kenworthy, 2006, p.47), Calthorpe's neighborhood scale TOD site design (Calthorpe, 1993 cited in UNHSP 2013, p.93), Stockholm's "necklace of pearls" (Cervero and Murakami, 2008 p. 23) and Copenhagen's "finger plan" (Cervero 1998, cited in Suzuki et al. 2013 p.4) (See Figures 5-2 -- 5-4).



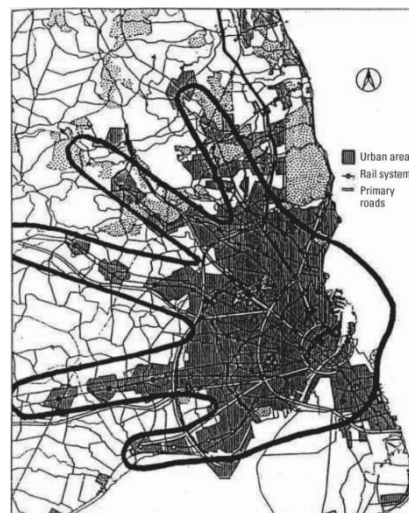
Source: Adapted from Calthorpe, 1993 (cited in UNHSP, 2013, p. 93).

Figure 5-2: Neighbourhood-scale TOD site design, with mixed-use development within a walkshed (650 metres) of a public transport stop, with densities tapering with distance from the station.



Source: Adapted from Cervero and Murakami

Figure 5-3: Public transport corridors as 'necklaces of pearls'.



Source: Adapted from Cervero (1998 cited in Suzuki et al. 2013, p. 4).

Figure 5-4: Copenhagen's Finger Plan for Urban development.

The common underlying regional strategy requires a focus on clustering housing and employment in nodes and on linking these developed nodes with transit. However, clustering development near transit is not beneficial if the development and the transit are not functionally related. Therefore, in order to realize the visioning and conceptual plans as illustrated in Figures 5.2 – 5.4, designated transit corridors for channeling the city growth are defined early in the planning process with the transit infrastructure built in advance to spur growth along the designated growth axes. As exemplified above, by evolving TOD nodes along transit routes that traverse the city-region, these nodes serve to firm-up the city form by accommodating a large portion of the city's population that would otherwise have been accommodated in extensive sprawling areas in diverse high density development.

5.3.1.2 Zone of Influence

The transit stations serve as centre points upon which a TOD focuses, accordingly, the sphere of influence of a station is defined by a walking distance of between 5-10 minutes to the transit station

(Calthorpe 1993; Cervero and Murakami 2008, p. 107). This is defined as falling between 600-1000m radiuses of a transit station and varies with the carrying capacities of the type of the rapid transit and the population threshold (ITDP 2014, Delhi Development Authority 2012). However, this zone of influence is usually segregated into rings or zones of varying intensity characterized by high density and functional mixed-use development.

The zone directly abutting the transit stations accommodates the highest density of 7-10 storey buildings and these taper off as one move away from this zone of intensity. In the example of the metro rail transit system in Delhi, and in the proposed development of TOD, the zone closest to the train station is referred to as the Intensity Zone at a 300 metres radius; this is abutted by the Standard Zone at a 600 metres radius; this is, in turn, abutted by the Transition Zones at 2,000 metres radius (Delhi Development Authority, 2012, p.4). Figures 5-5 – 5-7 visually illustrate the described character of density within each of the zones.



Source: Adapted from Feeney (2013).

Figure 5-5: Typical character of development in the Zone of Intensity (Zone 1) of a TOD node.



Source: Adapted from Philadelphia heights (2012).

Figure 5-6: Typical character of development in the Standard Zone (Zone 2) of a TOD node.



Source: Adapted from Toderian urban works (2013).

Figure 5-7: Typical character of development in the Zone of Transition (Zone 3) of a TOD node

5.3.1.3 Transit Oriented Development (TOD) Typology

A study by Dittmar and Ohland (2007 p.38), Guerra and Cervero (2011) reported standards and minimum thresholds for TOD practices while focusing on the indices as; TOD type, Landuse mix, minimum housing density, housing types, scale, regional connectivity, transit modes and frequency of bus/rail services (see Tables 5-1 and 5-2).

The study by Guerra and Cervero (2011) cited TOD guidelines for San Diego and the metropolitan area of Portland with a minimum density threshold of 6,300 and 7,500 dwelling units per square kilometre respectively around a light rail service.

Table 5-1: TOD Typology.

TOD TYPE	LAND-USE MIX	MINIMUM HOUSING DENSITY	HOUSING TYPES	SCALE	REGIONAL CONNECTIVITY	TRANSIT MODES	FREQUENCY	EXAMPLES
Urban Down town	Primary Office center Urban entertainment Multifamily housing Retail	>60 units/acre	Multifamily Loft	High	High Hub of radial system	All modes	<10minutes	Printers Row (Chicago) LoDo (Denver) South Beach (San Francisco)
Urban Neighborhood	Residential Retail Class B Commercial	>20 units/acre	Multifamily Loft Townhome Single family	Medium	Medium access to downtown Sub regional circulation	Light-rail Street Car Rapid Bus Local bus	10 minutes peak 20 minutes Off peak	Mockingbird (Dallas) Fullerton (Chicago) Barrio Logan (San Diego)
Suburban Center	Primary office Center Urban Entertainment Multifamily Housing Retail	>50 units/acre	Multifamily Loft Townhome	High	High access to downtown Subregional hub	Rail Street car Rapid bus Local bus Paratransit	10 minutes peak 10-15 minutes Off peak	Adlington Country (Virginia) Addison Circle (Dallas) Evanston (Illinos)
Suburban Neighborhood	Residential Neighborhood Retail Local office	>12 units/acre	Multifamily Loft Townhome Single family	Moderate	Medium access to Suburban Center Access to downtown	Light-rail Rapid bus Local bus Paratransit	20 minutes peak 30 minutes Off peak	Crossing (Mountain View, CA) Ohlone-Chynoweth (San Jose, CA)
Neighborhood Transit Zone	Residential Neighborhood Retail	>7 units/acre	Townhome Single family	Low	Low access to a center	Local bus Para transit	20-30 minutes Demand responsive	
Commuter Town	Retail center Residential	>12units/acre	Multifamily Townhome Single family	Low	Low access to downtown	Commuter Rail Rapid bus	Peak service Demand responsive	Prairie Crossing (Illinois) Suisun City (California)

Sources: Adapted from Dittmar and Obland (2004, p. 38).

Table 5-2: Transit-supportive density levels.

Mode	Service	Minimum residential units per net acre	Remarks
Local Bus	Minimum (20 bus/day)	4	10 million non-residential CBD s.f.
Local Bus	Intermediate (40/day)	7	
Local Bus	Frequent (120/day)	15	35 million non-residential CBD s.f.
Express Bus (foot)	Five buses in two hour peak period	15 (2 square mile area)	50+ million non-residential CBD s.f.
Express Bus (auto)	5-10 buses in two hour peak period	3 (20 square mile area)	10 to 15 miles from CBD (preferably 20+ million non-residential CBD s.f.)
Light Rail	5 minute peak-hour headways	9 (corridor of 25 to 100 square miles)	20 to 50 million non-residential CBD s.f.
Heavy Rail Rapid Transit	5 minute peak-hour headways	12 (corridor of 100 to 50 square miles)	50+ million non-residential CBD s.f.
Commuter Rail	Twenty trains per day	1 to 2	Only to largest downtowns

Source: Adapted from Pushkarev and Zupan (1977 cited Guerra and Cervero, 2010, p. 3).

The thresholds provided here serve as guide for evolving TODs in order to ensure that the envisioned patterns of development function optimally. Therefore, these prescriptions can be adapted to local peculiarities with cognizance of existing potentials and constraints.

Consequent upon the highlighted potential benefits of TOD, it may suffice to suggest that TOD can therefore be adopted as the strategy for transforming extensive sprawling low density suburban areas with the use of intensified and infill development. Indeed, when rich diverse, high density, TODs are planned to be strongly coupled with, and functionally related to, efficient transit this can allow more residents to live and work near transit stations. This can serve to support ridership and investment in transit infrastructure, and align passenger mobility in favour of transit and non-motorized modes.

5.3.2 Planning for Rapid Transit

As highlighted earlier in Section 5.2, rapid transit infrastructure can be in the form of a metro, Light Rail Transit (LRT) or Bus Rapid Transit (BRT). The analyses in this section suggested that the BRT system may serve as the appropriate transit infrastructure in view of its implicit efficiency gains. There exist some exemplary cases of good transit practices of BRT in Latin America (Curitiba, Bogota, México City), in Asia (Jakarta, Ahmedabad, Guangzhou, Singapore) and in Africa (Johannesburg) that has been adopted to reform fragmented, un-reliable, small-capacity, informal bus services struggling to move the large volume of commuters through daily traffic congestion.

Findings from earlier studies on BRT systems have shown that, by freeing existing road-ways to create dedicated bus ways in cities, bus-based transit capacities and speeds that closely resemble those achieved in the rail system can be put in place in a city (Peñalosa, 2004, p.124). This efficiency gain

with BRT system can serve as incentive that should attract private funds and partnerships into the BRT transit infrastructural development in the global south cities.

5.3.2.1 Bus Rapid Transit (BRT)

According to the study by ITDP, BRT has been described as an innovative mass transit system which integrates exemplary efficiencies and the quality of metros with the flexibility and relatively low cost of buses, while offering significant environmental benefits. Outstanding BRT systems achieve marked levels of efficiency in terms of speed, capacity, passenger comfort and convenience comparable to rail-based systems and, remarkably, can be built at a fraction of the cost and time for construction (ITDP, 2011). Indeed, BRT can provide opportunities for cities to implement efficient and affordable transit solutions that meet the needs of an increasing urban growth and mobility demand.

A. Preference for BRT as an effective tool to lessen private car-dependence and related externalities

The three factors of time, cost and operational efficiency have served to place BRT as a viable option for driving transport systems in cities towards an efficient and sustainable pathway. ITDP (2011) listed these factors as follows:

- i) Timely Implementation: Comparatively, from planning to the commission of BRT, the time period is less than creating rail-based options and thus is essentially quite attractive to politicians who face short election cycles.
- ii) Cost: Capital costs and operating costs are comparatively lower in comparison to rail-based options.
- iii) Network Connectivity: The extensive nature of the bus-based transit and its ability to operate on normal streets creates an opportunity for BRT.

According to ITDP and EMBARQ, the implementation of BRT systems has been responsible for reduced travel times, positive environmental impacts (through the reduction of GHG emissions and air pollution), public health benefits (by reducing road accident, fatalities, harmful air pollutants) and has increased physical activities for users (ITDP, 2011, EMBARQ 2013, p.10) (See Table 5-3).

Table 5-3: Summary of Typical Impacts of BRT Systems.

Impact	How does BRT achieve the benefit?	Empirical Evidence
Travel time savings	<ul style="list-style-type: none"> • Segregated busways separate BRT buses from mixed traffic; • Pre-paid level boarding and high-capacity buses speed passenger boarding; • Traffic signal management and high-frequency bus service minimize waiting times 	<ul style="list-style-type: none"> • Johannesburg BRT users save on average 13 minutes each way (Venter and Vaz 2011) • The typical Metrobús passenger in Istanbul saves 52 minutes per day (Alpkokin and Ergun 2012)
GHG and local air pollutant emissions reductions	<ul style="list-style-type: none"> • Reduce VKT by shifting passengers to high-capacity BRT buses • Replace/scrup older, more polluting traditional vehicles • Introduce newer technology BRT buses • Better driver training leads to improved driving cycles which have lower fuel consumption and emissions 	<ul style="list-style-type: none"> • In Bogota, the implementation of TransMilenio combined with new regulations on fuel quality is estimated to save nearly 1 million tCO₂ per year (Turner <i>et. al.</i> 2012). • Mexico City's Metrobús Line 1 achieved significant reductions in carbon monoxide, benzene and particulate matter (PM_{2.5}) inside BRT buses, traditional buses and mini-buses (Wöhmschimmel <i>et. al.</i> 2008)
Road safety improvements – reductions in fatalities and crashes	<ul style="list-style-type: none"> • Improve pedestrian crossings • Reduce VKT by shifting passengers to high-capacity BRT buses • Reduces interaction with other vehicles by segregating buses from mixed traffic • BRT can change drivers' behaviors by reducing on-the-road competition and improving training 	<ul style="list-style-type: none"> • Bogota's TransMilenio has contributed to reductions in crashes and injuries on two of the system's main corridors (Bocarejo <i>et. al.</i> 2012) • On average, BRTs in the Latin American context have contributed to a reduction in fatalities and injuries of over 40% on the streets where they were implemented.
Reduced exposure to air pollutants	<ul style="list-style-type: none"> • Cleaner vehicle technologies and fuels lower concentration of ambient air pollution citywide or inside the BRT vehicles; • Reduce time passengers are exposed to air pollution at stations or inside the bus by reducing travel times. 	<ul style="list-style-type: none"> • After the implementation of TransMilenio, Bogota reported a 43% decline in SO₂ emissions, 18% decline in NO_x, and a 12% decline in particulate matter (Turner <i>et. al.</i> 2012). • By reducing emissions of local air pollutants, especially of particulate matter, Metrobús Line 1 in Mexico City would eliminate more than 6,000 days of lost work, 12 new cases of chronic bronchitis, and three deaths per year saving an estimated USD \$3 million per year (INE 2006).
Increased physical activity	<ul style="list-style-type: none"> • Spacing of BRT stations tend to require longer walking distances than all other motorized modes with the exception of Metro • Higher operation speeds increases passengers' willingness to walk to stations 	<ul style="list-style-type: none"> • Mexico City's Metrobús passengers walk on average an additional 2.75 minutes per day than previously • Users of the Beijing BRT have added 8.5 minutes of daily walking as a result of the BRT system

Source: Adapted from EMBARQ (2013 p.11).

Similarly, experiences of cities where the BRT system is currently being operated have demonstrated remarkable gains in terms of the reduction in private car trips and increase in vehicle speed. The gains include reduction in transport-related GHG emissions, increase in travel safety, increase in the physical activity of commuters (resulting from walking to and from bus stations) and gains in terms of man-hours. Colin (2013) reported that, since the introduction of the BRT (Metro bus) in Mexico City, there have been 45%, 69%, and 3% reductions in the emission levels of CO₂, Benzene, and PM 2.5 respectively. A reduction in the level of road accidents by 80% was also recorded. In Istanbul, Turkey, the introduction of the BRT has saved each passenger 28 days in time per year, removed 200,000 private automobile vehicles from the road, reduced CO₂ emission by 600,000 tons, and accidents rate fell by 30-40% (Colin, 2013). Also, the time for the crossing between Europe and Asia through Istanbul reduced remarkably to 15 minutes when riding on the BRT as against 90 minutes by private

automobile vehicle. Similarly, the studies of Venter and Vaz (2011) of BRT users in Johannesburg, and the study of BRT users by Alpkokin and Ergun (2012) and Yazici et al. (2013) in Istanbul, show that users save an average of 13 and 52 minutes respectively each way (to and fro) during their daily commute. Furthermore, in terms of physical activities, the BRT users in Mexico City walk an average of 2.75 minutes more per day than before the city implemented its BRT system (Mexico City Household Travel Survey, 2007 cited in EMBARQ 2013, p. 39). Similarly, as a result of the BRT system, commuters in Beijing have added 8.5 minutes of daily walking time (Peking University data and Beijing Transport Annual Report 2007, cited in EMBARQ 2013, p.39). This daily walk time caused by the implementation of the BRT system is in consonance with the WHO's recommendation that adults aged between 18-64 years should engage in at least 150 minutes of moderate-intensity aerobic physical activity throughout the week or do at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week or an equivalent combination of moderate and vigorous-intensity activity (WHO, 2013). This implies that a 10 minutes' walk to and from the bus station by residents in a BRT corridor is recommended as a contribution to the healthy development of residents.

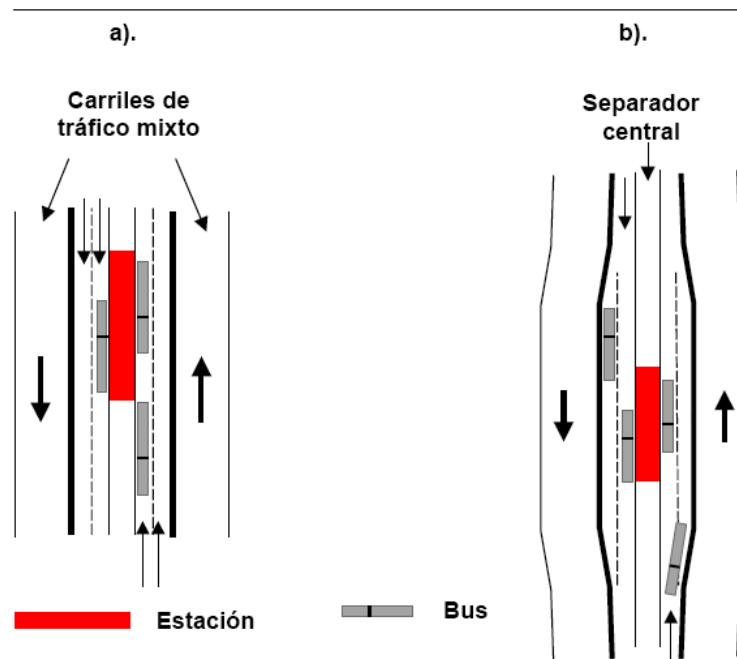
The evidence illustrated above indicate that with a BRT system, fragmented and unreliable bus systems in cities can be reformed and modernized to provide a good quality and efficient service with improved commute experience for passengers and this can attract riders by choice from their private automobile users.

B. Major components of the BRT System

The components of the BRT system has been identified to include its exclusive segregated lane, centrally located bus stops, high capacity articulated/bi-articulated bus (rolling stock), elevated passenger boarding platform, real-time passenger information system, bus route map, control centre (intelligent unit), branding and bike share facility. The details of the role of these components are discussed below:

I. Exclusive Segregated Lane

Compared to a regular bus, the journey on an efficient BRT is much quicker because BRTs enjoy bus-only lanes. In some instances, provision is made for a passing lane option at bus stations to avoid bus queuing when a bus docks for passengers to board (see Figure 5-8).



Source: UNCRD, 2013.

Figure 5-8: Passing lane options at a BRT station.

The 'a' passing lane option at a bus station would require the provision of a double lane with one of the lanes serving as a passing lane and the other as a 'docking lane' all through the corridor. Since the dual lane runs throughout the corridor, this option requires a huge investment in the provision of road infrastructure. On the other hand, the 'b' passing lane option only requires the provision of the passing lane and the docking lane within the region of the bus station. In the study by ITDP (2013), the exemplary application of the option with the passing lane in the BRT system in Transmileneo, Bogota is illustrated (See Figure 5-9).



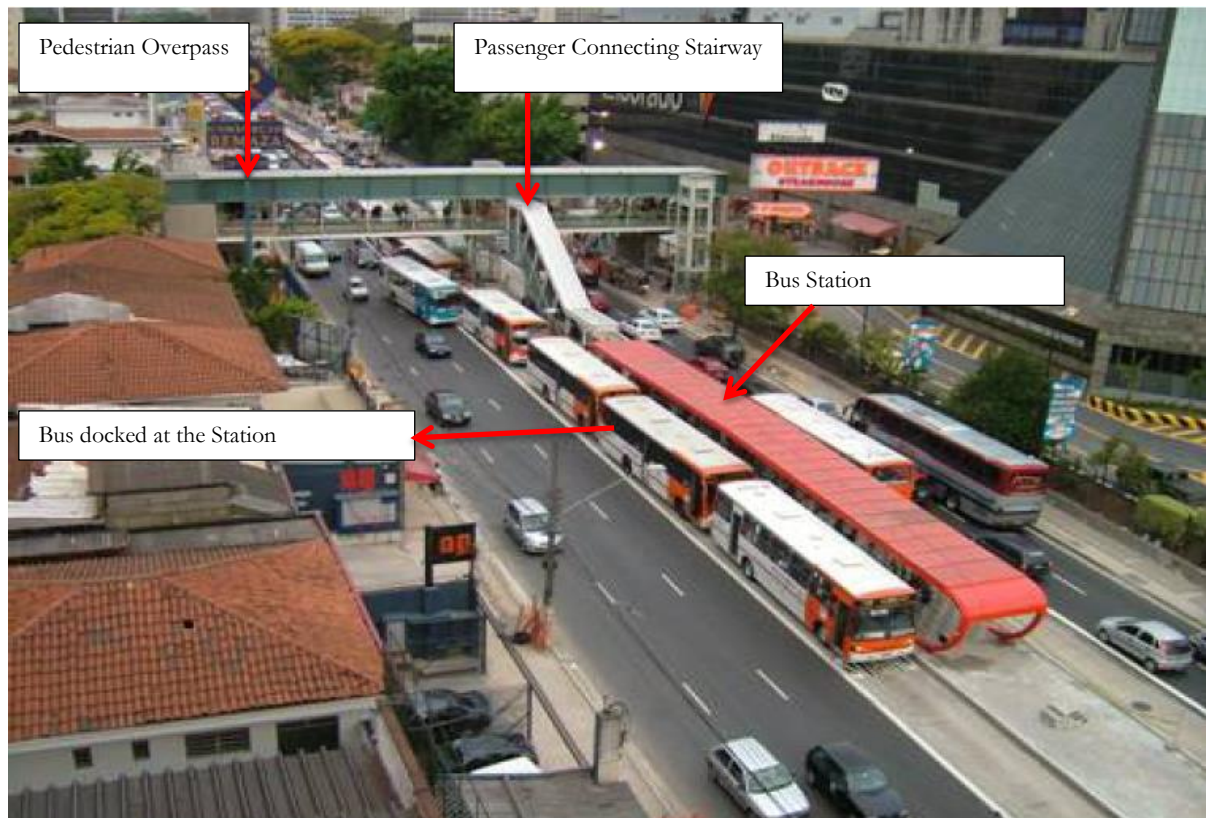
Source: Adapted from ITDP (2012, p. 24).

Figure 5-9: Segregated Bus Lane in TransMileneo, Bogota, Columbia

Evidently, since the dual lane does not run through the whole corridor, this option does not require huge investment in the provision of road infrastructure and hence the cost of providing road infrastructure is reduced.

II. Location of Bus Stations

The location of the BRT bus station can be aligned to the curb-side where the BRT lane has Curb-alignment, and there is also the option of median alignment where the BRT lane is centrally located. The examples of bus station aligned to the median are shown in Figure 5-10.



Source: UNCRD, 2013.

Figure 5-10: A typical example of bus station located on the median and pedestrian overpass feeding passengers to BRT station in Sao Paulo, Brazil.

Evidence of curb alignment reveals compromises of efficiency because of conflicts with turning vehicles and increased infrastructure cost because two stations on either side of the road must be built instead of a shared one in the middle (Diaz 2008, p.31).

In addition, Figure 5-10 also show a typical example of how a bus station is fed with passengers by an overpass. The passengers walking over the overpass are protected from sunshine and precipitation by a roof cover. This factor is an additional incentive that can attract passengers to the BRT system.

III. Rolling Stock

Rolling stock on a BRT system are mostly articulated or bi-articulated buses with a high passenger carrying capacity of between 160 – 250 passengers. These high capacity vehicles can indeed be a tool to reform informal mini-buses, and importantly, reduce daily VKT and lower per capita fuel usage and emission levels from the daily commute in cities (See Figures 5-11 and 5-12).



Source: Adapted from Suzuki et al, (2010 p. 174)

Figure 5-11: Typical example of 250-passengers Capacity BRT Rolling Stock in Curitiba



Source: Adapted from Buswatchnz (2010)

Figure 5-12: Typical example of 160-passengers capacity BRT Rolling Stock in Christchurch

In order to keep the emission levels from the rolling stock on the BRT system low, the buses are required to comply with set emission standards.

According to the study by ITDP (2013) on BRT Standard, diesel vehicles require the use of particulate matter traps, ultra-low-sulphur diesel fuel and selective catalytic reduction to achieve compliance to these standards. The efficiency level of reducing particulate matter emission from implementing Euro VI buses and US 2010 emission standards show twice the savings of particulate matter emission from Euro IV and V certified vehicles. By institutionalizing and ensuring compliance to these standards by the transport operators, particulate matter (PM), nitrogen oxide (NO_x) and CO₂ emissions, air pollution and global warming-related externalities can be lessened.

IV. Boarding Platform

The passenger boarding platform of the BRT system is built to be on the same level as the floor of the bus when it docks at the bus station. This is achieved by elevating the floor of the bus station to align with the height of the floor of the bus (see Figure 5-13)



UNCRD, 2013.

Figure 5-13: A typical boarding platform for easy entry/exit in Bogota, Columbia

As illustrated above, the proposed boarding platform permits seamless entry and exit by passengers and, importantly, can permit convenient entry/exit for the aged and physically challenged passengers.

V. Fare Payment by passengers

The BRT system uses contact-less off-board fare payment option which is similar to those found in rail systems. This is an improvement over the conventional method of cash payment and the issuance of a ticket at the point of entry which increases boarding time in informal bus service. By swiping the BRT pre-loaded smart card over the turnstile at the entrance of the bus station the passengers gain access into the bus station and, upon arrival of the desired bus, the passengers board the bus in a timely manner (see Figure 5-14).



Source: Adapted from ITDP (2012).

Figure 5-14: Boarding Access via Turnstile Contactless Machine in Jakarta, Indonesia (Payment already being made earlier)

With this fare payment option, boarding time is reduced and, therefore, leads to an improvement in travel time. This improvement in travel time can serve to attract more riders onto the BRT system.

VI. Real Time Passenger Information System

The BRT system also integrates display boards for real time passenger information about bus arrival and departure times. The display boards provide information relating to the expected arrival and departure times of the respective buses in accordance with published schedules of bus service (see Figure 5-15 below).



Source: Morgan, 2009.

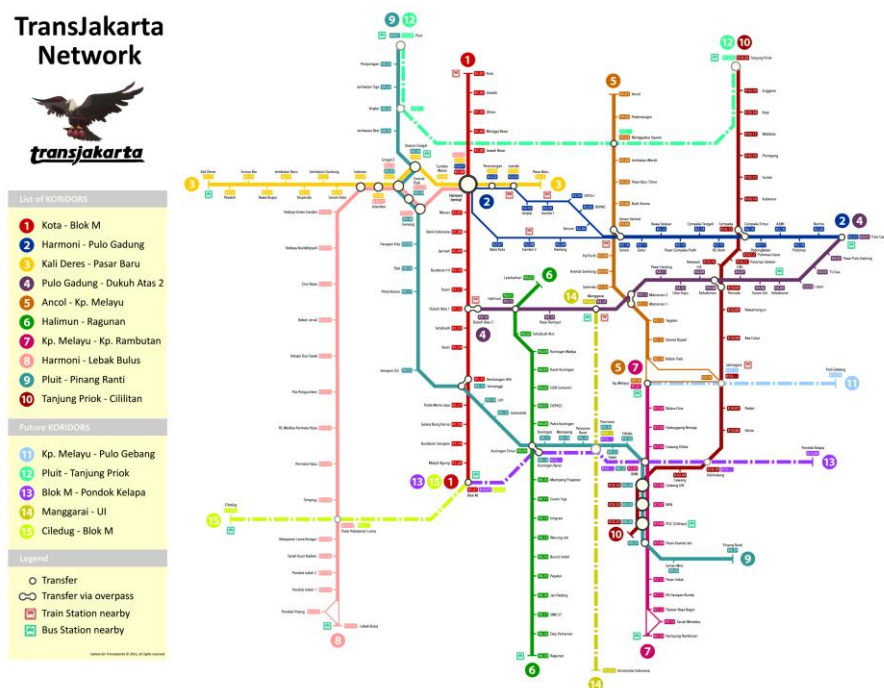
Figure 5-15: A typical BRT station with real-time passenger information in Portland, Oregon, USA.

Real time passenger information on the real time arrival and departure schedules of buses helps passengers to plan their trips and also to prevent overcrowding in the bus station, in that passengers

only come to the bus station a few minutes before the arrival of the expected bus in accordance with the schedule of bus service. Since arrival and departure times of buses are scheduled, the waiting time by passengers for buses are predictable and short. According to the conclusion by ITDP (2013), this predictability of the schedule of service by BRT buses is also an incentive that increases the potential ridership by choice for the BRT system from other modes, (especially potentially attracting private car drivers) in that, passengers can predict their departure and arrival times.

VII. Bus Routes' Map

Map displayed at the BRT station showing the network of the BRT routes is also a component of the BRT system (ITDP, 2013). The designated bus stations along the route and the code number for the designated buses that ply the routes is published as a route map for passenger information (see Figure 5-16 below).



Source: ITDP, 2013.

Figure 5-16: BRT route map in Jakarta, Indonesia.

This map therefore, provides information to passengers on the schedule of the BRT system. Accordingly, passengers are able to plan their travel, wait less at bus stations and save time in their commuting experience.

VIII. Bicycle Share Facility Scheme

The location of bicycle sharing facility within the BRT system is also an important component of the BRT system. The conclusions by ITDP (2013) shows that the location of this facility at BRT stations

and also at the entry/exit points of major residential areas/communities within the BRT corridor is important to last mile commute (see Figure 5-17).



Source: Adapted from ITDP (2013).

Figure 5-17: A typical bicycle share station along BRT corridor in Nantes, France.

The bikes should operate on safe segregated lanes linking the BRT stations and the residential areas; this is to permit the safety of bicycle riders from motorists. Bicycle share services may be required especially where commuters have to walk for more than 10 minutes to a BRT station.

IX. BRT Branding

The creation of brand for BRT is noted to be imperative to its successful implementation and optimal performance. The study by Penalosa (2004) and ITDP (2013) illustrate the role of branding the BRT systems in TransMileneo in Bogota, Columbia, and the TransJakarta in Indonesia. It is, therefore, important to brand BRT system in order to create an identity for the quality and efficient service provided by the system. The branding can provide an impetus for the enlightenment and sensitization of existing and potential riders on the BRT regime, and therefore attract existing commuters to the new transit system and also attract choice riders from other modes, especially commuters in private cars.

In view of the highlighted features of the BRT system, it may suffice to argue that it can be adopted as the appropriate rapid transit infrastructure because it sufficiently demonstrate the capabilities for transformation towards efficient and reliable passenger commuting experience in cities. By reducing

travel time on buses, encouraging riders and motorists to choose to ride on buses, and also by using more fuel efficient buses, BRT has emerged as an important tool in addressing climate change. In this regards, some BRT systems have been approved by the UNFCCC to generate and sell carbon credits (EMBARQ, 2013 p.35f). With cities' increasingly constrained budgets and the increasing demand for transit infrastructure, BRT system provides operational cost effectiveness and an opportunity to fund a practical and useful transport infrastructure.

5.3.3 Transport Demand Management (TDM) Strategy: Congestion Pricing

Penalosa (2008 cited in ITDP 2012) noted in his study that "...Traffic problems don't come from more cars, they come from more roads", he argued that more roads ease congestion and induce more cars and more congestion. This assertion provides the premise to corroborate the earlier analyses in Section 5.2 on the need to adopt a strategy to disincentives car usage and proliferation in order to improve travel time, and reduce traffic congestion and related impacts.

Some exemplary cases have proven that TDM strategies are viable and effective tool for improving traffic flow in cities pursuing these strategies. These include cities such as Bellevue in Washington State, USA; London, UK; Stockholm, Sweden and Singapore (Litman 2011, p.1; OECD/ITF 2010. p.6f; NNC 2008, p.1f). In the same vein, TDM strategies have also proven to lead to a decrease in peak period delays, decreases in bus delays, an increase in transit ridership, and a modal shift from automobile-dependent mobility patterns to transit-based mobility (Litman, 2006; Metro 2005a, 2005b, 2005c, 2005d cited in NNC, 2008.p.2).

Based on a review of the earlier studies undertaken in some cities (London, Stuttgart and Singapore), the gains from the implementation of TDM strategies are further summarized in Table 5-4 below.

Table 5-4: Impacts of selected TDM strategies

Strategy	Modal Share Impact
Congestion Pricing	London: 37% vehicle speed increased, 30% decrease in peak period delays; 50% decrease in bus delay. 14%-30% increase in transit ridership (London, Stuttgart and Singapore).
High Capacity Transit	20%-72% of new riders shifted to this mode from automobiles.
Parking Management (includes pricing and related strategies)	40%-50% reduction in parking demand in peak period as long term parking pricing increased; SOV (Single Occupant Vehicle) mode share 16%-25% lower when employees paid for parking

Source: Litman 2006, Metro, 2005 cited in NNC, (2008. p.2).

The evidence of a marked decrease in peak period delays, an increase in transit ridership, a modal shift in the choice of transit riders away from cars, and a reduction in parking demand due to the

application of congestion pricing TDM strategies indicates that remarkable improvements can be achieved in order to ensure efficient mobility patterns in cities.

5.3.3.1 Congestion Pricing

In this thesis, congestion pricing is used to refer to a form of TDM which involves roadway user fees levied on motorists. These fees are generally higher during traffic peak hours and lower, or not applied at all, during non-peak hours. The fee is usually introduced in order to achieve a reduction in traffic volume into a specific area of the city to more optimal levels. In line with the studies of Strompen et al. (2012 p.35) and UNHSP (2013, p.164), the rationale for congestion pricing is to reduce traffic congestion and its related externalities, reduce environmental impacts and encourage public transport usage.

A. Types of Congestion Pricing

There exist several arrays of congestion pricing strategies. They evolve based on the existing road profile and conditions, the existing challenges, the transformational need and local priorities. These congestion pricing options include Cordon Pricing, Area License, and Priced Lane (Strompen et al., 2012, p.37; US DOT, 2006 p.1, and Brown, 2011). These options are explained in the section below.

Congestion pricing, as identified by Strompen et al. (2012. p.37), can be in the form of:

- (i). Cordon Pricing: This requires the payment of a fee for passage into a part of the city which has traffic-generating potential (this is often the CBD (Central Business District)) and which is tagged as a charged zone or traffic restricted zone. Usually, higher fees are charged during peak hours (morning and evening peak hours).
- (ii). Area License: This requires vehicles to purchase a (day) license when operating within a defined area of a city.
- (iii). Priced Lanes or Corridors: In this case, vehicles using a specific road lane, tunnel or similar exclusive pathways are required to pay a fee. The road users here usually have the option to choose between paying for faster transportation on the priced lanes/corridors or to drive in the regular congested traffic. In the illustration by Brown (2011) of South California, USA, with a dichotomous highway tolling system, drivers willing to pay, get access to an exclusive express lane (that runs parallel to the original highway) called “Lexus Lane” and drive pass other drivers wallowing in the infinite gridlock. The cordon pricing may be the type of congestion pricing relevant to this study, since the focus is on reducing traffic congestion caused by daily influx of private cars into the core-city from the suburban areas.

In order to illustrate the gain obtainable from the introduction of a congestion pricing regime, Strompen et al. (2012 p.37) evolved an Impact Chain tool for illustrating the impact of congestion

pricing. The Figure below indicates the potential capability of congestion pricing to decrease the usage of private automobile vehicles and the resulting modal shift from private automobile trips to increased public transport usage (See Figure 5-18).



Source: Adapted from Strompen et al., (2012 p. 37).

Figure 5-18: Impact chain of congestion pricing.

Consequently, the impacts of implementing congestion pricing culminate into a mobility pattern characterized by diverse modal share that emphasizes public and non-motorized transport and a reduction in Vehicle Kilometre Travelled (VKT). Notably, the reduction in the level of transport-related CO₂ emissions provides a major impact by congestion pricing on the environment, other co-benefits include reduced level of traffic congestion, reduced travel time and a reduced level of fuel wastages. In view of the highlighted features of congestion pricing (cordon pricing), it may suffice to suggest that it can be adopted as the disincentive mechanism because of its capabilities to deter car usage and proliferation, and address traffic congestion challenges.

5.4 The Lessons of Experience from Relevant Case Studies using the identified Spatial Planning Strategies

This section focuses on the examples of the application of spatial planning strategies for addressing the challenges of traffic congestion and suburban sprawl in cities. It illustrates how spatial planning strategies that relate to Bus Rapid Transit, TOD and congestion pricing strategies have been used to transform the existing challenges in cities. The case studies on the application of the strategies are discussed below:

5.4.1 Empirical Evidence of the Application of the TOD Strategy

The work of Suzuki et al. (2013, p.95) succinctly captures the gap in research on TOD applications in developing countries, as they noted that, although the strategy has gained tremendous attention in policy circles, it rarely occurs in practice especially in rapidly growing global south cities. In an expression of optimism concerning TOD application, Hutchings cited in Atkins Global Report (2013) remarked that “in truth, I haven’t come across any negative impacts from designing and delivering TODs”. The application of TOD in Singapore, Stockholm, Curitiba, Bogota, Delhi and Ahmedabad are illustrated in the next sections. These case reviews provide insight into the contextualized application of TOD in cities.

5.4.1.1 Singapore

The application of TOD in Singapore was spurred on by the need to create interdependence and to stimulate interaction amongst designated function areas so as to balance city-wide mobility demands. According to Suzuki et al. (2013, p.71), TOD nodes in Singapore are developed alongside specialized functions areas such as industrial estates and dormitory communities which have generated interaction with, and dependence on, one another and have, therefore, achieved a balanced population, economy and spatial growth. Consequently, the character of development in these TOD nodes has been high density, mixed-use development located along transit corridors (See Figure 5-19).



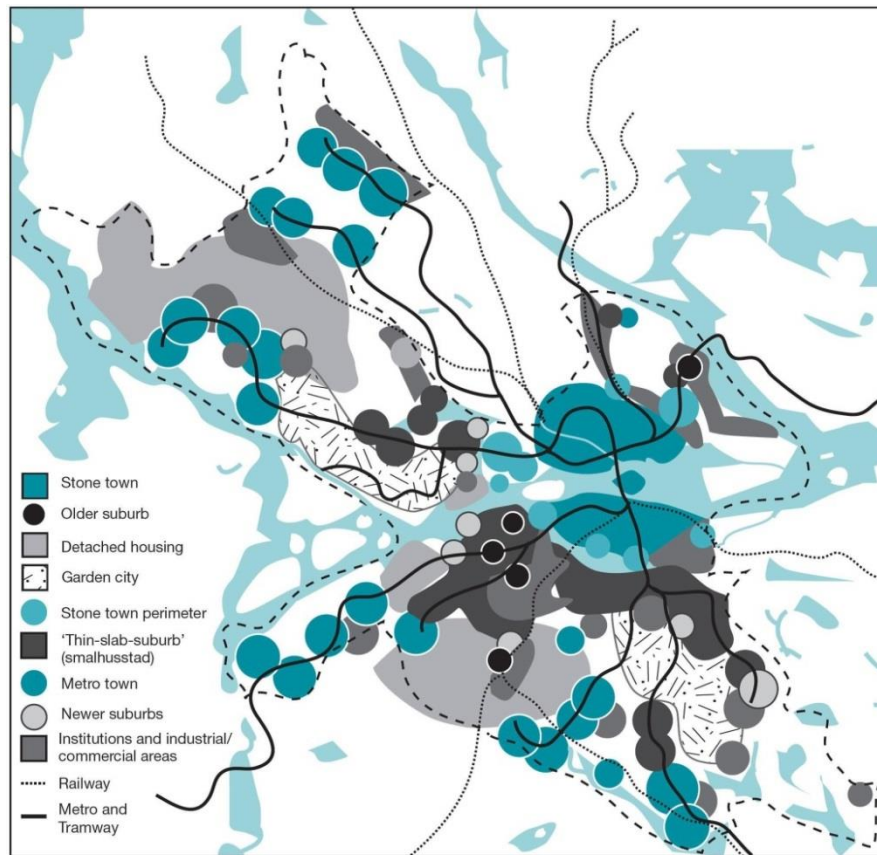
Source: Adapted from UBM's Future Cities (2013).

Figure 5-19: High Density mixed use development along the transit corridor in Singapore.

With this application of TOD, the spatial growth of Singapore has been aligned towards a smart compact urban form with a rich diversity that reduces the need for travel via private cars. The proximity of residents to transit stations optimizes the transit operation and consolidates a transit dependent mobility pattern for Singapore.

5.4.1.2 Greater Stockholm's 'Necklace-of-Pearls' Urban Form

Greater Stockholm has evolved along public transport-oriented corridors. As stated by UNHSP (2013, p.96), the emergence of Greater Stockholm was consequent upon strategic regional planning which gave rise to regional settlements and commutation patterns. The spatial expression of the city's transport-sector investments in radial rail lines is expressed in the 'Necklace-of-Pearls' urban form and in a balanced use of land for work and housing (See Figures 5-20 and 5-21).



Source: Adapted from Stockholm Municipality (2000, cited in UNHSP 2013, p. 97).
Figure 5-20: Stockholm's 'Necklace-of-pearls' built form.



Source: Adapted from Rhodes (2009).
Figure 5-21: High Density mixed use development along the transit corridor in Stockholm

The radial rail lines, therefore, represent a string connectivity of a hierarchy of nodes expressed in circles of units of spatial development consisting of rich diverse, functional and density mixed transit communities.

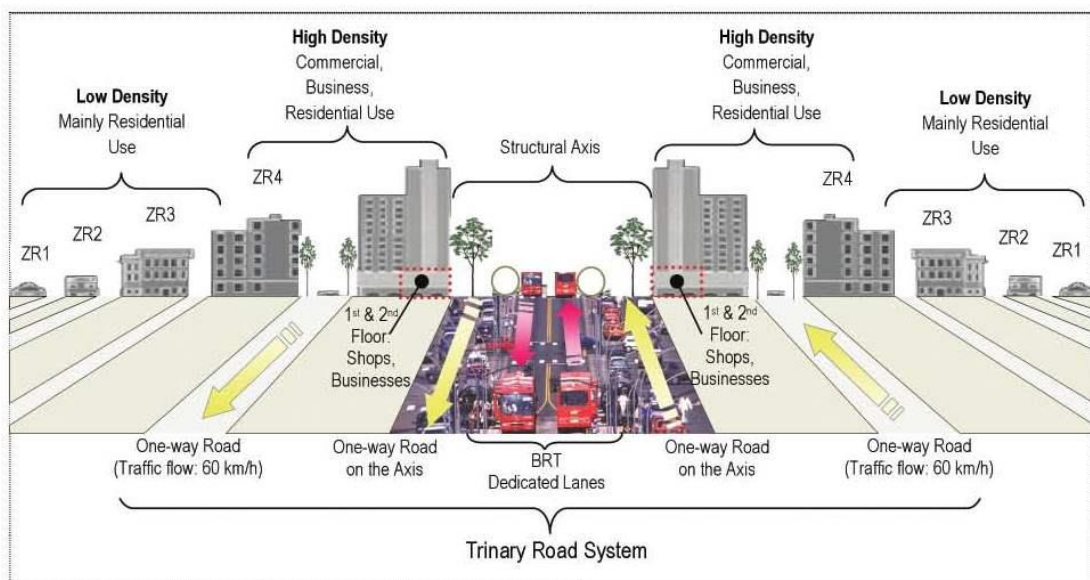
By the conscious creation of a balance in job-housing-retail activities/places along rail-served axial corridors, a pattern of a high share of transit-based trips have emerged; this includes a directional balance of travel flow during peak hours (UNHSP, 2013, p.97). Accordingly, travel flows have been

rationalized to produce short-to-moderate distance trips that are well served by the railway and fast-bus services. In McKinsey’s opinion, the related benefits include a high modal split in favour of public transport (higher than in the larger rail-served cities such as Berlin, Germany; and London, UK). The benefits also include comparatively low CO₂ emissions per capita in the transport sector (lower than Tokyo, Japan; New York, US; and Rome, Italy) (McKinsey and Company, 2008 p.19f). In addition, a large spectrum of residents in Stockholm routinely use public transport for commuting to work, with a reduced level in private cars’ usage.

5.4.1.3 Curitiba

Arguably, Curitiba in Brazil has emerged as an efficient city with exemplary characterization of coupling of bus-based public transport-oriented corridors’ development. In pursuit of inclusive accessibility for its populace via a transit-based mobility pattern, Curitiba has evolved along well-defined axial lineal corridors that are intensively served by dedicated bus-ways.

According to Suzuki et al. (2010, p.172), the concept of ‘Trinary’ – three parallel – roadways with compatible landuses and building heights that taper with distance from the BRT’ corridor was adopted in the development of Curitiba (See Figure 5-22). Reportedly, by the deliberate government policy of integrating all medium and large scale urban development along BRT’ corridors, accessibility has been enhanced and balanced corridor growth achieved.



Source: Adapted from Suzuki H. et al, (2010 p. 172).

Figure 5-22: High density mixed-use development focusing on dedicated bus-way corridor in Curitiba, Brazil.

As illustrated in Figures 5-21 (Stockholm) and 5-22 (Curitiba) above, zoning ordinances and urban design standards have been used to stimulate densification that has yielded optimum ridership for the BRT’ system. The first two floors of buildings along the bus-way in Curitiba are devoted to retail uses. Above the second floor, buildings allow for a setback of at least 5 metres from property line to allow the sun to shine on the bus-way. By including upper-level housing development along transit

corridors, property owners are entitled to density bonuses; this culminates in a vertical mixing of function and density within buildings (UNHSP, 2013, p. 98).



Source: Adapted from 2030 Palette Blog (2013).

Figure 5-23: High Density mixed use development along the transit corridor in Curitiba.



Source: Adapted from IPPUC (2013).

Figure 5-24: High Density mixed use development along the transit corridor in Curitiba.

As stated by Suzuki et al. (2010) and Cervero (2009), Curitiba has Brazil's highest public transport mode splits (45%), the lowest congestion-related economic losses and the lowest rate of urban air pollution (despite being an industrial city). Also, in 2005, Curitiba's VKT per capita (7,900) was only half as much as in Brazil's national capital Brasília due to its compact transit-centered built form (Santos, 2011). Based on 2002 data, Curitiba's estimated annual congestion cost per capita of US\$0.67 is only a fraction of São Paulo's (US\$7.34) (Suzuki et al. 2010). Reportedly, sustained political commitment achieved over 40 years of political continuity accounts for the success recorded in Curitiba. Thus, with a vision and the presence of a semi-autonomous municipal planning organization, the city was able to chart a sustainable urban pathway (Suzuki et al, 2010; Santos, 2011; The Institute for Research and Urban Planning- IPUCC cited in UNHSP 2013, p. 98). The benefits recorded from the contributions of coupling of transit and TOD have been reported to relate to savings in terms of ridership on transit, reduced VKT and reduction in related externalities. The savings in terms of land area saved from the avoidance of sprawl due to the densified urban form is not reported in the studies.

5.4.1.4 Bogota

The Metrovivienda Project is an initiative which provides affordable housing characterized by mixed-use development along the TransMileneo corridor. According to Suzuki et al, primarily, the Metrovivienda was pursued as an innovative way of addressing housing needs. In implementing this initiative, the private sector were provided with serviced land on which to construct affordable housing to address housing deficits and shortages faced by lower-income residents (Suzuki et al, 2013, p. 120). Accordingly, the underprivileged became residents located near TransMileneo stations with increased access to social facilities (schools, hospitals, parks, and libraries) (see Figure 5-25 and 5-26).



Source: Adapted from WWF Global, (2012).

Figure 5-25: High Density mixed use development along TransMilenio corridor in Bogota



Source: Adapted from 2030 Palette Blog (2013).

Figure 5-26: High Density mixed use development along TransMilenio corridor in Bogota (Metrovivienda)

By living in Metrovivienda housing projects, many of these households now save a large portion (about 20%) of their earnings which was previously spent on commuting via fragmented, unreliable bus service operated by informal operators in remote areas, in a bid to access social facilities (Suzuki et al. 2013, p. 120). In addition, low income populations who moved from the hillsides to the Metrovivienda currently enjoy better housing, shorter commutes and reduced expenditure on commuting.

According to the study of Cervero, before relocating, residents spent averagely \$1.40 a day on commuting; after moving, their daily commuting costs fell to \$0.80, due to proximity to the TransMilenio stations. As a TOD initiative, and with the highlighted implicit benefits to residents within the area, the Metrovivienda can be described as markedly improving the efficiency of passengers' mobility and the livelihood of residents. The city generates about 30-50% of revenue from the increase in land value that has resulted from the infrastructure investments in parks, cycle ways and pedestrian ways. These funds have been used to further finance the Metrovivienda projects and other social development purposes (Suzuki et al. 2013, p. 121).

The development of TOD along the TransMilenio corridors has helped to address the challenge of optimizing the operation of TransMilenio by generating ridership. It also helped to increase the standard of living of residents along the TransMilenio corridors because of increased accessibility. It has also contributed to the reduction in VKT and related externalities.

5.4.1.5 India (New Delhi and Ahmedabad)

The application of the TOD strategy in the Indian cities of New Delhi and Ahmadabad has not actually taken place, but there has been increasing recognition for the adoption of TOD. The need for the adoption of TOD arises from the opportunities and enabling environment created by the recently

implemented rapid transit infrastructure (the Metro in New Delhi and BRT in Ahmedabad). More importantly, the need to adopt TOD has become recognized because of the dire need to transform the sub-optimal performance of the rapid transit infrastructure by allowing more people to live near transit stations in order to increase the accessibility of its populace.

A. New Delhi

In recognition of the challenges of sustained auto-centric planning which prioritized the segregation of landuses and permitted extensive spatial form expressed in low density sprawl, and private car proliferation, the government of Delhi has pursued the implementation of a world class Metro, in order to achieve the transformation of these pre-existing challenges (Delhi Development Authority 2012, p. 2). However, because the implementation lacked the strategic visioning to integrate spatial development and the transit infrastructure, the Delhi Metro has been unable to deliver efficient, comfortable and affordable mobility options to all spectrums of the populace. This misfit has failed to entice huge patronage by commuters and has not been able to attract riders by choice from other modes. To sum up, the inefficiency of this transit has further exacerbated private car usage and its related challenges.

Currently, the government has recognized the relevance of TOD and has, therefore, evolved a TOD policy to restructure and redefine mobility and spatial development especially along the transit corridors in Delhi. According to the Delhi Development Authority (2012, p. 2), the primary objectives of implementing TOD are, firstly, to reduce private car dependency and spur on public transport use through design, policy measures and enforcement; secondly, through densification and enhanced connectivity, to provide greater access to public transport within walking distance for a large spectrum of people. In line with this policy's provisions and guidelines, it is hoped that, with sustained efforts to implement this TOD policy, the desired transformation can be achieved via a high modal share in favour of transit. This can, therefore, optimize the operation of the Metro system and generally increase citizens' overall accessibility.

B. Ahmedabad

In recognition of the challenges of rapid urban expansion, increasing private car proliferation and related impact of traffic congestion, and the fragmented public transportation, the government of Ahmedabad evolved a plan for the implementation of a BRT system. The BRT system in Ahmedabad termed Janmarg began operation in 2009.

The Janmarg BRT system was put in place to improve mobility in Ahmedabad by reducing travel time for commuters, reducing VKT and other related challenges implicit in the prevailing car-dependent mobility patterns. According to Suzuki et al. (2013 p. 100), the city paid excessive attention to improving mobility without any recognition for the need to shape urban growth. Accordingly, the

potential presented by the BRT corridor to evolve TOD to transform the spatial form of the city remain un-tapped.

With the increasing demand for housing and the need to stem the phenomenal growth of informal housing as reported by Bhatt (2003 cited in Suzuki et al 2013, p. 101f), the provision of affordable housing for the city's marginalized residents can be planned along Janmarg's BRT corridor. This coupling would generate ridership to support the optimal operation of Janmarg, create increased accessibility for a larger spectrum of the populace, free up income spent by the population on transportation which, in turn, assists in increasing their standard of living, and would also transform the city's extensive spatial form to a more efficient compact smart form.

The guidelines for the application of TOD in order to permit densification and mixed land-use development is presently lacking in Ahmedabad (Suzuki et al., 2013, p.106). However, the passage of the law in 2002 which allowed for the sale of additional Floor Area Ratio (FAR) for properties abutting major roadways including the BRT corridors can be explored and used to create a TOD character along the corridor of Janmarg. In line with the opinion of by Suzuki et al. (2013, p. 109), by raising the FAR to increase the maximum building volume on the Janmarg corridor to 3.5 (from the current permissible 1.8) the character of the development along this corridor can be reformed. This reform is hoped to, firstly, permit densification in the development of social housing initiatives and commercial space along the BRT corridors, and, secondly, by the adoption of a value capture scheme, funds can be generated to finance transit-linked social housing initiatives. Evidently, the benefit of integrating rapid transit infrastructures and TOD (as illustrated in other cities) can assist in reversing the challenges of inefficiencies in the transport and mobility system, and spatial development, in Ahmedabad.

To sum up, the sub-optimal performance that plagues the rapid transit infrastructure in Delhi and Ahmedabad has necessitated a re-evaluation of the link between transit and spatial development. The lesson here is to recognize that, without the integration of an efficient smart pattern of development with a rapid transit infrastructure, the ridership required to support the optimization of the operation of transit is missed, and the huge investment is also unjustified. The related co-benefit of the recalibration of modal share in favour of public transit trips (that would have been spurred by the efficiency of the metro/BRT) is missed; reductions in the level of traffic congestion and the related externalities of CO₂ emissions, loss of productive time and fuel wastage, and a reduction in rate of spatial sprawl are missed.

5.4.1.6 Solar-Powered Lifts for High Density Residential and Mid-rise Commercial Buildings

While it is noted that the application of TOD require high density residential development with multiple floors, the challenge of electricity power to drive elevator in major part of the suburban

settlements of global south cities could be a factor that may inhibit effective application of the TOD strategy. However, the recent innovation of the application of solar-powered lift in high rise buildings may provide the required solution. The reports by Schindler (2004) revealed the application of solar powered lift in Barcelona, Spain, and in Europe and India.

The new solar-powered elevator system uses a standard Schindler 3300 gearless machine room-less elevator, runs on a 220-volt, 6.2-kilowatt and known to be comparatively up to 60 percent more energy efficient than conventional hydraulic elevators (Hardcastle 2013, Sustainable Business, 2013, Green Building News, 2013, Masia, 2014, Curran 2013). Drawing power from roof-top solar panels sized specifically for daily traffic in elevators, it can operate solely on solar power which is separate from the city's power grid or a combination of both. One of the unique advantages is its proprietary Hybrid Energy Manager (HEM) which stores solar energy in bank of AGM batteries with about 7 kilowatt-hours capacity. This allows the elevator to operate at night or during a power outage (Curran, 2013, Sustainable Business, 2013, Green Building News 2013, Masia, 2014) (See Figure 5-27).



Source: Adapted from Hardcastle (2013).

Figure 5-27: Typical view of Solar-Powered Lifts for high density residential and mid-rise commercial buildings

According to Masia, a key feature is that the cab can hoist nine people (up to about 980 kilograms, or 2,156 pounds) on a 30-metres hoist (this implies going as high as the tenth floor of a building with average headroom of three metres per floor) (Masia 2014). A prototype is currently running in a low-rise residential building in Barcelona, Spain, and it has been introduced in Europe and India in 2013 and in the US and other markets in 2014 (Sustainable Business, 2013, Curran 2013).

This new system may increasingly offer a highly efficient, robust, and affordable solution for residential and low-rise commercial buildings, and therefore contribute to creating enabling environment for the implementation of TOD in global south tropical countries with frequent power outages. It is imperative to note that, while the solar powered elevator fills the gap of lack of or

inefficient power supply from city's electricity grid, it has the important co-benefit of reducing carbon-footprints from fossil fuel energy saved from the electricity grid that would have been used to power hydraulic lifts. Hence, the contribution to sustainable urban development via renewable energy efforts and climate change mitigation.

5.4.2 Empirical Evidence from the Application of Bus Rapid Transit (BRT)

5.4.2.1 Curitiba, Brazil

In line with earlier illustrations, the efficiency of passenger mobility achieved by the BRT system is similar to the efficiency previously achieved only by using rail technologies (ITDP, 2007). In Cervero's study, the Curitiba system is a methodical development of a world class all-bus transit network, in close coordination with physical land-use planning. Even though the decisions made were piecemeal, and incremental, they were quick, pragmatic and cost effective and, most importantly, fitted into the larger vision envisaged by guiding plan already prepared (Cervero, 1998, p. 266).

By this policy, more residents live and work near BRT stations in mixed-use developments channeled along the transit-served structural axes. This integration has resulted in leveraging the ridership in support of transit operation and, therefore, has justified the investment in transit.

With 70% of commuters riding on the BRT, the Curitiba BRT system runs on a 60km dedicated busway with a 250 passengers per bus capacity (See Figure 5-28), and now generate two million (2,000,000) daily passenger boarding's.



Source: Adapted from Suzuki et al, (2010 p. 174)

Figure 5-28: Bus Rapid Transit System in Curitiba.

The construction cost of the BRT system was put in the region of US\$1.5 million per kilometre (Levinson et al. 2003; Suzuki et al, 2010).

One of the strong success factors in Curitiba is the growing desirability by private car owners to ride on transit while leaving their private car at home. To sum up, the Curitiba BRT model remains a model for cities around the world, especially when cities need to address traffic congestion which results from car dependent mobility pattern and retrofit sprawling extensive spatial configuration.

5.4.2.2 TransMileneo, Bogota, Columbia

As stated by ITDP, the TransMileneo BRT project in Bogota, Columbia, has also emerged as an exemplary BRT experience with metro-like quality service and a high efficiency that attracts riders by choice from other modes. The TransMileneo moves 45,000 passengers per direction each hour over 28 kilometres (17 miles) per hour. Notably, the TransMileneo moves more people faster than technical experts previously thought was possible to the tune of 1.5 million daily passenger boarding (ITDP, 2007, p. 4; ESMAP, 2009).

The TransMileneo Metro Buses run on exclusive lane (not in conflict with any other vehicles). The system uses articulated 165 passenger high-platform buses. The vehicles stop at stations and open their doors simultaneously with the station doors. Passengers pay or are charged through a contact-less card at the stations' entrance. The BRT system is fully accessible to the handicapped as bus floors are at same level as the bus station. One hundred passengers can exit and a 100 more board the bus in seconds. These features contributed to remarkable improvements in the commute experience of passengers as compared with what existed before the implementation of TransMileneo (See Figures 5-29 and 5-30).



Source: Energy Sector Management Assistant Programme (ESMAP) (2009, p. 6).

Figure 5-29: Traffic Congestion, resulting from automobile dependence and inefficient public transport in mixed traffic, in Bogota before TransMileneo.



Source: Adapted from ITDP (2012, p. 16)

Figure 5-30: Typical Bi-articulated Buses on Exclusive Lane in the TransMileneo, Bogota, Columbia

In Penalosa’s account, these high-capacity articulated buses with their efficient passenger mobility has also gradually replaced the pre-existing fragmented, unreliable, chaotic and polluting small capacity buses. Hundreds of kilometres of sidewalks and cycle greenways (a network of 250km long bicycle ways) have been integrated into the new transit system and has permitted the high usage of non-motorized modes (Penalosa, 2003). Similarly, in Grutter’s (2006) estimates, Bogota’s TransMileneo has recorded remarkable savings of an average of 246,563 tons of CO₂ eq.

To sum up, the TransMileneo has emerged as exemplary model for transforming car-dependent mobility patterns in cities, into a new horizon that guarantees improved commuting experiences for commuters and with remarkable savings on such externalities as travel time, fuel wastage and CO₂ emissions.

5.4.2.3 Guangzhou, China

The city of Guangzhou (China), with a population of over 6 million and nearly 12 million in its metropolitan area, was becoming overwhelmed by congestion and by the operational in-efficiencies of the city’s bus system (Hughes and Zhu, 2011). In response to this situation, the city opened new 22.5-kilometres fully-segregated Bus Rapid Transit (BRT) corridor in 2010 directed at addressing the overwhelming challenges of traffic congestion (See Figure 5-31 – 5-32).

With a ridership of 27,000 people per hour, the ridership level has more than tripled the peak passenger flows of any other BRT system in Asia and more than any metro line in mainland China with the exception of Beijing’s Lines 1 and 2. The Guangzhou BRT has emerged as the leading bus corridor in all of Asia with an 805,000 daily boarding (an increase of 18% above the preceding year) (Hughes and Zhu, 2011 p.2f). The improvement has included improved trip times for bus riders (buses) as well as drivers (mixed traffic) in the corridor by 29% and 20% respectively, and an aggregate annual time saving of 52 million hours (equivalent to 158 million Yuan). Implicit in this new BRT

operation is a related reduction in annual operation costs by over 90 million Yuan which is about $\frac{1}{10}$ of the initial capital outlay into the project (Hughes and Zhu, 2011, p. 2f).



Source: Adapted from Hughes and Zhu (2011, p. 6).

Figure 5-31: Before BRT - Bus and Traffic Congestion, Ganding Station Area.



Source: Adapted from Hughes and Zhu (2011, p. 6).

Figure 5-32: After BRT - Efficient Traffic Flow at Ganding Station Area.

In pursuit of a holistic public transport system that is inclusive, safe, energy efficient and environmentally friendly, the city created a new high-quality greenway along the corridor and provided bike parking and bike share at each of the stations, as well as in locations in adjacent neighbourhoods (See Figure 5-33) (Hughes and Zhu, 2011, p.9).



Source: Adapted from Hughes and Zhu (2011, p. 9).

Figure 5-33: Safe, High Quality Walking and Bicycling Spaces along the Guangzhou BRT Corridor.

The savings from the Guangzhou BRT system is expressed in the reduction in traffic congestion, fuel consumption, air pollution, expenditure on fuel, CO₂ emissions, and Vehicle Kilometre Travel (VKT). Using the Emission Impact Estimation Methodology, Hughes and Zhu were able to calculate the inherent savings: Emission reduction from the modal shift to BRT equals 186,969 tons CO₂; emission reduction from BRT VKT reduction equals 190,078 tons CO₂; emission reduction from BRT speed increase equals 85,759 tons CO₂; emission reduction from mixed traffic speed increase equals 396,561 tons CO₂; and BRT yearly CO₂ emission reduction by source 2010 – 2019 equals 865,000 tones CO₂ (Hughes and Zhu 2011, p. 17-27). Evidently, the Guangzhou BRT model illustrates a highly cost effective, urban transportation system and the viability of “metro-scale” BRT in China, not only for Chinese cities, but for other cities on the pathways of pursuing local and global environmental sustainability.

Although the study of Hughes and Zhu (2011) was able to demonstrate remarkable savings on pollution, emissions, and the carbon footprint, their study did not include looking at the capacity of the efficient BRT system to support TOD and its ability to contribute to retrofitting the menace of a sprawling city and related savings in terms of usage of land.

5.4.2.4 Johannesburg, South Africa

The city of Johannesburg launched the BRT system (Rea Vaya) to form the backbone of the city’s public transport plans to reduce the use of private cars, relieve traffic gridlocks and achieve a 70:30 ratio of public transport to private transport use (ITDP, 2012). Some of the envisaged opportunities from the implementation of the BRT system in Johannesburg were the opportunity to recapitalize the aging taxi fleet to new large buses (ITDP, 2012).

The pre-existing transport system before the introduction of the Rea Vaya project was characterized by mini-buses which operated in mixed traffic; they provided fragmented, unreliable and unscheduled services. As a result, the commuting experience was plagued by traffic snarls with following

consequences on man-hour and fuel wastages, and CO₂ emissions (Callegari, 2010). The transformation of the cities' commuting experience by the Rea Vaya project into a transit-dependent mobility pattern has increasingly become beneficial (Jennings, 2012) (See Figures 5-34 – 5-35).



Source: Adapted from Callegari (2010)

Figure 5-34: Traffic Congestion resulting from automobile dependence and mixed traffic in Johannesburg.



Source: Adapted from Jennings (2012).

Figure 5-35: Rea Vaya BRT in Johannesburg.

According to ITDP, Phase 1 of the estimated R2-billion project was designed to operate articulated buses along exclusive median bus lanes in both directions across Johannesburg. The 120 km Phase 1 route with 150 stations, eight terminals and six depots was planned to cover almost half of Johannesburg. In addition to the 22 metres-long 427 articulated trunk buses, the system incorporated a variety of complementary and feeder services, including 4.13 metres-long feeder buses and 350 complementary 13.9 metres-long buses (ITDP, 2012).

The buses used on the BRT bus system have low-emissions engines which includes Euro IV diesel engines with particulate traps (Weinstock, 2009). The bus specification is above the national standard (Euro III). Presently, the Rea Vaya system runs along 25.5 kilometres of dedicated bus way using 18

metres-long articulated buses with a capacity of 122 passengers and carries 43,000 daily passengers boarding. The construction cost is put at US\$1.42 million per kilometres (Kumar et al., 2011, p.8).

To sum up, even though the Rea Vaya BRT system has not achieved all that is planned, the improvement since inception is no doubt incremental. It has been used to transform the existing proliferation of private car usage in Johannesburg, integrate existing stakeholders and improve the commuting experience for passengers.

5.4.2.5 Ahmedabad, India

Ahmedabad, the financial and administrative hub of Gujarat, occupies an area of 490 sq. km with a population of 5.5 million (with decadal growth of 75%) and encompasses 1.45 million vehicles with a growth level of 7% per year (Kost, 2009).

The Ahmedabad BRT project was evolved to address and retrofit the challenges of car proliferation especially the proliferation of motorcycles that account for 40% of the modal split, with 0.9 million bus trips per day and average trip length of 5.8kms (Kost, 2009). The completed construction thus far is 12.5 km of the planned 90km network, with 14 buses, 16,000-18,000 passengers per day and thus far it has attracted 27% of riders away from private vehicles.

However, the fundamental flaws with the Ahmedabad BRT system is a lack of parking enforcement, the number of pedestrian crossings are few, and there is no access for the disabled (Kost, 2009). These challenges may, therefore, continue to lessen the efficiency of public transport and may enhance the growing trend of private car usage.

5.4.2.6 Lagos, Nigeria

Lagos in Nigeria has emerged as a mega-city holding a 10 million-plus population. It is also one of the global south cities ridden with the menace of a growing car-dependent mobility pattern. Some studies have revealed that the related externalities implicit to this mobility pattern are expressed in a high level of traffic congestion, in loss of productive time, in particulate matter air pollution and transport-related GHG emissions (Suberu and Ayinla, 2012; Berry 2013; Mobereola, 2009) (See Figures 5-36 – 5-37).



Source: Adapted from Suberu and Ayinla (2012).

Figure 5-36: Traffic Congestion resulting from automobile dependence and mixed traffic in Lagos



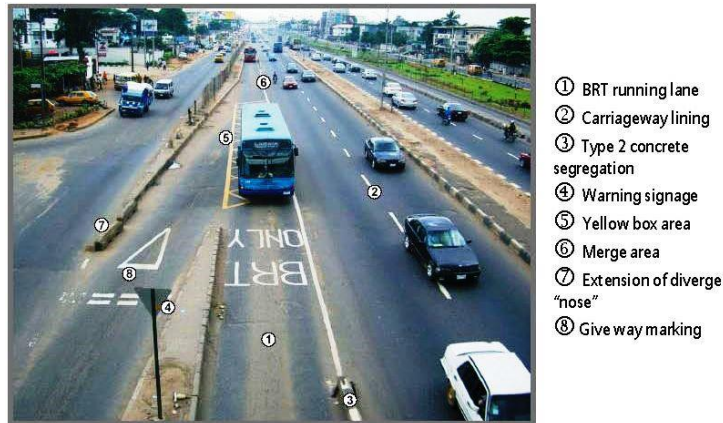
Source: Adapted from Berry (2013).

Figure 5-37: Traffic Congestion resulting from automobile dependence and mixed traffic in Lagos.

In response to these challenges, the government of Lagos has evolved a Transportation Plan with its fundamental components being an integrated mass transit system of seven (7) BRT corridors, and three rail lines. Phase I of the BRT corridor is 22 km long, running from Mile 12 to Lagos Island (Kumar et al, 2011, p.29). Phase II, which is under construction, is planned to run from Iyana Ipaja, a neighbourhood to the north, to Maryland, one of the busiest stations on the Phase 1 route. The BRT infrastructure is estimated to cost 4.5 billion Nigerian naira equivalent to about 38.3 million US dollars (Diaz 2008, p.30).

By disaggregating this cost, the cost of the BRT infrastructure is about 1.7 million US\$ per kilometre. The BRT system is run by two private operators with the provision of 220 red and light blue standard buses with a capacity of 75 passengers each (Diaz 2008, p.30). Notably, ridership has surpassed expectations, markedly by 200%, with 200,000 daily passengers' boarding and a remarkable reduction in travel time by 40% and waiting time by 35%, according to LAMATA (Lagos Metropolitan Area Transportation Authority) (Kumar 2011, p.9 Diaz 2008, p.30). However, with the huge demand for mobility across Lagos, there are still long queues to board the buses (Diaz 2008, Kumar, 2011, Mobereola, 2009).

The buses run in a dedicated, curb-aligned corridor for 65% of the corridor and in mixed traffic for 35% (Diaz 2008; Kumar 2011, p.8). Evidently, curb alignment compromises efficiency because of conflicts with turning vehicles and increases infrastructure cost because two stations on either side of the road must be built instead of a shared one in the median (Diaz 2008, p.31) (See Figure 5-38).



Source: Adapted from Moberola, (2009, p. 13).

Figure 5-38: A typical BRT bus in Lagos running on its corridor.

Notwithstanding, the new BRT system has been the only project on urban mobility that has had any significant effect on daily commuters in the last 40 years in Lagos. There is an urgent need for segregated sidewalks linking the BRT stations as hundreds of potential passengers walk on the roadside and face the daily risk of traffic accidents.

To sum up, it can be noted that while metro rail and LRT permit faster commuting time, the cost and time spent on the implementation is huge. Findings from earlier studies has shown the possibility of achieving a marked level of passenger mobility efficiency by adopting the BRT option, as it can be implemented at $\frac{1}{3}$ - $\frac{1}{5}$ of the cost of alternative technologies such as metro and LRT (UN-Habitat 2013, cited in EMBARQ 2013, p.9) as exemplified in the BRT systems in Bogota and Curitiba. Therefore, implementing a BRT system should be desirable for cities in the global south region plagued by the challenge of an automobile-dependent mobility pattern especially in view of the comparatively low cost required achieving a marked level of efficiency in passenger mobility. Importantly, in view of the short terms of election cycle of the political office holders (decision makers) who usually desire to initiate and complete such a project within their term of office for political campaign purposes, the BRT initiative should be an appropriate option.

5.4.3 Empirical Evidence on the Application of Congestion Pricing

Increasingly, there is a consensus amongst economists that congestion pricing represents the single most viable and sustainable approach to de-leverage traffic congestion and its related challenges (US DOT, 2006, p.1). Accordingly, application of congestion pricing is becoming popular with exemplary cases in Singapore, London and Stockholm. The application of congestion pricing in Tehran remain one of the good examples within the global south region (Allen, 2013 p.18; Shoar, 2008 p.151 Hashemi

and Jalali 2012, p.12) and its implementation is known to have helped achieve a marked improvement in traffic flow and air quality.

5.4.3.1 Singapore, Republic of Singapore

Singapore remains the watershed for road pricing system (congestion pricing) and had its inception in 1975 (Keong, 2002, p.2). The system has gained incremental improvement over time. The Singapore model of congestion pricing was designed as a ring (cordon) that engulfs the Central Business District. In the account of Bhatt et al. (2008, p.1), the ring is tagged as a “Restricted Zone” (RZ) covering an area of 2 square miles (3.2km²) (See Figure 5-39).



Source: Adapted from Bhatt et al. (2008 p.5).

Figure 5-39: CBD Priced Zone in Singapore.

The fundamental goal of the restricted zone and the congestion pricing regime is to strike a balance between the cost of vehicle ownership and usage in order to realize a more equitable system (Keong 2002, p.2; Suzuki et al., 2013, p.72). In essence, private car users are made to pay the full cost of owning and using private car; this is to prevent users on transit and non-motorized modes from becoming disadvantaged.

In 1998, the manually operated Area License Scheme/Road Pricing Scheme (ALS/RPS) was upgraded to Electronic Road Pricing (ERP) (Bhatt et al., 2008 p.1f; Keong, 2002 p.2; Suzuki et al. 2013, p.72; Schipper et al. 2007, p.1716). The ERP involves the use of an In-Vehicle Unit (IU) or transponder fitted on a vehicle’s dashboard; this ensures that the road users are charged electronically for entering the Restricted Zone (Bhatt et al., 2008 p.; Keong, 2002 p.2). The operation of the ERP is driven by three components; the IU and the stored-value smart card installed in the vehicle (antennae, vehicle detectors and enforcement camera systems are installed at the on-site ERP gantries) and servers, monitoring the system with a master clock installed at the control centre (Keong 2002 p.6).

Evidently, all these three components are required to be linked to each other seamlessly and to work in tandem to ensure efficient enforcement and monitoring of the system in order to avoid any errors.

As indicated by Bhatt et al. (2008 p.2), Herczeg (2011 p.3) and Keong (2002 p.2), the operating hours of the Singapore congestion pricing system ranges between 7:00am to 7:00pm (Monday through to Friday) with a charging fee varying between zero to approximately US\$2 per crossing of the cordon line. The charging fee is known to vary with the intensity of traffic and a hike in fee during peak hours is expected to prevent huge SOV commute during peak hours. The charged fee also varies by location, time-of-day and vehicle type. However, some exemptions from the congestion charge are made for some categories of vehicle. These include buses, motorcycles, police vehicles and High Occupancy Vehicles (HOV 4+) i.e. vehicles occupied by four and more passengers. Table 5-5 below summarizes the impact of Singapore’s congestion pricing system on mobility and the environment.

Table 5-5: Impacts of Singapore Congestion Pricing on Mobility and the Environment

Description of the System	Impacts on Mobility and Environment
<ul style="list-style-type: none"> -Hours of operation is effective from 7:00am to 7:00pm on weekdays - The charge per crossing the cordon is US\$2 (up to US\$4 on expressways) -Full electronic charging was implemented in 1998 - Buses, motorcycles, police vehicles and High Occupants Vehicle (HOV 4+) are exempted from paying charging fees. 	<ul style="list-style-type: none"> -13-24% reduction in traffic volume - average speed increased by 22% (10-15kph) -improved pedestrian safety and reduced CO₂ emissions -73% decline in car entries into the RZ -46% bus share increase -19% HOV 4+ share increase -commuter trips within the RZ increased by 42% 13% increase in traffic volume before 7:00am (when the enforcement of the congestion pricing commences) -25% decline in through traffic using the RZ in the morning -vehicle population reduced from 6% in 1997 to less than 3% in 2010

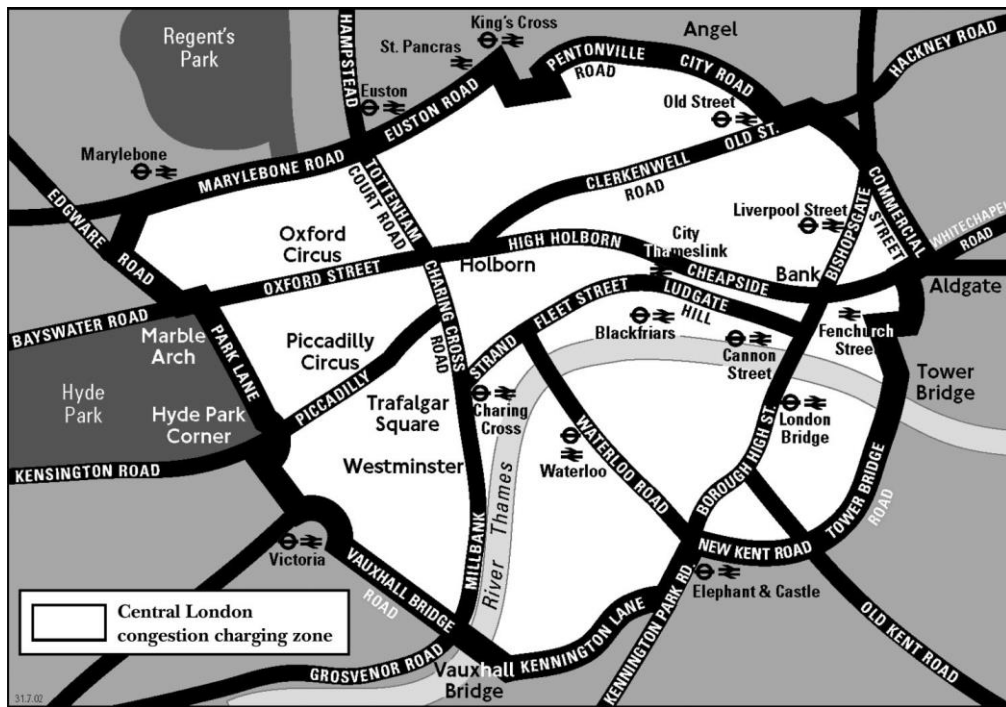
Source: Bhatt et al. (2008 p.2), Herczeg, (2011 p.3), Keong (2002 p.2), Suzuki et al. (2013 p.72), and US DOT (2006 p.7).

According to Bhatt et al. (2008 p.9f), the congestion pricing system in Singapore accounts for a marked level of impact because the system is backed by public support. Indeed, the illustrated savings expressed in reduced traffic volume, increased vehicle speed, reduced CO₂ emissions, enhanced pedestrian safety, and increase in bus modal share, reveal that congestion pricing can be efficient tool of immense utility in addressing the challenges of car proliferation and its related externalities.

5.4.3.2 London, United Kingdom

The London congestion pricing system owes its origin to its mayor, Ken Livingstone, in 2003. Amidst criticism from skeptics, the mayor recognized the dire need to address the proliferation of Single Occupant Vehicles (SOV) and the related challenges of traffic congestion in Central London.

As recorded in the studies of Litman (2011, p.2) and Leape (2006, p.160), the congestion pricing regime covered Central London (See Figure 5-40).

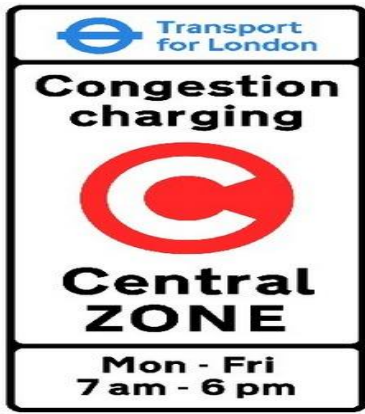


Source: Adapted from Leape, (2006 p.162).

Figure 5-40: The congestion charging area of Central London.

On weekdays between the hours of 7.00am and 6.30pm, motorists passing into the restricted zone are charged £5. This was increased to £8 in July 2005. Vehicles exempted from the congestion charge include motorcycles, licensed taxis, vehicles used by disabled people, some alternative fuel vehicles, buses and emergency vehicles. Residents in the charge zone get a 90% discount on annual passes (Litman 2011, p.2) The congestion pricing programme has not only enjoyed the support of the public and interest groups (including many opponents that initially criticized it) but residents of other areas in London have called for inclusion in the congestion pricing regime.

The central London charging area is indicated by signs and symbols on the roadsides and the roadways respectively (Litman, 2011. p. 2). In order to track a default driver, one of more than 700 vulture-like video cameras (See Figures 5-41 – 5-44) perched throughout the charging zone captures the license plate number of vehicles crossing into the defined restriction zone. The information is relayed to a computer database and, if applicable, the fine for the motorist is generated (Kennedy, 2003 cited in Litman, 2011. p.4).



Source: Adapted from Litman, (2011 p.3).

Figure 5-41: Signage for congestion charge zone.



Source: Adapted from Litman, (2011 p.3).

Figure 5-42: Symbol of a congestion charge zone.



Source: Adapted from Litman, (2011 p.3).

Figure 5-43: Signage of camera indicating congestion charging zone



Source: Adapted from Litman, (2011 p.3).

Figure 5-44: Typical view of congestion charging video cameras

Although there are no toll booths around the charging zone, payment of the charge can be made via a variety of payment mechanisms including retail outlets, kiosks, by telephone, online payment, and by text message using cell phones.

As observed by Litman (2011, p.4), the London congestion pricing regime is considered sub-optimal in the following regards:

- (i). The fee is not based on how many miles a vehicle is driven within the charging area.
- (ii). The fee is not time-variable, that is, the fee is not higher during the most congested periods and lower during less congested periods.

(iii). The fee does not vary by location. It would be more efficient to have higher rates on more congested roads.

(iv). The system has relatively high overhead costs.

(v). Transit service (particularly the tube) is crowded and unreliable, although congestion pricing revenue is invested to upgrade the system.

Nonetheless, the study by Litman (2011 p.11) and Beevers and Carslaw (2004, p.5) show that, in the first few months of the programme, it recorded a 20% decline in private car traffic (an equivalent of about 20,000 vehicles daily), leading to 10% automobile mode share (see Table 5-6).

Table 5-6: London congestion pricing and its impact on mobility and environment

Description of the System	Impacts on Mobility and Environment
<p>-Hours of operation is effective from 07:00am to 18:30pm on week days</p> <p>-The Charge for vehicles crossing the cordon is £8, for unauthorized vehicles entering or travelling within the charging zone</p> <p>-Residents of the zone get 90% discount for purchasing annual pass permit</p>	<p>-Number of vehicles declined by 18%</p> <p>-Traffic delays reduce by 25%</p> <p>-Change to public transport and car share</p> <p>- 7%-15% decrease of NO₂, CO₂ and Particulate Matter 10 emissions.</p> <p>-30% increase in travel speed</p> <p>-40% increase in bus ridership</p> <p>-14% decline in journey time</p>

Source: Bhatt et al. (2008, p.14), Herzog, (2011, p.3).

To sum up, the congestion pricing regime in London has had tremendous impacts on the social, economic and environmental facets in central London. Evident improvements have been recorded in speed during peak hours, a modal shift and improved air quality. The unintended consequence resulting from the reduced level of private car trips was some negative impact on some economic activities such as bulk goods' retailers who recorded a significant decline in sales during the first few months of the programme.

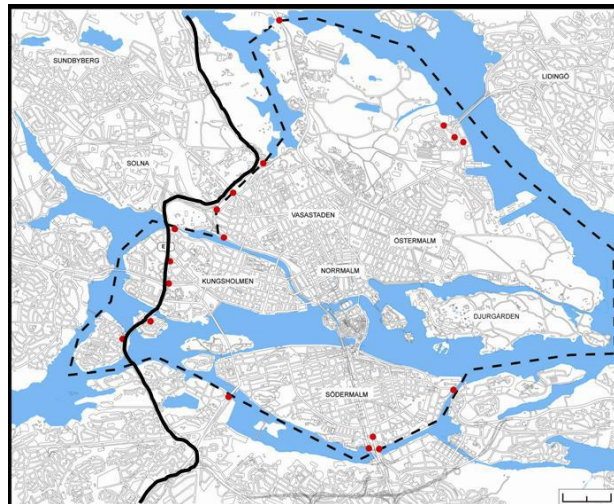
Thus it can be said that the illustrated savings show that congestion pricing is a viable tool, firstly, for addressing the challenges of the proliferation of private cars (and their externalities such as loss of productive time and fuel wastage due to increased travel time caused by traffic congestion); secondly, it is useful for deleveraging transport-related GHG emissions.

5.4.3.3 Stockholm, Sweden

In recognition of the increasing proliferation of private cars and the implicit challenges of traffic congestion, a congestion pricing regime commenced in Stockholm. It was introduced in 2006 as an experimental scheme scheduled for six months and was, therefore, halted in August 2006 (Eliasson, 2008).

The result of the referendum held in August 2007 on the introduction of congestion pricing favoured the full implementation of the congestion pricing regime (Borjesson et al. (2012, p.2), Eliasson (2008, p.1). This outcome was, no doubt, consequent upon the improvement in travel time and reduced congestion level recorded from the period of experimentation with the congestion pricing system and upon the acceptance of the congestion pricing system by skeptics.

In Stockholm, the congestion pricing zone is defined by a cordon ring engulfing the inner city of Stockholm with levies paid by private cars crossing into the cordon zone (See Figure 5-45). The dotted line defines the congestion zone, while the red dots totaling eighteen (18) denote the toll points. The solid line represents the non-charged Essinge By-pass (Borjesson et al. 2012, p.3; Eliasson 2008, p.7).



Source: Adapted from Eliasson, (2008 p.7).

Figure 5-45: Stockholm congestion charge zone.

The levies charged for passage into the congestion pricing zone is operational on weekdays between the hours of 06:30am to 6:30pm with no charges levied in the evenings, nights, Saturdays and Sundays, public holidays and days before public holidays. However, some vehicles are exempted from the congestion charge; these include taxis, buses, alternative-fuel cars and vehicles using the by-pass from and to the Island of Lingo. According to the studies of Borjesson et al. (2012, p.3) and Eliasson (2008, p.7), the maximum total charge for a daily pass is €6. The charge is €2 at peak hours (07:30am-08:30am and 16:30pm-17:30pm), €1.5 during the peak shoulder periods (30 minutes before and after peak period) and €1 during the rest of the time.

According to the study of Herczeg (2011, p.2), the primary objective of the Stockholm congestion pricing regime was to reduce transport-related CO₂ emissions and improve environmental quality, these objectives are evidently being realized. Other co-benefits which include an expansion of public transport infrastructure have been possible from the revenues realized from the congestion pricing system. A summary of the characteristics and benefits of the Stockholm congestion pricing system is highlighted in the Table 5-7 below.

Table 5-7: Characteristics and benefits of the Stockholm congestion pricing.

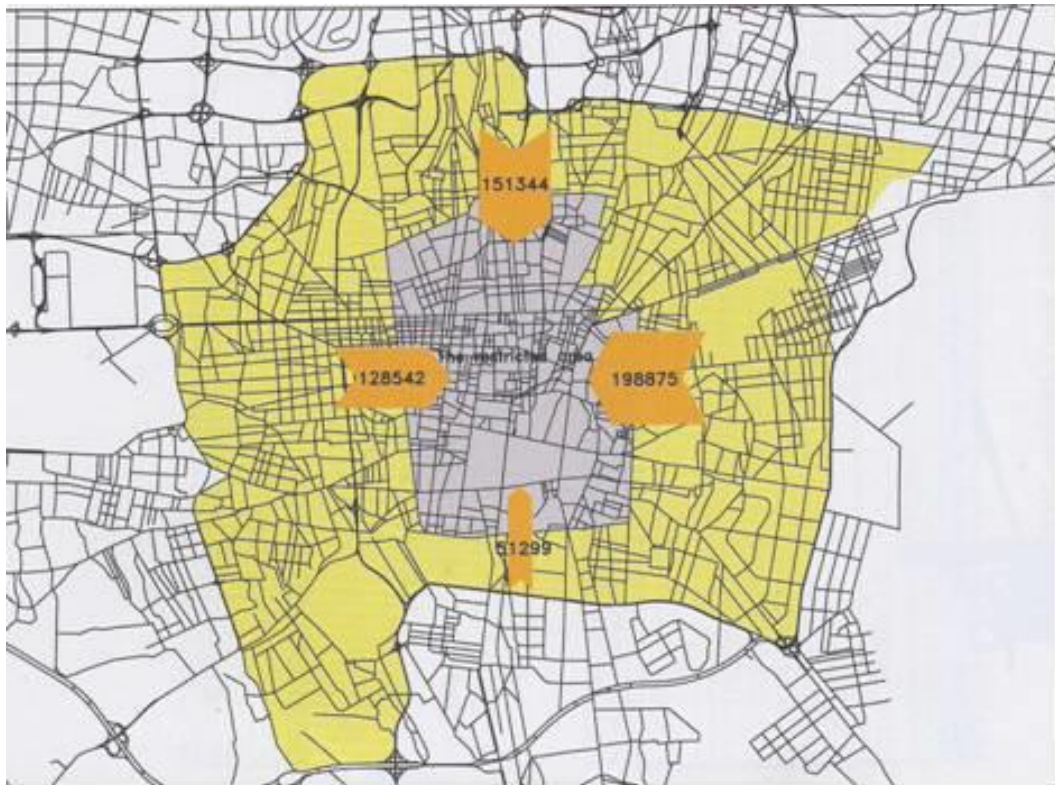
Description of the System	Implication on Mobility and Environment
<ul style="list-style-type: none"> -Hours of operation is effective from 06:30am to 6:30pm on weekdays -Charge is €1, €1.5 and €2 per crossings in different time periods, with a maximum of €6 charged daily - Taxis and buses are exempted -Hybrid vehicles were exempted until the end of 2008 	<ul style="list-style-type: none"> -Traffic declined by 10-15% -20-25% drop in traffic volume of most congested roads -14% reduction in vehicle distance travelled in the congestion zone -Public transportation use increased by 6-9% - 9% rise in hybrid vehicles entering the zone -10-14% reduction of CO₂ emissions (nationwide 2-3%) and 7-9% reduction of other emissions. -50% increase in modal shift from car to transit

Source: Bhatt et al. (2008, p.22) Herczeg, (2011 p.3).

Notwithstanding the gains made by the congestion pricing regime in Stockholm, it has been criticized on the grounds of being inequitable and favouring the affluent car users who can afford the levy and, thus, places economic burden on neighbouring communities and it negatively impacts on some retail businesses (Borjesson et al. 2011, Eliasson 2008, Herczeg 2011 p.3). In order to achieve an efficient congestion pricing system, it is important that the system is properly planned to involve and engage all stakeholders relevant to the congestion pricing system so as to prevent unintended consequences.

5.4.3.4 Tehran, Iran

In recognition of the dire need to address the challenge of traffic congestion and to improve the air quality resulting from transport-related air pollution, the authorities in Tehran defined a congestion charging zone tagged the “Restricted Traffic Zone” (RTZ) in 1981. The studies of Allen (2013, p.18) and Shoar (2008, p.15) show that the RTZ engulfs the inner Central Business District (CBD) of Tehran; the cordon initially measured about 19km² and later extended to cover 31km² of the area of the city (see Figure 5-46).



Source: Adapted from Shoar, (2008, p.53).

Figure 5-46: Existing Restricted Traffic Zone in Tehran.

The congestion pricing system was initially monitored manually by police officers stationed at the 65 gateway entrance into the charge zone. This proved to be quite ineffective as was evident in the over 35% rate of violations recorded (an equivalent of 159,000 vehicles) (Hashemi and Jalali 2012, p.12). Recognizing this sub-optimal performance, the authority has reformed the system. Currently, the system is monitored by automated speed cameras spread across the 105 gateway entrances into the charge zone which are equipped with Automatic Number Plate Recognition (ANPR) (Allen, 2013, p.18; Behrooz et al. 2013, p.7; Shoar, 2008, p.18; Hashemi and Jalali 2012, cited in ITDP 2012, p.12). With this reform, the number of defaulters has reduced remarkably.

In order to create awareness for road users of the congestion pricing system, there are symbols and signage of the video cameras at the entrance points into the RTZ informing drivers of proximity to the RTZ (see Figure 5-47).



Source: 2.bp.blogspot.com (2013).

Figure 5-47: Signage of entrance point to the RTZ including an image of a video camera.

According to Behrooz et al. (2013, p.7), every unauthorized entry into the RTZ is recorded by designated video cameras capturing the number plate of vehicles for appropriate sanction. Available records show that over 17,000 daily unauthorized entries are recognized by the video cameras mounted at the various entry points into the RTZ. A study by Shoar (2008, p.17) shows that the fee charged for entry into the RTZ varies from US\$11 for a day pass to US\$69 for a week long pass, and US\$174 for an annual pass. Regular road users who make an advanced payment for pass get a considerable discount.

A study by Hashemi and Jalali, (2012, cited in ITDP 2012 p.13) shows that the implementation of congestion pricing by implementing the RTZ cordon in Tehran has achieved the set objectives of a reduction in traffic congestion and an improvement in air quality, but the extent of the savings is not illustrated by data. It is also important to properly plan a congestion pricing system, to prevent unintended consequences, by properly sensitizing and engaging stakeholders relevant to the efficient implementation of the congestion pricing system in order to ensure that set target of transforming mobility in cities is achieved.

To sum up, a common theme running through all the case studies on the implementation of congestion pricing show that its implementation has contributed to a reduction in traffic congestion (and consequent reduction in travel time), a reduction in fuel usage due to reduced vehicle activities, and a reduction in transport-related air pollution and CO₂ emissions. The system also generates revenue that can be used to expand public transport infrastructure. The system can also be used as a tool/mechanism for optimizing the operation of transit operation by attracting ridership to transit, by

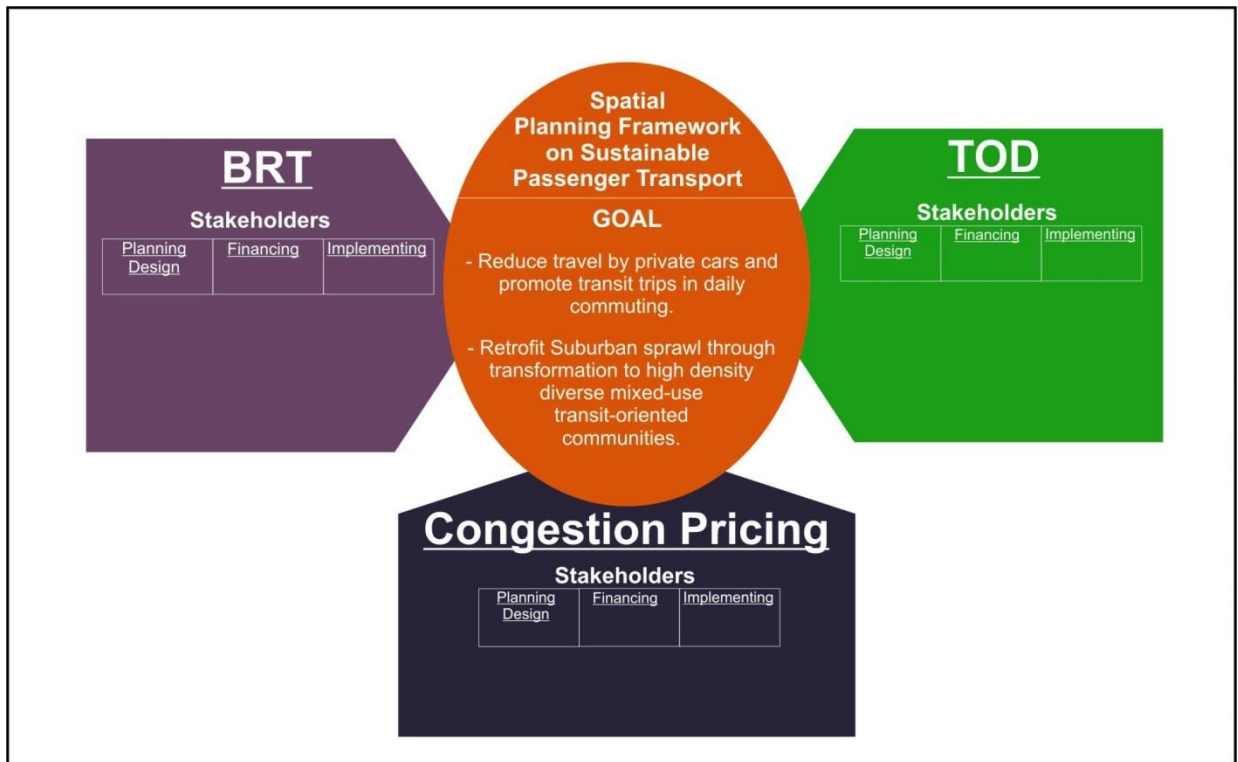
achieving a modal shift from car trips towards transit trips and by lessening the volume of daily motorized trips.

As a recap, while on one hand the preliminary analyses in Section 5.2 has suggested the appropriateness of TOD strategy to reform the sprawling spatial form in cities, BRT as rapid transit infrastructure to reform unreliable fragmented public transport system, and congestion pricing as TDM strategy to dis-incentivize private car proliferation and usage. On the other hand, the analyses in Section 5.3 and 5.4 provide detailed explanation of substantial empirical evidence of character and performance capabilities of these strategies to the explicated problem of traffic congestion and suburban sprawl in cities.

Consequently, it is evident from the analyses of these case studies, that the single application of either of these strategies in the various cities have produce some good result with impact on reduction of private car usage and related challenges of traffic congestion, delayed travel time, fuel wastage and transport-related CO₂ emission in cities. However, this single application of these strategies has not been sufficient to address all the deep-rooted ills and ramification of traffic congestion (suburban sprawl car-dependent mobility pattern). These therefore call for more innovative solutions/approach beyond the existing usual practice.

5.5 Designing and Developing the Artefact for Solving the Explicated Problem

In view of the detailed explanation of the character and performance capabilities of the TOD, BRT and Congestion Pricing strategies in this chapter, it is therefore the contention of this study that the required solution may require the innovative combination of a hybrid integrated solution of TOD, BRT and Congestion Pricing strategies. This contention is premised on the argument that synergetic impacts of the combination of the three strategies can provide a broad spectrum solution that can be sufficient to address the explicated problem of traffic congestion and suburban sprawl, and to produce optimal urban planning outcomes. This hybrid solution encapsulated into a spatial planning framework is therefore the artefact developed in this study to address the explicated research problem. The spatial planning framework is necessitated here, as the existing planning system in global south cities has not been sufficient to realize optimal urban planning objectives in view of pre-existing challenges focused on in this study. This existing planning system may not provide the requisite vehicle for delivery of these strategies, hence the spatial planning framework.



Source: Author's Analysis, 2013.

Figure 5-48: Spatial Planning Framework for the Developed Spatial Planning strategies (BRT, TOD and Congestion Pricing)

Within the context of the Design Science research strategy adopted in this study, the artefact (spatial planning framework for TOD, BRT and Congestion Pricing strategies) as developed in this chapter serves as the new solution that has shown indication of potential capacity to solve the explicated problem efficiently than current solution/practice. The artefact therefore shows how the 3 strategies would be combined to fulfill the defined requirements and address the explicated problem of traffic congestion and suburban sprawl in rapidly urbanizing global south cities.

The combined application of three unique yet related spatial planning strategies may require reforms to leverage the capacity of existing institutional arrangements in order to permit effective collaboration and coordination amongst the stakeholders and sectors relevant to the various facets of the three strategies.

The requirement for the adoption and institutionalization of the developed solution is the development of a framework at core of which is the strategic visions plan and therefore defines the processes, and actors require to achieve the framework. The framework outlines the institutional arrangement comprising of the key strategies (BRT, TOD, Congestion Pricing) and stakeholders/actors (planning/design, financing, implementing and linkages between the actors relevant to the framework). According to the Plymouth City Council (2014), the spatial planning framework serves as the delivery vehicle for the implementation of the related spatial planning

strategies. The framework therefore depicts a concrete theme in the institutionalization of spatial planning approach as reform to the existing urban planning system.

The capacity of the spatial planning framework to provide the premise for sectoral integration, avoidance of restrictive bureaucratic practices and platform for stakeholder-driven approach may help ensure the realization of the objective of the integrated solution/artefact. Since democratic culture of urban planning and stakeholder engagement is unpopular in global south cities, it may be slow to permeate the space governance fabric in global south cities; this may reduce the chances of success of the reforms using spatial planning approach. However, earlier studies do indicate that when community/users are engaged in defining the objectives and implementation of a strategic intervention/programme the feeling of ownership and social capital is generated and therefore contribute to making such programme likely to be successful. By this, the chances of the success of this artefact may be higher under the spatial planning regime in view of its capacity for stakeholder engagement.

In view of the contextualization of the research problem using the case city-Abuja in Chapter 3, the identified spatial planning strategies and the developed spatial planning framework as the Artefact in this chapter may be best understood when contextualized using a case city. Within the context of Design Science research strategy adopted for this study, the next two chapters focus on the Demonstrate Artefact phase, and Evaluate Artefact phase, the investigations in these chapters therefore substantial focus on the city of Abuja as the selected case.

As a recap, the novelty of this study lies in part in the creation of new knowledge which can be viewed from the strategic response of the developed spatial planning framework which encapsulates BRT, TOD, and Congestion Pricing strategies as a package of strategies to address the explicated problems of traffic congestion and suburban sprawl, and equally mitigate the institutional barriers to the implementation of the package of strategies. The strategic response is especially in response to the peculiarity of the extra barriers/challenges in global south cities which seldom exist elsewhere.

The peculiarity of the extra barriers/challenges observed in the case-city include government restrictive bureaucratic practices, lack of sectoral integration and collaboration, weak implementation of plan, long range and technocratic driven planning goal and objectives, weak organizational capacity, obsolete planning documents, and political interference in the implementation of urban plans. These challenges may be inhibitive to the successful deployment of the developed package of strategies in the case-city, not only because the components of the intervention are new in this case-city, but especially because existing un-democratic planning ethos may present difficulty to permit the new regime. The new regime with the developed package spatial planning framework requires inclusiveness, joining-up sectors, sectoral integration, capacity building and removal of restrictive bureaucratic practices. By this,

immediate acceptance of the developed package of strategies may be difficult to permeate the cities' fabric, what may be achieved may rather be a gradual and evolutionary process, and not an immediate acceptance.

The methodology adopted to gather evidence about how the challenges of traffic congestion and suburban sprawl, and the institutional barriers to implementing the developed package of strategies can be overcome was based on document review of relevant case reviews of earlier studies, and formal study reports, on the various approach/strategies for addressing the challenges of traffic congestion and suburban sprawl, including institutional reforms. The content analysis of these documents revealed detailed technical specification and guidance on how transit infrastructure such as metro, LRT, and BRT, has been adopted to address car proliferation and traffic congestion. It also elicits on how TOD and related strategies are used to encourage transit ridership and reduced car usage. It also elucidate on how disincentive mechanisms such as Congestion Pricing, metered-parking are used to deter car proliferation and stem traffic congestion level. The performance capabilities of the various array of strategies provided the evidence to suggest that the identified challenges in these cities can be overcome when these strategies are deployed appropriately.

The approach adopted for the integration of BRT, TOD, and Congestion Pricing as a package of strategies was drawn from document reviews. The content analysis of the documents reviewed show that the single intervention with transit infrastructure as metro, LRT or BRT have not been enough to curb the challenges of traffic congestion, and that the incentives presented by such strategy as TOD has the capacity to incentivize transit ridership due to proximity of commuters to transit station. These include the co-benefit to stem the trend of urban sprawl and improve quality of living in transit communities. Further, evidence shows that without such disincentive offered by Congestion Pricing strategy, motorists may still continue to commute via private cars. The potential impacts of the individual strategies provided the premise to suggest the integration of the three strategies in order to achieve combined synergetic effect that can be credible at addressing the deep-rooted ills of traffic congestion and suburban sprawl. The combination/integration of the strategies using a spatial planning framework was therefore suggested as the premise to reform institutional barriers and serve as the delivery vehicle for the deployment of the package of strategies.

5.6 Summary

The primary focus of this chapter is the Design and Development of an artefact/solution for addressing the problem of traffic congestion resulting from car-dependent mobility pattern and suburban sprawl in global south cities. The case reviews of earlier studies have shown indication that the single application of these strategies have recorded some level of success but have not been sufficient to solve all the complex deep-rooted ills of traffic congestion and suburban sprawl. Consequent upon the illustrated impacts of the single application of the strategies as shown in the

reported cases by earlier studies, it is therefore the contention of this study that these strategies are not mutually exclusive but rather complementary spatial planning intervention. By this, the sum of their impacts can outweigh their individual impact. The summary of the list of solution as selected component of the Artefact and the justification for the choice of the Artefact is presented below in Table 5-8.

Table 5-8: Summary of Solutions Accepted as Components of the Artefact

S/N	Components of the Research Problem	Defined Requirements	Solutions Accepted as Component of the Artefact	Justification for the Choice of Solution as Component of the Artefact
a.	Huge volume of daily motorized trips, traffic congestion and increased travel time for commuters	<ul style="list-style-type: none"> i. Reduced volume of motorized trips ii. Reduced level of traffic congestion iii. Reduced length of travel time iv. Deter the proliferation of car usage 	<ul style="list-style-type: none"> i. Restructure modal share in favour of transit trips ii. Application of Rapid Transit System of BRT to reduce travel time and encourage more transit trips i. Application of Congestion Pricing System to deter proliferation of car usage 	<ul style="list-style-type: none"> i. Engineering solution of road expansion to solve traffic problems has not worked, hence the need for alternative strategies of efficient rapid transit system ii. BRT was chosen as the rapid transit system because of its comparative efficiency gains in terms of travel speed, ridership capacity, convenience, less cost of infrastructure, and less time of implementation i. In the absence of TDM measure that imposes additional cost as deterrent on motorist, car proliferation and related impacts is imminent ii. Congestion Pricing as TDM strategy that impact significantly on cost of car usage can deter excessive car usage and proliferation and also spur choice riders from car commuting to transit trips
b.	Increasing trend of transport-related challenges such as time loss, fuel loss and CO ₂ emission	<ul style="list-style-type: none"> i. Reduced level of transport-related impacts (time loss, fuel loss, CO₂ emission) 	<ul style="list-style-type: none"> i. Application of Congestion Pricing System to deter proliferation of car usage 	<ul style="list-style-type: none"> i. BRT was chosen as the rapid transit system because of its comparative efficiency gains in terms of travel speed, ridership capacity, convenience, less cost of infrastructure, and less time of implementation. ii. The cost of BRT system is in the region of 1/10 of the cost of LRT and metro rapid transit system.
c.	Ineffective public transport characterized by mini-buses which struggles to move commuters daily	<ul style="list-style-type: none"> i. Moving more commuters in less number of motorized vehicles 	<ul style="list-style-type: none"> i. Application of Rapid Transit System of BRT with high capacity 160-250 articulated and bi-articulated buses 	<ul style="list-style-type: none"> i. Urban renewal intervention can improve living condition of an area but would require green field development. However, TOD strategy has the triple benefit of improving living condition, using land efficiently and enhancing convenience of commuters due to proximity to transit corridor which therefore enhance and optimizes transit operation
d.	Increasing trend of suburban sprawl and inefficient use of land evident in extensive spatial pattern of development make people live further away from core-city, and increases commuting distances	<ul style="list-style-type: none"> i. Transform suburban development into smart compact spatial pattern in order to reduced sprawl ii. Diverse mixed use community that make more people live near transit iii. Reduced need to travel by car 	<ul style="list-style-type: none"> i. Application of TOD strategy to achieve diverse mixed use community with reduced need for long travels, and located along transit corridor to ensure access to rapid transit for long trips (intra-city) 	<ul style="list-style-type: none"> i. The spatial planning framework and combined application of TOD, BRT and Congestion Pricing strategies indicates the capacity to efficiently address the challenges of traffic congestion and suburban sprawl ii. The planning procedures implicit in the spatial planning approach indicate capacity for sectoral integration, stakeholder and inclusive engagement, and avoidance of restrictive bureaucratic practices, these features are imperative to realizing timely and efficient urban planning outcomes.
e.	Ineffective planning system and weak institutional capacities of current urban planning organization which cannot cope with the complex challenges of traffic congestion and suburban sprawl in global south cities	<ul style="list-style-type: none"> i. Appropriate and responsive urban planning system that can address complex challenges ii. Strong institution that can timely and effectively respond to complex urban planning challenges 	<ul style="list-style-type: none"> i. Framework for combined application of spatial planning strategies ii. Institutionalization of spatial planning framework to reform the existing urban planning organization and the related planning procedures 	<ul style="list-style-type: none"> i. The spatial planning framework and combined application of TOD, BRT and Congestion Pricing strategies indicates the capacity to efficiently address the challenges of traffic congestion and suburban sprawl ii. The planning procedures implicit in the spatial planning approach indicate capacity for sectoral integration, stakeholder and inclusive engagement, and avoidance of restrictive bureaucratic practices, these features are imperative to realizing timely and efficient urban planning outcomes.

Source: Author's Analysis, 2013.

In view of the details presented in Table 5-8 above it is therefore argued by this study that the combination of these spatial planning strategies have the capacity to lead to realization of more optimal outcomes and efficiency gains, hence a desirable planning goal that should be adopted in cities.

The combination of these three spatial planning strategies (BRT, TOD and TDM) into strategic programme as shown in Figure 5-48 is therefore the artefact developed in this study as fulfillment of the defined requirements and solution for addressing the explicated problem of traffic congestion and suburban sprawl in global south cities. The developed spatial planning framework and the relevant planning procedure were therefore explained. This chapter concludes by recognizing and stating the need to contextualize the developed artefact within the context of the selected case-city in order to have clear and in-depth understanding of how the developed artefact can work to address the explicated problem.

In line with the Design Science structure explained earlier, in Chapter 2 Section 2.4, what follows next is the Demonstrate Artefact phase and focuses on showing that the artefact can work to solve the explicated problem in a selected case. Put simply, this is where the proof-of-concept is illustrated. This is usually done by applying artefact to a selected case, and to document the extrapolated outcomes from the selected case (case-city).

These outcome usually show the extent which the artefact can address the explicated problem in the selected case. This provides the premise to argue that the artefact may produce similar outcomes in cities with similar features.

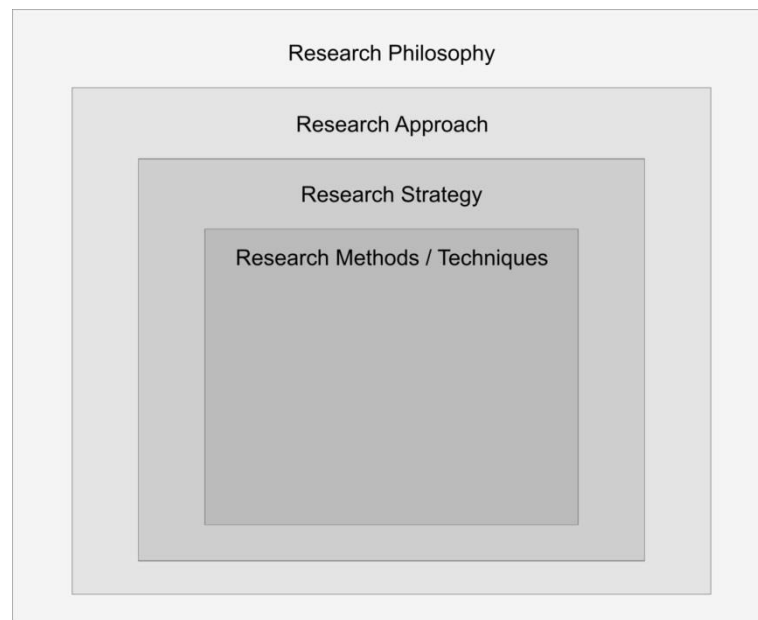
The demonstrated artefact and the related extrapolated outcomes provide the premise for research participants (expert urban planners) involved in the Evaluate Artefact phase to understand the artefact and make informed contributions as regard validating or invalidating the artefact. The input for both the Demonstration and Evaluation phase require empirically-based data sets from the selected case (case-city), the methodology for extracting these data set therefore require to be set out and explained. Therefore, the research methodology is the focus of the next chapter.

The next chapter focuses on the research methodology, the overall research philosophical leaning, including data led explanation of research approach research strategy, and research methods for realizing the set research objectives. The Design Science research strategy adopted provided the framework within which to explicate the research problems, develop a solution, demonstrate and evaluate the relevance and concreteness of the developed solution/artefact for addressing the explicated problems. The chapter consists of detail account of the data collection and analysis in this thesis.

CHAPTER 6: RESEARCH METHODOLOGY

6.1 Philosophy of Knowledge

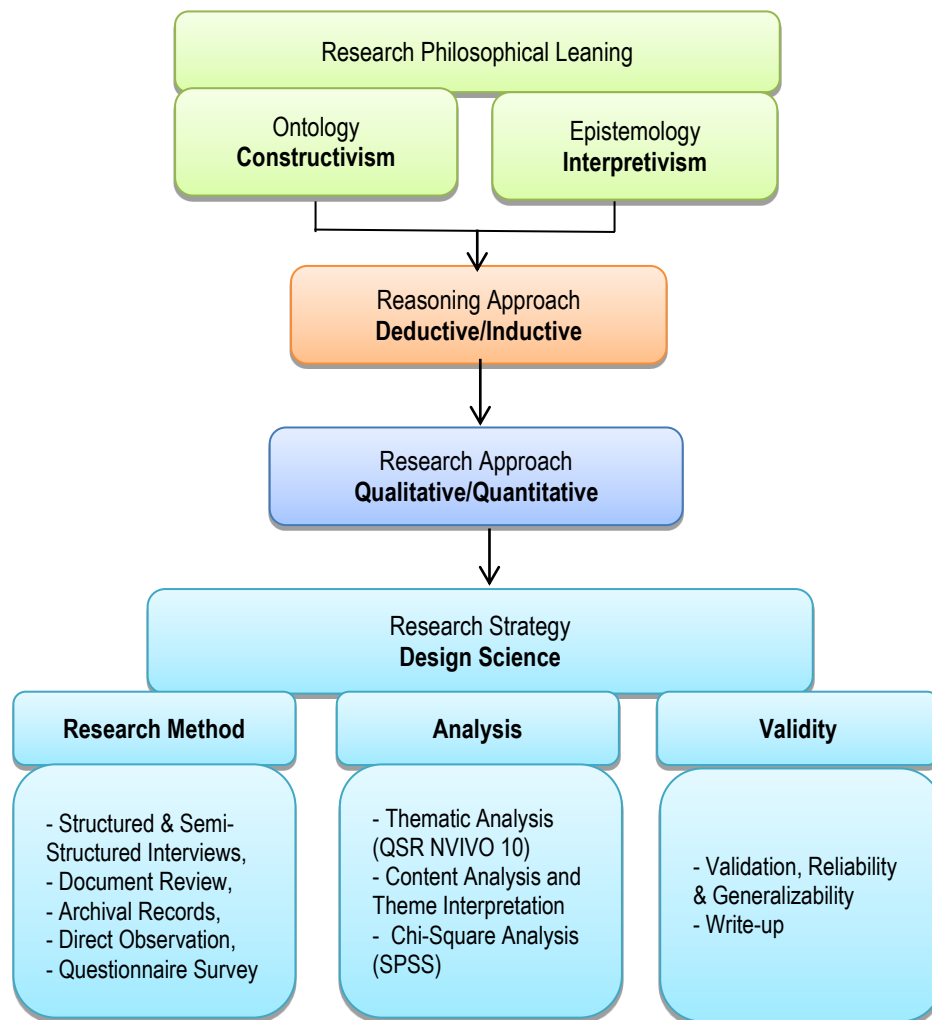
Research methodology represents a procedural framework guiding the logical thought processes in the design and execution of a scientific inquiry (Fellows and Liu 1997, Descombe 2007, p.109). The framework encapsulates several interrelated elements that include the research philosophy, research approach/reasoning, research strategy and research methods (Kaglioglou, 1998; Keraminiyage, 2009) (See Figure 6-1). This framework shows a general outlook of the procedures in the research process. Therefore, it suffices to describe research methodology as the overall framework for achieving the aim, objectives, and research questions in a study.



Source: Adapted from Kaglioglou et al. (1998), Saunders et al. (2007), Descombe (2007), and Keraminiyage (2009), emphasis added by Author (2013).

Figure 6-1: The Research Methodology Framework

As illustrated in Figure 6-1, the research methodology framework shows that the research philosophy defines the underlying assumptions in research and therefore informs the research approach and reasoning. The research strategy is in turn shaped and informed by the research approach/reasoning, while the research methods are informed by the research strategy. Detailed explanation of these research methodology elements as regards their specific relevance to this study are discussed in Figure 6-2 and Section 6-2 below.



Source: Grix (2002), Descombe (2007), Creswell (2009), Yin (2009), Freimuth (2009), and Egbu (2013), emphasis added by Author, (2013).

Figure 6-2: The Adapted Research Methodology Framework.

6.2 Research Philosophical Leaning

Philosophy is here used to refer to the rational investigation of questions about existence, knowledge and ethics (Webster Dictionary, 2013). It could also mean the premise by which a particular phenomenon is explained, or any personal belief about how to deal with a situation. According to Creswell (1998), (2003) Saunders et al. (2007), philosophical assumptions in research stems from the worldviews that explains the rules of inquiry, methods that have been applied, or can be applied in the conduct of scientific inquiry. In this study, the worldviews, rules and guidelines of inquiry employed by past and present research in the urban planning, transport planning and sustainability fields is imperative and relevant to the overall research process.

In the works of Gray (2009) and Crotty (2003), it is argued that there exist inter-relationships between the two major research methodology philosophical branches namely ontology and epistemology. This is because ontological assumptions logically precedes and informs the epistemological assumption adopted in a research. A thorough understanding of this relationship is therefore imperative and will

ensure appropriateness in the choice of a researcher's philosophical assumption, approach, strategies and method(s) for a scientific inquiry.

6.2.1 Ontology

Ontology discusses the “claim” and assumptions that are made about the nature of reality which include; claims about what exist, what it looks like, what units make it up and how these units interact with each other (Guba and Lincoln 1994, Johannesson and Perjons, 2012). Simply put, ontology is a systematic account of existence. Therefore, a researcher's ontological position is his/her answer to the question about the nature of the reality to be investigated.

There are two major divergent ontological views which include the view based on, objectivism and those based on constructivism.

6.2.1.1 Objectivism

Objectivist ontological position asserts that social phenomena and their meanings have an existence that is independent of the consciousness and experience of social actors, and that these phenomenon and actors have objective truth and meaning residing in them as objects (Gray, 2009, and Johannesson and Perjons, 2012). Therefore, a careful (scientific) research can attain that objective truth and meaning.

With the classification of urban planning problems in cities as “Wicked and Dangerous” (Webber and Rittel, 1966), the inherent complex and dynamic interrelationship between these problems and actors continues to shape the challenges faced by cities. The complexity of these urban planning problems are continually shaped by practitioners (actors) and institutional norms, and are expressed in multifaceted effects that include increasing urban population and mobility demand with related impacts on traffic congestion, and sprawling spatial pattern of development.

In line with the objectivists' claim that reality and phenomenon exist independently of human actions and experiences (Johannesson and Perjons, 2012), it therefore holds that, explanation about this phenomenon in cities and the actors involved would be general and devoid of context. In view of the complex interplay between actors and the described phenomenon in cities (which are not objects), it may be difficult to gain complete insight, and explanation about these phenomena, and the subjective interpretation that the various actors have about the phenomena. Within the context of this study, the phenomenon under investigation is the complex problem of traffic congestion and suburban sprawl in cities shaped by the Master Plan approach in operation in global south cities. With the actors (participants) in this research being value-laden human subjects (urban planning practitioners), with multiple perceptions of the multi-faceted phenomenon under investigation, it may be inappropriate to base the claim of reality on the objectivist assumption.

In sum, this need for interaction between the “known” (actors) and the “knower” (researcher) in order to gain insight into the interpretation of the phenomenon by actors therefore, do not make the objectivists’ claim an appropriate ontological premise to position this study.

However, the objectivists’ assumption may be relevant in this study when used as a premise to test and explain the solution resulting from the inquiry process, at a later stage of the research process. This would be relevant by perceiving the resulting solution as the required alternative conceptual model and a singular objective reality (empirically tested solution) that is independent of social actors. Therefore, predictions can be made about possible relationships between the solution and the predicted performance by collecting and analyzing data and using result as a basis for generalization.

6.2.1.2 Constructivism

The constructivists opine that the world does not exist independent of human actions, and the experience of human observation is used to gain knowledge (cognition) of it (Creswell, 2009, Johannesson and Perjons, 2012). This constructivist claim of the subjective and multiple interpretations of experience and reality by the participants and researcher is premised on the recognition of the importance of temporality and context in understanding the phenomenon under investigation. By this, meaning and interpretation are rooted in time, space, cultures, and societies, and all these are not general. Therefore, the constructivist ontological assumption/claim of reality may be appropriate to the phenomenon under investigation, as it recognizes the different context inherent in the subjective multiple interpretations held by participants as regards the live experiences of the user group on the challenges of traffic congestion and suburban sprawl across cities, and the perspectives of the practitioners in shaping this phenomena. With the participants in this research being value-laden human subjects (urban planning practitioners), there exist multiple, sometimes contradictory, yet co-existent interpretations of the phenomenon under investigation (Cohen et al. 2000).

Therefore, the ontological claim in this research is that the phenomenon of traffic congestion and suburban sprawl in cities is a problem because the subjects/participants (users and practitioners) perceive and experience this phenomenon as a challenge; hence, their interpretation gives meaning to the phenomenon. Therefore, in this study, the central task of the researcher is to locate the research findings within the views of the self that the participants hold, and to identify the meanings which the participants accord to the phenomenon. By this, this study is therefore aligned to the constructivists’ ontological position especially because of the multi-faceted and multi-dimensional character of the phenomena, and the inherently different perspectives that depict multiple realities held by participants. This ontological assumption is also adopted as the premise in this study because previous writers (Litman, 1998; Rydin, 1993; Nadin, 2006; Shaw, 2009; Cullingworth, 2006; Newman and Kenworthy, 2000; Cervero, 1998; Breheny, 1996; Healey, 1997; amongst others) in this field of urban planning have expressed in their studies, the strong belief that urban planning and transport planning problems

are complex dynamic issues that are inter-related, with multiplier effects that ramify various social, economic, environmental fabrics. These previous studies are therefore found to be inclined towards more than mere observation of actors, but the interaction between the researcher and the actors in order to construct meanings from the interaction on the multi-disciplinary and multi-dimensional nature of this field of study.

6.2.2 Epistemology

Epistemology concerns the philosophical assumption for deciding how we know what we assume exists, and how meanings and knowledge are produced and legitimized (Crotty, 2003, Grix, 2001, Johannesson and Perjons, 2012). It therefore deals with the nature, scope and general basis of knowledge. Within the context of this study, the epistemic questions are; how can one know and understand the complex urban planning challenges of traffic congestion and suburban sprawl in view of the existing Master Planning system in global south cities?, how can one know and understand if there exist an alternative planning system?, and how can one know and understand the factors required to ensure the successful application of this alternative in global south cities?.

In line with illustration by earlier studies, the works of Grix (2001) and Hay (2001) posit that the epistemological positioning in research has two divergent views which consist of positivism at one end and interpretivism at the other end.

6.2.2.1 Positivism

The positivist stance is premised upon the argument that characterizes the scientific method of inquiry (of knowing) which posit that all theories must be tested against observations of the natural world, rather than relying solely on reasoning, cognition, intuition or revelation (Loose, 1993, Crotty, 2003, Descombe 2007, and Creswell 2009). By this, theories identified from literature need to be tested against observation of the natural world (social reality), using the field work of observation and measurement to provide the required data (evidence) for testing the theories.

It is important to note that the constructivists' ontological positioning in this study, posits that the claim to reality and the existence of the research problem (traffic congestion and suburban sprawl in global south cities) is premised upon evidence from the perception, construct and interpretation of these participants (urban planning practitioners). These participants are value-laden human subjects with bias and contradiction, and consisting of multiple interpretations of the phenomenon being investigated (Cohen et al. 2000, p. 27). Therefore in order to investigate, gain insight and knowledge into these subjective narratives and multiple interpretations of the participants, the responses from these participants need to be captured. The positivist approach assumes that these participants are objects with objective knowledge that can be explained through observation and experiments (Johannesson and Perjons, 2012), and therefore, requires that these narratives be reduced into narrow

pre-determined responses which might not be appropriate to accurately describe the participants' subjective multiple thoughts and responses to questions about the phenomenon variables. Therefore, the data set on the experiences and subjective interpretation of the participants' views is therefore more useful to interpretations rather than testing the cause-and-effect relationship and prediction of theoretical/conceptual constructs with data from observation in the field as basis for explanation.

However, with the solution resulting from the circumscription and iteration of the research process in this study, sampled responses representing the large number of users of the solution would be relevant to make statistical test and generalization about the predicted performance capabilities of the solution. This could be premised upon questionnaire survey of users' perception about the prediction of the utility of the solution for solving the problems of traffic congestion and suburban sprawl in global south cities. This analysis should show if the responses from the survey data occurred by chance or influenced by the predicted performance of the solution to solving the research problem.

6.2.2.2 Interpretivists

The linkage between ontology and epistemology has been explicated by various studies, while the objectivists are aligned to positivist epistemological position; the constructivists are aligned to the interpretivist's epistemic claims (Grix 2001, Guba 2004, Creswell 2009). Since this study is aligned towards the constructivist ontological position which posits that the realities and interpretation of the urban planning practitioners (actors/human subjects) to be investigated in this study are inherently flawed by their experiences, therefore, these experiences can be identified, deconstructed and interpreted by the researcher. Hence, truth and meaning do not exist in some external world but are from the literal creation of the inquiry process involving the subject's (participants) interaction with the world by the evaluation of facts presented before them (Al Zeera, 2001, p. xxiii, Krauss 2005, p. 761, Egbu 2013, Potter, 1996, and Bryman 2001, p. 12f, Johannesson and Perjons, 2012). The interpretivists therefore hold the belief that in order to know and understand this world of meaning, the researcher must interpret it.

This interpretation can provide insights and knowledge about all the dimensions of traffic congestion and suburban sprawl in view of the existing Master Planning approach in global south cities. Therefore, in view of the above consideration and with due considerations to studies conducted by present and past authors in urban planning, transport planning and sustainability, the epistemological claim for this study is premised upon the interpretivists' stance.

Even though bias is more of an operational issue in research (Potter, 1996, p. 42) and can be reduced (if not eliminated), Schwandt therefore argues that the researcher must clarify the process involved in the interpretation, construction of meaning, and clarify how the meanings are embodied in the language and actions of the actors (participants) (Schwandt, 2001). It is important to note that the bias

and value of the researcher come to bear on these interpretation and findings. The challenges in the separation of fact and value is acknowledged, this is because the values, perspectives, and paradigms of the researcher comes to bear as the researcher is a major data collection tool.

6.3 Research Approach

With reference to the research methodology framework illustrated in Figure 6.1 and explained in section 6.2, it was stated that the underlying philosophical assumption (ontological and epistemological position) in a research informs the research approach. Evidence from the works of Descombe (2007), Yin (2009), and Creswell (2009) identified the existence of quantitative, qualitative and mixed method approaches. These research approaches are also inter-connected with the inductive and deductive reasoning level.

6.3.1 Qualitative Research Approach

In view of the adoption of the constructivist ontological position and interpretivist epistemological position in this study, these divergent socially constructed meaning and narratives by actors (practitioners) of social or human phenomenon such as traffic congestion and suburban sprawl in cities may be best captured by qualitative approach (Yin, 2009, and Creswell, 2009, Lord, 2012). This is because it provides the opportunity for recording, analyzing and attempting to uncover the perspectives, interpretations, and deeper meaning and significance of human behaviour and experience, including contradictory beliefs, behaviours and emotions.

Qualitative research approach is characterized by several related research strategies which majorly include Case Studies (Yin 2009), Ethnography (Dawson 2009), Grounded Theory (Strauss and Corbin 1990); and Design Science (Vaishnavi and Kuechler 2009, Hevner et al. 2004, Johannesson and Perjons, 2012) amongst others. The inquiry in this study focuses on providing evidence which shows; how can one know and understand the complex urban planning challenges of traffic congestion and suburban sprawl in view of the existing Master Planning system in global south cities?; how can one know and understand if there is an alternative planning system?; how can one know and understand the factors required to ensure the successful application of this alternative in global south cities?

6.3.2 Quantitative Research Approach

Quantitative research approach is characterized by elaborate surveys, which employ such methods as questionnaires (Descombe 2007, Creswell 2009). The quantitative research approach is posited to be purview of the “positivist” or the “empiricist” research paradigm, which consist of hypothesis, quantitative experiments, and upon results of statistical analysis (Regression Analysis, Chi-Square Analysis, Spearman’s Rank Correlation Coefficient amongst others) the stated hypothesis are rejected or accepted (Grix 2001, Creswell 2009).

Quantitative research approach is employed in scientific inquiry in order to test a theory (scientifically proven existing body of knowledge) made up of variable, measured with numbers and analyzed using statistical tools to determine whether the prediction of the theory is true (Creswell 2003). The analysis enables the researcher to determine to what extent there exist relationships between two or more variables (Grix, 2001, Creswell, 2003, Descombe, 2007).

Within the context of this research, quantitative data would be relevant not in locating and capturing the different interpretation of the participants in understanding the dynamic complex multi-faceted nature of the research problem, but in order to test the solution resulting from the inquiry process. The level of performance and appropriateness of the identified spatial planning strategies solution as stated by the practitioners can be tested using data from users' perception survey of commuters and residents of suburban areas. The result from the analysis therefore should whether the resulting spatial planning strategies solution to traffic congestion and suburban sprawl can produce the same level of performance as predicted by the practitioners. The result therefore provided a premise for generalization of findings to other global south cities.

In this study, the combination of both qualitative and quantitative approaches was adopted. The questions posed above provided the basis for adopting a mix of these research approaches in order to home-in on data sets to facilitate robust findings in this study. These findings therefore contributed to elicit knowledge about the problem of traffic congestion and suburban sprawl, and the resulting spatial planning strategies solution in the field of urban planning, transport planning and sustainability.

6.4 Deductive and Inductive Reasoning

The reasoning approach adopted in a research refers to the logic of the research as shaped by the existing body of knowledge gathered in the literature review phase, the way researchers utilize the data collected and subsequent data analysis (Loose, 1993, Saunders et al. 2007, Egbu 2013). According to Descombe (2007), the reasoning approaches in research are majorly categorized as deductive or inductive. Most research project involves the application of both deductive and inductive reasoning at certain level and degree.

On one hand, the deductive approach applies where the process of inquiry is top-down; moving from general to specific (Loose, 1993, Saunders et al. 2007, Descombe 2007). By this, relevant theories relating to the phenomenon under investigation are identified and narrowed down to hypothesis that can be tested by analyzing quantitative data (Collis and Hussey 2003, Descombe 2007). On the other hand, inductive reasoning approach applies where the process of inquiry is bottom-up; moving from specific to general (Loose, 1993, Saunders et al. 2007, Descombe 2007). Here, observation and interpretation of empirical data provides the premise for drawing conclusions from the results, the findings is used to evaluate and refine the identified theories and concepts, and to make generalization.

The resulting conceptual solution in this study can be narrowed down/reduced into variables with hypothesis that can be tested by analyzing quantitative data from the user perception surveys of commuters and residents. The results from these statistical tests should lead to the rejection or acceptance of the hypothesis on the predicted performance of the conceptual solution (BRT, TOD and TDM) as relevant to addressing the research problem of traffic congestion and suburban sprawl in global south cities.

Within the context of the present study, a mix of the deductive and inductive approach of reasoning is adopted in order to efficiently investigate the phenomenon under consideration towards providing answers to the research questions. On the one hand, the inductive reasoning approach (theory building) was relevant to evolving concepts and strategies (spatial planning strategies of BRT, TOD and TDM) that are context-specific to the existing challenges of traffic congestion, suburban sprawl, and institutional deficiencies in global south cities. On the other hand, the deductive reasoning approach (theory testing) was critical to scanning through literature and empirical evidence to identify and deduce theories, concepts and strategies (globally) relevant to explaining and addressing the existing situation in global south cities including Abuja. It is also relevant to testing the predicted performance of the identified conceptual solution as a basis for generalization of findings.

6.5 Research Strategy

In line with the research framework adopted and illustrated in Figure 6.2 and Section 6.2, the research strategy in a study is predicated upon the research approach and reasoning approach. This therefore necessitates the search and adoption of a robust research strategy. In view of this, it is therefore imperative to identify an appropriate research strategy that can sufficiently capture and be able to explain the complex, dynamic multi-faceted challenges and solutions to traffic congestion, suburban sprawl and institutional deficiencies in global south cities including Abuja-Nigeria. It is important to note that the research question is also an important consideration which provides a bearing on the choice of research strategy, in order to provide data sources that can yield relevant data that provide answers to the research questions.

The works of Yin (2009), Descombe (2007), Creswell et al. (2011) and Vaishnavi and Kuechler (2008) identified various research strategies which majorly include Case Study, Ethnography, Experiment, Grounded Theory, Action Research, and Design Science amongst others. Upon a thorough review of the characteristic of these array of research strategies and in view of the research problems, the stated research questions, the philosophical assumptions and the imperatives of a mix of research approaches, this study adopts the *Design Science* research strategy because of its ability to cover a diverse spectrum of methods, and data sources that emerges from the mix of research approaches (qualitative/quantitative and deductive/inductive) in the inquiry process.

6.5.1 The Design Science Research Strategy

The studies by Hevner et al (2004), Vaishnavi and Kuechler (2008), and Johannesson and Perjons (2012) argue that the design science research provides opportunity to integrate the combination of both qualitative and quantitative research approaches towards producing artefact to solve practical real – life problems while contributing to empirical research process.

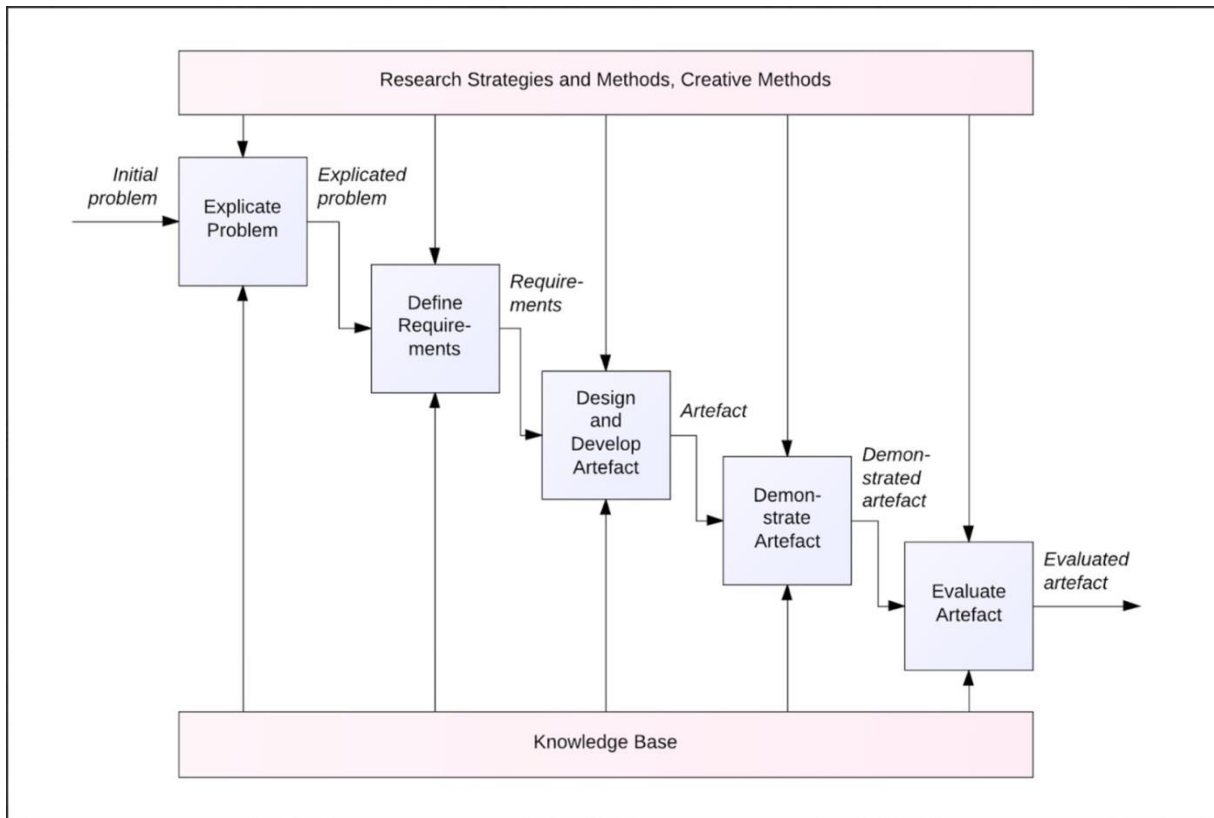
The Design Science research strategy is therefore relevant to this study because it presents the opportunity to establish the existence of the actual research problem, and develop a solution (artefact) that is relevant and generalizable for addressing the identified problems. This investigation focused on How and Why the existing Master Plan approach has created enabling environment for traffic congestion and produced a sub-optimal outcome? Is there an alternative urban planning approach? If so, how can this alternative be successfully applied?. This study is therefore aimed at evaluating the need for a spatial planning approach and related strategies as an alternative urban planning approach to the Master Plan system that is presently in use for addressing traffic congestion problems prevalent in global south cities using the example of Abuja-Nigeria.

The different stages in Design Science research involve the explicate problem to show the awareness of problem (existence of research problem), define requirements (suggestions from literature review), design and develop artefact (solution to explicated problem), demonstrate artefact (proof-of-concept), and evaluate artefact (performance measurement).

6.5.2 Research Design

The research design is premised upon the research objectives and questions with cognizance to the data collection source that are appropriate to home-in on datasets required to provide answers to the research objectives and questions set at the beginning of this study. The linkage between the research objectives and questions and relevant data source has been explained earlier in Table 2.1 in Chapter 2. The data sources identified and discussed include document review, direct observation, archival records, interview (structured/semi-structured), Focus Group Discussion (FGD) Session, and users' perception surveys.

The research design is a logical plan that provides a guide for the commencement and completion of a research inquiry process. Within the context of this present research, the research design is as illustrated in the framework in Figure 6-3.



Source: Adapted from Johannesson and Perjons (2012), with emphasis added by Author (2014).

Figure 6-3: Research Design Framework using Design Science Research Strategy

With reference to figure 6-3 illustrated above, the research design framework shows a line of sight and relationship between the research problem, literatures, methodology adopted and solution in order to realize the aim of the research. This research commenced with the Explicate Problem phase, Define Requirement phase, Design and Develop Artefact phase, Demonstrate Artefact phase, and Evaluate Artefact phase. The research process is concluded by drawing conclusions from the results of the Evaluate Artefact phase. The various stages involved in the application of the Design Science research framework in this study are therefore explained below.

a). Explicate Problem

This stage marks the commencement of the investigation in the application of the Design Science research strategy (Hevner et al. 2004, Vaishnavi and Kuechler, 2008, Johannesson and Perjons, 2012) and relates to establishing evidence of the existence of the research problem, this therefore provide the premise for the research to continue. In order to illustrate the relevance on the Explicate Problem phase in Design Science research, Parnas (1998, p.65) argued that “an often neglected lesson is that researchers should spend more time defining the problem before deciding to build a tool”. Indeed, without the ability to explain how and why an outcome is realized, we lose our ability to predict the outcome in different situations or with different participants (Ewert 1987, p.5 cited in Allison and

Pomeroy 2000, p.95). The Explicate Problem phase therefore provides an avenue for explanation, definition and understanding of the research problem and, justification for the research to continue.

With the choice of Abuja as the case city for illustrating global south cities, data from urban planning documents, archival records and direct physical observation were collected to show evidence of the challenges of traffic congestion and suburban sprawl in Abuja. The several departments charged with formulation and implementation of urban planning and transport planning strategies for addressing challenges of traffic congestion and suburban sprawl were also evaluated in terms of institutional capacities. Evidence from previous studies (Mabogunje 2002, Jinadu 2004, Oyesiku 2004, Jiriko 2007) which revealed insights on the existence of the problem of sub-optimal outcomes in the application of the Master Plan approach in global south cities, including Nigeria, were also considered. Is these evidenced as shown in Chapter 3 therefore suggests that the problem under consideration is significant not only to local practice but to most medium-sized rapidly urbanizing global south cities.

Therefore, the assessment of the present Master plan approach vis-à-vis the existing sub-optimal outcomes expressed in the evidence of traffic congestion and suburban sprawl in Abuja provided further evidence that the underlying causes of these challenges may be traceable to the ineffectiveness of the Master Plan approach. The Master Plan approach is the currently existing solution in these cities. Therefore, these present gaps in the present Master Plan solutions necessitate new solution that can improve on the performance of the existing solution. This therefore offers inspiration for the continuation of the research.

This therefore provides the premise upon which the research would focus, this include:

- What alternative shift in urban planning strategy/paradigm is required to address these challenges of traffic congestion and suburban sprawl to achieve optimal urban planning outcome?
- What are the extrapolated outcomes from the developed solution to address the explicated problem?
- What reforms are required for the application of developed solution to achieve optimal outcome?

b). Define Requirements

Upon the establishment of the explicated research problem which therefore shows the existence and awareness of a real-life problem, the Define Requirement phase commences. This involves suggestions from literature and the empirical evidence of solutions required for the various aspects of the problem (Hevner et al. 2004, Vaishnavi and Kuechler, 2008, Johannesson and Perjons, 2012). This therefore relates to identifying alternative planning strategies that demonstrate performance capabilities that surpass the performance of the existing Master Plan approach. This search focused especially on how

urban planners search for broad-based solution that can address the different socio, economic and environmental facets of traffic congestion and challenges of suburban sprawl in cities.

In this phase of the research process, there was an in-depth review of literature to identify relevant urban planning and transport planning concepts and strategies for addressing the explicated problem. These provide the premise to define the relevant requirements for the solution to be developed. Consequently, a set of factors is evolved to guide the selection of the alternative solution in order to show the capability to offset the challenges of traffic congestion and suburban sprawl attributed to the present Master Plan approach in the global south cities. These factors include firstly, the reduction of urban sprawl and the need to travel by car through physical planning measures; secondly, encouraging efficient transit system, transit usage and reduced commuter travel time; thirdly, establishing disincentive mechanism to deter car proliferation and traffic congestion; and lastly, a framework to permit the application of the relevant strategies.

Therefore, by fulfilling these requirements, the problem of traffic congestion and suburban sprawl in the global south cities can be addressed. This framework therefore enables researchers to learn about developing requirements for solution to address the explicated challenges in global south cities, and how urban planning practitioners adopt and institutionalize it.

c). Design and Develop Artefact

The resulting artefact of Design Science research may be abstract in nature, such as in the form of construct (concept), models, methods or instantiations (March & Smith, 1995, Vaishnavi and Kuechler 2008, Hevner et al, 2004, Johannesson and Perjons, 2012). Consequent upon the Defined Requirements phase and the suggested factors contained therein, the Design and Develop Artefact phase commenced, and involves the elaborate design. This phase is where most of the actual design takes place, which is the creative effort required in synthesizing existing knowledge on best practices from literature and empirical case reviews into an artefact for solving the explicated problem. The design and development of a spatial planning framework solution as a conceptual model in this study depicts one of the artefact from the Design Science research.

In line with the studies by Vaishnavi and Kuechler (2008), Hevner et al. (2004), and Johannesson and Perjons (2012), it is posited that a model is a Design Science artefact. The developed framework for spatial planning strategies (artefact) consists of the unique combination of BRT, TOD and Congestion Pricing strategies which can be used by urban planners to solve the challenges of traffic congestion and suburban sprawl in global south cities. Prior to this study, this solution has never been implemented before, even though individual application of the related strategies is gradually gaining relevance in global south cities. The performance capabilities and efficiency gains attributable to these

strategies as evident in literature and empirical cases reviewed suggest that optimal urban planning outcomes can be realized with the developed artefact.

In this study, the final deliverable from this design and development phase is conceptual model consisting firstly of a framework for the combination of spatial planning strategies of BRT, TOD and TDM into a single structure that is targeted at addressing and reforming traffic congestion challenges, and suburban sprawl, and secondly, set of institutional reforms required in terms of enhancing sectoral integration, eliminating the restrictive bureaucratic practices, ensuring that the resulting spatial planning strategies are context-specific and stakeholder-driven solution.

d). Demonstrate Artefact

In this phase, the developed artefact is demonstrated as an illustrative or real-life case in order to proof the feasibility of the artefact (proof-of-concept) (Johannesson and Perjons, 2012). By this, the BRT, TOD and TDM strategies encapsulated into the spatial planning framework was therefore adapted to the case area-Abuja, and the related conceptual specifications was used to extrapolate the metrics on savings especially in terms of reduction in private car usage if the strategies were applied. This therefore represent a “proof of concept”, which indicate that the developed artefact may work and produce optimal outcomes.

The demonstration of the artefact as a conceptual model of spatial planning strategies represent the application of the artefact in the case city in accordance to the principles and guidelines set-out in the Define Requirement and, Design and Develop Artefact phase. According to Viashnavi and Kuechler (2008), it is in this phase that the preliminary evaluation commences, as the performance capabilities of the artefact is compared with the functional specification (literature, conceptual, and empirical case considerations) stated in the Define Requirement phase. In sum, this phase revealed that in the instance of Abuja, the demonstrated artefact should solve the challenge of traffic congestion and suburban sprawl.

e). Evaluate Artefact (Performance Measurement)

Upon completing the Demonstrate Artefact phase, it is necessary to evaluate the artefact using empirical methods and data. Hevner et al. argue that the role of the Evaluate Artefact phase is “to determine how well an artefact works” (Hevner et al 2004), or solve the practical problems of traffic congestion and suburban sprawl that motivated the research (Johannesson and Perjons, 2012). There are multiple evaluation options, including action research, controlled experiments, simulation, or scenarios (Vaishnavi and Kuechler, 2004). However, Pries-Heje et al, (2008) argued that there is a wider diversity of evaluation strategies than may be currently assumed by the methodological literature on Design Science research.

In Design Science research literatures, evaluation is generally viewed from one of two perspectives. Particularly prominent are the recognized position of ex-ante (before practical use of artefact) and ex-post (during practical use of artefact) (Klecun and Cornford, 2005, Pries-Heje et al 2008, and Johannesson and Perjons, 2012). The ex-ante evaluation is therefore relevant in this study as it is not designated for real-life implementation. Pries-Heje et al (2008) argued in their study that evaluation can take the normative or descriptive form. In related studies, Bannister and Remenyi (2000), and Arnott (2006) illustrated that evaluation of the success of an artefact can be based primarily on the hermeneutic approach premised on the opinion of expert and experienced research participants concerned with the development and application of the artefact.

The evaluation in this study was done with consideration of three issues. Firstly, the extent to which the developed artefact demonstrates character and capabilities that can reform the explicated problem from the current urban planning approach which include the predict and provide engineering solution, lack of sectoral integration, presence of restrictive bureaucratic practices, and not being context specific. Secondly, the extent to which the developed artefact demonstrates the relevance and effectiveness to reform the existing challenges of traffic congestion and suburban sprawl in global south cities. This includes the things the artefact will do differently from the existing urban planning approach. Thirdly, the extent to which the developed artefact demonstrates compliance to the central novel idea contained in the identified underlying conceptual principles in the define requirement phase.

The hermeneutic approach of face-to-face interviews and focus group discussion sessions with expert group was adopted in the ex-ante evaluation; experienced urban planning practitioners (in public sector, private sector and the academia) were involved in the evaluation of the artefact developed in this study. The sets of observation (interpretation) derived from face-to-face interview session with these practitioners were fed back into the artefact for improvements. According to the study of Davenport and Prusak (2000, p.46), qualitative data such as narratives derived from interviews and focused group discussion sessions with participants in research are considered one of the best methods to communicate knowledge because of the ability to develop a diverse and rich context of an event through the articulation of thoughts, perspectives and emotions.

Another round of evaluation took place by presenting these modified artefact to these practitioners in FGD sessions in order to investigate and collate the observations on how and what is required to achieve optimal outcomes in the application of the artefact. These last rounds of feedback from the evaluation of artefact form the basis for a finalized version of the artefact.

However, in order to further achieve triangulation of data sources, and realize another layer of evaluation, the dataset from the users' perception survey was used to establish the usage levels of the artefacts especially as regards the reduction in private car usage if the artefact (spatial planning

strategies of BRT, TOD and Congestion pricing) were to be applied in the case-city. This is considered as the analytic sub-phase in which hypothesis are made about the behavior of the artefact. This analysis can show a mix of convergence and divergence with the views of the practitioners, and provided the premise for generalization of the findings to similar global south cities. A combination of the results/findings from this evaluation phase forms the premise for drawing conclusion.

6.5.3 Justification for Adopting Design Science Research Strategy

While the popularity and grounding of Design Science research in the social science realm is on the rise, it is imperative to note that the application of Design Science research in the built environment domain is a relatively new innovative research methodology strategy. There is a lot of research and thinking around the Design Science research paradigm (Hevner et al. 2004, Vaishnavi and Kuechler, 2008, Johannesson and Perjons, 2012, Venable et al., 2012, amongst others). The application of Design Science research strategy in this study therefore provides a premise for this research to make research methodological contributions.

One of the defining characters of Design Science research strategy is that it emphasizes practical problem solving and, performance improvement features and capabilities (Hevner et al, (2004). While the other research strategies highlighted in section 6.5 above seek to make explanation and produce theoretical knowledge, Design Science research aim to produce theoretical knowledge that is equally applied to create artefact targeted at improving practice (March and Smith, 1995, p.46). Therefore, the justification for adopting the Design Science strategy in this study are explained in recognition of its capacity for problem-solving, ordered sequence of research process triangulation, evaluation and circumscription.

a). Problem – solving

Design Science research strategy provide a premise for the researcher to identify an existing problem relating to operation or practice by assessing the performance of an applicable tool, method or process. The identification of a gap in this tool serves as the basis to evolve an artefact with proven capacity to address the stated problem (Vaishnavi and Kuechler 2008, Hevner et al, 2004). Within the context of this research, while the design science research strategy contribute to the development of an artefact in the form of an alternative urban planning approach, it equally has the co-benefit of methodological and methodical contributions to the inquiry process of urban planning and transport planning literatures which can be re-enacted in other related research.

b). Ordered Sequence of Research Process

The general framework of the Design Science research strategy consists of an ordered sequence of activities. This sequence provides the premise for a clear compartmentalized structuring of research inquiry process that can be easily followed and understood. This therefore, creates the opportunity for

repeatability of research process and outcomes. Within the context of this study, the general phases of the Design Science research strategy illustrated in Figure 6.3 provided the premise for structuring the chapters in this study and therefore ensured clarity of the major idea contained in the thesis.

c). **Triangulation**

The multiple data sources used at the different phases of the Design Science research strategy to provide answers to the research questions create a premise for data triangulation in the research and therefore enhance the credibility and validity of research findings. Within the context of this research, the research methods and data sources used provided the premise for various corroborative evidence to the research findings in this study.

d). **Evaluation and Circumscription**

Design Science research create enabling environment for iteration and circumscription at various stages of the research, this ensures that feedback are continually fed into the research process towards the refinement of the output and the inquiry process. Within the context of this research, the series of refinement of the process and the developed artefact ensures that the resulting artefact is context-specific and relevant to solving the problem of traffic congestion and suburban sprawl in the case area and similar global south cities.

6.6 Research and Data Collection Methods

With reference to the research methodology framework illustrated and discussed in section 6.1, the research method is the last phase in the framework and it is predicated on the research strategy. The choice of research method(s) should demonstrate the capacity to bring about data required by the research strategy to sufficiently address the research questions (Creswell 2003, Dawson 2011). This section considers methods (techniques, sources) through which relevant data can be collected and analyzed. These include the data collection methods, sampling methods, reliability, validity and generalizability, and data analysis methods.

The data collection method adopted in this study is a combination of the exploration of both quantitative and qualitative data sources. This is in view of the complex, dynamic and multifaceted nature of the research phenomenon (traffic congestion challenges and suburban sprawl) and human subjects (urban planning practitioners) which requires elaborate research strategy to capture the rich diverse context and data sources (Creswell 2003, Onwuegbuzie and Leech, 2004, 2007). Importantly, the quest for multiple data sources also stem from the broad spectrum of data required in the different stage of the Design Science research strategy. This mix of data sources would ensure the realization of data triangulation premised upon the convergence of findings from the multiple data sources (Creswell 2003, Dawson 2011). The benefits attributed to the combination of these multiple methods in a research was succinctly captured by the studies of Creswell 2003, and Onwuegbuzie and Leech (2004) (2007), the stated benefits include: triangulation that seek to achieve convergence and corroboration of

findings, complementarity that seek to achieve illustration and clarification of the findings, and expansion that seek to broaden the scope of the investigation and the resulting findings from the different data sources. These therefore provide the justification for the adoption of the multiple data sources in this study.

In line with the illustrated research design framework of the Design Science research strategy adopted in this study (see Figure 6.3), the data required for the different phases included data sourced from such methods as review of document, direct observation of traffic congestion and suburban sprawl, archival records of maps, satellite imageries and traffic count as applied in the Explication of Problem phase in Chapter 3 and in the Demonstrate Artefact phase in Chapter 7. The range of data required includes face-to-face semi-structured interview, focus group discussion session, and perception surveys of users and residents which is used in evaluating the relevance and performance capabilities of the developed artefact. These various instrument used in the collection of both qualitative and quantitative data for analysis and therefore provides the premise for providing answer to the research objectives 5-6 and questions 3.

A. Research Questions

The following three research questions are being investigated by this research.

- i. How has the existing urban planning approach in global south cities created an enabling environment for suburbanization and road expansion which has permitted the present level of traffic congestion and the related challenges of man-hour losses, fuel wastages and CO₂ emissions?
- ii. Why has the present planning approach permitted a weak level of sectoral integration amongst the urban planning sector, and other relevant sectors with regards to evolving and implementing spatial plans and urban infrastructure plans in global south cities?
- iii. How can an effective alternative framework for spatial planning strategies be developed in order to achieve sustainable transportation systems in global south cities?

6.6.1 Interviews

There exist various types of interview which include structured interview, semi-structured interview and un-structured interview. Descombe attempted an explanation of these interview types and described the structured interview as similar to a survey questionnaire. According to Descombe (2007, p.175), the structured interview is characterized by a tightly controlled format of questions and answers as is the case with questionnaires. This limited response allows for the standardization of

response and ease of analysis of the ensuing quantitative data. In semi-structured interviews there is a clear list of questions to be answered but the session is flexible in terms of the order of the topics, and interviewees are permitted to give open-ended answers, develop ideas and speak more widely on the issues raised by the researcher. The un-structured interview is described as a variation of the semi-structured interview and allows for wider thoughts and expression from the interviewees. Evidently, by allowing interviewees to use their own words, develop their own thoughts, and speak their own minds, this interview research method/technique therefore provides a better way of elucidating information on complex issues as in the case of the phenomenon under investigation in this study.

In Yin's analysis of the strength of an interview as a tenable source of evidence in qualitative research inquiry, it was stated that an interview is targeted, in that, it focuses directly on research themes, and very insightful, by yielding perceived inferences and explanations. However, the observed weaknesses include biases that can arise due to poorly articulated questions by the investigator, biased responses from respondents because of the questions being value laden, inaccurate responses due to poor recall, and reflexivity (Yin 2009, p.102). However, with the interviewer focusing on the line of inquiry as reflected in a well-articulated interview guide/protocol, and asking conversational questions in an unbiased manner, the impact of such weaknesses may be reduced if not eliminated. The structured and semi-structured interview approach is, therefore, adopted in this study. While the structured interview has been applied earlier in the Explicate Problem phase in Chapter 3, the focus here is on applying the semi-structure interview to evaluate the developed artefact as a premise for results, discussions and findings in this study.

However, since the research question 1-2 and objective 1-4 has been addressed in Chapter 3, the data source for addressing the research question 3, objective 5-6 are semi-structured interview, FGD sessions, and user perception surveys, the procedure for data collection with these data sources is explained below.

6.6.1.1 Semi-structured Interview

Within the context of this study, semi-structured interview was adopted in order to home-in on the several rich insights as regards the meaning, inferences and explanation of experienced urban planning practitioners about the existing problem of traffic congestion and suburban sprawl. This includes insights into the desirability for a shift from the present Master Planning approach towards an alternative urban planning approach. These participants are targeted experienced Town Planning practitioners (in urban planning consulting firms; in government establishments responsible for urban planning, transport infrastructure development, regulation and enforcement in Abuja; and the academia/research community). This includes practitioners in transport establishments, and transport

operator association that are able to make informed contributions and provide answer and perspectives that elucidate on the research questions.

In specific terms, the datasets from the semi-structured interviews helped to elucidate on research questions 1, 2 and 3. On one hand, the research questions 1 and 2 seek to investigate the explanation and perspectives of relevant urban planning practitioners on the explicated problem phase of this study. On the other hand, the research question 3 in part seeks to define the requirements upon which to predicate the design and development of the required solution (artefact). Further, it seeks to investigate and explain the perspectives of urban planning practitioners in the evaluation of the relevance and performance capabilities of the artefact developed in this study.

6.6.1.2 Sampling and Interview Procedures

There are two major sampling techniques available for use by social science researchers, namely “probability sampling” and “non-probability sampling” (Descombe 2007, p. 13). Probability sampling is premised upon the researcher’s assumption that the people or events that are chosen as the sample have some chance of being a representative cross-section of people or events in the whole population being studied (Descombe, 2007). Further, in probability sampling, several methods are involved which include random sampling, systematic sampling, stratified sampling, quota sampling, cluster sampling and multi-stage sampling. The sampling techniques within the non-probability sampling methods include purposive sampling, snowball sampling, theoretical sampling and convenient sampling (Descombe, 2007, p. 13).

Based on the adoption of interview as one of the relevant research method, non-probability sampling is adopted in this section of this study and used in the selection of the participants for the interview sessions.

A. Sampling and Interview Procedures for Semi-Structured Interviews

As mentioned above the semi-structured interview was dedicated to the transport operator association and urban planning practitioners. According to the illustration of snowball sampling technique by Descombe (2007, p.17), the snowball technique has been used in this research. The practitioner representing the FCT Transport Secretariat provided a link to the heads of all the certified transport operator association. These participants were therefore included in the sample. Their inclusion was based on their status as experienced practitioners occupying management positions and able to provide useful and reliable information on public transport operation. However, where further inquiry was necessary, each of the nominees were asked to, in turn, nominate person(s) with deep relevant knowledge of the inquiry; such nominees were included in the sample. Through this multiplier effect of the snowball sampling technique, the researcher was able to sample a larger number of quality and

informed respondents. The list of the selected participants in this study is contained in Table 6-1 below.

Table 6-1: Listing of participants who took part in the semi-structured interviews

S/No	Respondent Name:	Position (Job Title)	Organization Name: B1 – B13	Parent Company:	Core Business of Organization	Date of Interview	Duration of Interview	Venue of Interview:
1	Public Officer (Urban Planning) 1	Director, Urban and Regional Planning Dept.	B1	Federal Capital Territory Administration (FCTA)	Development of the Federal Capital City	11/04/13	1:11:20	Director's Office, URP Dept. FCDA
2	Public Officer (Urban Planning) 2	Deputy Director, Strategic Planning Division	B1	Federal Capital Territory Administration (FCTA)	Development of the Federal Capital City	11/04/13	1:24:07	Deputy Director's Office, URP Department FCDA
3	Public Officer (Urban Planning) 3	Head of Regional, Planning Section	B1	Federal Capital Territory Administration (FCTA)	Development of the Federal Capital City	12/04/13	1:39:16	Office of the Head, Regional Planning Sector, URP Dept. FCDA
4	Public Officer (Urban Planning) 4	Director, Satellite Towns Development Agency	B2	Federal Capital Territory Administration (FCTA)	Development of Satellite Towns of Abuja	26/3/13	1:03:38	Director's Office, STDA Secretariat
5	Public Officer (Urban Planning) 5	Deputy Director, Housing Division	B2	Federal Capital Territory Administration (FCTA)	Development of Satellite Towns of Abuja	16/7/13	44:09	Deputy Director's office STDA Secretariat
6	Public Officer (Urban Planning) 6	Assistant Director, Physical Planning Division	B2	Federal Capital Territory Administration (FCTA)	Development of Satellite Towns of Abuja	27/3/13	48:36	Assistant Director's Office, STDA Secretariat
7	Public Officer (Transport Planning) 7	Director, Project Office	B3	Federal Capital Territory Administration (FCTA)	Development of Transport policies and programme for Abuja	21/3/13	1:25:50	Director's Office, The Project Office, FCT Transport Secretariat
8	Public Officer (Transport Planning) 8	Assistant Director, Transport Planning Section	B3	Federal Capital Territory Administration (FCTA)	Development of Transport policies and programme for Abuja	22/3/13	1:04:17	Office of the Assistant Director, Mass Transit Department
9	Public Officer (Transport Planning) 9	Head of Transport, Planning Section	B3	Federal Capital Territory Administration (FCTA)	Development of Transport policies and programme for Abuja	22/3/13	1:14:06	Office of the Head, Transport Planning Mass transit Department
10	Public Officer (Environmental Planning) 10	Director, Climate Change Department	B4	Federal Ministry of Environment	Monitoring and Management of CO ₂ emission and Climate Change in Nigeria	24/4/13	51:58	Office of the Director, Climate Change Department
11	Private Sector (Infrastructure Finance) 1	Managing Director, The Infrastructure Bank Plc.	B5	The Infrastructure Bank Plc.	Provision of Funds for Infrastructural Development	16/4/13	1:46:57	Office of the Managing Director, The Infrastructure Bank Plc. Headquarters
12	Public Officer (Traffic Enforcement) 11	Head of enforcement Unit, Vehicle Inspection Office	B6	Federal Capital Territory Administration	Road traffic Management	16/4/13	1:08:28	Office of the Head, Enforcement Unit, DRTS
13	Public Officer (Traffic Enforcement) 12	Sector Commander, FCT Sector Command	B7	Federal Road Safety Corps (FRSC)	Road Safety Management	9/10/13	1:09:58	Sector Commandant, Office of the FCT Sector Command of FRSC
14	Research Fellow	Professor of Urban	B8	Benue State University,	Academia/Researcher	14/11/14	1:43:07	Department of Urban

	(Urban Design) 1	Design, Head of Department (HOD)		Markurdi, Nigeria				and Regional Planning, Benue State University
15	Research Fellow (Regional Planning) 2	Professor of Regional Development, Senior Lecturer	B8	Benue State University, Markurdi, Nigeria	Academia/Researcher	25/11/14	1:59:35	Department of Urban and Regional Planning, Benue State University
16	Research Fellow (Transport Planning) 3	Ph.D. Transport planning, Senior Lecturer	B8	Benue State University, Markurdi, Nigeria	Academia/Researcher	25/11/14	1:03:06	Department of Urban and Regional Planning, Benue State University
17	Research Fellow (Urban Planning) 4	Professor Transport Planning, Senior Lecturer	B9	Federal University of Technology Minna, Nigeria	Academia/Researcher	13/11/14	1:48:06	Department of Urban and Regional Planning, Federal University of Technology Minna
18	Consultant (Urban Planning) 1	CEO, and a Chartered Town Planner	B10	Fola Consult Limited, Abuja, Nigeria	Urban and Regional Planning Consultancy Services	16/12/14	1:20:20	Office of the CEO, Fola Consult Limited, Abuja.
19	Consultant (Urban Planning) 2	CEO, and a Chartered Town Planner	B10	Urban Aesthetics Consultants, Abuja, Nigeria	Urban and Regional Planning Consultancy Services	16/12/14	1:22:58	Office of the CEO, Urban Aesthetic Concepts, Abuja
20	Consultant (Urban Planning) 3	CEO, and a Chartered Town Planner	B10	Envicon Team Consultant Limited, Abuja, Nigeria	Urban and Regional Planning Consultancy Services	13/12/14	1:15:58	Office of the CEO, Envicon Team Consultant Limited, Abuja
21	Consultant (Urban Planning) 4	Principal Partner, and a Chartered Town Planner	B10	Envicon Team Consultants Limited, Abuja, Nigeria	Urban and Regional Planning Consultancy Services	13/12/14	1:07:14	Office of the CEO, Envicon Team Consultant Limited, Abuja
22	Research Fellow (Urban Planning) 5	The President, and a Chartered Town Planner	B11	Nigerian Institute of Town Planners (NITP)	Research and Formulation of Urban and Regional Planning Policy and Practice Guidelines	23/12/14	1:19:09	The President's Office, NITP Secretariat
23	Public Officer (Public Transport Funding) 13	Coordinator, State Programme (FCT-Abuja)	B12	Federal Capital Territory Administration	Funds of the Provision of Public Transport vehicles and Mass Transit Buses	3/10/13	31:10	Coordinator's Office, FCT SURE-P, FCTA Secretariat
24	Public Officer (Public Transport Funding) 14	Deputy Coordinator, State Programme (FCT-Abuja)	B12	Federal Capital Territory Administration (FCT)	Funding of the Provision of Public Transport Vehicles and Mass Transit Buses	3/10/13	44:07	Coordinator's Office, FCT SURE-P, FCTA Secretariat
25	Transport Operator Association 1	General Manager, AUMTCO	B13	Abuja Urban Mass Transit Company (AUMTCO)	Provision and Operation of Public Transport Service	20/03/13	48:26	General Manager's Office, AUMTCO
26	Transport Operator Association 2	Chairman, SECDA	B13	Self-Employed Commercial Drivers Association Abuja (SECDA)	Provision and Operation of Public Transport Service	22/03/13	1:06:21	Chairman's Office SECDA
27	Transport Operator Association 3	Managing Director, Nationwide Unity	B13	Nationwide Unity Transport Company Limited	Provision and Operation of Public Transport Service	9/9/13	1:18:42	Managing Director's Office, Nationwide

		Transport Company Limited						Unity Transport Company Limited
28	Transport Operator Association 4	Operation Manager, FABREM Transport Company Limited	B13	FABREM Transport Company Limited	Provision and Operation of Public Transport Service	9/9/2013	1:02:07	Operation Manager's Office, FABREM Transport Company Limited
29	Transport Operator Association 5	Chief Consultant, Trade Union Congress and Investment Company Limited	B13	Trade Union Congress and Investment Company Limited	Provision and Operation of Public Transport Service	10/10/13	58:25	Chief Consultant's Office, Trade Union Congress and Investment Company Limited
30	Transport Operator Association 6	Secretary General, Nigerian Union of Road Transport Workers (NURTW)	B13	Nigerian Union of Road Transport Workers (NURTW)	Provision and Operation of Public Transport Service	3/12/13	1:12:11	Office of the Secretary General, Nigerian Union of Road Transport Workers (NURTW)

Source: Author's Analysis, (2014).

B1-FCDA URP; B2- STDA, B3- FCT Transport Secretariat; B4 – CCD FME; B5 – TIB; B6 – DRTS; B7- FRSC; B8- BSU; B9 – FUTM; B10 – Urban Planning Consulting Firm; B11- NITP; B12 – FCT SURE-P; B13 – Transport Operator Association

(i) Transport Operator Association

Participants in this group were the licensed transport operators in Abuja and were purposively selected because of their relevance to the research theme; they included AUMTCO, SECDA, FABREM, NURTW, TUC, and Nationwide Unity.

(ii) Urban Planning Practitioners

Participants under this group are the purposively selected professionals/practitioners in government departments, urban planning consulting firms, and the academia identified as relevant actors in the preparation or implementation of transportation infrastructure, land-use and spatial development plans in cities especially in Abuja. These included professionals/practitioners working with agencies charged with the responsibilities of providing, regulating and facilitating public transport infrastructure (FCT-Transport Secretariat, FCT-Directorate of Road Traffic Service, Federal Road Safety Corps, FCT-Subsidy Re-investment and Empowerment Programme and The Infrastructure Bank Plc.); practitioners working in the agency charged with the environmental regulation (the Federal Ministry of Environment); practitioners working in the agencies charged with urban planning and regulation of land-use in Abuja (FCDA Department of Urban and Regional Planning and STDA Physical Planning and Housing Division); and practitioners working in reputable and renowned private sector consulting firms that have engaged in the preparation of several urban development plans; and practitioners working in academic/research institution whose research area focuses on urban transport infrastructure development in cities with particular focus on Abuja (Federal University of Technology Minna, and Benue State University, Makurdi).

Consequent upon a Participant Invitation Letter sent by the researcher to these agencies, a letter of consent was written back to the researcher by the establishments stating their willingness to participate in the study and also nominating a representative. This representative was mandated to represent the authority throughout the study and oblige the researcher with the needed information and support. The nominated representative served as the contact person who arranged the time and place of the interviews and this was usually held within the office of the respondents. A total number of 30 semi-structured interviews were conducted.

In summary, the total number of interviews conducted comprises of one hundred and forty seven (147) structured interviews with commuters and, thirty (30) semi-structured interviews with the Transport Operators Association, and urban planning practitioners.

6.6.1.3 Interview Protocol/Guide

The interview protocol is used during qualitative research for asking questions and recording answers (Creswell 2009, p.183). The questions contained in the protocol for structured interview are in structured format with controlled options of responses to choose from while the questions contained

in the protocol for the semi-structured interview are detailed and semi-structured and seek to probe for responses to the research question(s) (see Appendix V for sample of interview guide). Information from the semi-structured interview sessions were recorded by audio-taping, since audio recordings provide an accurate rendition of any conversation. These recordings were transcribed and coded for analysis and inferences. Notwithstanding the recording, the hand written notes were still taken to avoid information loss if the recording equipment failed.

A. Interview Protocol for Semi-Structured Interviews

In recognition of the multi-faceted and different interrelated dimensions of the problem of traffic congestion and suburban sprawl, and the differences in the background and affiliation of the participants listed above, the interview questions to these respondents were grouped. These grouping were made in order to ensure that the participants respond to questions relevant to their present roles and responsibilities. This therefore shows the quality and relevance of the responses to the inquiries from the interview sessions.

The interview sessions with the practitioners were guided by the interview guide/protocol described above (Section 6.6.4.4), and usually all these sessions commenced with ice-breaker questions which set the stage for the interview. On one hand, the questions relate to research questions 1 and 2 which seeks to investigate the explanation and perspectives of relevant practitioners of the explicated problem in this study, with inquiries focusing on the factors of lack of sectoral integration, institutional capacity and predict and provide engineering solution that characterizes the existing Master plan system. These data was relevant to identifying whether the institutional capacity of the current urban planning organization has played permissive role in the current challenges of traffic congestion and suburban sprawl facing these global south cities including Abuja.

On the other hand, the research question 3 seeks to investigate and explain the perspectives of practitioners in the evaluation (performance measurement of conceptual solution) phase of this study on developing an alternative planning system, and on the desirability of a shift from the current Master planning system to an alternative approach (spatial planning strategies of BRT, TOD and TDM). However, the resulting datasets are therefore able to provide answers to research questions 1, 2 and 3.

Some of the questions posed to these participants include; If the practitioners agree that the present level of traffic congestion and suburban sprawl is a challenge? If these challenges can be attributed to the inadequacy/ineffectiveness of current planning system and institutional framework? Why do they think these challenges have continued to increase, notwithstanding the current efforts of the present planning organization? Do they think there is need for change in the planning system and institutional framework? What change do they think is required? How can this change be realized? Do they think

spatial planning strategies consisting of BRT, TOD and TDM as seen in other empirical application of spatial planning strategies can be relevant to achieve the reforms? What do they think should be added or removed from the spatial planning approach as an alternative to make it relevant as solution to the current challenges? What institutional reforms are required to make the application of this reform achieve optimal outcomes? The sessions were usually concluded by asking about additional information required from other sources.

6.7 Focus Group Discussion Sessions

Focused Group Discussion (FGD) is a face-to-face arrangement/interactive setting for obtaining the insight and perspectives of the research participants into a phenomenon. The participants are usually 8 – 12 and are mostly targeted participants selected because they possess understanding and reliable knowledge about the phenomenon under investigation (Descombe, 2007, Finch, 2011). The focused group discussion session takes place in a non-interfering environment gives an opportunity for participants to offer suggestions to the phenomenon being discussed or evaluated. The session is guided and moderated by a moderator in order to keep the session focused on the themes being considered. This session is usually audio/video recorded and transcribed for analysis. In pursuit of the realization of the evaluation of the conceptual solution in this study, the circumscription and iteration process presented by the Design Science research strategy provides the premise for the adoption of such tool as focus group discussion. This therefore created the avenue to further engage the interviewees (relevant stakeholders such as practitioners in urban planning and related establishments, the academia, transport operator associations and transport users' groups) in carefully planned focus group discussions sessions. This is an expanded evaluation session with multiple participants in order to further evaluate the refined artefact in view of the feedback received in earlier interview sessions with each of the stakeholder. This includes measuring the performance of the spatial planning strategies (artefact) in view of the related metrics and technical specifications of the conceptual model. Some of the questions asked in the focus group discussion sessions include: why they think the refined conceptual solution will work, what should be added or removed to make it work? What institutional reforms are required to realize optimal outcome from the implementation of the solution (see Appendix VI for detail questions in the FGD guides).

6.7.1 Procedure of the Focused Group Discussion (FGD) Session

The discussion group was organized into four sessions to focus on such themes as Transit Oriented Development (TOD), Bus Rapid Transit (BRT) systems, Congestion Pricing as TDM strategy, spatial planning framework and institutional reforms. In order to ensure that the concepts are well understood by the participants so that they could make informed contributions. The strategies were explained and illustrated using images of proposed TOD communities, BRT, congestion pricing

infrastructure and framework for institutional reforms for Abuja, with occasional reference to the exemplary case studies (e.g. Bogota, Curitiba, and Guangzhou). These explanations were also aided by tabular illustrations of the extrapolated savings achievable from the application of the strategies to the case city. Accordingly, stakeholders relevant to each group sessions were grouped together, with each group containing 7 to 10 persons. The sessions were held in a permissive non-interfering environment. These participants were chosen based on the relevance of their respective operational purview and the theme of the focus group. This was to ensure participation by persons who could provide relevant and incisive contributions to the session. In order to comply with the regulation of keeping the size of the focus group to between 7-10 persons, it became imperative to select 3 participants out of the 5 operators in the transport operation association. The selection of the 3 participants was purposively selected; this selection was premised on the depth and incisiveness of perspectives offered by these participants during the earlier interview sessions.

The first themed session was designated to discuss the BRT system, the relevant stakeholders in this session included the F.C.T. Transportation Secretariat, the Transport Operator Association (AUMTCO, TUC Transport, Nationwide Unity), the Transport User Group (commuters and private automobile vehicle drivers), and practitioners from the Infrastructure Bank (IIB), the Federal Road Safety Corps (FRSC), the F.C.D.A. Urban and Regional Planning Department, the S.T.D.A. Physical Planning Division, urban planning consulting firm, the academia, the F.C.T. Directorate for Road Traffic Service, and the F.C.T. SURE-P.

The second themed session was designated to discuss the Transit Oriented Development model and the institutionalization of spatial planning. The relevant stakeholders in this session included practitioners in F.C.D.A. Urban and Regional Planning Department, the S.T.D.A. Physical Planning Division, urban planning consulting firm, the academia, the F.C.T. Transport Secretariat, the Transport Operator Association (AUMTCO, TUC Transport, and Nationwide Unity), and the Transport User Group (commuters and private car drivers).

The third themed session was designated to discuss the congestion pricing system, the relevant stakeholders in this session included the FCT Transportation Secretariat, The Infrastructure Bank (IIB), the F.C.T. Directorate for Road Traffic Service, the F.C.D.A. Urban and Regional Planning Department, the S.T.D.A Physical Planning Division, urban planning consulting firm, the academia, and the Transport Users Group (private automobile vehicle drivers).

The fourth themed session was designated to discuss the spatial planning framework and institutional reform required to deliver these strategies, it is an elaborate session that included all the relevant stakeholders that participated in all the FGD sessions. This session probes for the appropriateness, relevance, requirements for the implementation of encapsulation of the 3 strategies using spatial

planning framework which defines the stakeholders and integration required for all the components of the strategies and framework.

The sessions were held at the conference room of the STDA with the first session commencing at 10.00am. Each session lasted between 40 – 60 minutes. The sitting arrangement provided the opportunity for the participants to sit around a table while focusing on the PowerPoint presentation board. The microphone provided in front of each participant allowed the contributions by each participant to be properly heard by all the participants. The sessions was kept in focus, on the time schedule and productive because the researcher served as the moderator and was assisted by a research assistant, who served as the time keeper. The moderator was unobtrusive, non-judgmental and, did not fail to probe for ideas contrary to the themes and issues being investigated.

The investigation in each of the discussion sessions was guided by an interview guide (protocol) relevant to the theme being investigated in each focus group. These guides contained well-worded, loosely-structured questions and probes. Some of the question asked in the focus group discussion sessions include: why they think the refined conceptual solution would work, what should be added or removed to make it work? what institutional reforms are required to realize optimal outcome from the implementation of the solution. In line with the pledge by the researcher when inviting the participants, to provide incentives in the form of food and candies, these were provided during the session. These incentives may not have spurred an additional interest by the participants because they were mostly senior executives who provided the contribution of their time to the research because they felt the research to be important. However, the candies were handy for consumption by the participants during the session.

The rationale for the group discussion was to explore the advantages of a group discussion session in creating an enabling environment for generating richer, complete and more revealing information than that produced from the series of earlier stakeholder interviews. This is towards complying with the evaluate artefact phase prescribed by the design science research strategy in order to achieve rigour in the research process, and to evaluate the spatial planning strategies (artefact) in order to improve its performance for making it relevant to the case area.

6.8 Users Perception Survey

In order to enhance the Evaluate Artefact phase and enrich the rigour of the results and conclusions from this research, this study investigated the perception of users/residents group. The quantitative dataset obtained from the field was therefore used to validate the prediction by the experienced practitioners (research participants) as regard the performance capabilities of the spatial planning strategies (artefact) developed by this study. The data set require for this phase of the research is

derived from questionnaire survey because it has the capacity to home-in on data sets from large spectrum of respondents that can be representative of the user group (Descombe, 2007 p.7).

The survey questionnaire contains close-ended questions with pre-determined option for the respondents to choose from, this therefore makes the grouping and analysis of the data convenient (Dawson, 2009, Oppenleim, 2000, Descombe, 2007). In this study, the questionnaire was designed to collect data on the perception of commuters in mini-buses and private cars resident in the suburban areas because they are familiar with the impacts of the challenges of traffic congestion and suburban sprawling residences. Evidence exists from previous studies that people are more likely to respond to questionnaire that covers issues that affect them (Descombe, 2007).

The questionnaire consists of a combination of some set of questions that requires a tick (✓) in response to listed options of responses (see Appendix V for detail questions in the Users' perception survey). The questionnaire also consisted of multiple-choice and questions in text form combined with a five-point Likert scale with the scale ranging from 1 (Strongly agree) to 5 (Strongly disagree). Within the section on the conceptual solution, images illustrating the character of BRT and TOD were inserted, this include features of congestion pricing, this ensure that the respondents understand the characters of the solutions and make informed choices amongst the listed responses.

The datasets from this survey is relevant to objectives 5 and 6, and research question 3, which seek to develop spatial planning strategies as TOD, BRT and TDM as solution (artefact) for addressing the challenges of traffic congestion and suburban sprawl. In specific term, the objective of the investigation was to establish the ridership level on the proposed BRT, and the acceptance level by residents concerning living in TOD nodes, as a basis for extrapolating the savings realizable from the application of the strategies based on the conceptual specification. The results from the analysis of the survey data therefore provide the premise for validating the extrapolation of the performance capabilities of these spatial planning strategies. This therefore provides a premise for further conclusion on the applicability of these spatial planning strategies, while identifying areas for further research.

6.8.1 Pilot survey

Prior to the survey, the questionnaires were extensively pre-tested on small purposively selected group of commuters in mini-buses and private cars who are residents of the suburban areas. Their eligibility for selection was based on their responses to be commuters in either the mini-buses or in private cars and on being resident in any of the three major suburban areas (Nyanya-Karu, Kubwa-Bwari and Kuje-Gwagwalada axes). The goal of the pilot survey was to identify ambiguous questions or wording and any other challenges that can inhibit the efficiency of the questionnaire. The illustrations of BRT

and TOD strategies, and the goal of the research spurred on enthusiasm in the majority of the participants and they, therefore, expressed their willingness to participate in the survey. However, although a few others expressed a lack of time to participate in the survey.

The feedback from the pilot survey included the need to insert visual illustration of a BRT system and TOD strategies in the questionnaire, and the need to make the choice of grammar and vocabulary for the questions simpler. The feedback also included reducing the total number of questions. This feedback provided the opportunity to improve the questionnaire. A total of twenty-five questions were distributed in the pilot survey and seventeen questions were returned representing a 68% success rate.

6.8.2 Sample selection and procedure of the users' perception survey

In this section, the procedure for sample selection and conducting the survey is discussed. This discussion consist of two segments which focuses on survey of commuters in mini-buses and private cars resident in the suburban areas, and residents of areas designated as nodes in the core-city.

6.8.2.1 Commuters in Mini-buses and Private Cars resident in the suburban areas

The respondents in this survey were identified on home-work trip destination basis, i.e. persons that have journeyed to their respective work places in the core-city employment areas along the three routes (AYA, Kubwa-Bwari and Airport Road). The respondents in the perception surveys were selected using a stratified cluster sampling method. By this, the elements of *stratification* and *clustering* are combined. According to Trochim (2002), stratified cluster sampling brings about less error when compared to simple random sampling and combines the advantage of the cost savings of clustering with the error reduction of stratification by the creation of strata of cluster. Therefore, employment areas (referred to as cluster) in the core-city were stratified into strata consisting of similar clusters with public sector employment zone, private sector employment zone, and self-employed employment zone representing each stratum. These respective strata were further clustered by identifying the geographic location of various hubs within each stratum (see column 3 of Table 6-3 and Figure 6-4).



Source: Author's Analysis (2013).

Figure 6-4: Districts Containing Clusters of Employment Hubs in the Core-City of Abuja

On the field, the respondents were politely asked about the route they had taken to the core-city as the questionnaires were distributed. The respondents were given 3 days for completing the questionnaires. The office address of the respondents was obtained in order to easily track and retrieve the questionnaires from respondents.

Table 6-2: Selection of Sample Population.

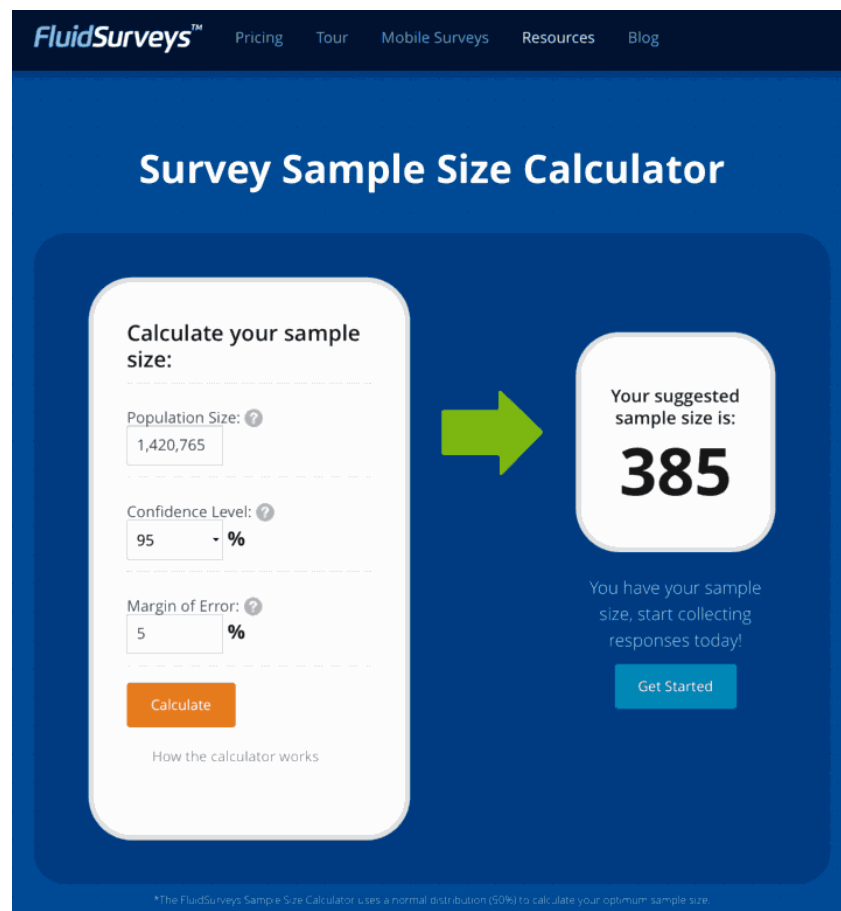
Sector (Stratum)	Sample Population (Clusters of Employment Hub)	Sample Population (Clusters of Employment Hub) Categorized into Districts	Selected Samples (Selected Clusters of Employment)
Public	Federal Civil Service Commission, Nigeria Customs Service Headquarter, Federal Road Safety Commission Wuse Zone 3, Old Federal Secretariat, Federal Secretariat, FCDA (Federal Capital Development Authority) Secretariat, NUC (National University Commission), RMRDC (Raw Material Research and Development Council), NYSC (National Youth Service Corp) Headquarter, INEC (Independent National Electoral Commission) Headquarter, FCT High Court, ERC (Education Resource Centre), FCT Water Board, Radio House, AEPB (Abuja Environmental Protection Board), AMAC (Abuja Municipal Area Council), Federal Ministry of Finance, Office of the Head of Civil Service of the Federation, FIRS (Federal Inland Revenue Service) Headquarter, AGIS (Abuja Geographic Information System), PHCN (Power Holding Company of Nigeria) Zone 4, UBEC (Universal Basic Education Commission), Federal Ministry of Works, FCT (Federal Capital Territory) NYSC Zone 5, FCT AMMC (Abuja Metropolitan Management Council) Zone 6.	<p><u>Garki District</u> Old Federal Secretariat, FCDA(Federal Capital Development Authority) Secretariat, FCT Water Board, Radio House, AMAC (Abuja Municipal Area Council), AGIS (Abuja Geographic Information System)</p> <p><u>Wuse District</u> Federal Civil Service Commission, Nigeria Customs Service Headquarter, Federal Road Safety Commission Wuse Zone 3, ERC (Education Resource Centre), FIRS (Federal Inland Revenue Service) Headquarter, PHCN (Power Holding Company of Nigeria) Zone 4, UBEC (Universal Basic Education Commission), FCT (Federal Capital Territory) NYSC Wuse Zone 5, FCT AMMC (Abuja Metropolitan Management Council) Wuse Zone 6.</p> <p><u>Central Area District</u> Federal Secretariat, AEPB (Abuja Environmental Protection Board), Federal Ministry of Finance, Office of the Head of Civil Service of the Federation.</p> <p><u>Maitama District</u> NUC (National University Commission), RMRDC (Raw Material Research and Development Council), NYSC (National Youth Service Corp) Headquarter, INEC (Independent National Electoral Commission) Headquarter, FCT High Court</p> <p><u>Mabuchi District</u> Federal Ministry of Works</p>	Old Federal Secretariat, , Federal Secretariat, FCDA (Federal Capital Development Authority) Secretariat,Federal Ministry of Works, UBEC (Universal Basic Education Commission),Federal Civil Service Commission, NYSC (National Youth Service Corp) Headquarter, FIRS (Federal Inland Revenue Service) Headquarter, FCT High Court, FCT Water Board, Federal Ministry of Finance, FCT AMMC (Abuja Metropolitan Management Council) Wuse Zone 6.
Total	24	24	12
Private Sector	Area 1 Shopping Complex, Utako Market, Wuse Market, Garki Market, Garki Area 10 Plaza, Sky Memorial, Lagos House, Banex	<p><u>Garki District</u> Area 1 Shopping Complex, Garki Market, Garki Area 10 Plaza, EFAB Mall</p>	Wuse Market, Garki Area 10 Plaza, Sky Memorial, Lagos House, Banex Plaza, EFAB Mall Garki Area 11,

	Plaza, Ceddi Plaza, EFAB Mall Garki Area 11, Melita Plaza Garki Area 11, Yushau Plaza Garki Area 11, Kano House, Ekiti House, Benue House, Dantata and Sawoe, Mangal Plaza, Amigo Plaza	Garki Area 11, Melita Plaza Garki Area 11, Yushau Plaza Garki Area 11, Dantata and Sawoe, Mangal Plaza <u>Central Area District</u> Lagos House, Ceddi Plaza, Kano House, Ekiti House, Benue House <u>Wuse District</u> Sky Memorial, Wuse Market <u>Wuse II District</u> Amigo Plaza, Banex Plaza	Dantata and Sawoe, Area 1 Shopping Complex, Mangal Plaza
Total	18	18	9
Self Employed	GSM Village, Utako Market, Wuse Market, Garki Market, Garki Area 10 Shopping Complex, Garki Area 1 Shopping Complex, Sky Memorial, Banex Plaza, Garki Area 2 Shopping Complex, Abari Shopping Complex Zone 5, Garki II Shopping Plaza, EddyVic Plaza Area 3 Junction	<u>Garki District</u> Garki Market, Garki Area 10 Shopping Complex, Garki Area 1 Shopping Complex, Garki Area 2 Shopping Complex, Garki II Shopping Plaza, EddyVic Plaza Area 3 Junction <u>Wuse District</u> GSM Village, Wuse Market, Sky Memorial, Abari Shopping Complex Zone 5 <u>Utako District</u> Utako Market <u>Wuse II District</u> Banex Plaza	Wuse Market, Sky Memorial, Garki Area 10 Shopping Complex, Banex Plaza, Garki Area 2 Shopping Complex, EddyVic Plaza Area 3 Junction
Total	12	12	6

Source: Author's Analysis, 2013.

This was followed by a ballot of a random selection of 50% of the clusters from each stratum of clusters. The selected clusters in the public sector stratum equaled 12, in the private sector stratum equaled 9, and in the self-employed stratum which equaled 6, as is shown in the fourth column of Table 6-2 above. Therefore, the respondents from the selected sampled clusters were selected on the basis of satisfying the criteria of having journeyed to work in the core-city employment area from any of the three axes either as a commuter in mini-buses or as commuters in private cars.

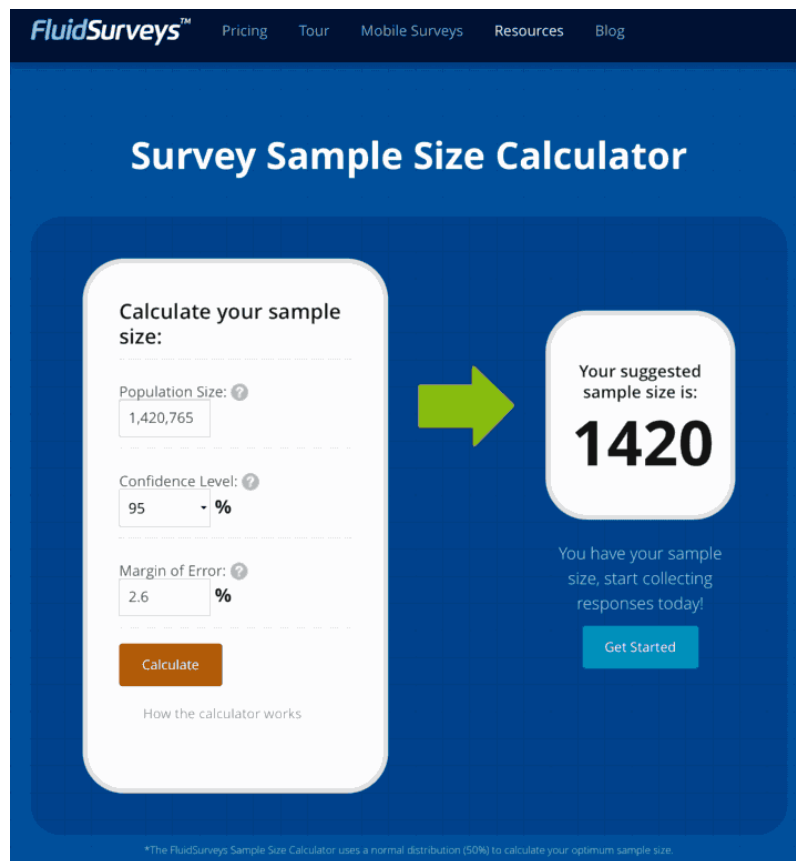
The target respondents in this survey were drawn from the estimated study population of 1,420,765 persons who are the daily commuters in mini-buses and private cars along the AYA, Kubwa-Bwari, and Airport road routes linking the suburbs to the core-city employment areas. Most research adopts a 95% confidence level and ± 5 confidence interval (Margin of error) for questionnaire surveys (Survey Systems, 2013; Fluid Surveys, 2013). In this study, a 95% confidence level has been adopted. By adopting ± 5 confidence interval, the sample size appropriate for a study population of 1,420,765 is put at 385 (See Figure 6-5).



Source: FluidSurvey, 2013.

Figure 6-5: FluidSurveys sample size calculator

However, in order to enhance the rigour and reliability of the research findings, the confidence interval (margin of error) was set at ± 2.6 and this put the sample size at 1420 (See Figure 6-6).



Source: FluidSurvey, 2013.

Figure 6-6: FluidSurveys sample size calculator.

By this, the sample size is relatively larger and the sample's results can be identical with the true value of the study population by a range of ± 2.6 . This margin of error indicates that the range in value of the results is accurate and reliable. A total of 1,420 questionnaires which represent 0.001% of the study population were administered (See Table 6-3 below).

Table 6-3: Sample Selection of Commuters.

Axis	Study Population (Commuters along the 3 Routes)	Selected Sample	Number of Questionnaires Administered	Confidence Interval	Confidence Level
Suburban Areas	1,420,765	1420	1420	2.6	95%
Total			1420		

Source: Authors Analysis, 2013, and *The Survey System, (2013)*, *Fluid Surveys, (2013)*.

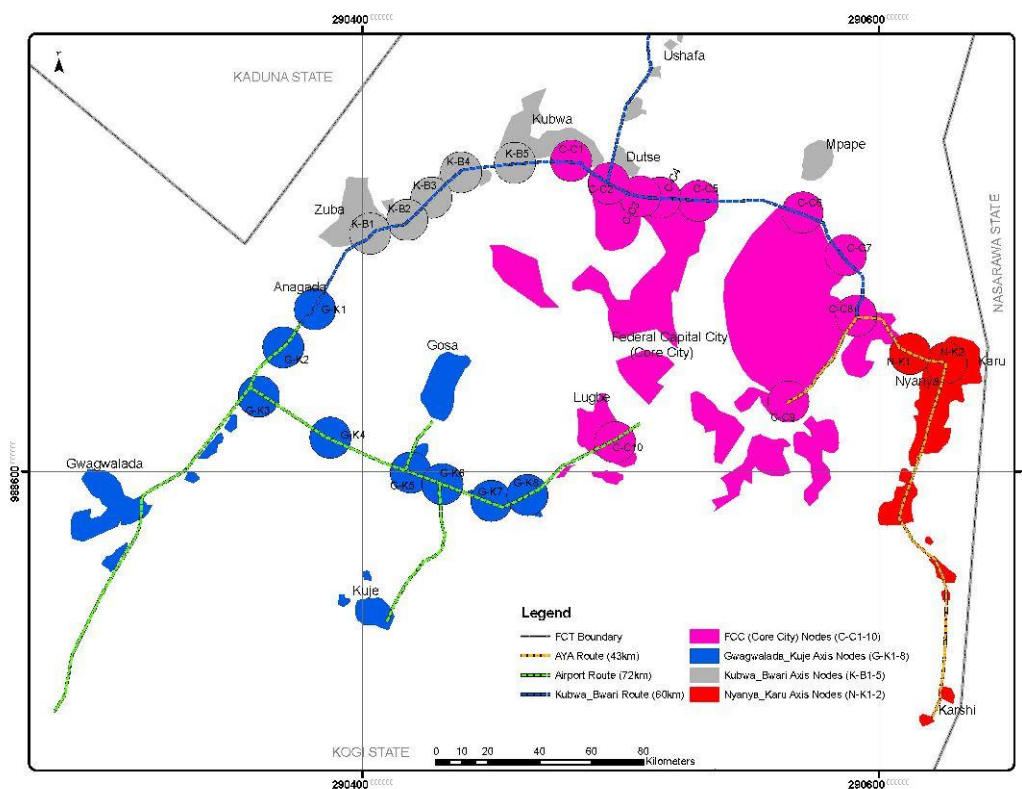
While larger sample size are known to be more reliable, and increase the reliability of the findings, the sample size selected in this study may appear small, this may depict the weakness in the sample size selected in this study. However, the sample selection guide (Systems Survey, 2013 and Fluid Surveys, 2013) indicates that the sample size adopted in this study may still suggest reliable findings. An important strength of the sample selection in this study (1420 selected sample; ± 2.6 confidence interval; 95% confidence level) is the balanced selection of respondents across the 3 axes and across

the 2 commuter groups (commuters in private cars and commuters in mini-buses). With this, the reliability of findings from the study may have been strengthened.

In order to achieve a balance in the selection of respondents across the three routes under consideration, the 1,420 questionnaires were divided across the three routes which equal 473 questionnaires per route. Accordingly, 473 questionnaires were administered to respondents who were commuters in mini-bus and private cars on each of the three routes (with 173 questionnaires designated for the commuters in mini-buses and 300 questionnaires designated for the commuters in private cars). This ratio of questionnaires between commuters in private cars and commuters in mini-buses was adopted because the primary focus of the artefact is the reduction in the daily huge motorized vehicular volume dominated by private cars. Less emphasis was placed on the commuters in mini-buses because the proposed BRT system should replace the existing public transport system, and the mini-bus commuters are expected to transition to the new BRT system.

6.8.2.2 Residents of Areas Designated as Nodes in the Core-city

In line with the preliminary plan of the conceptual solution, a total of 25 nodes were designated along the planned BRT routes with 15 nodes across the suburban areas and 10 nodes across the core-city (see figure 6-7). In order to select the respondents to these questionnaires, 50% of the total numbers of designated nodes in the core-city were selected using systematic random sampling. These, therefore, served as the sample areas for the questionnaire's administration. Therefore, the total number of nodes selected for questionnaire's administration was five, and the nodes are depicted as C-C1, C-C3, C-C5, C-C7 and C-C9 (see Figure 6-7).



Source: Authors Analysis (2013).
Figure 6-7: Selected Sample of Nodes.

In line with the selected sample nodes, a total of 305 questionnaires were administered across the five (5) nodes, this amounted to 61 questionnaires per node.

This number of questionnaires represented 4.06% of the total number of 7500 compounds (study population) in the designated nodes in the core-city (see appendix IV for assumptions and detail extrapolation). The confidence interval and the confidence level for this survey are as stated in Table 6-4 below.

Table 6-4: Sample Selection.

Axis	Study Population (Nodes)	Selected Sample	Study Population (Compound) ^a	Selected Sample	Number of Questionnaires Administered	Confidence Interval	Confidence Level
Core-City	10	5	7500 ^b	305	305	5.5	95%
Total					305		

Source: Author's Analysis, 2013, and *The Survey System*, 2013.

Note: ^aStudy Population (compound) is the product of the number of Sample Nodes and Estimated Compounds in each node (1500) in core-city area.

The selection of compounds for the questionnaire's administration was based on the systematic random sampling method as described by Descombe (2007, p.14). In order to select the respondents to the questionnaires, each of the five nodes was segmented into compounds using property boundaries that were evident on the satellite image of the area. Each of the compounds was numbered; this was to ensure ease of reference. Each node had approximately 1500 compounds. The application

of the systematic random sample method to select 61 respondents per nodes, therefore, implied selecting 1 compound after every 25th compounds. A voluntary respondent was chosen from each compound after a brief explanation of the goal of the research. The eligibility of the respondent was based on the criteria of being a householder within the selected compound that has expressed an interest in the research and voluntarily accepted to respond to the questionnaires. Since the investigation in this section is also on users' perception of householders about being resident along routes designated for reform into BRT corridors, the nature of the questions contained in the questionnaires and the purpose of the questions are same as explained in Section 6.8 above. Accordingly, the questionnaires were distributed to respondents and they were given three days to complete. The residential address and the code number for each compound as defined by the researcher on the satellite image of the respective area were used to track and retrieve the questionnaires from the respondents.

6.8.2.3 Response Rate

Recognizing that a low response rate in a survey exercise is unlikely to provide credible statistics about the study population, the survey in this study was, therefore, designed with the goal of achieving a high response rate. This was to ensure that the findings met acceptable levels of scientific rigour with regards to the high level of response rate, representativeness and generalizability of the results.

Given that the upper and lower mark of response rate in a survey exercise is put at 50%-75% (Fowler 2002, Schutt 1999, Babbie 1990, Draugalis et al. 2008, p.4, Cumming et al. 2001, Baruch and Holtom, 2008), notably, the response rate achieved from the survey of commuters in mini-bus and in private car was 68% (353 questionnaires) and 80.2% (722 questionnaires) respectively. To sum up, out of 1,420 questionnaires distributed, 1075 (76%) completed questionnaires were returned to the researcher in a usable form. Similarly, the response rate achieved from the survey of residents of designated nodes in the core-city was 77% (234 questionnaires). The gross rate of response was, therefore, put at 77%. In these cases, the response rates are sufficiently high when compared to a typical survey exercise. By this, the reported findings may be regarded credible and therefore reflect the target population and be a true contribution to the scientific literature. This response rate can help to increase the validity of the conclusions to be drawn from the analyses of the users perception surveys as convergence or divergence from the prediction of the practitioners about the performance of the spatial planning strategies solution (artefact).

Indeed, in order to achieve robustness in the research findings, and to overcome the challenges of establishing construct validity and reliability of the findings in this study, all the sources of evidence highlighted above were employed in order to provide multiple corroboratory evidence to the Evaluate Artefact phase. This therefore provides answer to research objectives 5 and 6, and research question 3.

By this, the opportunity presented for data triangulation has leverage the rigour and quality of the research findings, and therefore present a premise for enhanced reliability in this study.

6.9 Reliability, Validity and Generalizability

6.9.1 Reliability

The pursuit of reliability in this study is traceable to the thorough evaluation and choice of the appropriate philosophical assumption/worldview, approaches, strategies and methods. The justifications provided for the adoption of each of the element in the research methodology framework support the claims of reliability in this study. Importantly, each of the research methods and data sources which include direct observation, archival records, interviews, and focus group discussion session, were adopted because their features demonstrate the capacity to access and home-in on data sets relevant to the research questions in this study. By maintaining a chain of corroboratory evidence, the reliability of the findings in this study is strengthened. Yin (2003) and Creswell (2009) argued in their study that qualitative researchers need to document the procedures of their study and document as many steps of the procedure as possible to ensure reliability. Therefore, all the procedures engaged in, were properly documented within this methodology chapter. Hence, this demonstrates that this study could be repeated successful.

Therefore, by maintaining a line of sight between the research questions, the review of literature, the conceptual solution, the data collected from the sources of evidence on the evaluation of the conceptual solution and the eventual conclusions, the reliability of these findings is realized.

6.9.2 Validity

By integrating several sources of evidence such as documents, archival records, direct observation interviews and focus group discussion into the different phases of this research, the researcher took advantage of the opportunities presented by the Design Science research strategy of multiple methods. This exemplifies the character expected from a rigorous research. The most significant advantage here is the development of converging lines of inquiry, a process of triangulation and corroboration (Hevner et al 2004, Vaishnavi and Kuechler 2008, Yin 2009). As a result, findings and conclusions emerging from the integration of these sources of evidence are more convincing and accurate. By this, construct validity is achieved, since the multiple sources of evidence essentially provide multiple measures of the same phenomena. Indeed, without these multiple sources of evidence, an invaluable advantage of the Design Science research strategy for rigour and validity will have been lost.

6.9.3 Generalizability

Qualitative research substantially focuses on developing solutions that are relevant to addressing a particular problem. However, even though the Design Science research strategy focuses a study towards solving an existing specific problem (in this case, traffic congestion and suburban sprawl in

global south cities using Abuja as an illustrative case), arguably the Design Science research strategy also provide good basis for generalization. Within the context of this study, the applicability of the findings on the solution to traffic congestion and suburban sprawl in Abuja to other similar cities would depend mostly on the features which the city of Abuja shares with other cities in the same class. In line with evidence from earlier studies, the features may include urban planning system, capacities of urban planning institution, rapid urban population growth, population and geographic size, rapid motorization levels, increasing trend of suburban spatial growth, and located in the global south region.

These features can serve as checklist bases for comparing the relevance of the findings in the illustrative case (the city of Abuja) to other similar medium sized global south cities towards making generalization. It is however worthy to note that, the bulk of the task of generalization rests with the reader (Yin, 2009), the findings from the Evaluate Artefact phase (ex-post) of the narratives, circumscription and iteration implicit to the Design Science artefact (in this case, BRT, TOD and TDM) provide the required information for readers to make informed judgments on generalization.

6.10 Data Analysis and Interpretation

The stream of data collected from the sources of evidence (observation, documents, archival records, interview, focus group discussion and users perception surveys) were analyzed in search of content and themes that elucidate the research questions (Creswell 2009, p. 185).

Within the context of this research, the meaning derived from the thematic analysis of photographic recording from the direct observation of traffic congestion and suburban sprawl, and opinion of commuters and urban planning practitioners on the awareness of this problem from structured interviews provided answers to research question 1 and 2. The content analysis of relevant planning documents to reveal the predict and provide engineering solution of building and expansion of roads as policy and programme to addressing traffic congestion provided corroboratory evidence about research question 1 and 2. Related evidence is also derived from quantitative analysis of the archival record of traffic counts of vehicle and passenger volumes along the routes under consideration. These therefore show the impacts of the present planning system and contribute to providing answers to research questions 1 and 2. In addition, frequency analysis of responses from commuters on man-hour loss, fuel wastage and CO₂ emission was made to corroborate literature evidence on impacts of traffic congestion challenges and elucidate on the explication of the problem.

Upon development of the spatial planning solution (artefact), the Evaluate Artefact phase presented the opportunity for the use of interview and focus group discussion methods to generate feedback as data from the circumscription and iterative process permitted by the Design Science research strategy.

The results from this Evaluate Artefact phase is premised upon thematic analysis of data derived from the synthesis of opinion of experienced practitioners from interviews and focus group discussion session and therefore provided answers to research question 3. The focus group deliberations were video recorded, while the interview were audio recorded, these were transcribed, coded and analyzed using QSR NVIVO 10. The focus of the analysis was on words, context, themes, frequency, extensiveness and intensity of comments, specificity of responses and the 'big idea' running through the session with reference to the solutions being discussed. These datasets were presented using frequency of aggregate responses on each theme including some selected excerpts of quotes from the interview transcripts to support the arguments.

It therefore suffices to note that the findings from the interview and focus group sessions in the Evaluate Artefact phase provided evidence that illustrate the appropriateness and applicability of the developed spatial planning solutions for addressing the challenges of traffic congestion and suburban sprawl in global south cities including Abuja. Hence, providing answer to research objective 6.

In addition, in order to validate the extrapolation of the performance of the conceptual solution of spatial planning strategies of BRT, TOD and TDM, the data from users perception survey was obtained from commuters in mini-buses and private car residents along designated BRT corridors and designated TOD nodes. The quantitative data sets derived from this questionnaire survey method includes responses on reduction in private car usage in favour of transit trips due to the impacts of BRT, TOD and congestion. The analyses were made using simple frequency and statistical analysis (Chi-Square analysis) in SPSS V16 to reveal the level of acceptability and usage of these solutions by users. These resulting metrics provided statistically analyzed evidence that contributed to the evaluation of the spatial planning strategies of BRT, TOD and Congestion Pricing. These therefore show the perceived impacts of the developed solutions and contribute to providing answers to research objectives 5 and 6, and research questions 3.

The interpretations of the meaning from the results were made by deriving meaning from the findings with reference to the literature and theories in such a way that these findings confirmed previous information or diverged from it. The interpretation therefore convey meanings relevant to the research problem and solution (artefact) in terms of how to solve the occurrence of these challenges of traffic congestion and suburban sprawl in medium sized global south cities.

6.11 Summary

This chapter demonstrates the overall Research Methodology framework upon which this study is based. The described framework consists of several elements which include the research philosophical leaning, approach, strategy and methods. The choice of the methodology framework in this study was

premised majorly upon review of previous studies on evolving urban planning solutions to challenges in cities, and partly on research methodology literatures on the built environment. This study adopts the research philosophy that is premised upon the constructivist ontological position, and the interpretivists' epistemological position and a mix of both qualitative and quantitative research approaches. The Design Science research strategy was adopted as the research strategy while combining multiple research method which includes direct observation, document review, archival records, face-to-face interview, and focus group discussion session and questionnaire survey.

Therefore, this study adopts a mix of both qualitative and quantitative research approaches with emphasis on qualitative approach. This is because the majority of the inquiry focused on interpretation of thematic analysis of qualitative data sets from interviews and focus group discussion sessions, with urban planning practitioners and direct observation of the challenges of traffic congestion and suburban sprawl. This includes content analysis of qualitative textual data sets from relevant urban planning documents. The quantitative approach focused on structured interviews with commuters and practitioners, the analysis of archival records of maps and satellite imageries of spatial development in the study area, volumetric counts of passenger and vehicles, and users' perception surveys. In sum, a total of 147 structured interview were conducted with commuters, 30 structured interviews were conducted with practitioners, 30 semi-structured interviews were conducted with practitioners, 4 focused group discussion session was conducted with practitioners, and 1420 questionnaire survey with commuters in the case-city.

The adoption of Design Science research strategy provided the opportunity to establish and explicate the research problem by using a combination of these quantitative and qualitative research methods, these therefore provided answers to the research question 1 and 2. The Defining Requirement phase, the Design and Development of the conceptual solution, the Demonstrate Artefact phase and the Evaluate Artefact phases of the Design Science research strategy all required the combination of multiple research methods to yield corroborative evidence. The results from these findings therefore provide a premise to draw reliable conclusions from this study.

The next chapter consist majorly of the contextualization of the developed artefact to the case city (Abuja) and the use of metrics (on the level of land usage, mode shift, and travel time) to demonstrate that the artefact has the capabilities to address the challenges of traffic congestion and suburban sprawl in the selected case-city. This demonstration of the artefact is essentially the proof-of-concept that the developed solution can work as intended in the case city (Abuja).

CHAPTER 7: CONTEXTUALIZING THE SPATIAL PLANNING STRATEGIES TO THE CASE CITY

7.1 Introduction

This chapter focuses on contextualizing the developed artefact within the case city Abuja. This represents the Demonstrate Artefact phase of the Design Science research strategy adopted in this study, and focuses on showing that the artefact can solve the explicated problem in one illustrative or real-life case. Essentially, it is the application of the developed artefact to a chosen case, this includes documenting the extrapolated outcome from the application of the artefact to the chosen case. In line with Design Science literatures, the Demonstrate Artefact phase primarily functions as a proof-of-concept, showing that the artefact could be used as intended, and therefore provides adequate test-bed for the artefact.

Accordingly, the application of the components of the artefact developed in this study which include TOD, BRT, and Congestion Pricing strategies was contextualized adapted to the existing situation in the case city Abuja in order to demonstrate that the strategies can work and, have the capabilities to address the challenges of traffic congestion, car-dependent mobility pattern and suburban sprawl.

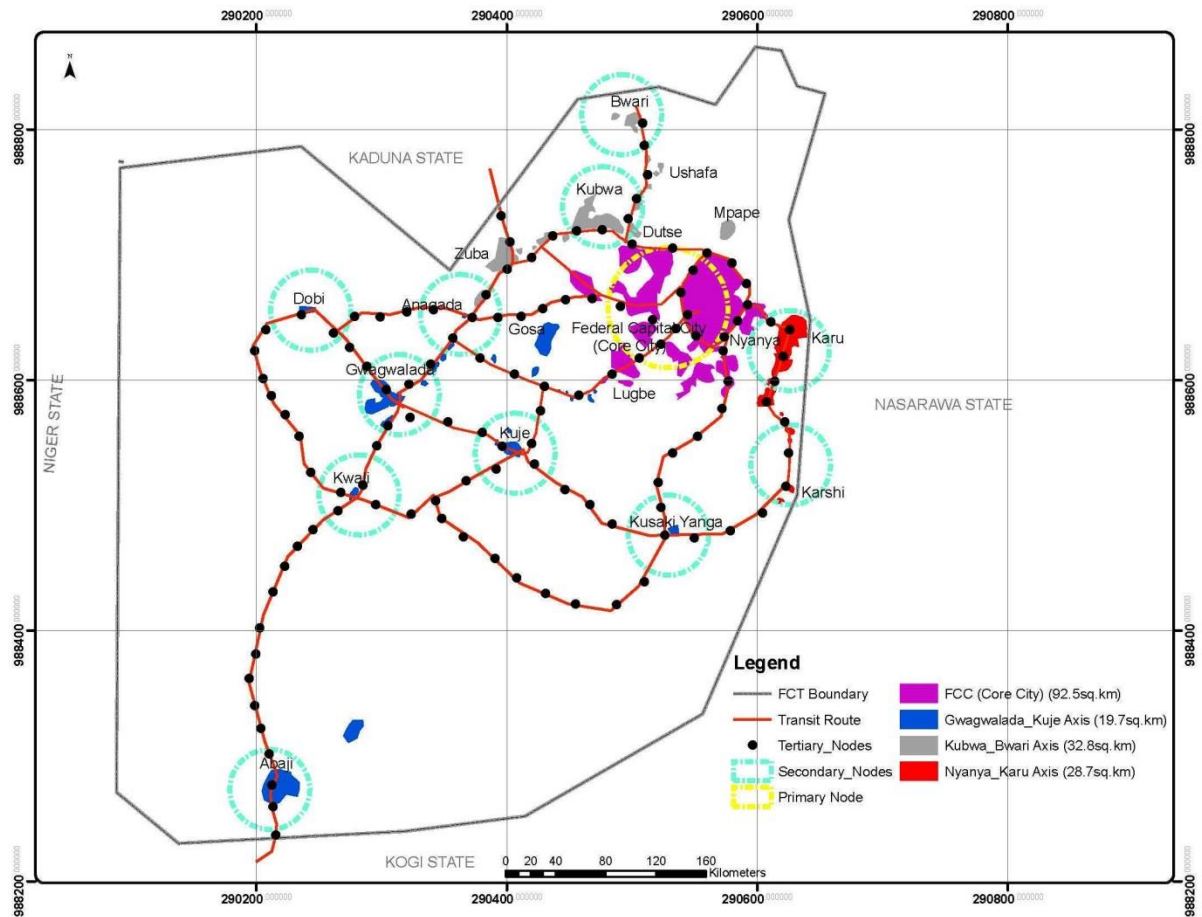
The literature specification of the performance capabilities of the developed artefact with regards to reducing car usage level and the level of sprawl was used to extrapolate the metrics of the impacts attributable to the 3 strategies in the case city. The comparison of the extrapolated outcomes from the application of the artefact in the case city with the outcomes in the existing situation (without the artefact) provides the premise to suggest that the strategies can work to produce optimal outcomes.

In specific terms, the demonstration of the artefact in the sections below focused on how the vision plan and the three components of the artefact which include BRT, TOD, and Congestion Pricing could transform the case city. The emphasis is majorly on a reduced level of private car usage, increased level of transit usage, smart pattern of physical development in the suburban areas along the three corridors under consideration in the case city, and institutional reforms to the current planning system and organization.

7.2 Decentralized Concentration

The vision plan of the developed artefact focuses on creating multiple centres of activities that balance activities and population and spurs multi-directional travel patterns through transit linkages across and between different levels of activity and population centres at the metropolis level (see Figures 4-2 and 5-20). The detailed composition of such plans has been explained earlier in Sections 4.2 and 5.4.1.2.

Therefore, in order to demonstrate this vision plan and its central idea to create balance of trips, population, employment and infrastructure between the core-city and the suburban areas, a plan that envisions the transformation of the city at the metropolis level has been developed. The composition of the plan consists of the creation of a decentralized concentration of layers of nodes to balance population and activities across the Abuja city-region (see Figure 7-1).



Source: Author's Analysis, 2013.

Figure 7-1: Conceptual plan for transforming mobility pattern and spatial development in Abuja.

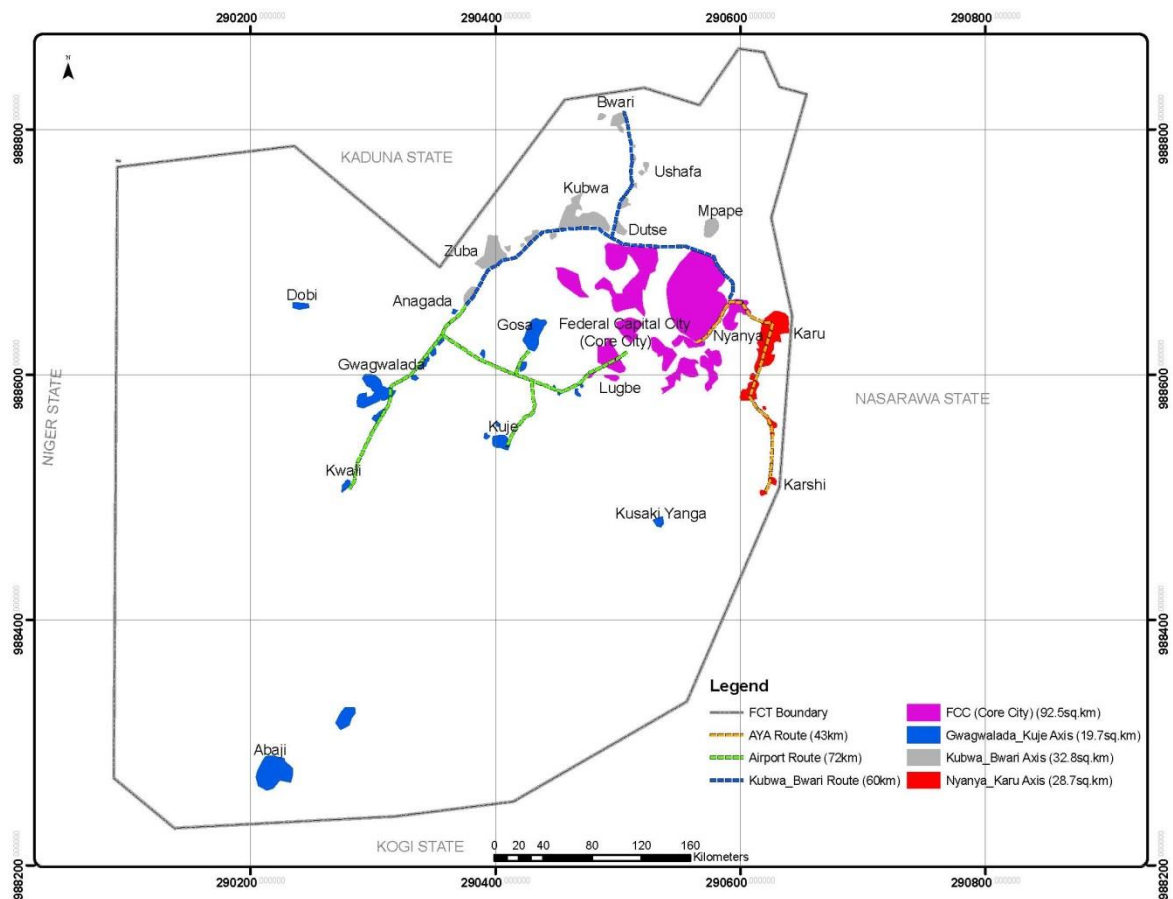
As shown in Figure 7-1 above, the plan for the transformation of the mobility patterns and the spatial development of the city has been conceptualized into three layers of nodes: primary, secondary and tertiary nodes. The existing core-city has been designated as the single primary node. A total of ten (10) secondary nodes have been designated outside the core-city with locations within the regional areas, not only because of the status of these settlements as already designated satellite towns or emerging satellite towns but also because of the level of interaction they generate with the core-city. These secondary nodes include the Bwari, Kubwa, Nyanya-Karu, Gwagwalada, Kuje, Kusak Yanga, Karshi, Anagada, Abaji, and Kwali suburban areas. It is envisaged that these secondary nodes can become locations for different specialized employment and service centres such as agriculture, tourism, education-related sectors, and government and private establishments. It is envisaged that these centres can attract populations and can also generate bi-directional trips amongst the centres, and between Abuja core-city and these centres. This can, therefore, balance the population, employment areas and the demand for mobility across the city-region. The third level of nodes is the tertiary nodes; they are the communities that should be located along the rapid transit routes (see Figure 7-2). These communities have been so designated partly because of their geographic proximity to the transit route

and also because of their potential to generate ridership for the optimization of the transit operation. It is suggested that the transformation of these communities from their present extensive spatial pattern into rich diverse, mixed-use, high density communities would not only optimize the use of land but also generate ridership for the optimization of the transit operation and further justify the investments in transit. With these communities becoming 'walk-able communities' that are small enough to reduce or eliminate the desire for private car usage yet large enough to provide for rich diverse opportunities, they therefore, depict a good urban setting. With the proximity of these communities to the transit corridors, long trips are more likely to be made via transit. Put simply, these tertiary nodes would, in other words emerge, as Transit Oriented Development (TOD) nodes and in line with specifications in earlier studies (Calthorpe 1993, Delhi Development Authority 2012, ITDP 2014) have a 300 - 800 metres radius as their sphere of influence. This spatial plan which consist of the visioning of spatial development and transit network at the metropolis level to reform the existing situation in the case city is consistent with the studies of Cervero (1998), Newman and Kenworthy (1999) (2006), Cervero and Murakami (2008), UNHSP (2013) and Suzuki et al, (2013) which argued that the transit metropolis remains the most sustainable urban form, and should be pursued by cities. This demonstrated solution therefore contribute to providing answers to the research question 3 which seek to develop alternative solution to the explicated problem of traffic congestion in global south cities.

7.3 BRT as the chosen Rapid Transit Mode

The benefits of BRT have been extensively discussed earlier in Section 5.4.2. Therefore, consequent upon several evidence provided by earlier and current studies which have explicated the benefits of the BRT system, the BRT system is, therefore, put forward and demonstrated to serve as the transit linkages to all the layers of the nodes as outlined in Figure 4-2.

Accordingly, with the demonstrated application of the BRT system in Abuja, the efficiency of the public transport and the travel patterns in Abuja can be transformed especially at the metropolis level as illustrated in the vision plan in Figure 7-1 above. This transformation should lead to recalibration of the existing modal share in favour of the public transport mode. This is because the implementation of an efficient BRT system is known to attract choice riders from other modes especially private car drivers. The demonstration of the BRT routes for Abuja is illustrated in Figure 7-2 below.



Source: Author's Analysis, 2013.

Figure 7-2: Proposed BRT route in Abuja.

As shown in Figure 7-2 above, the BRT routes/corridors have been designated to serve the three major axes under consideration. The designated BRT corridors, therefore, cover a total length of 175km. In this proposal, this BRT corridor replaces the existing high capacity bus routes that presently run in mixed traffic. The BRT corridors on the Gwagwalada-Kuje, Kubwa-Bwari and the Nyanya-Karu routes are designated to cover 43km, 72km and 60km lengths respectively on these three major routes. It is important to note that, in order to ensure that this proposals work optimally, the first phase of implementation of the proposed BRT routes has taken due cognizance of the existing programme of the FCT Transport Secretariat in Abuja which has designated high capacity buses to the major routes and mini-buses as feeder services from the core-suburban areas to these major routes linking to the core-city.

Accordingly, the first phase of implementation should consist of 25.77km (Giri Junction- Lugbe), 40.68km (Zuba Junction – AYA_ONEX Junction) and 12.5km (Nyanya – ONEX_Ring Road I Junction) on the Airport Road, Kubwa-Bwari, and the Nyanya-Karu Routes respectively. By phasing the application of the BRT corridors along the newly introduced high capacity bus routes, it should be easier to start the application of the BRT system. The subsequent phases can be extended beyond these corridors in line with the planned complete BRT designated routes (see Figure 7-2).

7.3.1 Components and Character of the BRT System adapted to Abuja

The BRT system as a component of the developed artefact has several integral sub-components relevant to its efficiency as explained in Chapter 5 Section 5.3.2.1. Accordingly, BRT system for Abuja should have a segregated bus lane, bus stations, a control centre and the contact-less off-board payment option as against the conventional method of payment of cash at the point of entry, in order to reduce boarding time. Display boards that show to passengers the real-time information about bus arrival and departure times, a BRT route map and bike facilities are also designated as part of the BRT components.

I. Exclusive Segregated Lane

The demonstration of this sub-component of the BRT system shows that the BRT corridor should have exclusive physically segregated lanes for the BRT buses as seen in the study by ITDP (2013) of Transmileneo, Bogota in Section 5.4.2.2 and Figure 5-30; this can prevent interference from other vehicles and ensure compliance of the BRT system operation with scheduled travel times of the BRT buses. The segregated lane should be aligned to the centre of the roadways of the routes designated as BRT corridors.

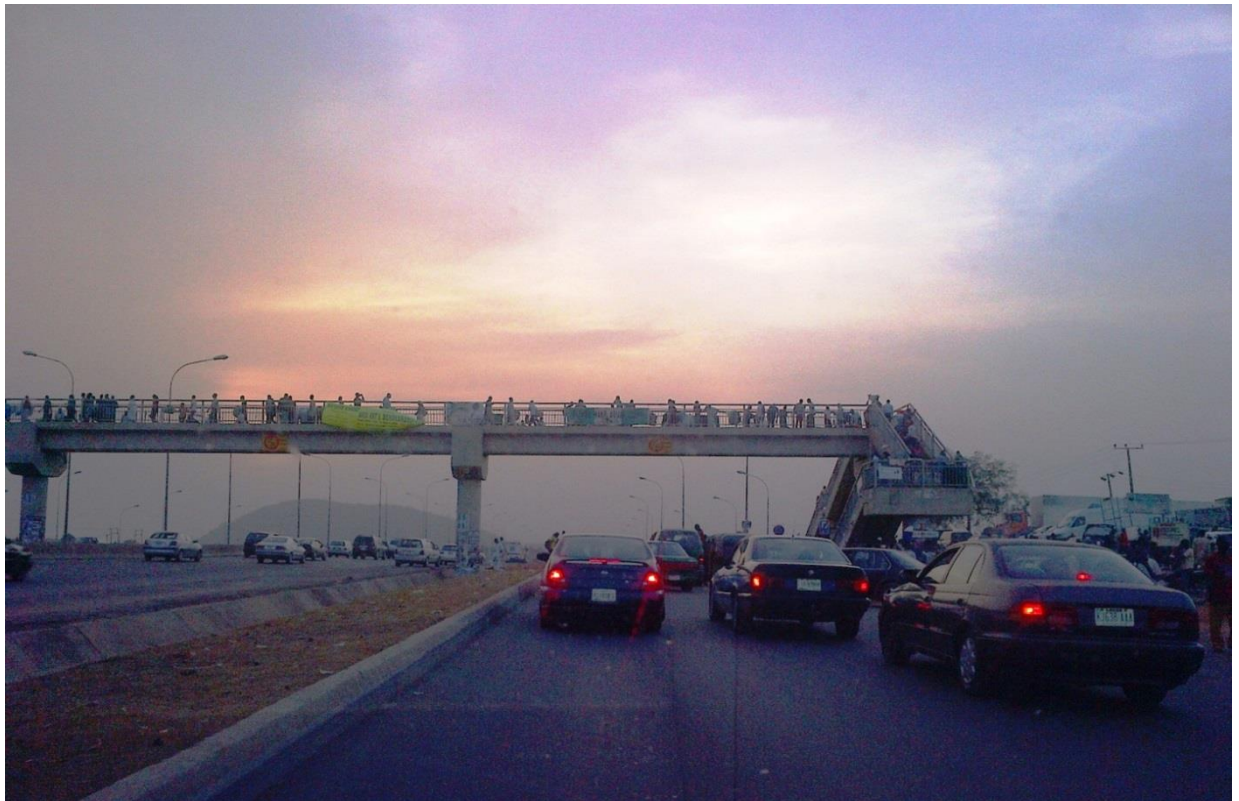
Figure 7-4 below shows a profile of the existing roadway along the routes under consideration. With cognizance of this present size of the right of way (75m) along the routes under consideration in Abuja, it is indeed possible to designate the segregated lane to the central part of the roadways (See Figure 7-3).



Source: Author's Field Survey, 2013.

Figure 7-3: Profile of existing roadway along Kubwa-Bwari route, Abuja

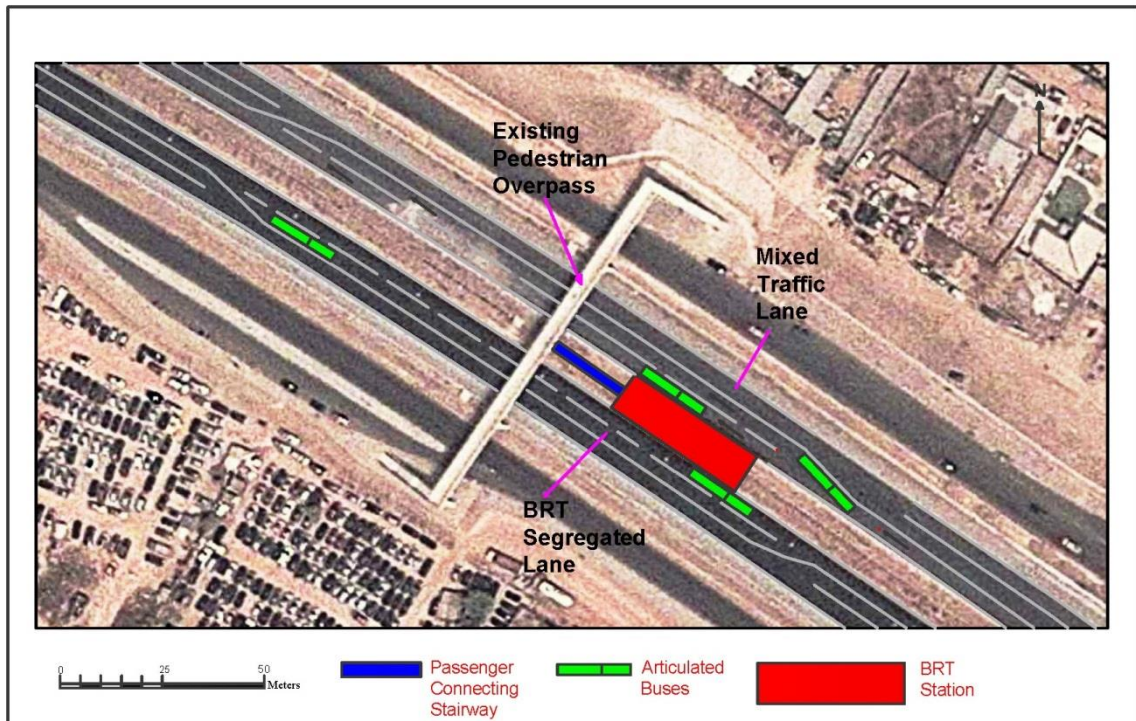
The pedestrian overpass in the existing road profile in Abuja can be adapted into the BRT system and designated to connect passengers via a connecting stairway to the centrally located BRT station (see Figure 7-3 and 7-5 below). This is seen in the study by ITDP (2013) of Sao Paulo, Brazil in Figure 5-10, in Section 5.3.2.1, sub-section II. The existing overpasses located at the major residential entry/exit points in the study area can be adapted to feed passengers into the bus station. These existing overpasses can, therefore, help to reduce the cost of the related infrastructure and ensure ease of application. The passenger connecting stairways is 2.5 metres wide and spacious enough to accommodate intending commuters and would not inhibit pedestrians from crossing through the overpass.



Source: Author's Field Survey, 2013.

Figure 7-4: The pedestrian overpass along Kubwa-Bwari route, Abuja

The described example in the studies on Sao Paulo shows a typical example of how a bus station is fed with passengers by an overpass. The passengers walking over the overpass are protected from sunshine and precipitation by a roof cover. Accordingly, the existing overpasses in Abuja should require such a shield or roof cover in order to prevent passengers' exposure to sunshine and precipitation. This factor can be an additional incentive that may attract passengers to the BRT system.



Source: Author's Analysis, 2013.

Figure 7-5: Proposed BRT station and related infrastructure along Kubwa-Bwari route, Abuja.

Figure 7-5 demonstrate the transformation around the existing roadway which includes the BRT station located in the road median, the connecting stairway that connects passengers from the existing overpass to the BRT station, the segregated bus lane and the passing lane. In order to serve bi-directional trips, the BRT station is centrally located in the road median and covers 360 square metres as shown in Figure 7-5 above. Accordingly, passengers can be connected to the bus station via an existing overpass by a connecting stairway and, therefore, easy access is guaranteed for the passengers. The median aligned bus station avoids the cost of two stations in curb aligned bus stop.

A single exclusive segregated bus lane can be demarcated all through the corridor. However, a passing lane should be provided around the bus station to allow other buses that are not scheduled to stop at that certain station to pass unhindered parallel to other buses already docked at the bus station. Even though this single exclusive segregated bus lane may permit an effective use of the roadway by the BRT buses, the provision of a double lane is essential for buses to pass-by stationary buses in order to enhance the reliability of the BRT operation. The external lane of the roadway is to be designated for use by mixed traffic. This shows that functional exclusive lanes for BRT can be achieved in Abuja to permit efficient operation of the BRT system.

II. Rolling Stock

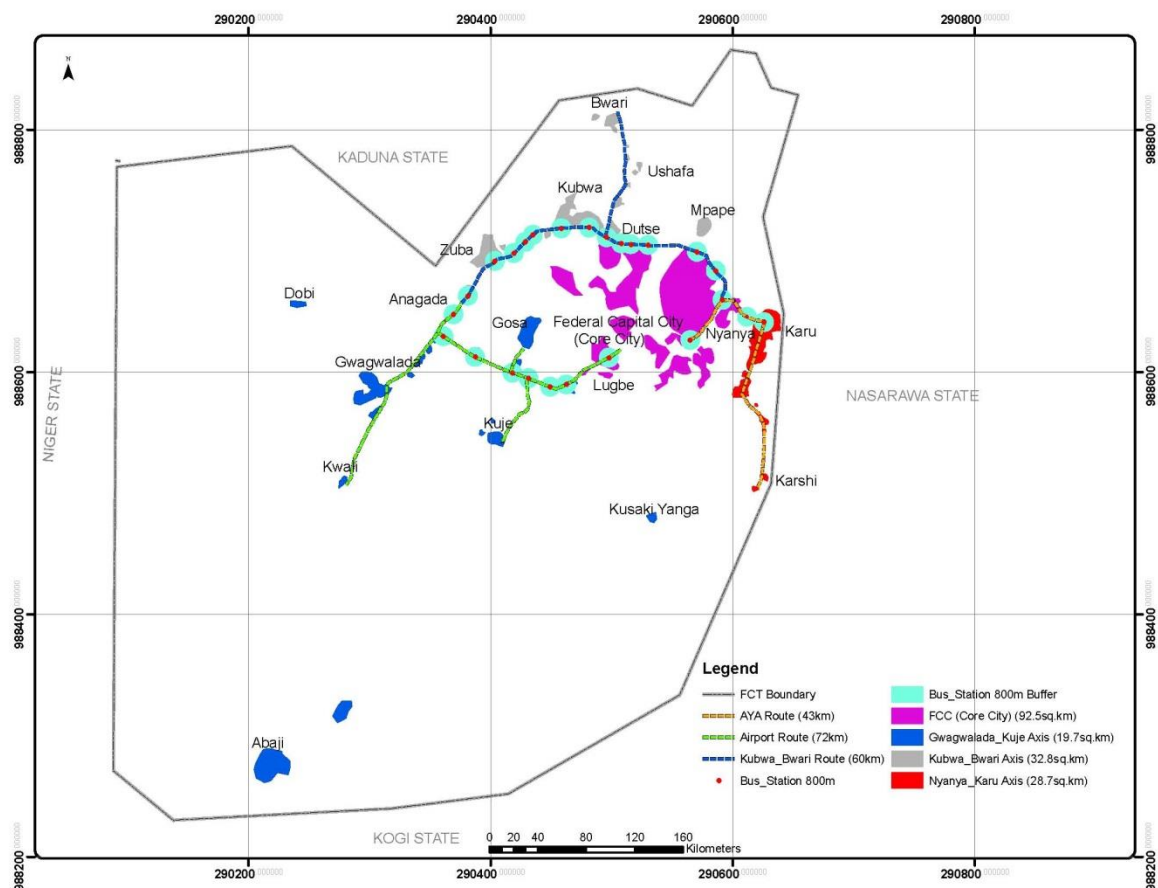
Rolling stock on a BRT system are mostly articulated or bi-articulated buses with a high passenger carrying capacity of between 160 – 250 passengers. This is seen in the study by ITDP (2013) of Transmilenio, Bogota, in Figure 5-9 and Suzuki et al. (2010) of Curitiba, Brazil in Figure 5-11, in

Section 5.3.2, sub-section III. In line with the developed artefact, it is therefore, suggested that 160 passenger articulated buses can be used to replace the existing fleet of 18 passenger capacity mini-buses and the newly introduced 57 passenger high capacity buses in Abuja.

This transformation can serve to reduce the huge number of informal mini-buses and, importantly, can reduce daily VKT and lower per capita fuel usage and emission levels from the daily commute along the routes under consideration. In order to keep the emission levels from the rolling stock on the BRT system low, the emission standards of the buses should have a minimum of Euro IV with particulate matter traps. By this, the implementation of the BRT system can contribute to achieving sustainable low carbon transportation in Abuja.

III. Location of Bus Stations

It is generally recommended that the location of BRT bus stations be placed at an average of 500-1000 metres apart (Calthorpe 1993, Delhi Development Authority 2012, ITDP 2014). In line with the developed artefact, the BRT bus stations in the planned system in Abuja should be located along the designated BRT routes. However, while huge efforts have been made to comply with these recommended distances between bus stations, efforts have also been made to ensure that the location of the bus stations recognizes existing settlements so that the communities along the BRT corridors are properly served. Accordingly, the BRT stations have been located close to the entry/exit points of major communities identified as having the potential to generate ridership for the BRT operation (see Figure 7-5 and 7-6).



Source: Author's Analysis, 2013.

Figure 7-6: Proposed BRT routes and Bus stations along the three major routes in Abuja.

In line with the demonstrated BRT network, the BRT corridors/routes on the Airport Road and the AYA and Kubwa-Bwari routes should have nine (9), four (4), and twelve (12) proposed bus stations respectively. Each of the bus stations is planned to serve its 800 metres' radius sphere of influence. This can permit commuters resident within this sphere of influence to walk for a maximum of 5 - 10 minutes from their homes to the bus station.

With the location of a single bus station in the central verge of the road as seen in the study by ITDP (2013) of Transmilenio, Bogota, in Figure 5-9 and Suzuki et al. (2010) of Sao Paulo, Brazil in Figure 5-10, in Section 5.3.2, sub-sections I and II (See Figures 7-6), both bi-directional trips of passengers can be served, in that the station can serve the buses docking on both sides. This should serve to reduce the cost of application of the BRT system, because the cost of building two stations on both sides of the road can be reduced to one.

IV. Boarding Platform

As a component of the BRT system, the passenger boarding platform should be on the same level as the floor of the bus when it docks at the bus station. This can be achieved by elevating the floor of the

bus station to align with the height of the floor of the bus as is seen in the study by UNCRD (2013) of Transmileneo, Bogota, in Figure 5-13, in Section 5.3.2, sub-section IV.

Accordingly, the boarding platform should permit timely and convenient entry and exit by all spectrums of passengers including the aged and physically challenged in the BRT stations in Abuja.

V. Fare Payment by passengers

The contact-less off-board fare payment option is proposed to be implemented for the BRT system in Abuja. This is seen in the study by ITDP (2012) of TransJakarta, Jakarta, in Figure 5-14, in Section 5.3.2, sub-section V. This new medium should serve as an improvement over the existing conventional method of cash payment and the issuance of a ticket at the point of entry which increases boarding time.

The boarding time in this fare payment option can be reduced and, therefore, leads to an improvement in travel time. This improvement in travel time should serve as incentive to attract choice riders onto the BRT system in Abuja.

VI. Real Time Passenger Information System

The BRT system in Abuja is to integrate display boards for real time passenger information about bus arrival and departure times. This is seen in the study by ITDP (2013) and Morgan (2009) of Portland Oregon, in Figure 5-15, in Section 5.3.2, sub-section VI. The display boards should provide information relating to the expected arrival and departure times of the respective buses in accordance with published schedules of bus service.

This predictability of the schedule of service by BRT buses is also an incentive that can increase the potential ridership by choice riders on the BRT system from other modes, (especially potentially attracting private automobile vehicle drivers) in that, passengers can predict their departure and arrival times.

VII. Bus Routes' Map

As part of the component of the BRT system adapted to Abuja, the network of the proposed BRT routes, the designated bus stations along the route and the coding for the respective designated buses that should ply the routes should be published as a route map to provide information to passengers. This is seen in the study by ITDP (2013) of TransJakarta, Jakarta in Figure 5-16, in Section 5.3.2, sub-section VII.

It is suggested that a BRT route map can be implemented in Abuja and should, therefore, provide information to passengers on the schedule of the BRT system. Accordingly, passengers can be able to plan their travel, with less waiting period at bus stations by commuters in Abuja.

VIII. Bicycle Share Facility Scheme

In order to address the challenge of distant last mile commute that is presented in the evidence in Sections 3.7.2.5 – 3.7.2.6 which shows that these residents live far away from existing bus stops and walk long distances to get to bus stops. By putting in place bike share facilities to facilitate movement by commuters between the residential areas and the bus stops, this may generate more ridership on the public transport.

A bicycle share service is therefore adapted to Abuja especially for commuters who have to walk for more than 10 minutes to a BRT station. The conclusions by ITDP (2013) shows that the location of this facility at BRT stations and also at the entry/exit points of major residential areas/communities within the BRT corridor is important to first/last mile commute. By installing bike share facilities for last mile of commuting, the portion of the income of commuters spent on commercial motorcycle and taxi fares for this last part of the commute in Abuja can be saved.

The example is seen in the study by ITDP (2013) of Nantes, France in Figure 5.17, in Section 5.3.2, sub-section VIII. It is therefore suggested that bicycle-share facility can be located at each BRT stations and at entry/exit points of the major residential areas along the BRT corridor, as this can further encourage more commuters in private cars to ride on the BRT system in Abuja. The bikes are designed to operate on safe segregated lanes linking the BRT stations and the residential areas; this is to permit the safety of bicycle riders from motorists.

Initial pessimism by commuters concerning riding on bikes may be expected because using bicycles for commuting is presently unpopular in Abuja, but with improved efficiency in public transport coupled with good branding of the bike facilities, the numbers of riders on bicycles may progressively increase. The facility should be routinely serviced and maintained to guarantee the commuters' confidence in the scheme. The facility can be financed via a value capture mechanism through firms/entities willing to use the bicycle facility as an advertising medium.

As a component of the developed artefact, the BRT system adapted to Abuja integrates branding. Branding of BRT system is known to ensure that the public transport system does not only attract existing commuters to the new transit system but also attract choice riders from other modes, especially commuters in private cars (Penalosa, 2004, ITDP, 2013). Accordingly, the BRT system in Abuja is to be branded as seen in the study of Penalosa (2004) on TransMileneo in Bogota, Columbia, and ITDP (2013) on Trans Jakarta in Indonesia. It is, therefore, suggested that the BRT system should be branded as "*TransAbuja*" in order to create an identity of a quality and efficient transit system that can be attractive to all spectrum of the population. The branding can therefore provide an impetus for the enlightenment and sensitization of existing and potential riders on the BRT system.

7.3.2 The Potentials of BRT as a Transformation Tool for the Existing Mobility Pattern

Consequent upon the foregoing sections and the demonstration of the BRT system in Abuja as a component of the developed artefact, it suffices to posit that the BRT system may have the capacity to address the challenges that characterize the existing transport system in Abuja as illustrated in section 3.7.2.8. This assertion is consistent with the studies of Penalosa (2004) and ITDP (2013), which concluded that BRT system integrate several components that can help address the present mobility challenges in global south cities in terms of man-hour losses, fuel wastages and transport-related CO₂ emissions.

7.3.2.1 Extrapolation of Savings on Man-hour Losses, Fuel Wastage and CO₂ Emissions from the Application of the BRT System and related Mode Share

Based on the analyses of evidence from earlier studies which states that, by implementing an efficient transit system, private car usage could be reduced by 20% - 60% (Litman, 2012). Essentially, the focus is on transferring the existing pool of commuters on the mini-buses to the BRT system, with 20% - 60% of private car users leaving their cars at home to ride on the BRT system. This shows that the existing private car trips can be reduced by an average of 40% due to the application of the BRT system. Based on this predicted mode share, the extrapolation on the potential savings realizable from adapting the BRT system to Abuja is made with cognizance to the existing car usage level (see related assumption and detail computation in Appendix II). The analyses in this section, therefore, compares the present level of traffic congestion and related factors of man-hour losses, fuel usage and transport-related CO₂ emissions levels with the potential savings achievable with these related factors should the BRT system be applied in the proposed scenario.

The demonstration of the BRT system in Abuja indicate the replacement of the existing public transport system (which is characterized by small-capacity, tightly-packed, polluting and un-reliable 18-passengers' capacity mini-buses) with 160-passengers' capacity articulated BRT buses, and by the reduction in the level of private car trips which becomes transferred to trips on the BRT system. Accordingly, existing private car trips becomes reduced by 40% in line with the percentage of private car drivers who are predicted to leave their vehicles at home to ride on the BRT system. By this, the modal share becomes recalibrated and skewed in favour of public transport trips.

It is envisaged that this transformation should be achieved because the efficient operation and improved travel time on the BRT system can be an incentive to attract riders by choice from private car usage. A comparison of impacts between the existing situation and the proposed situation with regards to CO₂ emissions, fuel usage and man-hour losses is reported in Tables 7-1 – 7-3.

I. Transport-related CO₂ Emission levels in the existing and proposed scenarios

Using the standard of 2.4kg CO₂ (petrol) and 2.7kg CO₂ (diesel) emission for every litre of fuel used by mini-buses and private car vehicles, the CO₂ emission level of the three routes is analyzed in this section (See Table 7-1).

Table 7-1: Profile of Transport-related CO₂ emission along the three routes^a

Scenario	Bus System		Private Automobile		Total Yearly CO ₂ Emission (Kg)
	Mode	Yearly CO ₂ Emission (Kg)	Mode	Yearly CO ₂ Emission (Kg)	
Existing Scenario	12,320 Mini-buses (15% of Daily Motorized Trips)	58,066,682.389	71,038 Cars = (85% Daily Motorized Trips)	210,405,698.456	268,472,380.846
Proposed Scenario	1,823 new articulated BRT buses	29,495,752.04	28,415 Cars (40% Daily Motorized Trips)	100,463,722.625	127,960,474.653
Savings	Savings (CO₂)	27,841,930.34		109,932,976.304	140,511,906.2

Source: Author's Analysis, 2013.

a – Appendix III

The aggregation of the savings from the application of BRT system and related modal share skewed in favour of transit mode, the CO₂ emission level in the existing scenario is reduced from 268,472,380.846 Kg CO₂ to 127,960,474.653 Kg CO₂. This represents a reduction of more than 50% from the existing level. This, therefore, indicate remarkable savings from the application of the BRT strategy. Evidently, this savings can progressively improve as the efficiency of the new transit regime improves and more riders by choice are attracted to transit mode, especially from the private car mode.

II. Fuel usage levels in the existing and proposed scenarios

With a per capita fuel consumption of the non-congestion off-peak period of 0.194 litres per passenger and the congestion peak period of 0.243 litres per passenger, the total yearly fuel usage for 166,968 passenger trips (home-work-home trips) on the existing mini-buses was extrapolated. Similarly, by analyzing the per capita fuel consumption of 1.285 per litre for 71,038 total daily passenger trips (home-work-home trips) by private car trips, the yearly fuel usage was extrapolated (see Table 7-2).

Table 7-2: Profile of fuel consumption along the three routes^a

Scenario	Bus System		Private Automobile		Total Yearly Fuel Usage (Litres)
	Mode	Yearly Fuel Usage (Litres)	Mode	Yearly Fuel Usage (Litres)	
Existing Scenario	12,320 Mini-buses (15% of Daily Motorized Trips)	24,230,136.59	71,038 (Cars) = 85% (Daily Motorized Trips)	86,930,673.34	97,846,035.20
Proposed Scenario	1,823 new articulated BRT buses	9,784,930.63	28,415 Cars = 40% (Daily Motorized Trips)	41,748,866.65	47,035,743.58
Savings		14,445,205.95		45,181,806.69	50,810,291.62

Source: Author's Analysis, 2013.

a – Appendix III

With the aggregation of savings from the application of BRT system and related modal share characterized by reduced private car usage, the fuel usage level of the existing scenario is reduced from 97,846,035.20 to 47,035,743.58 litres of fuel; this represents a reduction of more than 50% from the existing level of fuel usage. This indicates a remarkable saving from the application of the BRT system.

The savings realized may be attributed to the quality bus service and the reduced commute time on the BRT system, but also because of the unintended disincentive created by the current traffic congestion which leads to increased journey times by private cars.

III. Man-hour losses in the existing and proposed scenarios

Using the data on the occupations and the income classes of passengers on the existing mini-bus system and in private cars, the total income loss due to man-hour wastage in congestion is hereby analyzed in this section (see Table 7-3).

Table 7-3: Profile of man-hour loss along the three routes^a

Scenario	Bus System		Private Automobile		Total Yearly Man-hour loss Mode
	Mode	Yearly Man-hour loss	Mode	Yearly Man-hour loss	
Existing Scenario	12,320 Mini-buses (15% of Daily Motorized Trips)	17,327,934.35 hours (₦ 1,705,922,411.78)	71,038 Cars (85% Daily Motorized Trips)	14,793,898.30 hours (₦ 3,082,062,017.46)	32,121,832.651 hours (₦ 4,787,984,429.22)
Proposed Scenario	1,823 new articulated BRT buses	-	28,415 Cars (40% Daily Motorized Trips)	7,045,000.53 hours (₦ 1,467,613,742.05)	7,045,000.50 hours (₦ 1,467,613,742.05)
Savings (Man-hour)		17,327,934.35 hours (₦ 1,705,922,411.78)		7,748,898.57 hours (₦ 1,614,438,275.44)	25,076,832.15 (₦ 3,320,370,687)

Source: Author's Analysis, 2013.

a – Appendix III

The aggregation of savings for the BRT system adapted to Abuja and reduced private car usage shows that the level of man-hour implicit in the existing scenario can be reduced from 32,121,832.651 hours (₦4,787,984,429.22) to 7,045,000.50 hours (₦1,467,613,742.05) in the new regime. This represents a reduction of more than 400% from the existing level of man-hour losses and, therefore, shows a huge level of savings from the application of the BRT system and the consequent reduction in travel time.

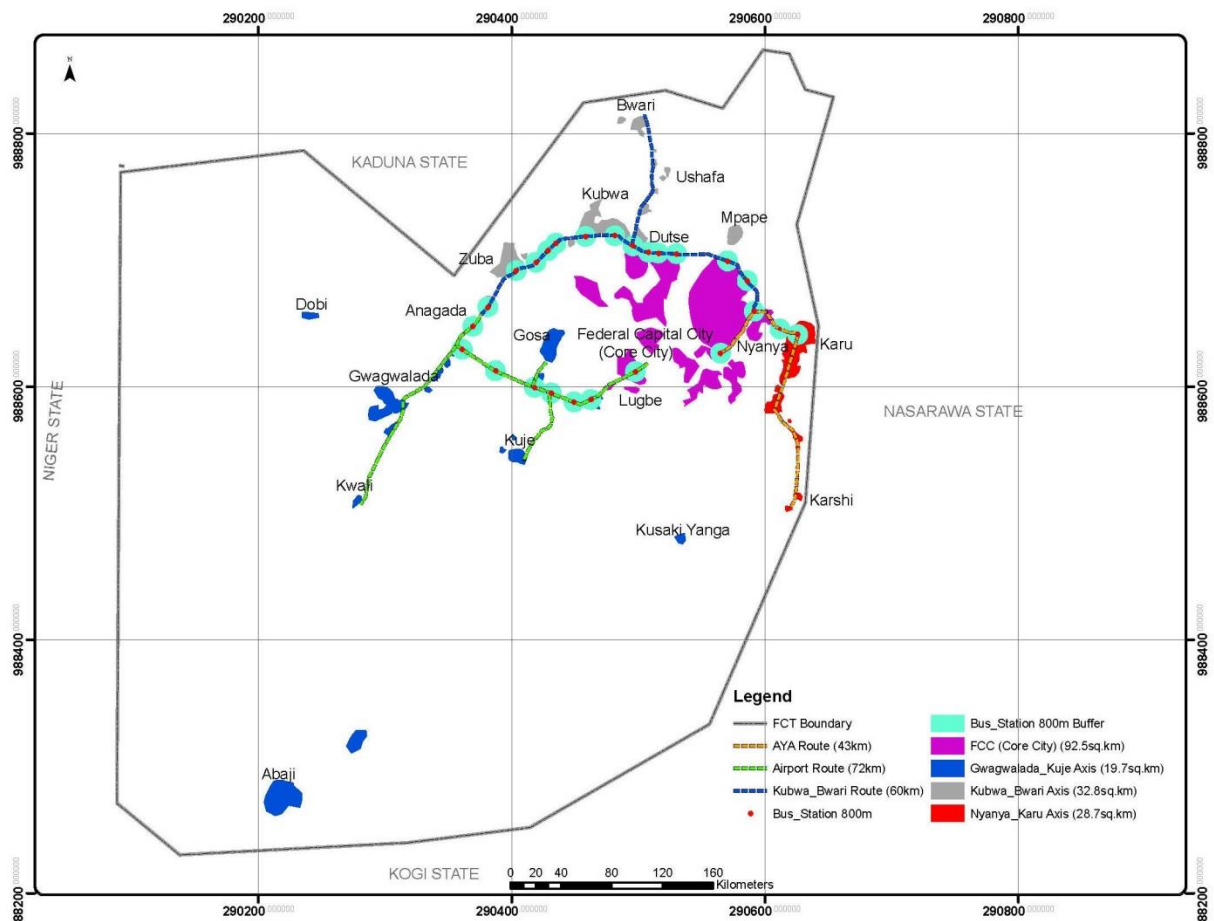
It can be noted that if this existing scenario continues unabated, the traffic congestion on the three routes can rise and may further de-leverage the sustainability of passenger mobility in Abuja. Based on the evidence from the analyses in this section on the savings realizable from the demonstrated application of the BRT system, it may therefore be appropriate to suggest that transforming the existing travel patterns by the application of the BRT system can help to achieve the recalibration of the mode share in favour of public transport in Abuja.

7.4 Transit Oriented Development (TOD)

In recognition of the important need to optimize the transformation of passenger travel in cities, a major component of the developed artefact focuses on the application of TOD strategy to reform, the

character of existing development along the demonstrated BRT routes in Abuja into high density mixed-use communities. This reform is not only targeted to achieving the benefits of improved passenger travel efficiency, optimization of transit operation but also, importantly, to help stem the trend of sprawl, to ensure efficient use of land that reduces VKT.

In line with the developed artefact which consist of the demonstrated vision plan, the BRT routes are planned as rapid transit linkages between secondary nodes and with the primary node, and is planned to have tertiary nodes located along these designated BRT corridors. The location of these tertiary nodes was made with recognition of the existing communities along these BRT corridors (See Figures 7-7 – 7-11).

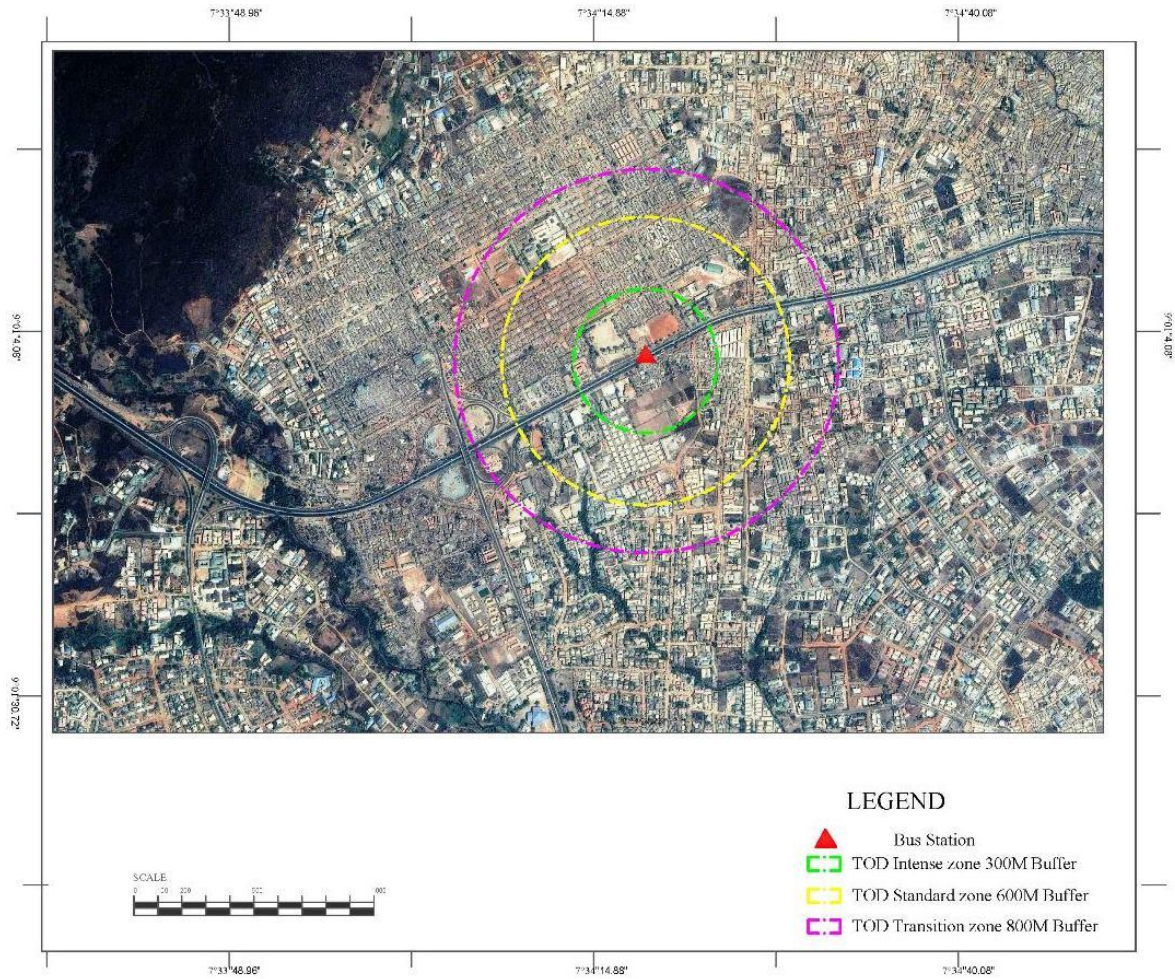


Source: Author's Analysis, 2013.

Figure 7-7: Proposed TOD Nodes along the major routes in Abuja.

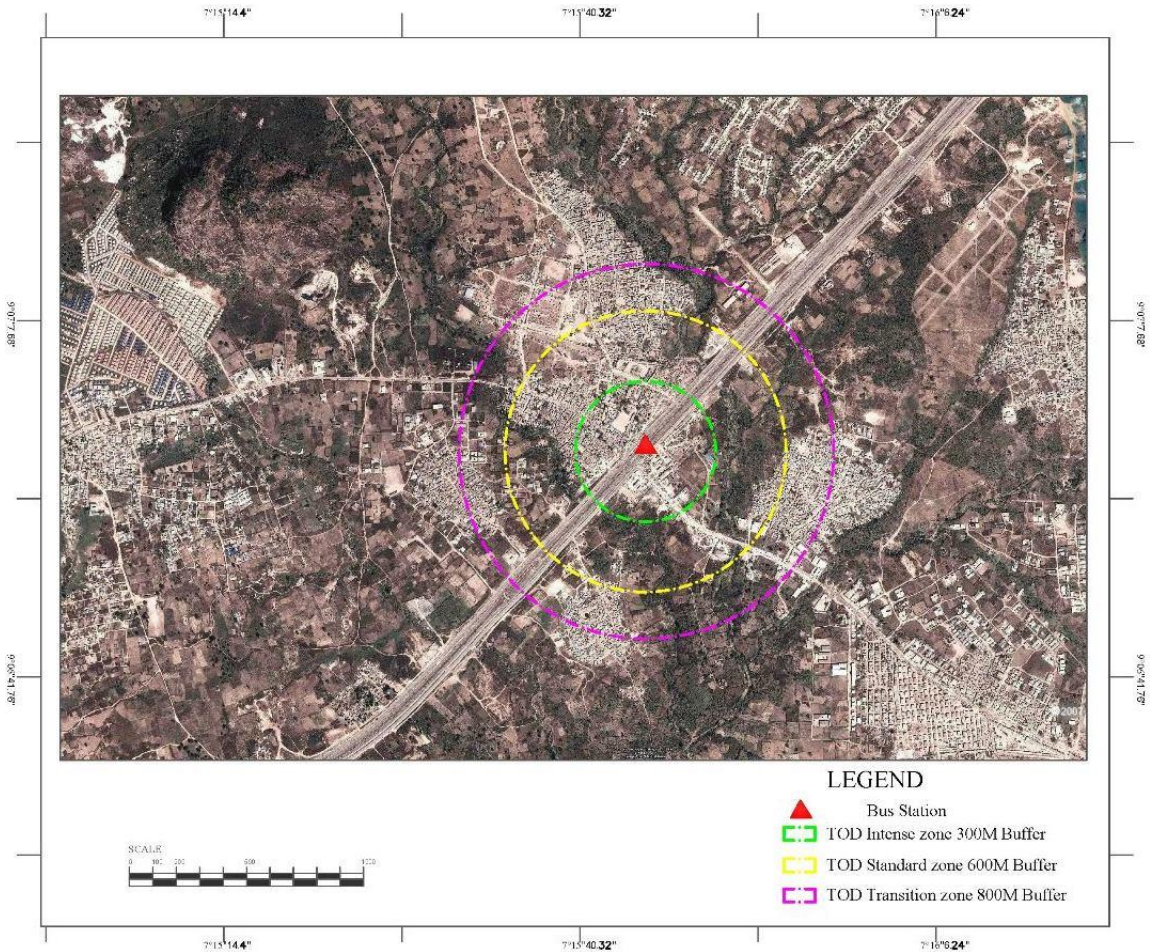
7.4.1 Detail Character of a Typical Designated TOD Node

The provision of the plan demonstrated in Figure 7-7 includes the designation of each BRT bus station as the nucleus of a TOD node. Figures 7-8 – 7-10 below demonstrate the three zones of influence of a TOD node along each of the three routes. These zones should be developed into rich diverse mixed use high density community of 10, 7, and 4 floors in zone 1, 2 and 3 respectively (See Figure 7-11).



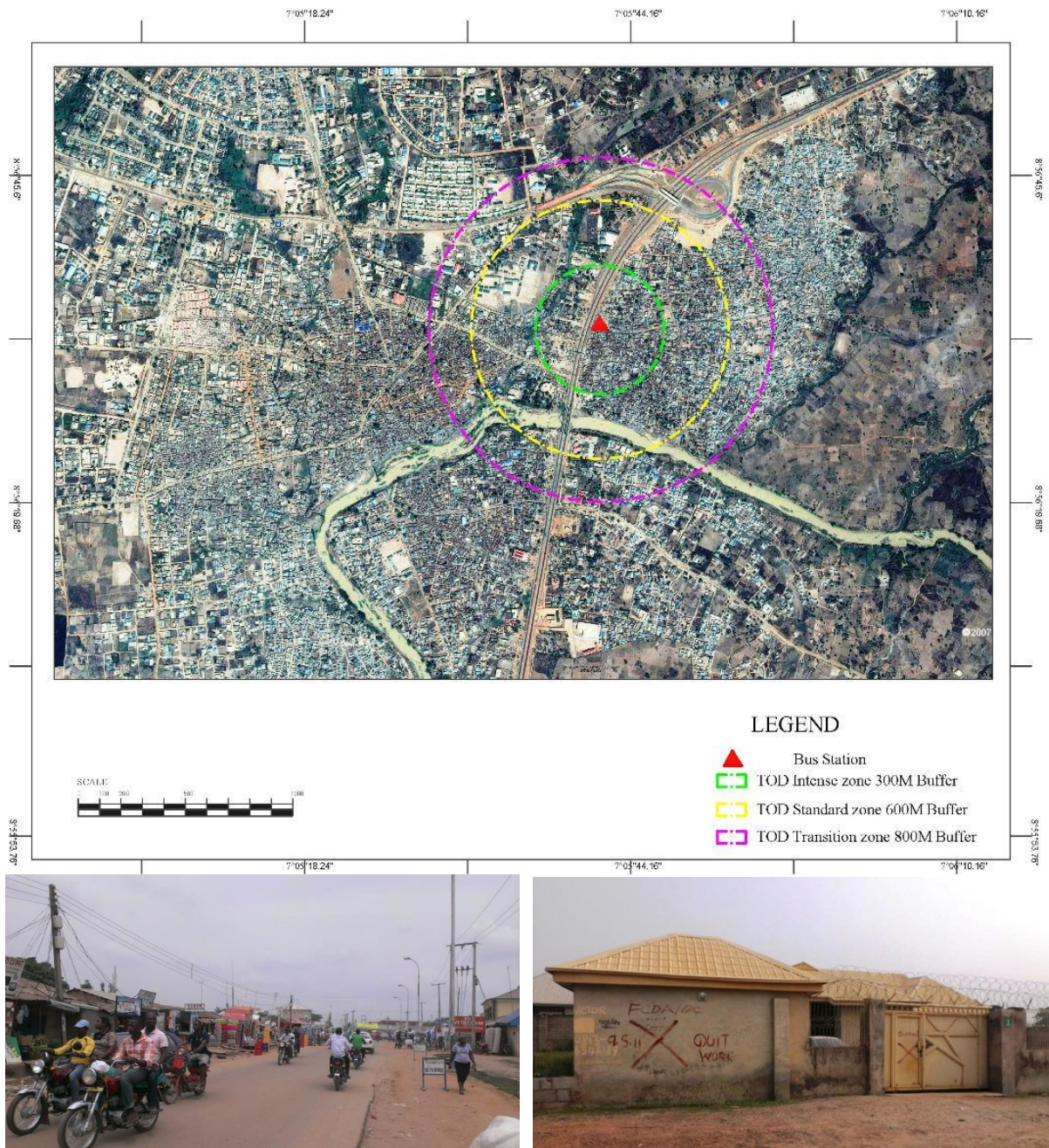
Source: Author's Analysis, 2013.

Figure 7-8: Typical spatial character within a designated TOD node along Nyanya-Karu route.



Source: Author's Analysis, 2013.

Figure 7-9: Typical spatial character within a designated TOD node along Kubwa-Bwari route.



Source: Author's Analysis, 2013.

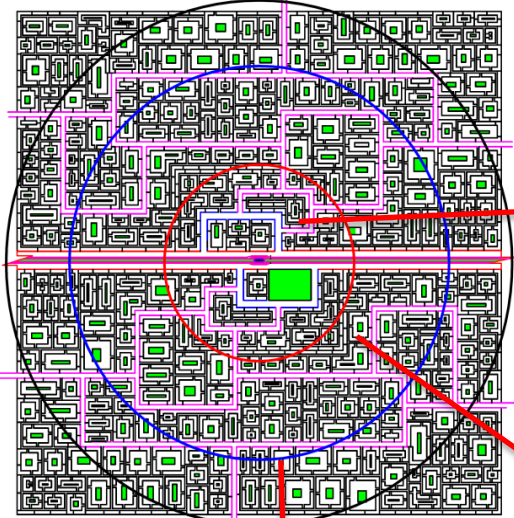
Figure 7.10: Typical spatial character within a designated TOD node along Airport Road route.

As evidenced in these figures, the present character of these existing suburban communities are mostly sprawling extensive low density pattern of development, the elements of unplanned and unregulated development is also apparent in these areas as seen in the satellite imageries.

In order to transform the existing pattern of development along the BRT corridors into TOD communities, the 800 metres radius sphere of influence around a BRT station demonstrated in Figure 7-7 above should serve as the focus of the transformation. Within each designated TOD nodes, three zones of influence should contain different levels of intensity. Accordingly, within Zone 1 (Zone of Intensity) which immediately abuts onto the BRT station should have 10 floors; Zone 2 (Standard

Zone) should have 7 floors, while Zone 3 (Zone of Transition) should have 4 floors. However, the ground floors in all the zones are designated for commercial use, employment areas and other public facilities. Hence, the dedicated floors for residential development are 9 floors, 6 floors and 3 floors in Zone 1, Zone 2 and Zone 3 respectively (see Figures 7-11 – 7-14).

Visual Impression of the character of development of the Proposed Regeneration Plan of typical Transit Oriented Development (TOD) nodes



Source: Author's Analysis, 2015

Figure 7-11: Proposed plan for transforming the existing development within each typical TOD node.



Source: Feeny, 2013

Figure 7-12: Character of development in the Intense Zone (zone 1) of the TOD



Source: Toderian, 2012

Figure 7-14: Character of development in the Transition Zone (zone 3) of the TOD



Source: Philadelphiaheights, 2012

Figure 7-13: Character of development in the Standard Zone (zone 2) of the TOD

As demonstrated in the Figures above, the emerging TOD communities within the sphere of influence of a BRT station can be transformed into smart, rich, diverse, high density mixed-use walk-able communities located 5 -10 minutes' walking distance to the bus station. By this new configuration, these smart and compact communities become small, intensively developed entities, small enough to reduce or eliminate the desire for private car usage, yet large enough to provide rich diverse opportunities in a good urban setting. Therefore, with the proximity of these communities to the transit corridor, long trips are more likely to be made via the transit mode. Also, this smart character can contribute to a reduced level of sprawl due to the leverage in the character of densification.

7.4.2 Extrapolation of savings from the Application of the TOD Strategy in Abuja

The computations of savings in this section focuses on the impacts of TOD on the reduction of private car trips, and the comparative analysis between the existing and proposed density, including the savings in term of land area and population.

The extrapolated impacts of living near transit corridors on the reduction of daily private car trips (and recalibration of mode share) relied on the specification reported in studies by Litman (2014) which indicates that a range between 55 - 59% reductions in private car usage is achievable upon implementation of TOD strategy. Consequent upon this evidence and prescription, it is therefore demonstrated that TOD on the 3 routes (designated BRT routes) under consideration can lead to the reduction in private car trips by 55% due to proximity of commuters to BRT corridor (See Table 7-4).

Table 7-4: The Extrapolated reduction in the level of Private Car Usage due to the Impact of the solutions of BRT and TOD only

Interventions	Volume of Private Car Trips			
	Existing		Extrapolated	
	Number	Percentage	Number	Percentage
No Intervention	71,038	100	-	-
BRT Only	-	-	28,415	40
BRT and TOD	-	-	39,071	55

Source: Author's Analysis, 2013.

This extrapolated reductions in private car usage illustrated in Table 7-4 above can expectedly impact on and contribute to savings in terms of the reduction in traffic congestion, travel time, fuel loss, and transport-related CO₂ emissions footprints. With more people living in TOD communities within short walking distance to bus stops, this therefore serve as incentives that may spur commuters in private

cars to live their cars at home and ride on the BRT due to the reduced commuting time presented by the BRT system.

Importantly, the co-benefits and impacts of adopting and developing these TOD communities which include the reduction in the trend of sprawl was also extrapolated and demonstrated, this was based on the comparison between the standards and prescription of density in the Abuja Development Control Manual and Regulation, and TOD standards in literatures.

Available evidence on the case city Abuja show that majority of suburban residents in Abuja live in tightly-packed small sub-standard rooms in the suburban areas, thus, showing a lot of persons living in small unit area in per capita terms. It may be inappropriate to compare this high room occupancy ratio with the density prescription in the TOD standards which is stated in dwelling units per unit area since the suburban developments are majorly unplanned, it may therefore be misleading to make comparison between the two situations. However, even if these suburban areas were to have planning layouts (in order to impose order) the density prescription would be as contained in Abuja Development Control Manual. Therefore, the standard of dwelling specified in the Abuja Development Control Manual and Regulation in Abuja and its application as seen in the field survey is therefore adopted for the comparison with the standard of the proposed TOD in order to demonstrate the related savings in this section.

The demarcation of the node into zones (as seen in Figures 7-11 – 7-14) should allow for ease of comparison in terms of potential density and population between the proposed nodes and the existing development pattern, since the transformation into TOD nodes should be into zones with differentiated density levels. Table 7-5 below illustrates the density prescription in terms of dwelling units in the existing and proposed situations in the designated TOD nodes.

Table 7-5: Land Area available in each TOD node and density prescription in the existing and proposed situation

Zone	Size in radius (m)	Land Area (Ha)	Land Designated to Residential Use (60%) (Ha)	Existing Prescription on Densities^a (Dwellings Per Ha)	TOD Prescriptions on Densities^b (Dwellings Per Ha)
Intense	300m	28.28	16.97	33.33	36.08
Standard	600m	84.83	50.89	17.77	28.86
Transition	800m	87.98	52.78	5.0	21.65
Total		201.08	120.64		

Source: Author's Analysis, 2013.

^aSourced from the Abuja Development Control Manual

^bSourced from Synthesis of TOD Standards (Pushkarev and Zopan, 1977, Dittmar and Ohland, 2007).

In recognition that other land uses are also contained within a planned settlement and especially a TOD community which is characterized by mixed use development, the landuse and spatial distribution in each TOD is planned to consist of residential development, road ways for circulation, recreational spaces etc. The residential development is therefore designated to take 60% of the total land area; this land distribution took cognizance of the landuse budget specified by the Abuja Master Plan (1979). In view of the proposed TOD plan which specifies different level of density for zones 1 – 3, and for the purpose of the comparison with existing situation in the case city, Zone 1 (Zone of Intensity) is assumed to correspondingly represent high density zone in the exiting situation; Zone 2 (Standard Zone) represent the medium density zone in the existing situation, while Zone 3 (Zone of Transition) represent the low density zone in the existing situation. The extrapolation and demonstrated savings in terms of the dwelling units achievable per unit area in each zone from the application of the TOD strategy in the communities is stated in Table 7-6 below:

Table 7-6: Comparative analysis of dwellings and land area savings from each designated TOD node

Zone	Size in radius (m)	Land Area (Ha)	Existing		Proposed TOD		Savings realizable from each zone ^c (Dwellings)	Savings realizable from each zone ^d (Land Area in Ha)
			Prescription on Densities ^a (Dwellings Per Ha)	Number of Dwellings realizable from each zone	Prescriptions on Densities ^b (Dwellings Per Ha)	Number of Dwellings realizable from each zone		
Intense	300m	16.97	33.33	565.61	36.08	612.3	46.7	1.40
Standard	600m	50.89	17.77	904.3	28.86	1,468.6	564.3	31.75
Transition	800m	52.78	5.0	263.9	21.65	1,142.7	878.8	175.76
Total		120.64		1,733.8		3,223.6	1,489.8	208.91

Source: Author's Analysis, 2013.

Note: The total gains require to be multiplied by 25 (There are 25 designated nodes).

^a Sourced from the Abuja Development Control Manual

^b Sourced from Synthesis of TOD Standards (Pushkarev and Zopan, 1977, Dittmar and Ohland, 2007)

^c This represent the difference between the Number of dwellings realizable from each zone in the existing situation (column number 5) and the proposed TOD (column number 7).

^d This is obtained by dividing the value of the savings realizable from each zone (dwellings) in column number 8 by the corresponding value of prescription on densities (dwelling per hectare) in the exiting situation as stated in column number 4.

Findings from Table 7-6 above show that the total volume of dwelling units in each nodes in the existing situation and the proposed situation account for 1,733 dwellings and 3,223 dwellings respectively, the savings is therefore 1,489 dwellings. The disparity in number of dwelling achievable in the two situations is a reflection of the intensity of the density prescriptions.

This indicates a remarkable saving in terms of capacity for accommodating population. Indeed, if this population was not accommodated in the new high density TOD communities, they would require more land to become accommodated using the existing population density current at the moment. This saving is computed as 208.91 hectares (2.08km²) per node due to the implementation of the TOD nodes (See Table 7-6 above).

Table 7-7: Comparative analysis of population savings from each designated TOD nodes

Zone	Size in radius (m)	Land Area (Ha)	Average Household size ^a	Existing		Proposed TOD		Savings realizable from each zone (Population) ^d
				Number of Dwellings realizable from each zone	Number of persons realizable from each zone ^b	Number of Dwellings realizable from each zone	Number of persons realizable from each zone ^c	
Intense	300m	16.97	8	565.61	4,524.88	612.3	4,898.4	373.5
Standard	600m	50.89	6	904.3	5,425.8	1,468.6	8,811.6	3,385.8
Transition	800m	52.78	4	263.9	1,055.6	1,142.7	4,570.8	3,515.2
Total		120.64		1,733.8	11,006.2	3,223.6	18,280.8	7,274.5

Source: Author's Analysis, 2013.

Note: The total gains require to be multiplied by 25 (There are 25 designated nodes).

^a Sourced from the 2006 Census Report by the National Population Commission

^b This is obtained by multiplying the value of the number of dwellings realizable from each zone in column number 5 by the value of corresponding household size for each zone as stated in column number 4.

^c This is obtained by multiplying the value of the number of dwellings realizable from each zone in column number 7 by the value of corresponding household size for each zone as stated in column number 4.

^d This represents the difference between the Numbers of persons realizable from each zone situation (column number 6) and the proposed TOD (column number 8).

Findings from Table 7-7 above demonstrate the savings in terms of population. In terms of population, the volume of population to be accommodated equals 11,006.2 and 18,280.8 persons in the existing situation and the proposed situation respectively; the savings is therefore 7,274.5 persons. (Note: the assumptions for the average household sizes relied on the specification of the National Bureau of Statistics (2012) of 6 persons per household for North Central states including Abuja. This study therefore adopts low, middle and high income household sizes of 4 persons, 6 persons and 8 persons respectively; this still gives the average of 6 persons per household as stipulated by the National Bureau of Statistics).

The demonstration of the proposed TOD communities as a component of the developed artefact indicates the potential of accommodating more population than currently prevails in the existing pattern of development. The difference in population capacities between the existing and the proposed pattern of development (for the land area covered by the TOD nodes) is 7,274.5 persons which equals a 66.01 percentage increase.

As demonstrated in Figure 7-7 above, a total of 6 nodes, 2 nodes and 7 nodes along the Kubwa – Bwari, AYA – Nyanya, and Airport road routes respectively falls within the suburban areas. The extrapolated savings along the respective routes have been stated in Table 7-8 below.

Table 7-8: Land area and population savings due to transformation with TOD across three designated routes within suburban areas

Route	Number of Node	Land Areas Gained		Population Gained	
		Unit per Node (sq.km)	Total across all Node (sq.km)	Unit per Node	Total across all Node
Kubwa – Bwari	6	2.08	12.48	7,274.5	43,647
AYA – Nyanya	2	2.08	4.16	7,274.5	14,549
Airport Road	7	2.08	14.56	7,274.5	50,921.5
Total	15		31.2		109,117.5

Source: Author's Analysis, 2013.

The findings presented in table 7-8 shows that majority of the savings could be recorded along the Kubwa – Bwari, and the Airport road routes. This situation may therefore attract the city's population growth towards these two axes which may consequently create a balance from the redistribution of the large trips generated from the AYA – Karu axes.

In addition, as shown in Figure 7-7 above, 7 nodes, 2 nodes, and 1 node along Kubwa – Bwari, AYA – Nyanya and Airport road routes respectively falls within the areas of the core – city. The extrapolated savings along the respective routes has been stated in table 7-9.

Table 7-9: Land area and population saving due to transformation with TOD across the designated routes within the areas of core – city

Route	Number of Nodes	Land Area Gained		Population Gained	
		Unit per node (sq.km)	Total across all Nodes (sq.km)	Unit per Node	Total across all Nodes
Kubwa – Bwari	7	2.08	14.56	7,274.5	50,921.5
AYA – Nyanya	2	2.08	4.16	7,274.5	14,549
Airport Route	1	2.08	2.08	7,274.5	7,274.5
Total	10		20.8		72,745

Source: Author's Analysis, 2013.

The findings presented in Table 7-9 shows that majority of the savings could be recorded along the Kubwa – Bwari route. This situation may therefore attract the city's population growth towards this axis. These findings demonstrate the viability of prioritizing the implementation of these strategies along the Kubwa – Bwari routes because of the opportunities it presents. The total land area that can be gained due to the transformation by TOD across the suburban areas and the areas of the core-city is put at 52.0km²; while savings in terms of population is put at 181,862 (see Table 7-10 below).

Table 7-10: Land area and population savings due to transformation with TOD nodes in suburban areas, and areas of the Core-city

Area	No of Nodes	Land Area Gained		Population Gained	
		Unit per node	Total	Unit per node	Total
Suburban Areas	15	2.08	31.2	7,274.5	109,117.5
Area of Core-city	10	2.08	20.8	7,274.5	72,745
Total			52.0sqkm		181,862.5

Source: Author's Analysis, 2013.

The demonstrated savings show that the application of the TOD transformation along the BRT corridors can ensure the realization of remarkable savings in terms of land area, sprawl. Additionally, the huge demand for long distance commuting can therefore be reduced.

7.4.3 Value of Savings

In order to further demonstrate the value of the savings that can be achieved from the proposed transformation, the extent of saving in terms of sprawl is extrapolated. The analysis of the extrapolation is expressed in terms of the extent of annual sprawl/land cover that can be saved and averted by the reforms with the designated nodes in the suburban areas and areas of the core-city.

(a) Suburban areas

The total land saving from the designated 15 TOD nodes in the suburban areas equals 31.2km². By holding the annual rate of spatial sprawl constant at 3.54%, the projected land usage in 15 years equals 153.3441km².

Therefore: if it takes 15 years to reach the sprawl/land cover of 153.3441km²,

It would take “x” years to reach the sprawl/land cover of 31.2km².

Thus, it would take 3.05 years to reach the sprawl/land cover 31.2km².

(b) Core-city

The total land saving from the designated 10 nodes in the planned areas equals 20.8km². By holding the annual rate of spatial sprawl constant at 0.99%, the projected land usage in 15 years equals 109.6138km².

Therefore: if it takes 15 years to reach the sprawl/land cover of 109.6136km²,

It would take “x” years to reach the sprawl/land cover of 9.92km².

Thus, it would take 2.84 years to reach sprawl/land cover of 9.92km².

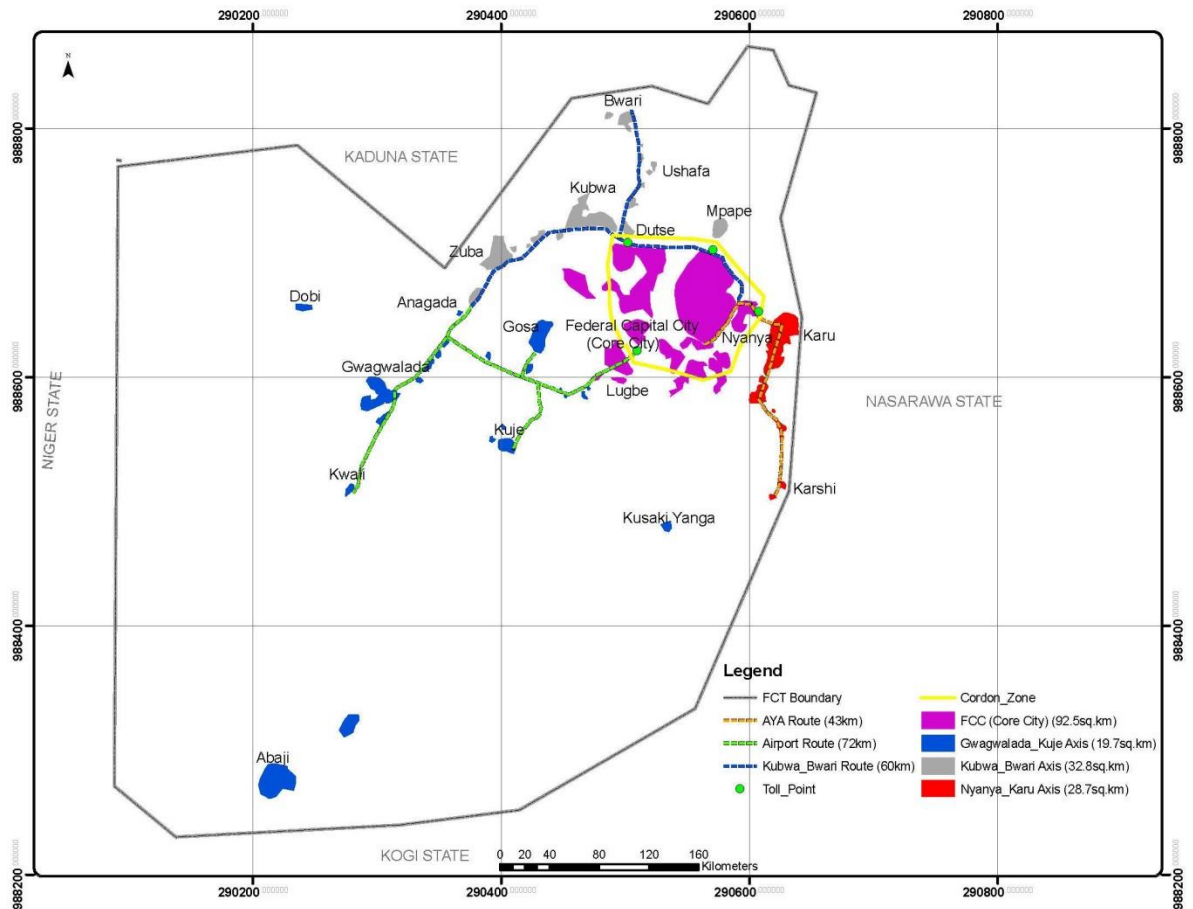
The value of the savings therefore shows that while 3.05 years of sprawl in the suburban areas can be averted, 2.84 years of sprawl in the core-city is averted due to the reforms with proposed TOD nodes. It, therefore, suffices to note that, the transformation of the communities within the spheres of influence of the BRT stations in TOD communities on the 3 routes under consideration, can lead to a remarkable level of savings in terms of land area. Creating reforms with the TOD nodes thus indicate that more population can be accommodated in the TOD nodes when compared to the present number of persons accommodated in the present extensive spatial pattern of development along these corridors. Therefore, with reforms with the TOD strategy, the increasing trend of sprawl can be avoided and land can be used more efficiently. As a corollary to this, the residents of the transformed communities live closer to corridors served by efficient BRT system and this should lessen the huge demand for private car usage for long distance commuting. This improvement is expected to be perceived as an incentive by residents within these communities to shift from their persistent usage of private cars in order to become choice riders on the BRT system.

7.5 Transport Demand Management in Abuja

This section demonstrates the application of congestion pricing (Transport Demand Management) as a component of the developed artefact, and therefore focuses on its capacity to serve as a complementary intervention in order to create disincentives for private car usage. The goal of this component of the artefact is on skewing modal share toward transit use and reduced private car usage.

7.5.1 The Application of Traffic Restricted Zone (TRZ)/Congestion Pricing Cordon in Abuja

The demonstration of the congestion pricing system in Abuja is based on identified entry points into the core-city, with a cordon drawn to circumscribe the Traffic Restricted Zone (TRZ) in the core-city. The cordon covers an area of 186.29 km² with five congestion charging/toll points located on the Outer Northern Expressway (Murtala Muhammed Way) intersection with Ring Road II labelled as CD-1; on the Outer Northern Expressway (Murtala Muhammed Way) intersection with Ring Road I (Nnamdi Azikiwe Way) labelled as CD-2; on AYA Road before the AYA/Asokoro Fly-over labelled CD-3; on the Airport Road Intersection with Ring Road II labelled as CD-4; and on the Awolowo Way intersection with Ring Road II labelled as CD-5 (see Figure 7-15).



Source: Author's Analysis, 2013.

Figure 7.15: Proposed traffic restriction zone and designated toll points.

Automated speed cameras equipped with Automatic Number Plate Recognition (ANPR) should be installed across the 5 points of entrance into the charged zone (TRZ). By this, every unauthorized entry of cars into the TRZ can be recorded by a designated video camera which captures and matches the number plate of the vehicles against databases of registered vehicles in order to verify those eligible for entry (See Figures 5-44 and 5-45).

Entries without permit should be fined. A bill should be generated and sent to the address of the driver for payment to be made. The fare structure should be such that the fare charged for entries during the peak period is high, while the fare is low during the off-peak hours. With the congestion pricing regime in place, private car trips originating from the three routes/axes under consideration should pay a congestion charge for driving into the core-city.

In order to ensure effective implementation of the congestion pricing system, widely-circulated publicity campaign and the creation of awareness for road users on the congestion pricing regime should be made. These include symbols and signage indicating the presence of video cameras at the entrance points into the TRZ, thus informing drivers of their proximity to TRZ.

7.5.2 Extrapolated Savings and Revenue from the Application of Congestion Pricing and related Mode Share

The extrapolation and demonstrated impacts of implementing congestion pricing is premised on the prescription of an average 20% reduction in private car usage as a result of congestion pricing regime (Litman, 2014). As stated above, the level of reduction of private car trips is put at 55% due to application of BRT and TOD strategy, the cumulative reduction from the application of Congestion Pricing should therefore amount to 75%, this therefore represent the additional impacts and savings in term of the reduction in private car usage due to the implementation of congestion pricing (See Table 7-11). Consequent upon this prescription, it is therefore suggested that in specific terms, the implementation of congestion pricing can lead to the reduction in private car trips by 20% due to the disincentives presented by the payment of congestion pricing. This extrapolated reduction in private car usage can impact on the recalibration of mode share in favour of public transport trips and contribute to savings in terms of the reduction in traffic congestion, travel time, fuel loss, and transport-related CO₂ emissions footprints.

Table 7-11: The Extrapolated reduction in the level of Private Car Usage due to the Impact of Congestion Pricing Strategy

Interventions	Volume of Private Car Trips			
	Existing		Extrapolated	
	Number	Percentage	Number	Percentage
No Intervention	71,038	100	-	-
BRT Only	-	-	28,415	40
BRT and TOD	-	-	39,071	55
BRT, TOD & Congestion Pricing	-	-	53,279	75

Source: Author's Analysis, 2013.

The reduced level of private car usage in the extrapolated mode shift due to the reforms with the three strategies (namely BRT, TOD and congestion pricing) is put at 17,759 private cars which represent 25.0% of the daily motorized trips across the three axes. This represents 75% reduction in the existing daily motorized trips across the three axes as a result of the cumulative impacts (incentive/disincentive) of the 3 strategies which incrementally spur the reduction in the level of private car usage. The product

of the volume of these private car trips during peak-periods and off-peak periods, and the daily charge of congestion pricing during these respective periods, amount to the daily revenue realizable from the congestion pricing system. When this is computed over the year, the yearly revenue from congestion pricing system is obtained. Two scenarios of congestion charge are demonstrated; while scenario one has ₦1000 and ₦500 for peak and off-peak period respectively, scenario two has ₦500 and ₦200 for peak and off-peak period respectively (see Table 7-12).

Table 7-12: Profile of revenue realizable from the congestion pricing system.

Scenario	Period	Volume of Vehicle	%	Cost per Vehicle Entry	Total of Daily Revenue	Total of Yearly Revenue
Scenario One	Peak	9235	52	₦ 1000	₦ 9,235,000	₦ 2,216,400,000
	Off-peak	8524	48	₦ 500	₦ 4,617,500	₦ 1,108,200,000
Scenario Two	Peak	9235	52	₦ 500	₦ 4,262,000	₦ 1,022,880,000
	Off-peak	8524	48	₦ 200	₦ 1,704,800	₦ 409,152,000

Source: Author's Analysis, 2013.

When implemented efficiently, in line with the exemplary empirical cases, the impact of these measures on the expenditure of private car users on transport should gradually reduce the number of daily motorized trips. This can therefore, ensure the achievement of a mode shift that skews mode share in favour of public transport and help achieve efficient passenger mobility in Abuja. As a co-benefit, the revenue realized from the congestion pricing system can be used to expand investments in the public transport system. It is pertinent to also note that the level of revenue realizable from the congestion pricing regime can progressively reduce as the level of modal share reduces in favour of public transport usage. Therefore, there is a need to exercise caution with solely basing transport investments on the revenue realizable from the congestion pricing system. This is because the primary goal of implementing congestion pricing is not to generate revenue but rather to create disincentives for private car usage and reduce private car proliferation and the related externalities.

7.6 Final Structure of Modal Share due to the Application of the Developed Artefact (Framework for Spatial Planning Strategies)

The extrapolated impact of the developed artefact and its related strategies on the reduction of private car usage, and the resulting mode share is the focus in this section. The private car trips have been demonstrated to become reduced by using the combination of incentives and disincentives that the developed artefact and its spatial planning strategies present.

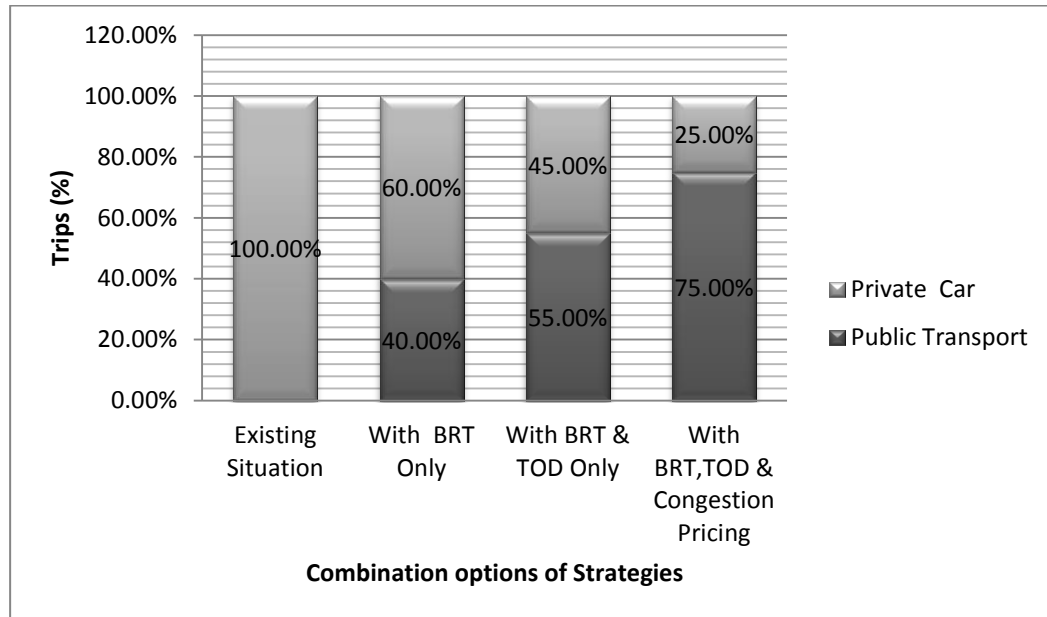
In consonance with evidence from the literature which states that, by implementing an efficient transit system, private car usage would be reduced by 20% - 60% (Litman, 2012). The application of the BRT system in this study is designed to focus on transferring some spectrum of the existing pool of commuters in private cars unto the BRT system. Accordingly, a 40% reduction in private car usage has been suggested in this study (See Table 7-11 above), this represent the mean of the ratio (20% - 60%) stated by the earlier studies. This therefore represent the spectrum of commuters in private cars who can be spurred to leave their cars at home to ride on the BRT system because of the incentive and convenience it present for improved travel time for commuters. These demonstrate that the existing private car trips can be reduced by 40% due to the application of the BRT system.

The impacts of the TOD strategy on the reduction of private car usage level and the recalibration of modal share relied on the specifications reported by the studies by Litman (2014) which indicates that a range between 55 - 59% reductions in private car usage is achievable upon implementation of TOD strategy. Consequent upon this evidence and prescription, it is therefore demonstrated that the application of TOD on the 3 routes (designated BRT routes) under consideration can lead to the reduction in private car trips by 55% due to the proximity to efficient BRT system (See Table 7-11). This predicted reduction can impact on and contribute to savings in terms of the reduction in traffic congestion, travel time, fuel loss, and transport-related CO₂ emissions footprints.

The analysis of the impacts of the application of congestion pricing strategy is premised on the prescription of 10% - 30% (with average of 20%) reduction in private car usage as a result of reforms with congestion pricing regime (Litman, 2014). As stated above, the level of reduction of private car trips is put at 55% due to BRT and TOD, the cumulative reduction can therefore amount to 75% (See Table 7-11), this therefore demonstrate the additional impacts and savings in term of the reduction in private car usage due to the application of congestion pricing in this study. Consequent upon this prescription, it is therefore demonstrated that in specific terms, the application of congestion pricing can lead to the reduction in private car trips by 20%, and a cumulative effect of 75% due to the disincentives presented by the payment of congestion pricing. This predicted reduction in private car usage can impact on recalibration of mode share in favour of public transport trips and contribute to savings in terms of the reduction in traffic congestion, travel time, fuel loss, and transport-related CO₂ emissions footprints.

In sum, the extrapolated reduction in car usage level attributable to application of developed artefact equal 40.00% when the BRT system only is applied; 55.00% when the BRT system and TOD only are

applied, and 75.00% when the BRT system, TOD and congestion pricing are applied. In line with the extrapolated outcomes attributable to the developed artefact and related spatial planning strategies of BRT, TOD and congestion pricing system, the related modal share is demonstrated in the Figure 7-16 below.



Source: Author's Analysis, 2013.

Figure 7-16: Modal share impact on car trips on the three routes due to reforms with the spatial planning strategies

Consequent upon the demonstrated combined application of the spatial planning strategies of the BRT system, TOD and the congestion pricing regime, the metrics on the impacts of the reforms with these strategies on the recalibration of modal share along the three routes as shown in Figures 7-16 above depict a gradual shift towards public transport trips

In these situations, the impact of each individual strategy may not be markedly outstanding; it is however, consistent with findings in earlier studies by Litman (2012) which illustrate that the efficacy of the impact of an individual strategy may be a function of how efficiently they are combined as complementary initiatives. This may therefore provide sufficient basis to argue that the combination of these strategies as prescribed in the artefact developed in this study can achieve optimal results. By this, the role of synergy with the strategies is established; as such, treating these strategies as complementary rather than as mutually exclusive strategies when making reforms to address the challenges of the explicated problems is imperative.

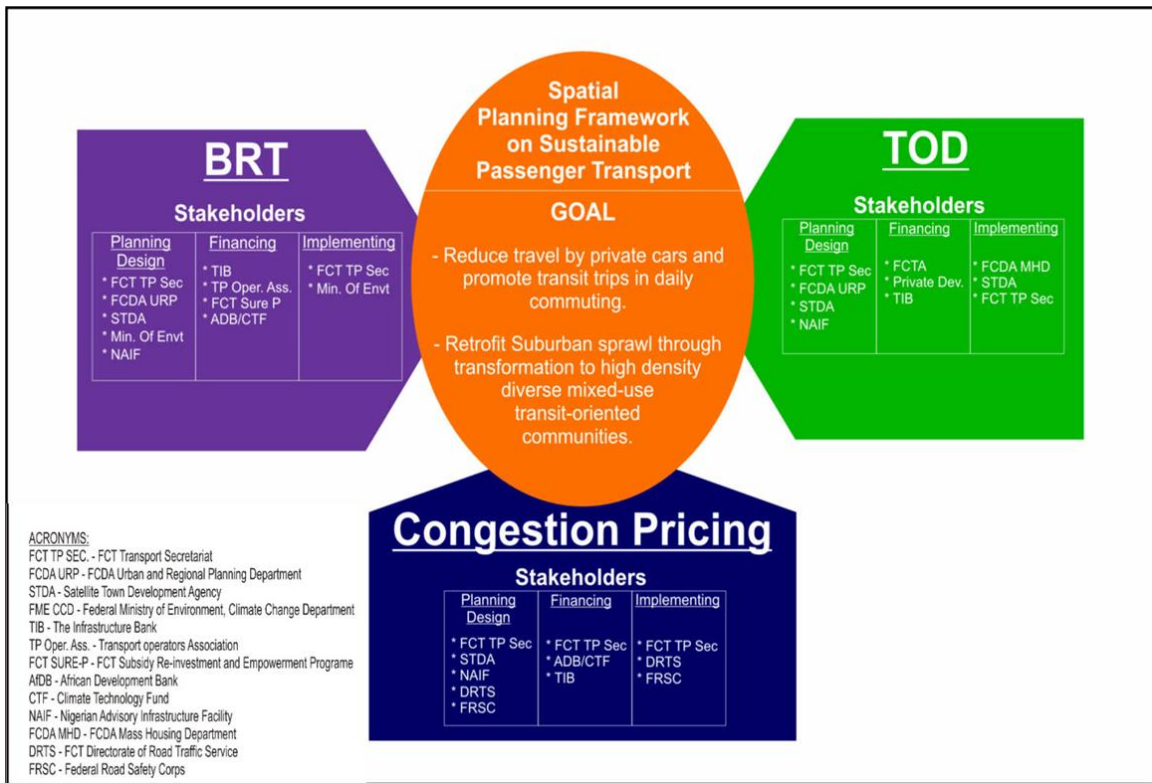
7.7 Institutional Reforms

Earlier studies by Le Grand (1998), Nadin (2006), RTPI (2007) and Shaw and Lord (2009) demonstrate that solutions to the explicated problem of the space-prescriptive Master Plan approach are embedded within the spatial planning approach. This has been explained in Section 4.5 and 5.5. Therefore, institutionalizing spatial planning approach can permit the encapsulation of the identified spatial planning strategies of BRT, TOD and Congestion Pricing into a framework. The new regime characterized by a spatial planning framework and the embedded strategies should have the requisite capacity to reform the explicated problem in the case city Abuja.

7.7.1 Spatial Planning Framework and Recommended Guide

This section seeks to demonstrate that the developed artefact integrates an urban planning approach and institutional arrangement that differs from what presently exist in most global south cities. This is in view of the explicated problem on existing institutional capacity (Chapter 3, Section 3.7.5) and, the component of the developed artefact on institutional reforms (Chapter 5, Section 5.5). This section therefore focuses on demonstrating the capacity of the spatial planning framework to serve as the delivery vehicle for the artefact (of decentralized concentration, BRT, TOD, and Congestion Pricing) in order to achieve optimal outcomes with reforms to the explicated problems.

This demonstrated framework provides contextualized prescriptions and guidelines for the integrated solution of combination of the three spatial planning strategies, and the sectors and stakeholders relevant to realizing reforms with the developed artefact in the case area. Further, the roles spelt out for the relevant sectors and stakeholders as regards planning, financing and implementation of each strategy contained in the demonstrated framework is guided by prescriptions stated in relevant urban planning documents, literatures and empirical cases. The identified respective stakeholders for the planning, financing and implementation phases of the reforms with the various strategies in Abuja have been spelt out in the demonstrated framework illustrated in figure 7-17 below.



Source: Author's Analysis, 2013.

Figure 7-17: Framework for the Spatial Planning strategies of BRT, TOD and Congestion Pricing

In general, the FCDA Urban and Regional Planning Department should be charged with the initiation of implementation of this framework and its related strategies, and create the platform for effective collaboration with the prescribed sectors and stakeholder to facilitate implementation. The detailed procedures for institutionalizing and applying this framework should be encapsulated into set of recommended guide that comprises of urban planning regulations for realizing reforms with these strategies. These guidelines can include standards generated from best practices and from local planning regulations in order to ensure that the resulting guidelines are context-specific and home-grown. The resulting recommended guide for implementing the spatial planning framework and the implementing agency should have the required legislative backing that can ensure the sustained implementation of the envisioned sustainable passenger transport and spatial development of Abuja.

7.7.2 The Recommended Guide and Plan Making Procedure under the Demonstrated Spatial Planning Framework

The defining character of the spatial planning approach in actual practice has been identified to include strategic visioning, avoidance of restrictive bureaucratic practices, sectoral integration, collaboration and stakeholder engagement, context-specific and home-grown strategies, and outcome-focused plan

(Le Grand, 1998, Rydin 1999, Nadin 2006, Cullingworth, 1999, Shaw and Lord 2009, Morphet 2011, and UNHSP 2009). The demonstrated reforms with the spatial planning approach should therefore require the institutionalization of these highlighted features. The new plan making procedure and framework under the spatial planning regime should therefore be predicated upon these features and characteristics. The new plan making procedure should include several elements; stakeholder engagement and consensus-building, evolving a vision plan (loose-fit), strategic and targeted spatial plan, sectoral integration, and routine capacity building and monitoring. These elements are further explained in the following paragraph below:

a) *Stakeholder engagement and consensus building.*

This element involves the mapping and identification of stakeholders with varying level of interest and influence in spatial plan framework for the 3 strategies. Inclusive of the stakeholders mentioned in the framework, other relevant stakeholders may include practitioners in the relevant urban planning organizations, practitioners in the private sector consulting firms, practitioners in the research community and representatives of the community, and user groups. These stakeholders therefore constitute the group that deliberates on existing identified problem(s) that affects a community/an area, with view to identifying the appropriate strategy in line with the vision plan. This stakeholder-driven process therefore serves to ensure that plan making procedure is not solely technocratic but rather bottom-up, inclusive, represent the aspiration of the populace, and capable of producing sustainable outcomes.

It is important to note that, the culture of democratic planning process that can permit effective stakeholder engagement and consensus building is alien in Abuja and global south cities and may not easily permeate the urban planning and transport planning fabric, and thus, may serve as inhibitive factor to this framework and the developed artefact.

However, platform for stakeholder engagement create the opportunity for ensuring that the resulting solutions to identified problems are home-grown and context-specific, in that, they recognize the existing peculiarities and potentials that exists in a study area. This may be what is required to optimally realize the objectives of the developed artefact.

b) *Evolving a vision plan.*

The analysis of the contributions from the stakeholders and consensus building stage provide inputs into the planning process. A vision plan can therefore be evolved (if none exist) to show the big picture of the integration of TOD nodes and transit linkages (BRT network). Notably, the vision plan

should be loose-fit and permit great deal of flexibility in order to respond to change and dynamics of the various components. The vision plan should therefore be subjected to regular review in order to accommodate the relevant dynamics and make the plan relevant to emerging realities.

The predict and provide engineering solution to provision of infrastructure to address predicted demand (e.g. traffic demand) should therefore be replaced by the debate-and-decide approach where community and relevant stakeholders envision the intervention required to address existing and anticipated challenges of increasing mobility demand and suburban sprawl in the city.

c) Targeted Strategic Spatial plan.

While the vision plan should provide overview and framework for the entire nodes and BRT network at the city level, the target strategic and action plan can be adopted and therefore serve to provide the required detail plan and intervention for addressing a specific phase of the plan. This plan should target different area of intervention which may include TOD, BRT line, BRT station, Bike Share, parks and green spaces etc., without losing sight of the goal of the vision plan. With these targeted plans, outcomes from the intervention can therefore be timely and effective, while also contributing to the overall goal of the vision plan for the city.

d) Evaluation of plans and strategies by stakeholders.

The targeted strategic and spatial plan contain proposed strategies and intervention for addressing identified and explicated problem, the review and evaluation mechanism for these plans by relevant stakeholders should therefore become institutionalized mandatory operational procedure. This review and evaluation mechanism can serve to ensure that the feedback from the stakeholders about the relevance and effectiveness of the proposed intervention are sought in order to further refine the proposed intervention. By this, the resulting intervention contained in the plans therefore can be relevant, situation-specific, keyed into the overall objective, and help achieve optimal outcome.

e) Sectoral Integration.

The intervention contained in the targeted strategic and Spatial Plan usually ramifies different facets and can require collaboration from the various related sectors. It is therefore proposed that there should be in place a platform that permit collaboration and integration vertically across different layers of authority and horizontally across various relevant sectors that impacts or are impacted by the implementation of the intervention contained in the plan. This therefore ensures the reduction in conflict of authority, duplication of duties, reduction of externalities and un-intended consequences,

and also ensures the realization of an optimal outcome from the implementation of the interventions contained in the plan.

f) Routine capacity building and monitoring.

Evolving targeted strategic and Spatial Plan that can be relevant, effective and context specific to match identified intervention require credible and reliable skills from the relevant practitioners. This is especially relevant in the urban planning organization which should be charged with supervising the plans and their implementation. By this, the planning organization should institutionalize routine capacity building for its personnel as this can leverage the capacity of the practitioners to evolve relevant problem-solving methodologies and make informed decision for realizing optimal outcomes from the plans. The monitoring of the 10-15 years plans in line set key performance indicators should be done annually (or within a shorter period in special instances), as this can ensure that the desired outcomes from respective plans are tracked and achieved.

In sum, these above described elements indicate how the plan making procedure should be with adoption of the spatial planning framework to reform the existing planning system and weak institutional capacities. The benefits can therefore include stakeholders-driven process and, a flexible plan that timely respond and match the dynamics of the challenges of passenger mobility in cities.

7.8 The Unintended Consequences envisaged with the Demonstrated Reform with the Developed Artefact of the Spatial Planning Strategies

One of the contemplated unintended consequences is the possible increase in land value that may occur in areas adjoining the BRT corridor and designated bus station upon the development of the BRT system. It is imperative to note that by living in decent communities within the walking distances to transit corridors, some percentage of transport-related expenditures can become freed and spent on other endeavor to improve standard of living of residents in these transit communities. These transit communities may therefore become choice locations for city residents because of the advantages they present. This demand may translate into increase in land and property value and may lead to displacement or gentrification of low income groups.

While this is recognized, the study developed mechanism to avert or address this issue. The mechanism imply concession to resident of area within 800m sphere of influence of the BRT stations, these residents are to be re-accommodated within the redeveloped housing units in this area. This can be feasible because the new development should be vertical high density development (with functional and density mixes), the existing residents can be re-accommodated within floors 1-3 while the other

floors 4-10 can be designated to new residents and therefore provide a premise for the developer to recoup investments and also realize their profit motives.

One other unintended consequence that was contemplated is the possibility of increase in private car usage when traffic congestion eases with the implementation of an exclusive BRT lane and the congestion pricing regime. This assumption may be true especially because earlier studies indicated that car proliferation and traffic congestion is linked to the perception of private car ownership and usage as status symbol that leverages the social credential of people in global south cities. This assertion may also be explained by earlier study which posit that this described situation of increasing car usage regardless of an existing efficient transit system may actually happen when parking is free or when car users do not pay the full cost of car usage (tax, road pricing, metered parking) due to subsidies by government. In addition, the study by Kennedy (2003) argues that if a finite resource is free, human beings tend to use it all up, regardless of the consequences. If it has a cost, they tend to use it more rationally. Evidence of tax, road pricing and metered-parking regime as dis-incentives to car usage in Singapore and London indicates a reduction of private car proliferation and traffic congestion, because a huge percentage of the income of car owners goes into car usage bill/expenditure.

Therefore, it may therefore suffice to posit that the application of congestion pricing can be a mechanism that dis-incentivizes car usage and encourage more transit trips. By a continual revision of the price level of the congestion charge as deterrent, the traffic congestion level resulting from the excessive private car usage can be reduced. While initial inertia of skepticism are expected from users about the importance of congestion pricing regime, as seen in study by Eliasson (2008), Borjesson et al. (2012), Litman (2011), Beevers and Carslaw (2004) acceptance and compliance with the congestion pricing regime are usually achieved over time.

A recap of the strategies demonstrated in this chapter reveals that, the demonstrated capabilities and illustrated efficiency gains attributed to the developed artefact appear as a viable solution to the explicated problem. This is because it consists of the unique combination of three spatial planning strategies as compared to the contemporary application of the individual strategies. It may therefore suffice to suggest that the developed artefact may be the way forward to sustainably address the explicated problem.

While this chapter has provided the premise to demonstrate what the possible solution to the explicated problem could be, further investigation is necessary to confirm whether the developed solution can work and address the explicated problem effectively. This would be the focus of the

remaining part of this thesis. Therefore, robust investigations are required in the field to validate whether this artefact can work to address the explicated problem and realize the demonstrated results and efficiency gains. These set of investigations require a research strategy that is appropriate for investigating an intervention that is yet to be implemented in actual practice as is the case with the developed artefact. While this instance of the solution as a theoretical intervention do not make such research strategy as case study, grounded theory or ethnography quite appropriate, the Design Science research strategy as explained in Chapter 6 appear suited for these investigation.

As set out earlier in Chapter 6, some of these investigations may require collecting and analyzing expert opinion (Urban and Transport Planners in government establishments, Private Consulting Firms and the Academia). These expert opinion are important for providing feedback on one hand, on either the applicability and appropriateness of the artefact, and amendments required to optimize the performance capability of the artefact, or on the other hand, to invalidate the performance capabilities of the artefact. This can be done by questionnaire surveys, or semi-structured interviews. The investigation may also include users' perception survey of commuters to provide information for establishing the actual level of performance of the suggested intervention such as the reduction in private car usage as a result of commuter choice to ride on the transit system (BRT) if BRT, TOD and Congestion Pricing strategies were introduced. This additional layer of information on the capability of the suggested intervention from this user group should serve to elucidate on whether the expert opinion and predictions corroborates or is at variance with findings from the actual user groups.

These data sets would require contact with expert and user groups in a particular or chosen case city in order to carryout empirical investigation. However, since a single case city (Abuja) has been selected to demonstrate the performance capabilities of the artefact, it may be more insightful, reliable and accurate to investigate expert groups and user groups in this case city. This is because; the familiarity of these groups to the prevailing traffic congestion challenges in the case city may provide a basis to home-in on informed responses on the suggested intervention in the case city, this is likely to enhance the reliability of the findings. Without such familiarity with the situation in a city, responses by participants may be rather generic, hypothetical, inaccurate and unreliable.

The remaining part of this thesis would focus on providing answers to the testing of the developed solution in the field in order to confirm and validate its appropriateness and applicability. While Chapter 8 focuses on the results, discussion and findings from the evaluation of the artefact by expert

groups and user groups, the Chapter 9 consist of the conclusions drawn from the findings, and the recommendations emerging from the conclusions drawn.

7.9 Summary

This chapter consists of the Demonstrate Artefact phase of the Design Science research strategy and has demonstrated capabilities of the spatial planning framework and related strategies developed as artefact in this study to reform the existing Master Planning approach and the related challenges of traffic congestion and suburban sprawl. This therefore addresses the research question 3 set out at the beginning of this thesis.

In this chapter, evidence from the case city has illustrated how the developed artefact of spatial planning approach and related strategies of BRT, TOD and Congestion Pricing was contextualized using the case city-Abuja in order to demonstrate the applicability, relevance and effectiveness of these solutions to address the explicated problem of traffic congestion and suburban sprawl in global south cities. The comparison of the performance capabilities of the existing urban planning tool and the developed artefact is summarized below in Table 7-13.

Table 7-13: Comparison of Performance Capabilities of Existing Tool and the Developed Artefact

S/N	Component of the Research Problem	List of Defined Requirements for the Artefact	Existing Tool and its Performance Capabilities as solution to the Explicated Problems	Developed Artefact and its Performance Capabilities as Solution to the Explicated Problems
a.	Huge volume of daily motorized trips, traffic congestion and increased travel time for commuters	i. Reduced volume of motorized trips	Nil	i. Application of BRT as rapid transit system ii. Restructure of modal share in favour of transit trips and reduce volume of motorized trips (40% reduction in car trips) and traffic congestion.
		ii. Reduced level of traffic congestion	i. Engineering solution of road building and expansion to address traffic congestion. Its impact leads to temporary reduction of traffic congestion.	
		iii. Reduced length of travel time	i. Engineering solution of road building and expansion. However, there is no reduction in travel time. In aggregation, annually, 21 days is lost in traffic by each commuter in Abuja.	i. Application of BRT as rapid transit system which leads to reduction in travel time due to dedicated BRT lane
		iv. Deter the proliferation of car usage	Nil	i. Application of Congestion Pricing (20% reduction in car trips)
b.	Increasing trend of transport-related challenges such as time loss, fuel loss and CO ₂ emission	i. Reduced level of transport-related impacts (time loss, fuel loss, CO ₂ emission)	i. Engineering solution of road building and expansion to address traffic congestion. ii. It leads to temporary reduction in these impacts	i. Application of BRT as rapid transit system and Congestion Pricing in Abuja can lead to; ii. Reduction in motorized traffic and transport-related impacts by 50% reduction in fuel usage level, 50% reduction in transport-related CO ₂ emission level, 400% reduction in man-hour losses.
c.	Ineffective public transport characterized by mini-buses which struggles to move commuters daily	i. Moving more commuters in less number of vehicles	i. Mini-buses struggling to move commuters daily and fleet of single-occupant private car commuters	i. Application of BRT rapid transit system high capacity 160-250 articulated and bi-articulated buses
d.	Increasing trend of suburban sprawl and inefficient use of land evident in extensive spatial pattern of development make people live further away from core-city, and increases commuting distances	i. Transform suburban development into smart compact spatial pattern in order to reduced sprawl ii. Diverse mixed use community that make more people live near transit iii. Reduced need to travel by car	i. Spatial development pattern is characterized by low density development with increasing need for travel by car due to distant commuting pattern ii. Few people leave near transit corridor due to extensive sprawling spatial pattern	i. Application of TOD strategy to achieve diverse mixed use commuting with reduced need for long travels, and located along transit corridor to ensure access to rapid transit for long trips (intra-city). ii. This can reduce car trips by 55% and enhances convenience of commuters due to large number of persons living near transit corridor (5-10 minutes' walk to BRT station)
e.	Ineffective planning system and weak institutional capacities of current urban planning organization which cannot cope with the complex challenges of traffic congestion and suburban sprawl in global south cities	i. Appropriate and responsive urban planning system that can address complex challenges ii. Strong institution that can timely and effectively respond to complex urban planning challenges	i. Increasingly trend of daily motorized trips and traffic congestion, and suburban sprawl ii. Landuse zoning which enhance spatial differentiation of uses	i. Framework for the combined application of BRT, TOD and Congestion Pricing spatial planning strategies can reduce private car trip by a cumulative 75% and reduce travel time for commuters. The planning procedure in spatial planning regime could also ensure stakeholders and inclusive engagement that can permit timely and efficient urban planning outcomes.

Source: Author's Analysis, 2013.

With regards to the BRT system, the demonstration of all the components of the BRT system to the existing three routes in Abuja was made in line with technical specification contained in various BRT guides and empirical applications. The mode share recalibration between private car trips and transit trips, and the metrics on the related savings were also extrapolated and demonstrated to reflect reduction in car usage level by 40%. With regards to the TOD concept, demonstration of TOD nodes along the BRT corridors along the three routes under consideration and, the design of the character of each node were made in line with technical specification contained in various TOD guides and empirical applications of densities and mixing of use. The extrapolated mode share recalibrations between private car trips and transit trips and the metrics on the related savings were also demonstrated to reflect reduction in car usage level by 55%. Similarly, the metrics related to the savings on land usage due to densification (shift from the existing extensive sprawling spatial pattern) were also extrapolated and demonstrated.

With regards to the congestion pricing system, designation of the Traffic Restriction Zone (TRZ) as cordon for congestion charge zone, and the designation of each of the cordon points were demonstrated in line with technical specification contained in various congestion pricing guides and earlier studies. The mode share recalibrations between private car trips and transit trips and the metrics on the related savings from the combined application of BRT, TOD and Congestion Pricing strategies were also extrapolated and demonstrated to reflect reduction in car usage level by cumulative 75%. Lastly, the institutional reforms required to achieve efficient transformation with these strategies/solution in line with theoretical and conceptual specifications was therefore demonstrated to integrate enabling legislation, emphasize sectoral integration and stakeholder engagement, and eliminate restrictive bureaucratic practices.

In line with the Design Science structure explained earlier, the next phase is the Evaluate Artefact phase. The next chapter involves the presentation of the graphical illustrations, metrics of the performance capabilities and extrapolated outcomes of the artefact in the case-city before expert groups in interview and FGD sessions.

The findings are contained in 3 subsections; firstly, it contains findings from face-to-face interview sessions with the identified practitioners in public sector and the academia. Secondly, it involved findings from FGD sessions with the identified practitioners in public sector, private sector and the academia. Lastly, it involved findings from users' perception surveys with the identified users who are commuters on the routes under consideration and residents along the proposed BRT corridors. The

findings on the usage level of the solutions provide the premise to validate the extrapolated performance level of the demonstrated artefact (conceptual solution) and the specifications made by the practitioners. This therefore shows the convergence or divergence which indicates whether the solutions may work or not work in practice.

CHAPTER 8: RESULTS, DISCUSSIONS AND FINDINGS

8.1 Introduction

This chapter represents the Evaluate Artefact phase specified by the Design Science research strategy adopted in this study. The findings in this chapter are premised on the case city Abuja as an instance to evaluate the artefact and provide answer to objective 5 and 6, and research questions 3 in this study. While the existing situation and the experienced practitioners in the case city may provide sufficient premise to test (evaluate) the artefact, it is important to remark that using a single city to test the artefact may not provide the premise for diversity of feedback as would have been possible with different cities. However, since the selection of the case city in this study is based on features that are common to most global south cities, it may therefore suffice to use this case city to test the artefact and also generalize its applicability.

The evaluation consists of analyses of the feedback from the various iterative process of face-to-face interview and FGD sessions with transport operator association, experienced practitioners in government urban and transport planning establishments, and urban planning consulting firms. These include practitioners in the academia/research community (See Table 6-1 on list of participants). The purposive selection of the respondents as explained in Chapter 6 was due to their experienced background in urban planning which should provide the premise to home-in on useful feedback and contributions. In addition, even though these participants are experienced practitioners in urban planning practice and related fields, they were presented with graphical representation of the artefact (solutions) and accompanied by metrics which demonstrate the potential performance capability of the artefact for achieving optimized outcomes.

The experienced practitioners are needed to provide incisive and informed contributions/feedback that can be useful to improving the relevance and performance of the artefact (spatial planning strategies of TOD, BRT and Congestion Pricing). The evaluation also focused on the reforms required to institutionalize the spatial planning framework for delivering the artefact and the implicit strategies. Essentially, the goal here is to realize an artefact that is context-specific, relevant and appropriate to addressing the explicated problem of traffic congestion in the case city and other global south cities.

The second part of the chapter focuses on further evaluation of the performance of the artefact by the users' group (commuters and residents) using datasets from the users' perception surveys. These therefore provide the premise to validate or invalidate the extrapolated performance level of the refined artefact specified by the practitioners. The results from the analysis of the responses from a

representative sample of the study population provided a basis for generalization of findings across similar global south cities.

8.2 Evaluation of Artefact (Solutions) in Interview Sessions with Practitioners

This section presents the results of the evaluation of the artefact and the implicit spatial planning strategies of BRT, TOD and congestion pricing by the relevant practitioners in face-to-face semi-structured interview sessions.

8.2.1 Decentralized Concentration

The adoption of decentralized concentration serves as the vision plan to reform the present mobility pattern and the spatial form of the city in order to stem the continuous huge daily motorized trips and achieve the balancing of population and activities across the city's metropolitan area. The opinion of the urban planning practitioners (FCDA, STDA, and Academia) results from thorough and experienced analysis of the appropriateness of this intervention / solution to these present challenges (see Detail Vision Plan in Section 7.2 and Figure 7-1).

About 82% of these respondents are of the view that the adoption of decentralised concentration presents an opportunity to re-envision the city of Abuja by creating multiple centres of activities that balances activities and population, and spurs multi-directional travel patterns through transit linkages across and between different levels of activity and population centres at the metropolis level. By this, it is suggested that the designated sub-centres can serve as attraction points to re-distribute and reduce the volume of trips attracted to the core-city and, therefore curb traffic congestion on the routes linking the core-city to the suburban areas. This may also provide the opportunity and co-benefit to reform the extensive spatial pattern of development to reflect rich diverse high density mixed use communities that centres on the designated secondary and tertiary sub-centres.

Even though the decentralized concentration is embedded within the spatial planning framework, the existing Master Plan approach and its capacity to evolve blueprint for the city may still be relevant in evolving the vision plan.

An important and concrete theme that re-occurred (runs through) in the responses from the interview sessions is that majority of the practitioners noted that while this targeted strategy for reform appear innovative with potentially optimal outcome, the desired objectives may not be realized in the absence of strong political will, enabling legislation, sectoral integration, capacity building and stakeholder engagement implicit to the spatial planning approach.

8.2.2 Opinion of Practitioners on the introduction of BRT System

Earlier, the BRT system has been demonstrated as the appropriate transit infrastructure for achieving the reforms in the existing mobility pattern in view of the comparisons made by various studies on the exemplary character of the BRT system as a viable alternative transit infrastructure (See Section 5.4.2 and 7.3 for details). The opinion of the participants from transport operator association and practitioners from the government establishments, private sector, and the academia as regards the evaluation of the BRT system were investigated and presented in this section.

This investigation was made in interview sessions by showing the graphical illustration of the BRT system and its components as seen in Bogota, Curitiba and Guangzhou and the savings recorded for implementing the BRT system (See Section 5.4.2). This was followed by graphical illustration of the adaptation and demonstration of the BRT system to one of the routes (Kubwa-Bwari) under consideration in Abuja, showing the exclusive lanes, bus station and passenger linkage to bus station using existing pedestrian overpass (See Section 7.3 and Figure 7-3). This include the extrapolated savings and metrics on recalibrated modal share attributable to the reforms on the 3 routes under consideration in terms of man-hour, fuel loss, and transport-related CO₂ emission due to improved travel time, replacing mini-buses with articulated buses, and the reduction in the volume of private car trips into transit trips on the BRT system (See Section 7.3.2.1).

When asked about if they think the BRT system can work in cities facing traffic congestion challenge including Abuja, the majority of the opinion of the respondents (89%) shows strong enthusiasm and the desirability for the application of this BRT system. As they posit that, in view of its components especially its exclusive lanes, it can serve to reform the entire transportation fabric, reduce commuters travel time and improve commuters' experience in Abuja, and other global south cities facing similar challenges. Some of the opinions are captured in the quote/excerpts below.

Without any doubt, I agree, if implemented properly. By this, the right-of-way of the BRT buses should be exclusive, and enforcement be put in place against any contravention by cyclist, motorist, and mini-buses etc. indeed, if implemented and enforced properly, I am in no doubt that the desired result would be achieved. – Private Sector 1 (Infrastructure Financing).

The BRT System would definitely be a viable tool for transforming the existing transport system in Abuja. ...but even with that, the roads still need to be expanded first to make provision for the private car owners that would still be on the road. You cannot do without them, you cannot rule it out. – Public Officer (Traffic Enforcement)

12.

When asked about how and why they think the BRT system can work, about 11% of the responses reveal that it's only the rail transit infrastructure that has the capacity to effectively transform the present inefficient public transport system. This is in view of the huge number of persons that needs to be moved, they are therefore not convinced that the BRT system can do the job. Indeed, evidence from the metrics provided by the number of commuters moved efficiently in the BRT system in Bogota and Guangzhou demystifies such pessimism, especially where the BRT system is well applied and complies with the characterization of the good standard practice.

Another important observation by some of the practitioners is to ensure that the BRT system is integrated with the proposed rail network that is yet to be built in the core-city, as this can ensure modal integration. The suggestion here includes the location of the BRT station close to the proposed rail station where possible. This observation is noted to be imperative to ensuring the optimization of the BRT operations, in that, the convenience of commuters at accessing both the BRT and rail service is ensured, and therefore indicates that the BRT system can work.

Some of the practitioners opined that some spectrum of private car drivers may never stop driving because the social class status attributed to ownership and usage of private cars, and that further, this may also explain why bike usage as a component of the BRT system may not be applicable in Abuja and other sub-Saharan African cities.

In sum, the practitioners' opinion majorly indicated the applicability of the BRT system as a credible alternative to reform the existing public transport system vis-à-vis its illustrated performance capabilities. However, the practitioners are quick to note that, in view of the peculiarities that exist in these cities, what is required to achieve the desired reforms with the BRT system involves, strong political will, enabling legislation that creates the enabling environment for private sector participation and collaboration with other relevant sectors and stakeholders. These also include effective traffic enforcement mechanisms, and capacity building on the part of the transport operators association.

8.2.3 Opinion of Practitioners on the Implementation of TOD

The investigation in the interview sessions was aided with the graphical illustration of the TOD concept and its characterization as seen in Bogota, Curitiba and Singapore and the benefits recorded from the application of the TOD strategy (See Section 5.4.1). This was followed by graphical illustration of the character of the existing unplanned, unregulated pattern of development in each designated node in the suburban areas, and the adaptation and demonstration of the TOD concept to

Abuja with a typical node located along one of the routes (Kubwa-Bwari) under consideration (See Sections 3.7.2.5 and 7.3, Figure 7-7 – 7-14). This shows a typical TOD community within the sphere of influence of a BRT station transformed into smart, rich, diverse, high density mixed-use walk-able community located 5 -10 minutes' walking distance to the BRT station.

The demonstrated savings and metrics on recalibrated modal share attributable to TOD reforms on the 3 routes under consideration in terms of reduced private car usage, and the reduction in the trend of sprawl due to reduction in the level of land usage resulting from vertical densification was presented to the practitioners in the interview sessions (See Section 7.3.2.1).

When asked about if they think the TOD concept can work, the majority of the reaction of the practitioners (81%) shows desirability for reforms with the TOD concept, not only because it can contribute to the generation of ridership on the BRT, but because it can serve to transform the existing overly extensive spatial pattern which uses land inefficiently. The contribution of the TOD concept (which allows resident to live near transit station) was noted to provide incentive in terms of proximity to bus station, as this may incentivize private car drivers to leave their car at home and ride on the BRT. Some of the opinions are captured in the excerpt/quote below.

I strongly advocate for this pattern of development, particularly along important corridors. The existing pattern of development along the Kubwa-Bwari route (Outer Northern Expressway), demonstrate a misuse of potentialities and resources, such corridors are supposed to accommodate more persons by planning densification of development in order to take advantage of the corridors. This should oppose the existing pattern of single-family dwelling abutting this corridor. The present pattern of development along these corridors is indeed wastage of resources. – Public Officer 6 (Urban Planning).

When asked about how and why they think the TOD concept can work, some of the responses of the practitioners reveal that due to the high rise building that characterizes the TOD, the proposed residents may find it difficult to cope with this new way of living since they are used to living in bungalow-type buildings.

This described TOD model has the chance of being successful because more commuters have the opportunity of living close to transit corridors, and have convenient access to transit services. However, since these spectrum of residents will now live in high rise building, the desire to live in this new pattern of development may be low especially in upper floors due to the lack of regular power supply which may inhibit water supply to dwelling units in upper floors and

convenient access to upper floors using lifts due to unstable power supply to energize the lifts. – Research Fellow 2 (Regional Planning).

This initial inertia was envisaged while adopting the TOD solution, because living in high rise building is alien to the populace in the case city. However, the mechanism adopted to address/mitigate this issue is to evolve measures within the TOD development that ensure that existing residents are re-accommodated in the floors 2-4, while new willing residents can be accommodated in the subsequent floors. It is noted that there is also the likelihood that with time and with the quality of life offered by these new transit communities, people may be incentivized by these factors and may gradually become familiar with living in high-rise buildings.

Another observation made by the practitioners was in recognition of the challenge of unstable power supply in this part of the world, which means that lifts in buildings may not function all the time, and this could inhibit convenient access to floors beyond the 4th floor when power from the electric grid is not available. This may therefore inhibit the functionality of the high rise development and jeopardise the concept. This observation is quite useful, as such, alternative power source to power the lift need to be explored, so that the TOD concept becomes refined and able to address this existing peculiar challenge. This iterative process of interactions with the experienced practitioners and important feedbacks therefore presents the opportunity to make this resulting TOD solution context-specific and home-grown, and to realize optimal outcomes.

In sum, the practitioners' opinion majorly indicated the potential applicability of the TOD concept as a credible alternative for reforms to the existing character of the development along the transit corridors to reflect mixed-use high density communities. This is also identified as crucial in the desired transformation of the mobility pattern in Abuja. Therefore, the designated BRT stations should serve as the nuclei and impetus for the reforms, with people living near the transit stations within superior, aesthetically pleasing transit communities.

However, the practitioners also noted that, in view of the peculiarities that exist in these cities, what is required to achieve the implementation of the TOD concept involves strong political will, enabling legislation that creates the enabling environment for private sector and stakeholder participation. These also include, capacity building on the part of the practitioners in government establishments charged with the planning, development, management and regulation of spatial development.

8.2.4 Opinion of Practitioners on Congestion Pricing

This investigation was made in interview sessions by demonstrating to the respondents the graphical illustration of the Congestion Pricing system and its components as seen in London, Tehran, Stockholm, and Singapore and the savings recorded for the application of the Congestion Pricing system (See Section 5.4.3). This was followed by graphical illustrations of the adaptation and demonstration of the Congestion Pricing system to Abuja with defined cordon that circumvents the core-city. This represents the Traffic Restricted Zone (TRZ) (See Section 7.5.1). The illustration included metrics on the demonstrated recalibrated modal share and the extrapolated savings attributable to the reforms with the Congestion Pricing system on the 3 routes under consideration in terms of potential revenue to be generated from the payment of congestion pricing in two different scenarios of pricing (scenario one has ₦1000 and ₦500 for peak and off-peak period respectively, scenario two has ₦500 and ₦200 for peak and off-peak period respectively, See Section Table 7-12 on revenue).

When asked about if they think the Congestion Pricing system can work, the majority of the reactions of the practitioners (78%) show strong interest on the desirability for the reforms with the Congestion Pricing system, as they opined that it can serve to dis-incentivize private car usage on the routes under consideration. These spectrum of respondents opined that the congestion charge in scenario one with ₦1000 and ₦500 for peak and off-peak period respectively should be appropriate, and that with a low cost charge as in the scenario two presented may not produce any meaningful deterrent because of the high desire for private car usage in Abuja and other cities. Some of the opinions are captured in the excerpt/quote below.

Indeed, there is the need for a mechanism for reducing the proliferation of private car usage in cities including Abuja. This described strategy of congestion pricing demonstrates the capacity to impose additional costs on motorists, and can therefore serve as deterrent to private car usage in cities. – Research Fellow 1 (Urban Design).

The daily huge influx of private cars into the city daily can also be attributed to the very cheap cost of parking in the core city. Therefore, the additional cost that congestion pricing will introduce can indeed help reduce the increasing trend of car usage and related traffic congestion. – Consultant 2 (Urban Planning).

The evidence from the opinion of the practitioners appears to be supportive of the reforms with the congestion pricing regime as a measure to reduce private car usage and thus gradually shift some spectrum of commuters in private cars to becoming riders on the BRT system.

Notably, the responses of the practitioners on the support for reforms with the congestion pricing system results from its demonstrated capacity to serve as disincentives to the private car drivers as illustrated in the empirical examples. Further, it was opined that the sustained application of this Congestion Pricing regime with a relatively high fees and fines charged may lead to a gradual cultural shift in the perception of car ownership and usage as leverage on social status. This can therefore contribute to goal of reforming the transport fabric in these global south cities including Abuja.

When asked about how and why they think the Congestion Pricing system can work, the responses from the practitioners reveal that the present project on the new registration of vehicles and Drivers' Licence jointly by the FRSC and DRTS in Abuja is imperative to the success of the reforms with of the congestion pricing system because it ties a licence holder to a specific vehicle. This is regarded as a good step at leveraging the database on drivers in Abuja, and therefore shows that the application of the congestion pricing system may work in Abuja and other global south cities when these databases are harnessed.

8.2.5 Institutional Reforms

In this section, the demonstrated institutionalization of the spatial planning framework and its related strategies as solution to reform the existing Master Plan approach and the explicated problems in global south cities, including Abuja, therefore formed the basis for the investigation in interview sessions with the practitioners. The graphical illustration of the spatial planning framework (See Section 7.7.1 and Figure 7-17), which outlined the sectors and stakeholders relevant to each strategy, was presented before the practitioners. In addition, the recommended guide which consists of the regulation and planning procedure under the spatial planning framework also provided premise for the evaluation sessions.

The range of opinions of the practitioners reveals that there are several issues which need to be addressed in the existing Master Planning system in order make it relevant to addressing the present challenges in cities, especially as regards making reforms with the BRT, TOD and TDM strategies.

The analysis of the responses revealed array of emerging issues as 36% of the respondents opined that capacity building of urban planning practitioners in existing planning organizations is needed; 18% opined that enabling legislation is required to provide a legal framework for the policy shift, to ensure sustenance of a policy on sectoral integration and prevent political interference; 32% opined that institutional reform is needed as a pre-requisite to achieve the required shift; and 14% opined that

stakeholder engagement is required for sectoral integration to ensure that all relevant stakeholders and collaboration with all the relevant sectors is achieved.

The findings from the interview sessions therefore reveal suggestions for a pathway to achieve the desired reform to the existing Master planning system, some of these suggestions by the practitioners are reported in the excerpts/quote below.

I strongly feel there is the need for reforms as existing government urban planning organizations have been ineffective at shaping physical planning in cities. This may be because of government bureaucracies and other issues of deficit of institutional capacity. The spatial planning approach may be viable alternative urban planning approaches for addressing these challenges in view of the features you have described.— Research Fellow 3 (Transport Planning).

Yes, but there is more. There is a gap between planning and implementation. The implementation of plans or reforms requires legal backing, enforcement and commitment. Plans should be implemented as planned. Synergies and sectoral integration is required, even amongst the populace/residents, between the government and residents/citizens, synergies are required so that the plan can be effectively implemented and protected. – Public Officer 6 (Urban Planning).

There has to be structural review in the planning organization, such that no manipulation is allowed; Office holder (practitioners) should be empowered to take decisions commensurate to their level without interference; there should be safeguards for office holders against interference from politicians, there should be motivation for the office holders, (such as welfare packages) and capacity building. With this, there would be stability; plans would be implemented in line with scheduled programme. – Public Officer 1 (Urban Planning).

It can be noted that all the emerging issues highlighted above are all components of spatial planning approach; this may indicate the need to shift and reform the existing planning system towards the institutionalization of spatial planning approach in order to reform the existing Master Plan approach in order to achieve the set objectives from spatial planning strategies of TOD, BRT, and Congestion Pricing.

8.2.5.1 Support to Reforms using Spatial Planning

While recognizing that the described solutions for addressing the challenges implicit in the existing planning system can be achieved mostly via institutional reforms, the opinions of the practitioners were sought on their support for reforms to the existing planning system towards spatial planning approach. Consequent upon explanation and illustration of the features of the spatial planning approach to practitioners in the interview sessions, the 68% of the practitioners responded that Yes they support

the adoption of the spatial planning approach to reform the existing planning system. Some of the opinions from the interviews concerning support for the reforms are captured in the excerpts below.

We need to acknowledge that we are at a crossroad and declare the need for a shift from the existing Master Planning paradigm in these cities. There should be a workshop involving all stakeholders and sectors in order to define the solutions. This include capacity building for practitioners in government establishments, and rethinking the curriculum in planning schools, so that it reflect the current urban planning trends and solution to challenges in cities. This will support the shift away from the age-long Master Plan approach and it rigid features. — Research Fellow 5 (Urban Planning).

“We don’t need spatial planning; the Master Plan approach has made adequate provisions for the growth of the city, but its deficiency lies in the delays of implementation of the proposal, which therefore lead to on-going unplanned suburban development. It is also important for all sectors to synergize plans”. – Public Officer 1 (Urban Planning).

Yes, I think that we should at this point depart from static Master plans in our city management, we should adopt an alternative approach because spatial activities determines your plans, and so as the activities grows, it determines your planning intervention and whenever that happens, you try to address whatever challenge that might arise because of any activities.. - Consultant 3 (Urban Planning).

With this expression of support by some spectrum of practitioners for reforms to the existing planning system, spatial planning may, require to be institutionalized and backed by enabling legislation; it may serve as leverage that strengthens the existing planning system. This may therefore create the enabling environment for the application of the spatial planning framework and the related strategies of decentralized concentration, BRT, TOD and congestion pricing for transforming the mobility challenges and the spatial pattern of development in Abuja.

In sum, the analyses of the narratives across all the spectrum of respondents in the interviews shows that the practitioners in the public sector do not appear to be quite conversant with new trends in urban planning approaches and strategies and are therefore found to be stuck to the old ways/approach to urban planning. This is consistent with the findings of UNHSP (2009) which argues that practitioners in most institutionally-weak global south cities hold on to the vestiges of the modernist planning approach (Master Planning) and it has continue to shape these cities notwithstanding the sub-optimal outcomes. However, some of these practitioners in the public sector appear slightly receptive to change and ready to adopt the new approach and strategies especially with the illustration of metrics which demonstrates the impacts of adopting the spatial planning strategies as

seen in other cities, even though they often inflexibly opine that the old Master Plan approach is still very relevant. However, the practitioners in the private sector and the academia appear to have reasonable degree of familiarities with the developed artefact/solution, and offer more incisive insights on how to efficiently adapt the proposed solutions to the case area and similar cities in order to make the solutions context-specific and home-grown, and realize optimal outcomes.

In sum, the demonstration of the artefact/intervention spurred feedback from the interview sessions with the experts, the suggested modifications required to make improvements to optimize the artefact/intervention include integration of BRT station and solar-powered lifts in TOD. Accordingly, the artefact was amended to ensure that where possible, BRT stations are located in proximity to proposed LRT network especially along the Kubwa –Bwari route and the Nyanya – AYA route. Similarly, the artefact was amended to integrate solar-powered lifts within the development in the TOD communities. This amendment of the artefact, therefore present the premise for subjecting the modified artefact to another round of evaluation in the FGD sessions for possible improvements and enhanced relevance of the artefact/intervention, to the explicated problem.

8.3 Focus Group Discussion Sessions

The feedback and amendments suggested by the practitioners in the interview session for refining the demonstrated artefact/solution necessitate the need for further evaluation to the amended and refined artefact. The FGD sessions therefore provided the platform for another round of evaluation of the amended and refined artefact/solution, (spatial planning framework) and related strategies of BRT, TOD and congestion pricing, and represent another round of the evaluation phase. The participants in the FGD, the structure and the procedure of the FGD sessions have been discussed in details in Section 6.7. The sessions were grouped according to the themes of the proposed solution (BRT, TOD and congestion pricing) with the relevant practitioners participating in the relevant group interactions in a setting that permits group interactions.

8.3.1 Focus Group Discussion Session on BRT

This investigation was made in FGD session by making PowerPoint slides showing the graphical illustration of the adaptation and demonstration of the BRT system to one of the routes (Kubwa-Bwari) under consideration, showing the exclusive lanes, bus station and passenger linkage to bus station using existing pedestrian overpass (See Section 7.3 and Figure 7-5) This include the predicted recalibrated modal share and savings attributable to this reform on the three routes under consideration in terms of man-hour, fuel loss, and transport-related CO₂ emission due to improved travel time,

replacing mini-buses with articulated buses, and the reduction in the volume of private car trips into transit trips on the BRT system (See Section 7.3.2.1).

When asked about if they think the BRT system can work, the majority of the opinion of the practitioners (88%) shows support for making reform with the BRT system, as it can serve to reform the entire transportation fabric and improve commuters' experience in Abuja, and other global south cities facing similar challenges. Some of the opinions are captured in the excerpts/ quote below.

I am in agreement that with the provision of the required infrastructure like the exclusive dedicated lane for the BRT system, travel time will be reduced, and its efficient characteristics will bring about efficient commuting experience for commuters in Abuja. Accordingly, proliferation of private cars should reduce on these routes since it would take less time to travel in a comfortable and convenient BRT bus. – Transport Operator Association 1.

The BRT is a noble idea and should be pursued; the Lagos State Government has started its implementation. The progress achieved in Lagos can be attributed to the commitment and consistency of government, there have been policy continuity and very little in terms of policy change. If you have policy continuity there will be achievements, but whenever you have policy shift, progress may be inhibited and you will need some time to reconcile it. - Consultant 2 (Urban Planning).

Undoubtedly, BRT system is a veritable way of reducing transport-related GHG emissions, if it is properly controlled, not only to reduce volume of motorized trips (and VKT), but also by paying attention to the emission footprints of the BRT buses, in order to ensure that the buses are high energy efficient buses with reduced emission footprints. – Public Officer 10 (Environmental Planning).

When asked about how and why they think the refined BRT system can work, some of the responses of the practitioners reveal that with the refinement of the solution, especially the integration of the BRT system with the proposed rail system (that is yet to be built), can ensure modal integration. This should ensure the optimization of the BRT operations when the rail system is implemented, in that, the convenience of commuters at accessing both the BRT and rail service is ensured, and therefore indicates that the BRT system can work.

The practitioners were unanimous in saying that since it worked in other cities; it is very likely to work in other global south cities including Abuja. It should be experimented, especially in view of the demonstration of its adaptation to the existing situation along the routes under consideration and the stated efficiency gains in Abuja. However, it was pointed out that it is important to ensure strict

enforcement and compliance to traffic regulations to ensure the achievement of efficiency and the desired result from the BRT system. It was also pointed out that this demonstrated efficiency of the BRT system which can ensure that increasingly; more private car drivers are attracted to riding on the BRT system.

8.3.1.1 Financing and Implementation of the BRT System

In further investigation of the applicability of the BRT system in Abuja, the opinions of the stakeholders were sought on sources of finance for making reform with the BRT system. Some of the opinion of the practitioners on the potential funding sources for the proposed transformation is therefore captured in the excerpts/quote below:

There are many windows of support for finance e.g. the FCT Transport Secretariat is supporting the transport operator association to take facility from The Infrastructure Bank, which is being guaranteed by the FCT government, and other private sector funding options to ensure the transition of owners of mini-buses to high capacity buses. – Public Officer 7 (Transport Planning).

I think the PPP model can be explored by the study of PPP as a funding option to drive the realization of the implementation of urban infrastructure plans. PPP should be explored as a source of funding as seen in the Putra Jaya city in Malaysia. Private Sector investments played major role in the development of infrastructure in Putra Jaya. – Public Officer 4 (Urban Planning).

With funding from ADB, World Bank, Clean Technology Funds (loans/Grant). – Public Officer 7 (Transport Planning).

The BRT System can also help to achieve saving of Certified Emission Reduction credit that can be traded in order to get funds that can be used to expand the BRT infrastructure. – Public Officer 10 (Environmental Planning).

The analysis of these responses reveal that opportunities for funding the application of the BRT system in Abuja can be driven by the government, the private sectors or combination of both through partnerships. The transport stakeholders opined that funds can be sourced through agencies like AfDB, World Bank and the Clean Technology Fund (CTF) etc. Also, private sector equity that can aid the existing and new operators of buses in accessing loans in order to purchase the articulated buses could be realized from The Infrastructure Bank in partnership with the FCT Transportation Secretariat.

In line with earlier studies and the findings from the analysis of the opinions of the respondents, the financing and implementation of the BRT system may constitute of several stakeholders. Accordingly, the concept plan for the BRT system can be facilitated by NAIF through partnership with the FCT Transport Secretariat, FCDA and STDA. The financing and implementation of the BRT infrastructure of dedicated bus lanes, bus stations, real-time passenger information boards and the BRT control centre can be sought from the AfDB and CTF with facilitation by the FCT Transport Secretariat. In part, the financing of the bus stations can also be through value capture mechanisms, in that, placement of advertisements in the bus stations can also generate substantial revenue which can be invested into the development of bus stations.

It is opined by the Department of Climate Change that when the BRT infrastructure is completed and becomes operational, the BRT system can sell Certified Emission Reduction (CER) credit. The funds realized through this can be used to expand and improve the BRT system so as to achieve incremental improvement that can optimize the operation of the transit and continually attract riders by choice from private car usage. It may therefore suffice to note that a combination of the application of the identified funding sources can ensure the sustained application of the BRT system, and therefore avert the challenges of deficit of funds that inhibits the implementation of plans in cities in this region.

In sum, the practitioners' opinion majorly indicated the applicability of the BRT system as a credible alternative to reform the existing public transport system vis-à-vis its illustrated performance capabilities. However, the practitioners are quick to note that, in view of the peculiarities that exist in these cities, what is required to achieve reforms with the BRT system involves strong political will, enabling legislation that creates the enabling environment for private sector participation. These also include, capacity building on the part of the transport operators association, and the practitioners in government establishments charged with the planning, development, management and regulation of transport infrastructure. Importantly, enabling legislation and institutional framework are also key because they reveal how to operationalize sectoral integration to integrate the relevant departments and establishments, and ensuring that these establishments are headed by relevant and qualified professionals (urban planner and transport planner). The responsibility for the management of this reform should be by a body made up of members from existing units of the FCT Transport Secretariat, DRTS and the FRSC. Continuous sectoral integration with these establishments working synergistically to share information would ensure the smooth running of the BRT system.

However, a large spectrum of the practitioners opined that there is the need for a dedicated agency to drive the application of this spatial planning framework and related strategies and be charged with the

responsibilities to coordinate the described integrated solution, sectoral integration and achieve the joining-up of the sectors relevant to each of the strategies. It is opined that the new dedicated agency as seen in the BRT system in Lagos-Nigeria (Mobereola, 2009) can serve to achieve efficiency by reducing the potential for delay and bureaucracy in decision making. This implementation of a dedicated agency is consistent with the evidence in the study by Cervero (2013) on Transmileneo BRT system in Bogota.

8.3.2 Focus Group Discussion Session on TOD

The investigation in the FGD session was aided with PowerPoint graphical illustration of the TOD concept and its characterization as adapted and demonstrated to a typical node located along one of the routes (Kubwa-Bwari) under consideration (See Sections 3.7.2.3 and 7.4, Figure 7-7 – 7-14). This depicted a typical TOD community within the sphere of influence of a BRT station transformed into smart, rich, diverse, high density mixed-use walk-able community located 5 -10 minutes' walking distance to the bus station. Solar-powered lifts are integrated within these buildings in order to ensure uninterrupted and convenient access to all the floors within these buildings.

The extrapolated savings demonstrated on the three routes under consideration in terms of reduced private car usage, and the reduction in the trend of sprawl due to reduction in the level of land usage due to vertical densification was presented to the practitioners (See Section 7.4.2).

When asked about if they think the TOD concept can work, 84% of the responses indicated support for the reforms with the TOD concept, especially with the refinement of the TOD concept to integrate solar-powered lift to address the challenges of deficits of power supply. The contribution of the TOD concept (which allows residents to leave near transit station) therefore provide incentive in terms of proximity to bus stations, as this may incentivize private car drivers to leave their car at home and ride on the BRT. Some of the opinions are captured in the excerpts/quote below.

In addition, aligning mixed use high density development along BRT route is a trend found around the world. Aligning this character of development along the proposed BRT route in Abuja is commercially viable and should be encouraged as this would not only permit increased ridership on the BRT, but also a decent living condition that increases the quality of life of resident of the sub-urban areas in the satellite towns of Abuja, which is known to be abode for the low income persons. – Transport Operator Association 3.

In view of the described detailed character of the proposition on the TOD solution, the strategy has the potential of being successful because a large spectrum of commuters would now live in proximity to transit corridors, and have convenient access to transit services. In addition, since the proposition consists of lifts powered by solar power, this may

reduce this dis-interest of living in upper floors by residents in this mixed-use high density community, even though; the culture of living in multi-storey buildings may gradually become popular. – Research Fellow 4 (Urban Planning).

This can be good reform to the existing extensive character of development in these suburban areas and make commuters live near transit corridors. The convenience of commuting provided by this pattern of development may encourage commuters in private car to commute via the efficient BRT system. This may therefore, contribute to the reduction in traffic congestion along these major routes linking the core-city. The high density pattern of development can also ensure that land usage is efficient and infrastructure provision is optimized.—Consultant 3 (Urban Planning).

It, therefore, suffices to point out that the practitioners relevant to the reform with TOD along BRT corridors in Abuja recognize the initiative as a viable strategy for addressing the explicated problem of traffic congestion.

The responses on the adoption of solar-powered lift to mitigate the challenge of unstable power supply in this part of the world which was an earlier remark about the possible challenge of non-acceptance of the TOD strategy by resident, was commended as a huge step to ensuring that the TOD concept work optimally. As this should ensure that all the floors in the high-rise buildings within the TOD nodes can be conveniently accessed, and with this, residents can be willing to live in these transit communities.

When asked about how and why they think the TOD concept can work, some of the responses of the practitioners reveal that due to the high rise building that characterizes the TOD, the residents may find it difficult to cope with this new way of living since they are used to living on the ground floor. This initial inertia was envisaged while adopting the TOD solution; however, the strategy adopted to mitigate or address this issue is to institute mechanisms within the project which ensure that existing residents are re-accommodated in the floors 2-4, while new willing residents can be accommodated in the subsequent floors. It is noted that there is also the likelihood that with time, people should become familiar with living in high-rise buildings.

In sum, the practitioners' opinion majorly indicated the applicability of the TOD concept as a credible alternative for reforms to the existing character of the development along the transit corridors to reflect mixed-use high-density communities. However, the practitioners also noted that, in view of the peculiarities that exist in these cities, what is required to achieve reforms with the TOD concept involves strong political will, enabling legislation that creates the enabling environment for private sector participation. Importantly, enabling legislation and institutional framework are also key because

they reveal how to operationalize sectoral integration to integrate the relevant departments and establishments imperative to realizing reforms with the TOD concepts.

8.3.3 Focus Group Discussion Session on Congestion Pricing

In the FGD Session, the opinion of practitioners was sought and then analyzed on the capacity of the congestion pricing system to address the challenges of the present high-motorized commuting pattern along the three routes in Abuja. This investigation in FGD session was made by showing PowerPoint Slides of graphical illustrations of the adaptation and demonstration of the Congestion Pricing system to Abuja with defined cordon that circumvents the core-city. This represents the Traffic Restricted Zone (TRZ) (See Section 7.5.1). The illustration included the extrapolated savings attributable to reforms with the Congestion Pricing system on the 3 routes under consideration in terms of revenue generated from the payment of congestion pricing (in two different scenarios of pricing (scenario one has ₦1000 and ₦500 for peak and off-peak period respectively, scenario two has ₦500 and ₦200 for peak and off-peak period respectively, See Section Table 7-12 on revenue).

When asked about if they think the Congestion Pricing system can work, the majority of the reactions of the practitioners (82%) showed strong enthusiasm on the desirability for reforms with the Congestion Pricing system, as they opined that it can serve to dis-incentivize private car usage on the routes under consideration. Some of the opinions are captured in the excerpts/quote below.

With effective enlightenment and sensitization, traffic management mechanism like congestion pricing, private car usage can be reduce, and the ridership on the BRT system increased. In line with this, the proposed modal shift in your prediction is not too ambitious, it is practicable and can achieve the desired result of reducing daily motorized trips and related. – Public Officer 7 (Transport Planning).

This strategy is appropriate to reducing traffic congestion in Abuja. Reduced level of traffic congestion helps in achieving efficiency because you are going to have time for the pursuit of socio-economic activities rather than spend productive time in traffic. I think the strategy is worth pursuing in Abuja. Abuja is a new city and let give it a trial, why don't you send a memo to the Honourable Minister of Abuja on this proposition.—Consultant 2 (Urban Planning).

Your proposition on congestion pricing as a mechanism of deterrent to private car usage is appropriate. In Abuja presently, the parking system is poorly developed, motorist indiscriminately park on the pedestrian access way, and parking cost is nearly free. This is where government can come in because it takes the will of government to bring the change, by putting in place enforcement mechanism as Congestion pricing, additional costs can imposed on private car usage and this may serve to deter increasing trend of car usage. – Research Fellow 1 (Urban Design).

Indeed, the opinions of the practitioners is supportive of reforms with the congestion pricing as a measure to reduce private car usage and thus gradually shift some spectrum of commuters in private cars to becoming riders on the BRT system.

Notably, some of the responses of the practitioners reveal that the sustained application of this Congestion Pricing regime with a relatively high fees and fines charged may lead to a gradual cultural shift in the perception of car ownership and usage as leverage on social status. This therefore may contribute to reforming the transport fabric in these global south cities including Abuja.

8.3.3.1 Recalibration of modal share

Another important component of the focus group discussion sessions is the aggregated modal share. The overall aggregated modal share impact of the extrapolated performance levels of the combination of the spatial planning strategies of BRT, TOD and congestion pricing was presented in Table 7.11. This show the extrapolated individual impacts of these strategies, and how the combination of the impacts can skew the modal share in favour of transit trips. This therefore summarizes the overall impacts and give an outlook of the performance expected of these strategies in terms of the reduction in private car usage and the related saving in terms of reduced travel time (reduction in fuel loss, time/man-hour loss, and transport-related CO₂ emission). This includes the reduction in the inefficient land usage implicit to the application of the TOD strategy to achieve a smart compact urban form that reduce the usage of land and reduces the city's footprint.

The practitioners unanimously opined that the presented evidence of the strategies demonstrates capabilities of the strategies to reform the existing challenges in Abuja, and in cities facing the similar challenges. However, the practitioners cautioned that the expected results may not be immediate as it may unfold gradually, in that, the strategies are new in this part of the world. They also remarked that it is important that all the prerequisite policy framework, legislation and enforcement mechanisms required to successfully realizing all the strategies should be complied with, as this can ensure the realization of the desired results.

8.3.4 Focus Group Discussion Session on Institutional Reform

This represent another round of evaluation and the validation of the artefact with focus on the spatial planning framework (and related strategies), it therefore further establish the level of practitioners' support for reforming the existing planning system in order to achieve effective urban planning outcomes in Abuja. Upon illustration and explanation of the features of the spatial planning approach to practitioners in Focus Group Discussion session, 83% of the practitioners responded that 'Yes' they

support the adoption of the spatial planning approach to reform the existing planning system. Some of the opinions of the practitioners in the focus group discussion session are captured in the excerpts/quote below.

The describes features of spatial planning approach show that it embodies a lot of elements, however, I think it is a matter of semantics, whether you called it Master Plan or spatial planning. It appears to me that by reforming and leveraging the existing Master Plan approach to become more flexible, more accommodating, and more dynamic; we would have succeeded in implementing the spatial planning approach. And, with this reform, the capacity to address the existing challenges would be realized in these cities. – Research Fellow 2 (Regional Planning).

Yes, I think that we should at this point depart from static plans resulting from the Master Plan approach in our city management; we should adopt this described spatial planning approach. This is especially because the present dynamics and complexities in global south cities requires a flexible and proactive approach that responds to these trends, these capacity is demonstrated by the spatial planning approach.—Consultant 3 (Urban Planning).

There is need for policy formulation in order to set the stage for the legal and institutional framework required for the implementation of all the proposed solutions. Enforcement and regulating agencies should become insulated from political interference; this will ensure effective and un-biased discharge of duties. The transformation of the Lagos State transport sector was successful with the political will of the government and cooperation of all relevant stakeholders. – Public Officer 11 (Traffic Enforcement).

In specific terms, the opinions expressed by the practitioners revealed several issues which need to be mainstreamed into the existing planning system, and therefore, reveal the need for reforms. These issues include enabling legislation to support the application of the artefact and related spatial planning strategies and to ensure that the application of the vision plan for the city is sustained. The enabling legislation should also cover the framework for seamless integration and collaboration amongst sectors relevant to implementing the proposed plans and solutions.

Also the building of strong institutions that is stronger than individual personalities is imperative, as this can prevent interference in the implementation of plans by elected political office holders and, therefore, ensure scheduled implementation of the proposed plans. It is also noted that strengthening the capacity of institutions can equip them to efficiently implement the proposed plans and strategies. However, since the highlighted areas of reform are the defining character of the spatial planning approach, by the institutionalization of spatial planning, spatial plans and urban infrastructure plans that address mobility challenges and the sprawling spatial pattern of development in the Abuja can be reformed.

Further, reforms in terms of the creation of a new dedicated agency opined by the practitioners, and as seen in empirical cases including Lagos, Nigeria (Lagos Metropolitan Area Transportation Authority - LAMATA) (Mobereola, 2009) and Bogota (Cervero, 2013) are exemplary steps. These may help in achieving successful reforms in global south cities including Abuja. With the leverage in capacity and enabling legislation for the described dedicated agency, effective collaboration amongst all the stakeholders relevant to the application of the stated spatial planning framework and related strategies can be ensured.

It is important to remark that notwithstanding the complexity of the integrated solution (artefact), and the expressed need for stakeholder engagement to achieve the reform, this artefact may still be adopted (to reform explicated problem) under the present less-democratic Master Plan approach, however, the outcome may be less-optimal. This is because in situation where reforms are pursued without stakeholder engagement and democratic urban planning procedure, the beneficiaries usually do not feel the sense of ownership of and support for the reforms, and this may lead to sub-optimal outcomes from the reforms.

The spatial planning approach is known to integrate stakeholder engagement. This is expressed by Newman and Kenworthy (2006) as the debate and decide approach which puts the stakeholders/beneficiaries at the centre-stage (core) of making reforms to address the challenges in cities, this may be what is required to achieve better outcomes. Nevertheless, since stakeholder engagement is a critical component of the spatial planning approach, predicating reforms with the artefact (spatial planning framework) and related strategies on the spatial planning approach in global south cities may inhibit outcomes from the reforms due to the deficit of democratic urban planning culture and stakeholder engagement in this region.

However, since engagement spurs collaboration, and stakeholder confidence, mainstreaming spatial planning approach may be imperative, and may lead to gradual acceptance and institutionalization of stakeholder engagement and realization of better outcomes in urban planning reform in global south cities. This therefore indicate that spatial planning approach may present better premise and opportunity to realize the reforms with the spatial planning framework and related strategies (artefact) in global south cities.

In sum, the feedback/contributions spurred by the demonstration of the artefact in the FGD sessions with experts revealed the suggested areas of modification to the artefact in order to make improvements that should optimize the artefact/intervention. These suggested modifications include a

dedicated agency to drive the reforms spelt out by the artefact, and strict enforcement of traffic regulations. Accordingly, the artefact was amended to reflect the creation of a strong dedicated city planning agency with real planning powers and willingness to take positive lead that can permit the institutionalization of the spatial planning framework to drive the reforms with the artefact in the case area. Similarly, the artefact was amended to reflect/integrate strict enforcement mechanism that can guarantee compliance to traffic regulation to ensure the efficiency of the BRT operation. These modifications therefore formed the basis for a finalized version of the artefact as the tool relevant to addressing the explicated problems traffic congestion and suburban sprawl.

8.4 Evaluation of the Artefact with Users' Perception Surveys in the Case City Abuja

In order to provide another layer of evaluation to the developed artefact, this section seeks to establish the actual performance level of the developed artefact (solutions). Accordingly, the perceptions of the users (commuters in mini-buses and private cars) were surveyed in order to gain insight into the actual performance level of these solutions (BRT, TOD and Congestion Pricing) in the case area. The performance level referred to here is derived from the acceptability and usability level of the strategies by the users, and also show the level of the modal share between public transport and private cars trips as a result of the impacts of BRT, TOD and Congestion Pricing. These findings provide answer to Research question 3 and Research objectives 5-6, on developing the artefact and evaluating its relevance and efficiency to address the explicated problems of traffic congestion and suburban sprawl. The results therefore provide the premise to evaluate the artefact and suggest if the solutions can work in actual practice, and thus, provide the premise for the generalization of the findings in this study.

The choices of responses open to selection by respondents may have been limited by the narrow and limited questions put to the respondents (user groups). This may have had limiting effect on the quality and depth of responses and the conclusions drawn from the field in this study. However, the implication of this situation on the research finding may not be serious, in that, the goal of the users' perception survey is majorly to provide responses that are indicative of support or otherwise for the developed artefact/intervention in order to validate or invalidate the extrapolated performance of the artefact. The deep and incisive questioning and response on the efficiency and relevance of the artefact/intervention was done in semi-structured interview sessions with experts and experienced practitioners that are able to understand the complexity and working/operation of the artefact and make informed contributions towards the improvement of the artefact/intervention.

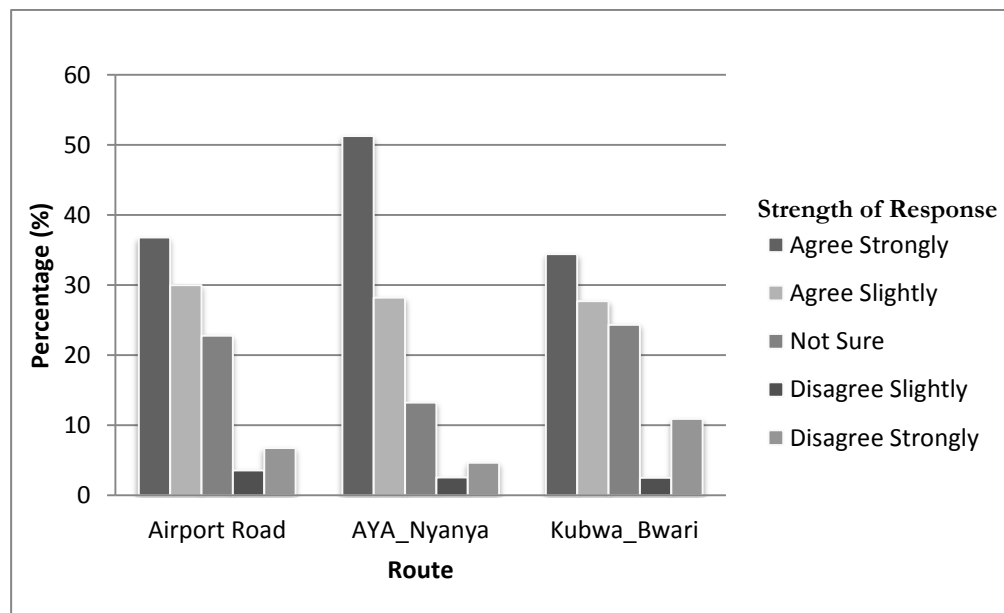
The procedures for this perception survey and the selection of the respondents have been explicated in detail in Section 6.8. The results from the perception survey on BRT, TOD and Congestion Pricing are reported in the sections below.

8.4.1 Users Perception Survey of the BRT System

The opinion of transport users was investigated about decision to ride on the BRT system based on its comparative efficiency over the existing public transport system characterized by mini-buses. The investigation focused on the following: would you support the introduction of the BRT system, would you leave your cars at home and ride on the BRT? An analysis to the responses to these questions has helped to identify the expected ridership levels on the BRT system.

I. Support for the Introduction of the BRT System by Commuters in Private Cars

The responses from the survey of commuters in private cars reveal that 36.8% and 34.5% of respondents from Airport Road and Kubwa-Bwari route respectively agreed strongly in support of the introduction of the BRT system. Evidently, the responses from these two routes are not as high as that obtained from the respondents on the AYA route with 51.28% stating that they agreed strongly with the introduction of the BRT system (see Figure 8-1).



Source: Author's Analysis, 2013.

Figure 8-1: Support for the introduction of BRT system by commuters in private cars

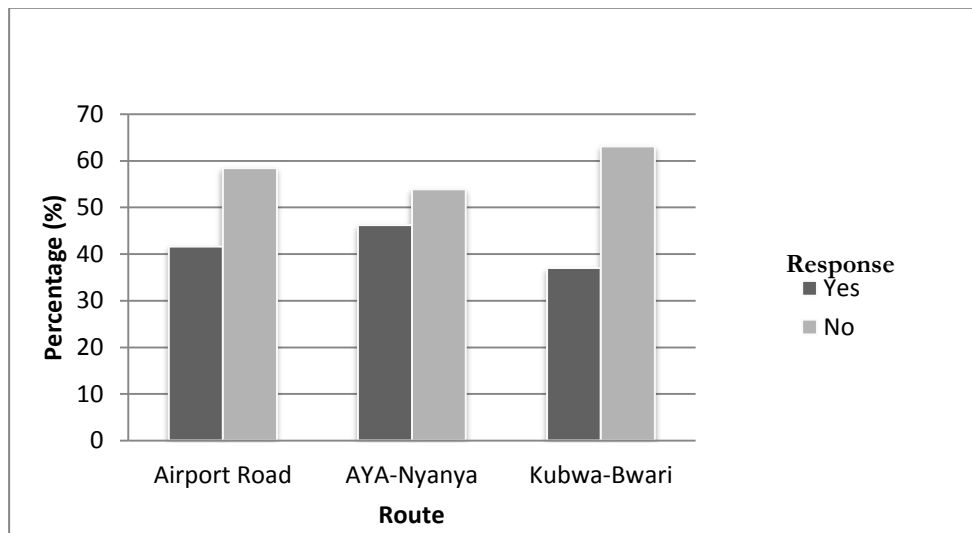
The differentiation in response across the three axes may be due to the fact that the commuters in private cars from the Kubwa-Bwari route and the Airport Road route experience comparatively lesser

congestion times, as observed in Section 3.7.4 above, due to the observed comparatively wider width of the carriage ways of these two routes.

In the same vein, the un-enthusiastic responses may also have been due to the perception of ownership and usage of private cars as a key social aspirational goal that leverages social status, in that, people riding on public transport are perceived as persons belonging to the lower classes of the society. It is interesting to note that the existing unintended disincentive created by the existing high traffic congestion on the AYA route may explain the high level of response from the commuters in private cars who agreed to the introduction of the BRT system. This affirmative response to the introduction of BRT indicates that the transport users in Abuja are in dire need for an efficient system that impacts positively on travel time. This situation also shows that when deliberate disincentives are created such as using traffic calming, high levels of parking fees and congestion pricing mechanisms, these private automobile drivers may become attracted to riding on the BRT system.

II. Desire of commuters in private cars to leave their cars at home and ride on the BRT System

In order to establish the volume of private car drivers that would be riders by choice attracted to the BRT system, commuters in private cars were questioned for their opinion concerning riding on the BRT and leaving their vehicles at home. The findings are reported in Figure 8-2 below.



Source: Author's Analysis, 2013.

Figure 8-2: Desire of commuters in private cars to leave their cars at home and ride on the BRT System.

The findings from the survey on preferences for riding on the BRT shows that 41.60%, 46.16% and 36.97% of respondents on the Airport Road, AYA and Kubwa-Bwari routes respectively stated 'Yes' as

their choice to leaving their vehicles at home to ride on the BRT system. The mean of the aggregated responses on the three routes (Airport Road, Kubwa – Bwari and AYA routes) indicates a ratio of 42%:58% for the ‘Yes’ and ‘No’ responses respectively. The AYA route recorded the highest number of respondents indicating affirmation to leaving their car at home and riding on the BRT system.

While the 42% represents the actual spectrum of commuters in private cars that agree to leave their cars at home to ride on the BRT in the case area, this level of reduction in private cars shown in this study is consistent with evidence in the literature of the define requirement which states that, by implementing an efficient transit system, private car usage level can be reduced by 20%-60% (Litman, 2012). Therefore, by making reforms with BRT system, the safe, comfortable, convenient, efficient and reliable journey times presented by the BRT system is likely to spur and attract commuters in private cars to ride on the BRT system.

However, the observed comparatively high level of respondents that indicated ‘No’ on both Airport Road and the Kubwa – Bwari route may be connected to the present wider width of the carriageways on these roads which results from the on-going road expansion, and the comparatively low level of traffic congestion. Conversely, the less-wider carriageway on the AYA route and the very high levels of traffic congestion on this route culminates in the frustration experienced by commuters in private car on this route and may therefore explain the high level of responses that indicated ‘Yes’ to leaving their cars at home to ride on the BRT system. It is worth noting that some years ago (2006), the AYA route was expanded to achieve a segregated dualization of the carriageway, and this momentarily eased traffic congestion challenges, but today it appears as though no expansion was made. This situation in Abuja illustrates the assertion in earlier studies by Litman (1998) and Newman and Kenworthy (2000) that traffic behaves like gas that occupies a given space and that continued road building and expansion only creates a temporary solution for easing traffic congestion and soon makes the expansion efforts irrelevant. Therefore, the presently less-congested Kubwa-Bwari and Airport Road routes due to expansion efforts would become congested in time. Hence, the key to addressing this traffic congestion challenge may be to direct efforts at facilitating the movement and accessibility of commuters by an efficient transit option rather than facilitate further the movement of automobile vehicles.

8.4.1.1 Statistical Analysis of Users Perception Survey on the introduction of BRT system

In order to improve the rigour of the results and research finding, the data sets were statistically analysed, in search of relationship between the variables. The nature of the data sets provided a direction and guide to the selection of appropriate statistical analysis. In this study, the data

set/variables from the user perception survey that was used for the analysis are ordinal and nominal variables/data, this therefore made the Chi-Square Crosstabulation statistical analysis relevant.

According to Leard Statistics (2013), the basic assumptions that require to be satisfied by variables and data set in order to adopt Chi-Square statistical analysis are stated below.

- a. The two variables should be measured at an ordinal or nominal level (i.e. categorical data).
- b. The two variables should consist of two or more categorical groups. Example of the variables that meet this criterion include gender (2 groups: Males and Females), ethnicity (e.g., 3 groups: Caucasian, African American and Hispanic), physical activity level (e.g., 4 groups: sedentary, low, moderate and high), profession (e.g., 5 groups: surgeon, doctor, nurse, dentist, therapist), and so forth.

Sequel to the above assumption and, the data set and variable described above in Figures 8-1 – 8-2 as nominal and ordinal, the Chi-Square analysis was therefore employed.

This section presents a statistical analysis and explanation of the responses from the survey in Figures 8-1 – 8-2 using the Chi-Square analysis. The statistical analysis elucidates on the association between the desire of motorists to leave their cars at home to ride on the BRT and the introduction of BRT system to address traffic congestion challenges. Therefore, a hypothesis has been put forward to show the association between the introduction of BRT system on the number of motorists who may leave their cars at home and shift to become riders on the BRT system.

The hypothesis is stated thus;

- (i) H_0 : There is no significant association between desire of motorists to leave their cars at home to ride on the BRT **and** the introduction of convenient, high capacity BRT system in Abuja.

Results of the Statistical Analysis from the Users Perception Survey

The output from Chi-Square Test of Association consist of several tables, majorly these include Case Processing Summary, Crosstabulation matrix, and the Chi-Square Tests. While the Cases Processing Summary table provides simple summary of the cases under consideration, the Crosstabulation matrix and Chi-Square tables provide insights into how the two variables under consideration are related. The detailed explanation of the Crosstabulation and Chi-Square Tests tables are provided below.

a. Crosstabulation

Crosstabulation describes the relationship between categorical (nominal or ordinal) variables in tabular form. The cell entries in the table indicate the number of cases (count), this include the cross-match of scores from each variable i.e. a cross-match of value in a row of one variable against value in a column for the other variable. Within the crosstabulation table, the frequency of the count and the use of percentages helps to spot patterns in the data, this pattern suggest a level of association between the two variables under consideration.

The crosstabulation matrix table of the two variables under consideration from the statistical analysis in this section is presented in Table 8-1 below.

Table 8-1: Desire of commuters in private cars to leave their cars at home and ride on the BRT system * Would you agree that the introduction of a convenient BRT system will be appropriate for addressing congestion challenges in Abuja?

Crosstabulation

			Would you agree that the introduction of a convenient BRT system will be appropriate for addressing congestion challenges in Abuja?					Total
			Agree Strongly	Slightly Agree	Not Sure	Disagree Slightly	Disagree Strongly	
Desire of commuters in private cars to leave their cars at home and ride on the BRT system	Yes	Count	122	91	48	25	7	293
		Expected Count	117.7	76.7	50.7	33.3	14.6	293.0
		% of Total	16.9%	12.6%	6.6%	3.5%	1.0%	40.6%
	No	Count	168	98	77	57	29	429
		Expected Count	172.3	112.3	74.3	48.7	21.4	429.0
		% of Total	23.3%	13.6%	10.7%	7.9%	4.0%	59.4%
Total	Count	290	189	125	82	36	722	
	Expected Count	290.0	189.0	125.0	82.0	36.0	722.0	
	% of Total	40.2%	26.2%	17.3%	11.4%	5.0%	100.0%	

Source: Author's Analysis (2013).

Some observation that can be drawn from Table 8-1 includes:

- (i). Out of the 290 (40.2%) commuters in private cars who responded by 'Agreeing Strongly' that the introduction of the BRT system will be appropriate to address traffic congestion challenges in Abuja,

only 122 say 'Yes' to leave their cars at home to ride on the BRT system while 168 say 'No' to leaving their cars at home to ride on the BRT system.

(ii). The cumulation of responses of commuters in private cars who 'Agree Strongly' and 'Agree Slightly' that the introduction of a convenient BRT system will be appropriate for addressing congestion challenges in Abuja accounts for a total of 66.4% (40.2% + 26.2%). While the total responses indicating 'Not Sure' equals 17.3% and the cumulation of responses indicating 'Disagree Slightly' and 'Disagree Strongly' equals 16.4% (11.4% + 5.0%).

The counts and percentages provide some useful insight and quick glance into how the two variables are related. As evident above, in comparative terms, the percentage of commuters in private cars not willing to leave their cars at home to ride on the BRT is more than those willing to do so, while the percentage of commuters in private cars who 'Agree' to the assertion that the introduction of BRT system can address traffic congestion challenges in Abuja are more than those who 'Disagree'. Therefore, by comparing percentages of Yes/No responses of commuters in private cars who agree to leave their cars at home and ride the BRT against the percentages of responses of Agree Strongly, Agree Slightly, Not Sure, Disagree Slightly, Disagree Strongly to the assertion that the introduction of BRT system can address traffic congestion challenges, the relationship between the two variables can be discerned.

However, it is pertinent to note that, to rely on the spread of the percentages as a premise for establishing the association between the two variables could be an over-simplification of all the other intricate elements. This is especially because the spread of the percentages could have arisen due to randomness in the distributions or otherwise. This, therefore necessitates the Chi-Square Statistics Test to test and establish whether there exist any association between the two variables under consideration.

(b) Chi-Square Tests of Association

In the Chi-Square statistics test output table, the important components relevant to the test of association between the two variables under consideration are the Pearson Chi-Square statistics value, its corresponding degree of freedom (df) and computed p value (Asymp. Sig.), (See Table 8.2 below).

The assumed level of significance for the analysis has been set at 0.05. Accordingly, when the computed p-value is greater than the assumed level of significant (α) of (0.05), the null hypothesis is accepted and vice versa.

Table 8-2: Chi-Square analysis of preference of commuters in private car to leave their car at home and ride on the BRT system

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	15.135 ^a	4	.004
Likelihood Ratio	15.870	4	.003
Linear-by-Linear Association	8.491	1	.004
N of Valid Cases	722		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 14.61.

Source: *Author's Analysis (2013)*.

As evident from the results of the analysis displayed in Tables 8-2 above, the test of the hypothesis shows that commuters' support for the introduction of BRT system and the desire of commuters to leave their cars at home to ride on the BRT were crosstabulated, the result of the Chi-Square test of association shows that; $X^2 = 15.135$, $df = 4$, $p = 0.004$. Since the computed p-value is less than the assumed level of significance (α) of 0.05 (i.e. $p < 0.05$), therefore, the null hypothesis is rejected. It is therefore concluded that there is association between the two variables under consideration. Simply put, it can be stated that there exist association between commuters' support for the introduction of BRT system and the desire of commuters to leave their cars at home to ride on the BRT system in Abuja.

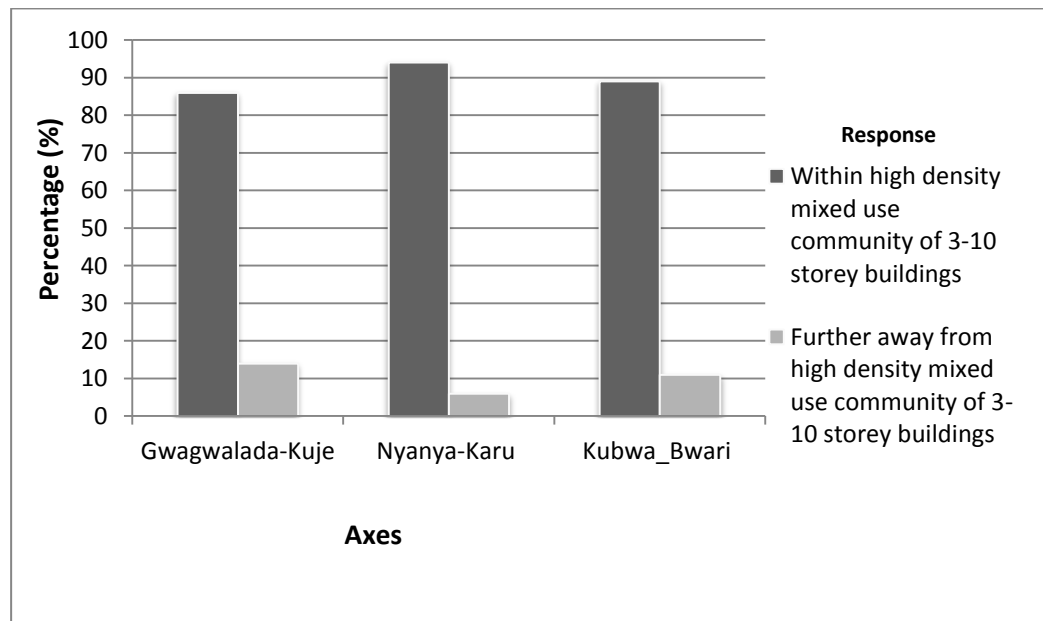
The association detected between the two variables may have been due to the efficiency gains attributable to the BRT system which includes reduced travel time, reliable travel time, effective bus scheduling (reduced length of waiting time), well-protected bus stops from sunshine and rain, comfortable commuting experience and convenient access to BRT station. These may also include dissatisfaction with the routine stress connected with prolong driving in traffic jam, fuel wastage, wear and tear of cars due to prolong driving and frequent acceleration and deceleration in traffic congestion. This therefore suggest that the introduction of BRT may impact on the reduction in car usage level by commuters, the consequent reduction in traffic congestion, and the achievement of efficiency in passenger mobility in Abuja. In addition, by addressing the level of congestion, the related externalities may also be reduced, if not eliminated.

8.4.2 Perception of Respondents about living in TOD Nodes

The opinion of commuters resident in the suburban areas and areas along the proposed BRT corridors was investigated about the decision and willingness to live in the area if transformed into rich, diverse, mixed-use high density TOD communities. This include their decision to ride on the BRT due to the

comparative proximity TOD communities to BRT station as against current dispersed pattern with majority of residences farther from public transport corridors. The opinion of the commuters was sought on the following: Are you willing to live within or farther away from a mixed use high density community located within 5-10 minutes walking distance to the bus station? What number of floor will you be willing to live between 2nd - 10th floor? Would you leave your car at home and ride on the BRT because of the proximity of your residence (in the reformed community) to the BRT station? The analysis of the responses to these questions has helped to identify the expected/potential residents of the proposed TOD communities, ridership levels on the BRT system, and the level of reduction in private car usage.

In order to ensure that the responses from the respondents was based on an understanding of the character and capacity of the TOD concept to transform the suburban areas and ensure increased accessibility to efficient public transport for commuters, the features of the TOD community was graphically illustrated in the questionnaires used for the users perception survey. The responses from the investigations were analyzed and reported in Figures 8-3 – 8-14.

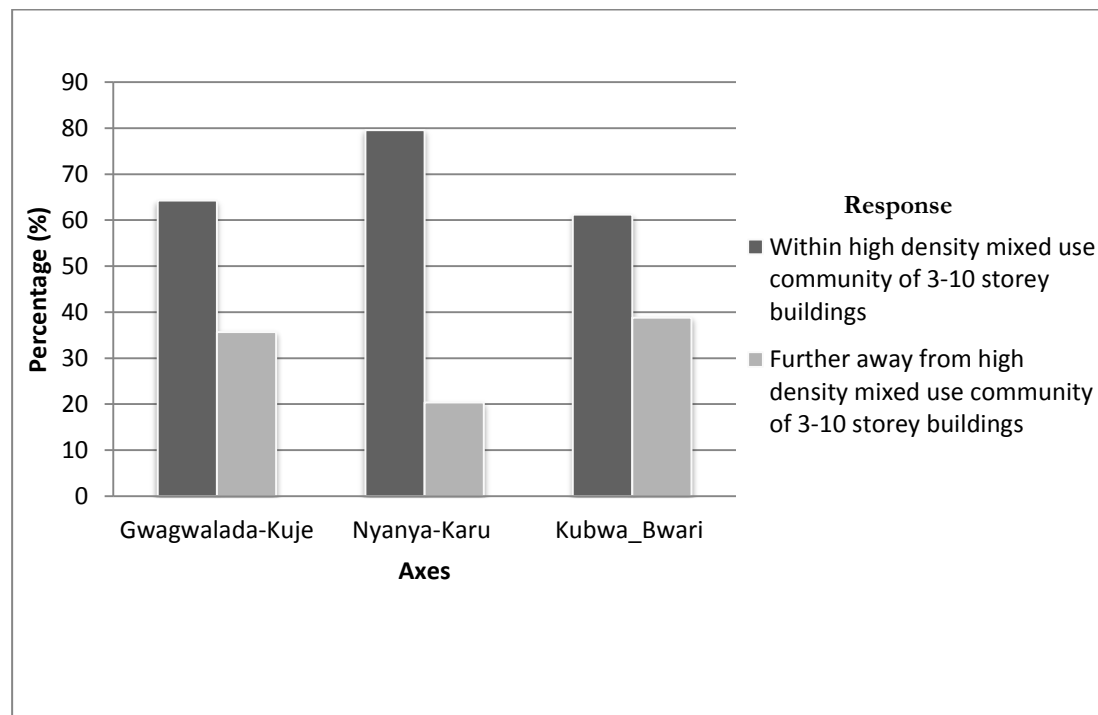


Source: Author's Analysis, 2013.

Figure 8-3: Desire of commuters in mini-buses to live within high density mixed use community located within walking distance to a BRT Stations

Figure 8-3 above shows that 86%, 94% and 89% of commuters who travel in mini-buses (residents across the three axes of Gwagwalada-Kuje, Nyanya-Karu, and Kubwa-Bwari respectively) responded

that, if their community was transformed into a high density mixed-use community of 3-10 storey buildings and within walking distance to a BRT station, they are willing to live within this type of development. However, 14%, 6% and 11% opined that they would live further away from the above described community. To sum up, an analysis of the responses of these respondents shows that a large spectrum of these respondents may be dissatisfied with the present character of development in their suburban areas because the residences are located far away from bus stops. These responses may, therefore, indicate a desire and support for the transformation/re-development of these communities into TOD communities.

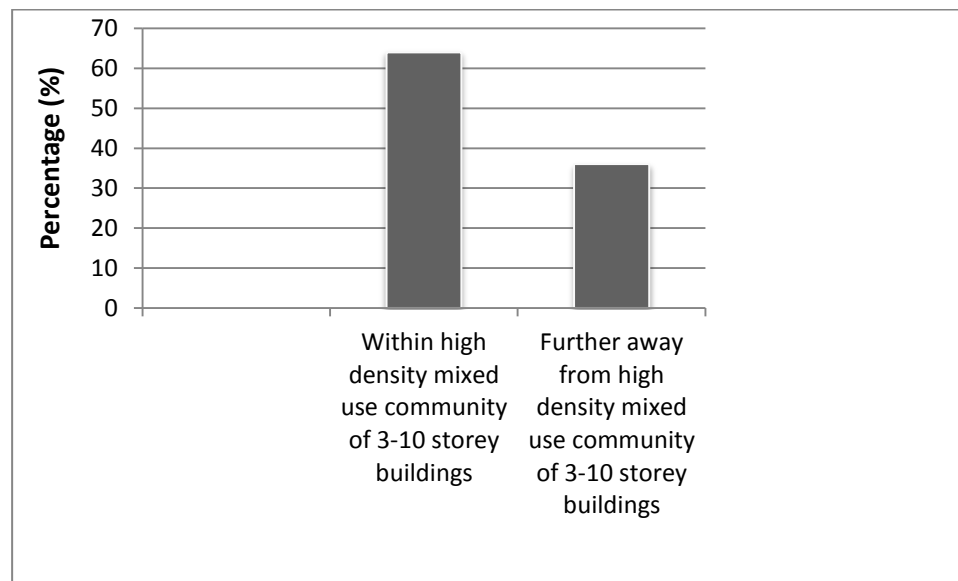


Source: Author's Analysis, 2013.

Figure 8-4: Desire of commuters in private cars to live within high density mixed-use community located within walking distance to a BRT station.

The analysis of the responses from the commuters in private cars in Figure 8-4 above shows that 64.3%, 79.6% and 61.2% of residents across the three axes of Gwagwalada-Kuje, Nyanya-Karu, and Kubwa-Bwari respectively opined that they are willing to live within a high density mixed-use community of 3-10 storey buildings and within walking distance to a BRT station if their community is transformed. This represents the majority of the residents questioned in the suburban areas. However, 35.7%, 20.4%, and 38.8% of respondents from the Gwagwalada-Kuje, Nyanya-Karu and Kubwa-Bwari axes respectively opined that they would live further away from the above described community. However, the share of respondents who expressed a desire to live within the described community is

not as high as number of commuters who travel in mini-buses who said they would live in such a community (see Figure 8-3). This is not unconnected to the suggestion that commuters in private cars are lower-middle income people who live in bungalows in some pockets of the suburban areas. To sum up, these analyses also show that a large spectrum of commuters in private cars may be dissatisfied with the present character of development in the suburban areas. However, other spectrum of these respondents who expressed unwillingness to live within the transformed community may become attracted to live within these transformed communities as other middle income persons become residents of these communities.

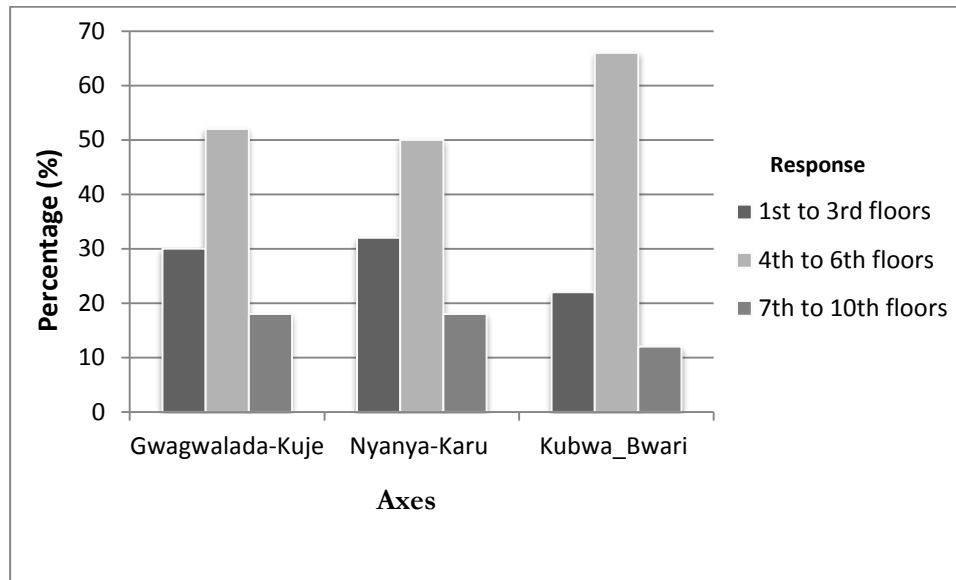


Source: Author's Analysis, 2013.

Figure 8-5: Desire of commuters to live within high density mixed use community located within walking distance to a BRT station.

Figure 8-5 above shows the analysis of the responses of residents in areas designated as TOD nodes along corridors of the BRT system in the areas of the core-city. The analysis shows, on the one hand, that 64.6% of the residents indicated that they are willing to live within high density mixed-use community of 3-10 storey buildings located 5-10 minutes' walking distance to a BRT station if their present community is transformed. On the other hand, 35.4% of the residents of this area indicated that they would live further away from such a transformed community. This responses is skewed in favour of desire to live within transformed community, this may be because the residents walk over long distance or pay additional cost for motorized commute to get to the bus stop and may therefore impact on their transport expenditure. It may also be that the illustration of the character of the TOD community presents an improved living condition and accessibility as compared to the existing

situation. The commuters whose opinion is otherwise may gradually become attracted to living in these transformed communities as the community becomes transformed into TOD communities and the efficiency of the BRT system becomes evident.

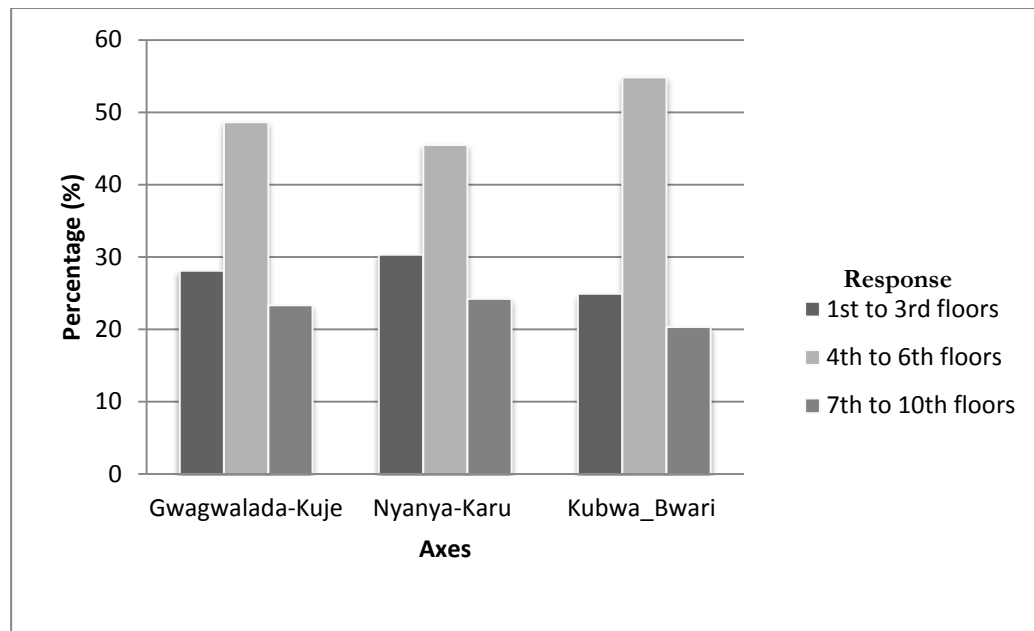


Source: Author's Analysis, 2013.

Figure 8-6: Mini-bus commuters' choice of floor to live within a high density mixed-use development in suburban areas.

As revealed in Figure 8-6 above, the majority of the commuters travelling in mini-buses who are resident in the suburban areas responded that they would live on the 4th- 6th floors, with 52%, 50% and 66% from the Gwagwalada-Kuje, Nyanya-Karu, and Kubwa-Bwari axes respectively. Also, some residents have expressed their desire to live on the 1st-3rd floors of the high density buildings in the mixed use community; these included 30%, 32%, and 22% of respondents in Gwagwalada-Kuje, Nyanya-Karu, and Kubwa-Bwari axes respectively. In the same vein, 18%, 18% and 12% of respondents from the Gwagwalada-Kuje, Nyanya-Karu and Kubwa-Bwari axes respectively expressed their desire to live on the 7th-10th floors. These responses can be attributed to the fact that the majority of these respondents presently live in a single floor unplanned haphazard development and their decisions regarding living in high storey buildings is guided by their familiarity with the present extensive character of the suburban areas where they currently live. At this stage, since the responses is not based on actual experience of the reforms, this level of response may be considered as encouraging; the habit of living in high storey buildings may progressively become popular. By this, the character of development can gradually become aligned towards a high density vertical development in

the suburban areas of Abuja especially along the transit corridors, other parts of the suburban areas and the city at large.

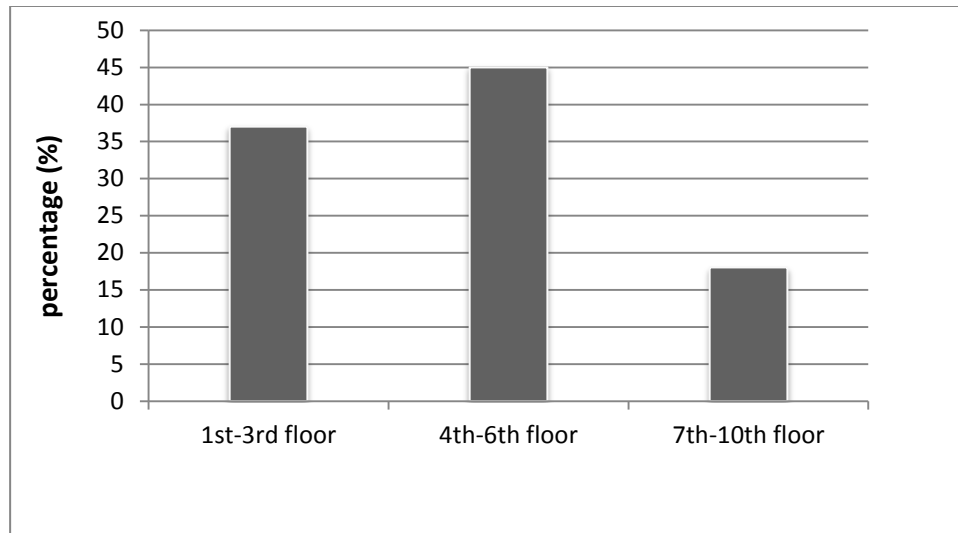


Source: Author's Analysis, 2013.

Figure 8-7: Private car commuters' choice of floor to live within a high density Mixed-use development of in the suburban areas

The analysis in Figure 8-7 above reveals the responses of the commuters in private cars who are resident in the suburban areas, with responses showing that 48.6%, 45.5% and 54.8% of the respondents from the Gwagwalada-Kuje, Nyanya-Karu and Kubwa-Bwari axes respectively opined that they would live on the 4th- 6th floors. Similarly, 28.1%, 30.3%, and 24.9% in Gwagwalada-Kuje, Nyanya-Karu and Kubwa-Bwari axes respectively expressed their desire to live on the 1st-3rd floors of a high density mixed-use community. In the same vein, 23.3%, 24.2% and 20.3% of respondents from the Gwagwalada-Kuje, Nyanya-Karu and Kubwa-Bwari axes respectively expressed their desire to live on the 7th-10th floors. These responses are not unconnected to the fact that the majority of these respondents are lower-middle income level people who already live in rented single dwelling houses in the suburban areas and have aspiration to own such houses. As such, their responses are not so much in support of a high density mixed-use community. This may be because they can afford to have an informal title to land in the suburban areas due to a lack of stringent conditions, and because development of buildings in the suburban areas can evade detection by the weak planning institutions. However, it is hoped that, with the development of these communities into high density mixed-use TOD communities with quality living condition and aesthetically pleasing environment, different income spectrums may become attracted to living in these TOD nodes. With time, the character of

development across the suburban areas may gradually become aligned towards a high density vertical character of development.

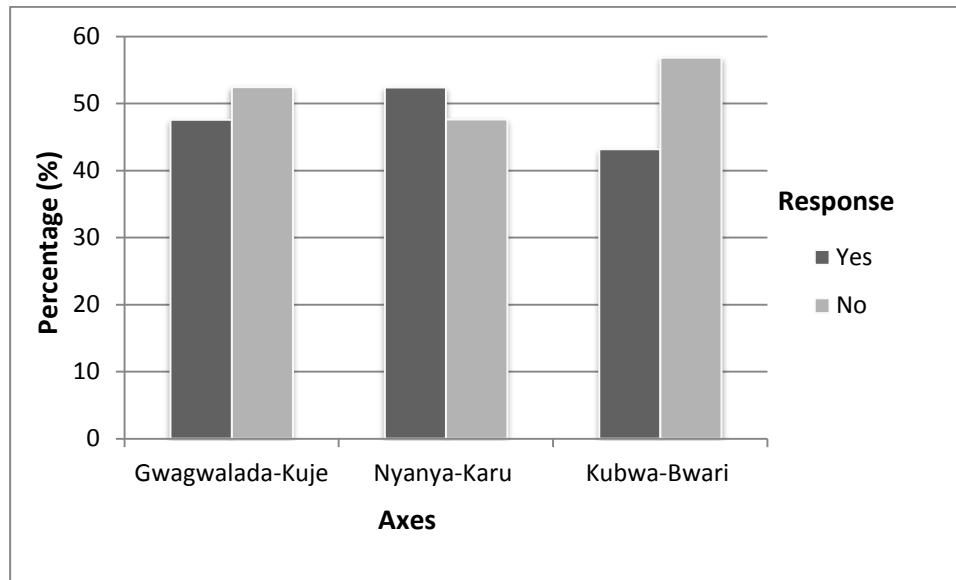


Source: Author's Analysis, 2013.

Figure 8-8: Commuters' choice of floor to live within a high density mixed-use development in the areas of the core-city.

For residents of areas designated as TOD nodes in the areas of the core-city, an analysis of their responses about the choice of floor to live within a high density mixed-use development of 3 -10 storey buildings is as shown in Figure 8-8 above. The analysis reveals that 45% would chose to live on the 4th-6th floors in a high density community, 37% would chose the option to live on the 1st-3rd floors while 18% would chose to live on the 7th-10th floors.

These responses are not unconnected to the fact that majority of these respondents are high and upper-middle income level people who are already familiar with living in single dwelling houses that mostly characterizes the development in the core-city. Their responses may indicate that they are not so much in support of living in a high density mixed-use community. It is, however, hoped that with the development of these communities into high density mixed-use TOD communities with quality living condition, people in the high and upper-middle income spectrum could become attracted to living in these TOD nodes due to proximity to efficient transit routes and the new aesthetically pleasing environment. Accordingly, the character of development across this part of the core-city can gradually become aligned towards a high density vertical character of development which can reduce the level of spatial sprawl.



Source: Author's Analysis, 2013.

Figure 8-9: Decision of commuters in private cars to leave their cars at home and ride on the BRT system were they resident of TOD nodes in the suburban areas

The analysis of the responses from commuters in private cars resident in the suburban areas across the three axes was investigated in order to reveal the number of commuters in private cars who would be willing to leave their cars at home to ride on the BRT system were they to live in a high density mixed-use TOD community, located 5-10 minutes' walking distance to BRT bus stations. Figure 8-9 shows that 47.56%, 52.38% and 43.16% of the commuters in private cars from Gwagwalada-Kuje, Nyanya-Karu and Kubwa-Bwari respectively opined that "Yes" they were willing to leave their cars at home to ride on the BRT because of the proximity of their residence in TOD to a BRT station. Conversely, 52.44%, 47.62% and 56.84% of these respondents from Gwagwalada-Kuje, Nyanya-Karu and Kubwa-Bwari respectively opined that "No" they were not willing to leave their cars at home to ride on the BRT.

This low level of response of commuters in private cars unwilling to leave their cars to ride on the BRT system is not unconnected in part to the strong social class-value attached to ownership and usage of private cars as suggested by earlier study by Penalosa (2004), and also evident in the interview data from the responses of practitioners reported in Sections 8.2.4 and 8.3.1 in this study; and partly because the cost of parking charges in the core-city is free.

To sum up, Figure 8-9 above shows that, from the spectrum of commuters travelling in private cars across the three routes, a mean average of 47.7% of the respondents would shift their mode from private car trips to the BRT system, while an average of 52.3% of the respondents opined that they

would continue to drive their private cars. This represents an increase (an increase from 42% to 47%) in the percentage of commuters in private cars that would agree to shift from private car mode to public transport mode. This increase is no doubt not unconnected to the additional incentive provided by the development of TOD community which can spur commuters in private cars to become residents in TOD nodes closer to efficient BRT routes/corridors.

While the 47% reduction represents the actual commuters in private cars that agreed to leave their cars at home to ride on the BRT in the case area, the demonstrated level contained in artefact/ solution is put at 55% reduction of commuters in private cars that should leave their cars at home to ride on the BRT. The difference between the demonstrated and actual situation (i.e. 8%) does not appear wide. Accordingly, the extrapolated related impact and savings in terms of travel time; man-hour, fuel loss, and CO₂ emission, and land usage should be in the same region and margin. This level of demonstrated reduction in private cars usage derived from survey in this study is consistent with earlier studies which states that, by implementing diverse mixed use high density TOD community along an efficient transit corridor, private car usage would be reduced by 55%-60% (Litman, 2014). Evidently, in making reforms with TOD, the convenience of living within proximity to an efficient transit system with efficient and reliable journey times presented by the BRT system, commuters in private cars can be attracted to ride on the BRT system.

8.4.2.1 Statistical Analysis of Users' Perception Survey (TOD residents in suburban areas)

This section present a statistical analysis and explanation of the response from the perception survey in Figures 8-4 and 8-9 using the Chi-Square Analysis. The statistical analysis elucidate on the association between living within high density mixed use community located 5 – 10 minutes walking distance to BRT station (TOD) and desire of motorist to leave their cars at home to ride on the BRT system.

Therefore, a hypothesis has been put forward to show the impact of the living within high density mixed use community located 5 – 10 minutes walking distance to BRT station (TOD) on the number of motorists who may leave their cars at home and shift to become riders on the BRT system.

The hypothesis is stated thus:

- (i) H₀: There is no significant association between desire of motorists to leave their cars at home to ride on the BRT system **and** living within high density mixed use community located 5-10 minutes walking distance to BRT station (TOD).

Results of the Statistical Analysis from the Users' Perceptions Survey

The assumed level of significance for the analysis has been set at 0.05. Accordingly, when the computed p-value is greater than the assumed level of significance (α) of (0.05), the null hypothesis is accepted and vice versa.

- (i) H_0 : There is no significant association between desire of motorists to leave their cars at home to ride on the BRT system **and** living in high density mixed use community located 5-10 minutes walking distance to BRT station (TOD).

Table 8-3: Chi-Square analysis of decision of commuters in private cars to leave their car at home and ride on the BRT system were they resident of the proposed TOD nodes in the suburban areas

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.674E2 ^a	1	.000		
Continuity Correction ^b	264.688	1	.000		
Likelihood Ratio	348.432	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	267.001	1	.000		
N of Valid Cases ^b	722				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 99.39.

b. Computed only for a 2x2 table

Source: Author's Analysis (2013).

As evident from the results of the analysis displayed in Tables 8-3 above, the test of the hypothesis shows that commuters' support to live in high density mixed use community located 5-10 minutes walking distance to BRT station (TOD) and the desire of commuters to leave their cars at home to ride on the BRT were crosstabulated, the result of the Chi-Square test of association shows that; $X^2 = 2.674E2$, $df = 1$, $p = 0.000$. Since the computed p-value is less than the assumed level of significance (α) of 0.05 (i.e. $p < 0.05$), therefore, the null hypothesis is rejected. It is therefore concluded that there is association between the two variables under consideration. Simply put, it can be stated that there exist association between commuters' support for the introduction of BRT system and TOD, and the desire of motorists to leave their cars at home to ride on the BRT system in Abuja.

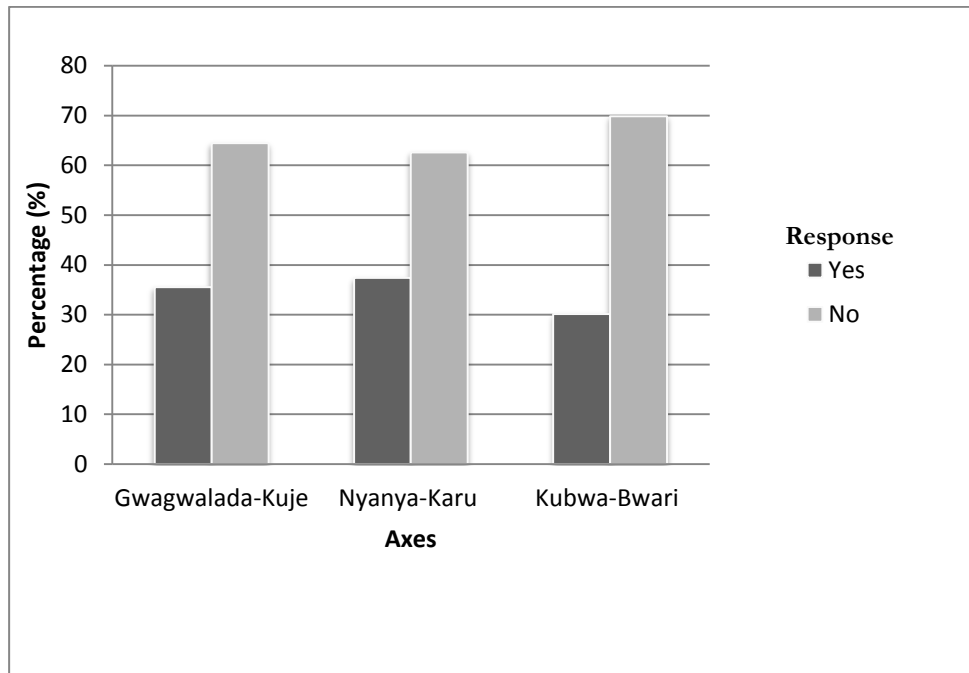
The association detected between the two variables may have been due to the efficiency gains attributable to the combination of BRT and TOD strategies which includes reduced travel time,

reliable travel time, effective bus scheduling (reduced length of waiting time), improved living condition in transit communities, proximity to BRT station, and comfortable commuting experience. These may also include dissatisfaction with the routine stress connected with prolong driving in traffic jam, fuel wastage, wear and tear of cars due to prolong driving and frequent acceleration and deceleration in traffic congestion. This therefore suggest that the introduction of the combination of BRT and TOD strategies may impact on the reduction in car usage level by commuters, reduction in traffic congestion, and the achievement of efficiency in passenger mobility in Abuja. In addition, by addressing the level of congestion and sprawl, the related externalities may also be reduced, if not eliminated.

To sum up, it can be argued that the reduction in travel time of commuters in private cars due to an efficient BRT system and due to living in high density mixed use community located 5-10 minutes walking distance to BRT station (TOD) in Abuja can be a factor that offers explanations about the desire of motorists to leave their cars at home and ride on the public transport (BRT). This level of willingness of these commuters may therefore suggest that making reforms with BRT and TOD in the suburban areas may be imperative.

8.4.2.2 Bicycle Share Facility

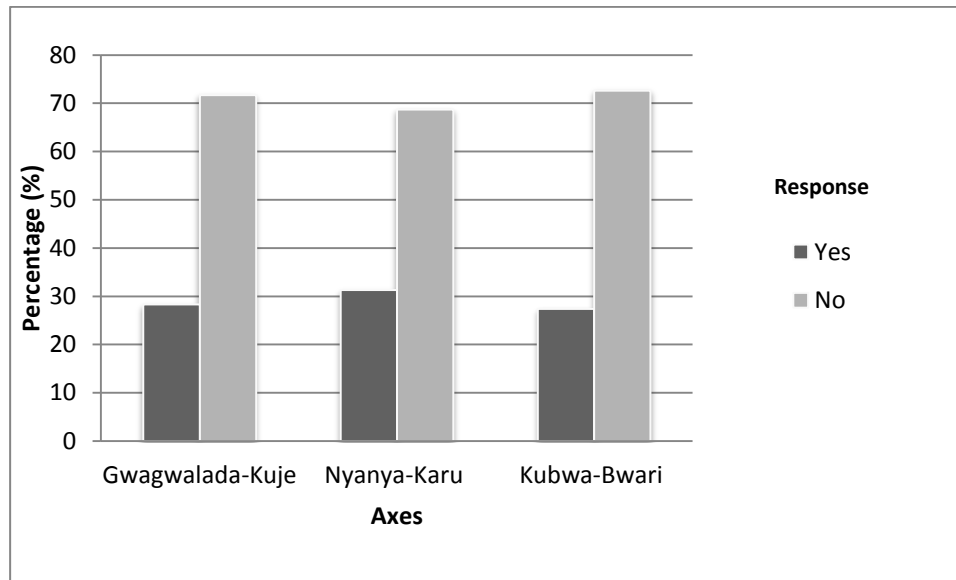
The commuters who travel in mini-buses and private cars were investigated concerning their response about riding on bike (from a bike share facility) to and from a BRT station, especially in instances where places of residence of the respondents within the suburban area is located beyond 10 minutes' walking distance to the BRT station.



Source: Author's Analysis, 2013.

Figure 8-10: Desire of commuters in mini-buses to ride a bicycle to and from a BRT station.

The analysis in Figure 8-10 above shows the responses of commuters who travel in mini-buses which reveals that 64.44%, 62.62% and 69.84% of respondents across the three axes of Gwagwalada-Kuje, Nyanya-Karu, and Kubwa-Bwari axes respectively opined that they would not ride on a free bicycle to and from a BRT station. Conversely, 35.56%, 37.38% and 30.16% of respondents across the three axes of Gwagwalada-Kuje, Nyanya-Karu, and Kubwa-Bwari axes respectively opined that they would ride a free bicycle to and from a BRT station. This huge proportion of respondents who expressed unwillingness to ride on a bike from a bike share facility may be due to the negative perceptions of riding bicycles in this region of the world. Riding a bike is perceived as being a symbol of people belonging to the lower echelons of society. However, with good branding and a good publicity campaign, the use of bikes may become popular and gradually replace the use of commercial vehicles for the last/first mile commute to and from the bus stops. By making reforms with the bike share facility, it may lead to the reduction in the costs (fuel, CO₂ emissions, fare cost) of getting to the BRT station and, therefore, further increase ridership on the BRT system.



Source: Author's Analysis, 2013.

Figure 8-11: Desire of commuters in private cars to ride a bicycle to and from a BRT station

Figure 8-11 shows an analysis of the responses of commuters travelling in private cars about whether they would ride on free bikes (from the shared bike facilities) if located at BRT stations and at the entry and exit points of major residential areas within the TOD nodes. By this facility, commuters with private cars resident within these TOD nodes have the opportunity to ride bikes to and from the BRT station in instances where their residences within the TOD is located beyond 10 minutes' walking distance to a BRT station. The analysis reveals that 71.7%, 68.7% and 72.6% of respondents across the three axes of Gwagwalada-Kuje, Nyanya-Karu, and Kubwa-Bwari axes respectively indicated that they would not ride a free bicycle to and from a BRT station. 28.3%, 31.3% and 27.4% of respondents across the three axes of Gwagwalada-Kuje, Nyanya-Karu, and Kubwa-Bwari axes respectively indicated that they would ride a free bicycle to and from a BRT station.

The riding of a bicycle is quite unpopular amongst residents and even more unpopular with owners of private automobiles because private car ownership and usage is perceived as a key social aspirational goal in Abuja and this region at large. This may explain the seemingly low level of enthusiasm in the responses of the respondents about riding a bicycle to and from BRT stations.

However, additional information provided by the respondents in this investigation revealed that residents whose houses are located 20 – 30 minutes' walking distance to the bus stations (who are the largest spectrum) responded that they actually do not walk over this distance but rather ride on commercial motorcycles to get to the bus stops. This, therefore, increase the portion of income spent

on transport by these commuters from the suburban areas. By making reforms with the bike share facilities for last mile commuting, the portion of the income of commuters spent on commercial motorcycle and taxi fares for this last part of the commute can be saved. However, with choice riders attracted to ride on the BRT due to its efficiency, the use of bicycles to and from BRT stations by commuters who normally travel in mini-buses and private cars could gradually emerge especially with good branding and publicity campaign for the free bike facility.

8.4.2.3 Extrapolation of savings from results of users' perception survey on TOD

Based on the findings from the users perception surveys on; the level of residents who agree to live within the TOD communities, how respondents are spread over the different floors within the TOD communities, and the impact of this high density transit communities on the reduction in the trend of sprawl. The computations include the impacts of living near transit corridors on mode share of daily motorized trips.

The demarcation of the TOD node into zones (as seen in Figures 7-9 – 7-11) allows for ease of comparison in terms of potential density and population between the demonstrated nodes and the actual acceptability and usage levels, since the transformation into TOD nodes is categorized into zones (intense, standard and transition) with differentiated density levels. Table 8-3 below makes comparison between the demonstrated and actual, land usage and land savings in each TOD nodes. While the proposed situation refers to the demonstration made by the TOD solution (artefact) about the land usage and land savings in each TOD nodes (See Table 7.4 – 7-6 in Chapter 7 section 7.4.2), the actual situation refers to the land usage level in each TOD nodes derived from the analysis of the choices of the respondents about living in what dwellings? in what zone? within the TOD nodes.

In line with the demonstration made in (See Tables 7-5 in Chapter 7 section 7.4.2), the analysis was made by structuring each TOD node into 3 zones with Intense zone (7-10 floors), Standard zone 4-6 floor) and the Transition (1-3 floors). Further, Figures 8-4 – 8-17 (Section 8.4.2.) which show the percentages of the responses on the investigation about the Choices of commuters in mini-buses and private cars of what floor upon which to live within a high density mixed-use development of 1-10 storey buildings in the TOD nodes along BRT corridors was analyzed. Accordingly, the mean of these analyzed responses of the commuters in mini-buses and private car was computed in order to identify/establish the ratio of persons who agree to live in 1-3 floors, 4-6 floors and 7-10 floors within the TOD communities. With 1-3 floors, 4-6 floors and 7-10 floors assumed to represent the Transition zone, Standard zone and Intense zone of a TOD node respectively, the comparative analysis between

the demonstrated and actual level of occupation and the related savings of the TOD is made. By this, the difference between the demonstrated number of dwelling units per zone in a TOD node, and the actual number of people who agree to live in each respective zone is used to validate the demonstrated occupancy level and the related savings in terms of dwelling units and land area (See Table 8-4).

Table 8-4: Comparison between the Extrapolated and Actual situation on the number of dwellings to be occupied in the zones of each TOD node

Zone	Size in radius (m)	Extrapolated Situation in a TOD Node		Actual Situation in a TOD Node		Difference realizable from each zone (Dwellings)	Percentage of Difference realizable from each zone (Dwellings)	Savings realizable from each zone ^c (Land Area in Ha)
		Number of Dwellings to be occupied in each zone	Percentage of Dwellings to be occupied in each zone	Number of Dwellings to be occupied in each zone	Percentage of Dwellings to be occupied in each zone			
Intense	300m	1,904.3	50.91	722.3	19.31	-1182	50.0	-32.76
Standard	600m	1,468.6	39.27	1,975.2	52.81	506.6	21.43	17.55
Transition	800m	367.4	9.82	1042.8	27.88	675.4	28.57	31.19
Total		3,740.3	100	3,740.3	100		100	16.04

Source: Author's Analysis, 2013.

Note: The total gains is required to be multiplied by 25 (There are 25 designated nodes).

The findings from the comparative analysis in Table 8-4 above therefore show that the respondents may actually be less willing to live in the intense zone, as the numbers of respondents who agree to live in the intense zone are 50% less than the demonstrated level of occupation of the dwellings in the intense zone. Conversely, the number of respondents who agree to live in the standard and transition zones are more than the demonstrated levels by 21.43% and 28% respectively, in aggregation, the increased level in the choice of respondents to live in the standard and transition zones represent 50% more than the proposed levels.

The inertia detected from the respondents about living in the intense zone may find explanation in the argument that, majority of the existing character and pattern of development in the suburban area (which is the domain of the respondents) is extensive low density development. As such, adapting to a new way of living in high rise buildings in the proposed TOD communities may provide the explanation, this initial inertia is expected, and expected to become reduced and fade away over time.

While, the analysis shows reduction in the level of choice of respondents for occupying the dwellings in the intense zone, there is a corresponding increase in the level of choice of respondents for occupying the dwellings in the standard and transition zones (which indicates offset for the initial reduction). In

sum, the findings show a variation in the structure and distribution of the residents across the zones in the TOD nodes as against the proposed distribution of dwellings and level of its occupation across the zones. The additional savings attributable to the new structuring and distribution of the level of occupation within each TOD nodes equal 16.04 hectares, and when aggregated across the 25 designated nodes, it amounts to **16.04 hectares X 25=401 Hectares**.

The differences between the extrapolated and the actual situation as explicated above, do present a major alteration to the savings realizable from the application of the TOD strategy, it may therefore suffice to argue that the demonstrated efficiency of making reforms with TOD to create smarter community may be viable and desirable. This is because with the proximity of these communities to the transit station, long trips are more likely to be made via the transit mode. Also, this new smart character of spatial development could contribute to a reduced level of sprawl due to the densification by the transformation of these communities. Hence, the demonstrated smart compact TOD communities of small nodal intensively developed entities, may indeed become desirable communities small enough to reduce or eliminate the desire for private car usage, yet large enough to provide rich diverse opportunities in a good urban setting for global south cities.

8.4.2.4 Savings Realizable from the Application of TOD in Terms of reduced private car usage

This second part of the analysis on savings focuses on the savings from TOD which relates to the level of reduction in private car trips due to the incentive and convenience presented to commuters by living in mixed use high density TOD communities located within 5 – 10 minutes walking distance to a BRT station. This was investigated by asking about the desire of commuters in private cars to leave their car at home and ride on the BRT due to the above described incentive and convenience presented to commuters by TOD (The relevant figure is presented above in Figure 8-9).

In line with the extrapolation made in the demonstrated TOD solution of 55% reduction in the level of private car usage as a result of commuters in private cars living in TOD communities within 5-10 minutes walking distance to BRT station (See Figure 8-9 in Chapter 8 section 8.4.2.5), a comparative analysis was made between the demonstrated and actual situations. While the demonstrated situation refers to the extrapolation made by the TOD solution (artefact) about the ratio of reduction in private car usage from commuters in private cars (55%) because they are residents of TOD communities (See Table 7-4 in Chapter 7 section 7.4.2), the actual situation refers to the reduction in private car usage realizable due to willingness of commuters in private cars to becoming residents of TOD. The latter is derived from the analysis of responses on the Decision of commuters in private cars to leave their cars

at home and ride on the BRT system because they agree to living within TOD nodes (47.7%) (See Figure 8-9).

By this, the difference between the demonstrated level of reduction in private car usage as a result of the impact of the TOD and the actual number of respondents (commuters) who agree to leaving their cars at home and ride on the BRT system because they are residents of TOD nodes is therefore established (See Table 8-5). This is used to validate the extrapolated mode share between public transport and private car trips.

Table 8-5: Comparison between the Extrapolated and Actual situation on the level of Car Usage due to the Impact TOD Solution

Interventions	Volume of Private Car Trips						Difference between Extrapolated and Actual	
	Existing		Extrapolated		Actual		Percentage Increase	Percentage Decrease
	Number	Percentage	Number	Percentage	Number	Percentage		
No Intervention	71,038	100	-	-	-	-	-	-
BRT Only	-	-	28,415	40	29,836	42	5.0%	-
BRT and TOD	-	-	39,071	55	33,885	47.7	-	13.2%

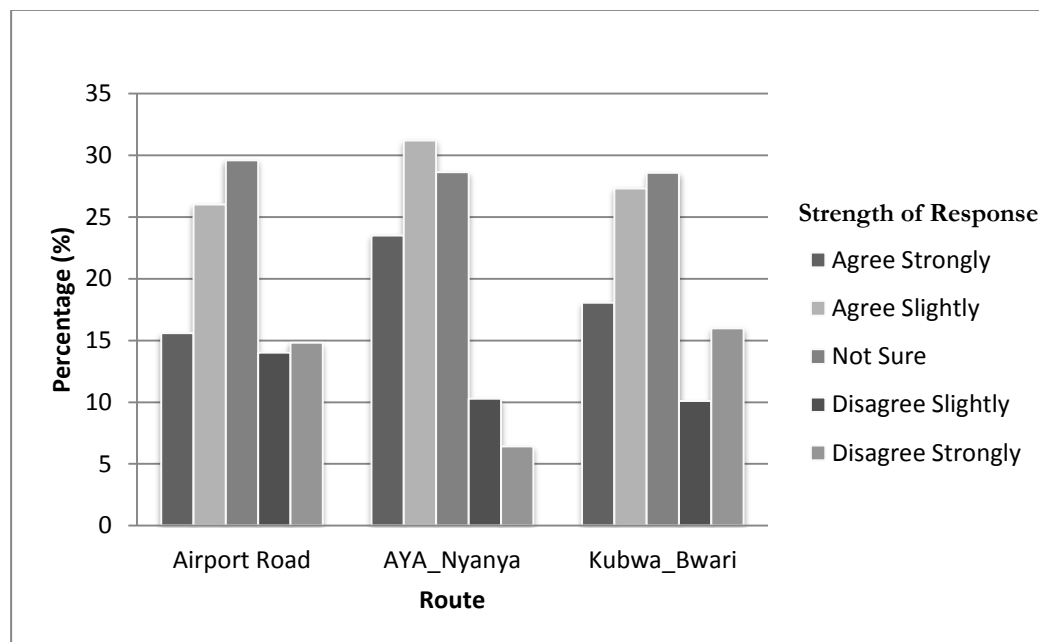
Source: Author's Analysis, 2013.

In view of the analysis presented in Table 8-5 above, the difference between the extrapolated situation and the actual situation is put at -7.3% which represent 13.2% decrease from the level of private car usage attributable to the TOD solution. It therefore means that the extrapolated reduction in private car usage by commuters in private cars and related impacts (savings) fall-short by 13.2%. In aggregate, the application of the TOD solution creates incentives and convenience for commuters in private car to live near transit, this therefore provide evidence of impacts that consolidate the impact of the efficiency of the BRT system on the reduction of private car trips, and further spurs the reduction in private car usage. This TOD solution therefore represents additional impact towards the reduction of private car usage even though there is a short-fall in the extrapolated level. Indeed, the TOD solution indicates a consolidation to the earlier impact of the incentives for faster commute created by the efficiency of the BRT system.

8.4.3 Congestion Pricing

In this section, the opinion of commuters in private cars resident in the demonstrated diverse, mixed-use high density TOD communities along the demonstrated BRT corridors has been investigated about the decision and willingness to leave their private cars at home and ride on the BRT system were they to pay congestion charge for driving private cars into the core-city during peak hours. The opinion of these respondents was investigated on the following: Would you leave your car at home and ride on the BRT due to the payment of congestion charge? An analysis of the responses to these questions has helped to identify the expected residents of the demonstrated TOD communities along BRT corridors who are willing to leave their cars at home and ride on the BRT due to the payment of congestion charge, hence the level of reduction in private car usage.

In order to ensure that the responses from the respondents was based on an understanding of the character of congestion pricing, the features of congestion pricing was described in the questionnaires used for the users perception survey. The respondents were commuters in private cars. The responses from the investigations were analyzed and reported in Figures 8-12 – 8-30.



Source: Author's Analysis, 2013.

Figure 8-12: Potentials of the application of congestion pricing to deter car usage in Abuja.

The findings from the survey of responses of commuters in private car reveal that 15.6%, 23.5% and 18.1% of the respondents on Airport Road, AYA and Kubwa-Bwari routes respectively stated that the introduction of congestion pricing has the capacity to deter private car proliferation. Conversely, 26.0%, 31.2% and 27.3% of respondents on Airport Road, AYA and Kubwa – Bwari routes

respectively opine that they agree slightly to the introduction of congestion pricing as a viable tool to stem the present level of huge daily motorized trips in Abuja. Lastly, 29.6%, 28.6% and 28.5% of the surveyed commuters in private car on the Airport Road, AYA and Kubwa-Bwari routes opined that they are not sure if the introduction of congestion pricing measure is capable of reducing the huge daily motorized trips.

From the foregoing analysis, majority of the respondents choose “agreed slightly” and “not sure” to the inquiry on the capacity of the introduction of disincentive to deter commuters in private cars from driving into the core-city during peak hours. This is followed by the spectrum of respondents who “agreed strongly” that the disincentive can deter commuters in private car from driving into the core city during peak hours. It is however, worthy to note that the present parking fees within the core-city is relatively low (₦100.00 per hour approximately \$0.62 per hour), see Figure 8-13 and 8-14.



Source: Author's Field Survey, 2013.

Figure 8-13: Information board showing parking charges within the core-city of Abuja.



Source: Author's Field Survey, 2013.

Figure 8-14: Sample of parking fee ticket within the core-city of Abuja.

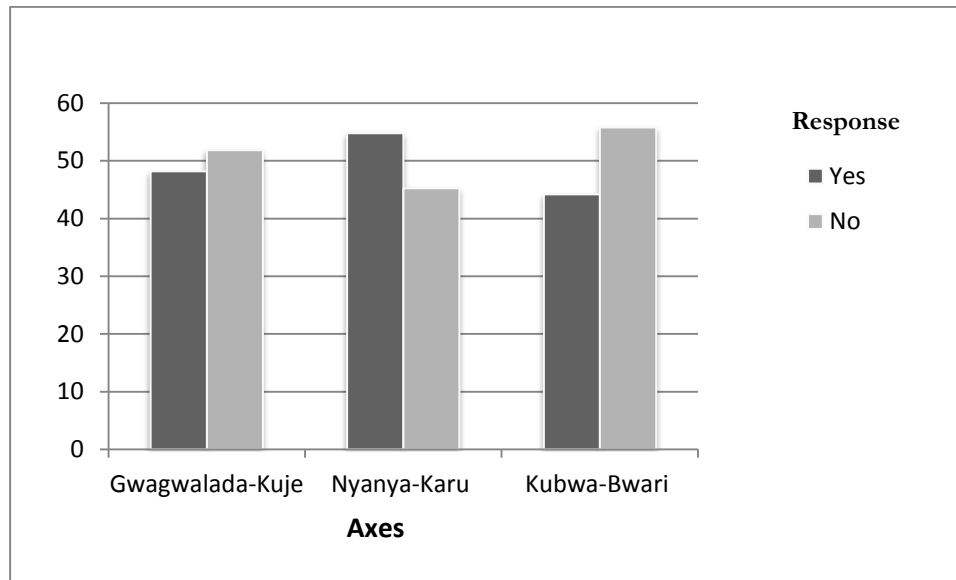
The respondents no doubt are under the impression that the described congestion fee or fine would also be in the same low-cost region. As such, they may not mind to pay the charges and continue to commute in their private cars.

It is important to note that with an efficient BRT system in place, with high parking fees and the congestion pricing regime, commuters in private car may be deterred from continued driving. This is not only because empirical evidence illustrate same, but because the cost of driving private car should take a huge chunk of the disposable income of commuters in private cars. This additional cost may therefore gradually shift commuters in private car to riders on the BRT system. Hence, the volume of daily motorized trips stemming from commuters in private car trips may therefore be reduced to a minimal level.

8.4.3.2 Impact of Congestion Pricing on Mode Shift

In line with findings from earlier studies, the application of congestion pricing results in a mode shift in favour of public transport. The level of shift is observed to vary, partly in response to an increase in the personal expenditure of private car users and partly due to the level of improvement in travel time on the transit as a result of a reduced level of motorized trips. In view of this, it is envisaged that making reform with congestion pricing in Abuja, the present level of modal share can be re-calibrated to reflect a reduction in private car trips since the congestion pricing regime should impose an additional cost on the drivers. This can make driving more expensive and, therefore, deter private car usage. In addition, with an efficient BRT, private car users could become attracted to use the BRT as choice riders.

With cognisance of the earlier sections 8.4.1 and 8.4.2, on the implementation of the demonstrated BRT system, and the transformation of communities located along the BRT corridors into high density mixed-use TOD communities, the opinion of the residents concerning leaving their cars at home based on the BRT and TOD initiatives has been reported as 42% and 47.7% respectively. However, as the third component of the artefact, investigation on the reforms with congestion pricing system was made, the opinion of the residents of the TOD nodes was also sought in order to identify the impact of the application of congestion pricing on mode shift. The findings are reported in Figures 8-15 – 8-21 below.



Source: Author's Analysis, 2013.

Figure 8-15: Desire of TOD residents in the suburban areas to leave their car at home and ride on the BRT system when congestion pricing is introduced.

The analysis of the responses from commuters in private cars resident in the suburban areas across the three axes was investigated in order to reveal the number of commuters in private cars who would be willing to leave their cars at home to ride on the BRT system were they to live in a high density mixed-use TOD community, and would pay congestion charge for driving into the core-city. Figure 8-15 shows that 48.10%, 54.40% and 44.10% of the commuters in private cars from Gwagwalada-Kuje, Nyanya-Karu and Kubwa-Bwari respectively opined that “Yes” they were willing to leave their cars at home to ride on the BRT because of the proximity of their residence in TOD to a BRT station. Conversely, 51.90%, 45.60% and 55.90% of these respondents from Gwagwalada-Kuje, Nyanya-Karu and Kubwa-Bwari respectively opined that “No” they were not willing to leave their cars at home to ride on the BRT.

The analysis reveals that in actual situation the average of the commuters in private cars who said “Yes” to leaving their car at home and riding on the BRT across the three axes is put at 49.05%, while 50.95% opined that they would still continue to drive their cars. By this, more than half of commuters in private cars may still continue to commute via private cars. In comparative terms, this level of response indicates an increase over the level of commuters in private cars that agreed to leave their cars because they live near TOD. Thus, when this is expressed in terms of mode shift, the effect of the introduction of congestion pricing notably leads to an increase in the numbers of people that may leave their cars at home and become riders on the BRT system in Abuja.

It is important to remark that, the level of reduction of private car usage by 49.05% derived from the actual situation (questionnaire survey) is below the extrapolated level of 75% reduction of private car usage due to reforms with congestion pricing. By this, the impact of congestion pricing on the reduction in car usage may not be as extrapolated. However, since some signs of reduction are evident, this minimal level of reduction in car usage due to congestion pricing regime may increase with time as illustrated by earlier studies.

8.4.3.3 Savings Realizable from the Application of Congestion Pricing in Terms of reduced private car usage

The analysis in this section focuses on savings from the application of the congestion pricing system which relates to the level of reduction in private car trips due to the disincentive it presents with the payment of congestion charge by commuters in private cars who live in mixed use high density TOD communities located within 5 – 10 minutes walking distance to a BRT station. This was investigated by asking about the desire of commuters in private cars to leave their car at home and ride on the BRT due to the disincentive of paying congestion pricing (The relevant figure is presented above in Figure 8-15). In line with the extrapolation made in the demonstrated reform with congestion pricing system with extrapolated 20% reduction in the level of private car usage as a result of commuters in private cars paying congestion pricing for driving into the core-city (See Section 7.5.2 and Table 7-11), a comparative analysis was made between the demonstrated and actual situations.

The demonstrated situation refers to the application made in view of the congestion pricing solution (artefact) about the level of reduction in private car usage from commuters in private cars because they are residents of TOD communities and would pay congestion pricing for driving into the core-city (See Section 7.5.2 and Table 7-11). The actual situation refers to the level of reduction in private car usage realizable from the analysis of the responses of commuters in private cars who agree to leave their car at home and ride on the BRT due to the payment of congestion charge (See Figure 8-15). By this, the difference between the demonstrated level of reduction in private car usage as a result of the impact of the congestion pricing and the actual number of respondents (commuters) who agree to leaving their cars at home and ride on the BRT system because they would pay congestion pricing is therefore established in Table 8-5. In cumulative terms, the extrapolated level of reduction in private car usage was put at 75% (55% reduction due to TOD is added to 20% reduction due to congestion pricing). The analysis of the responses of the actual commuters in private cars shows the mean/average of 49.05% of the respondents who agree to leave their cars at home and ride on the BRT; this may be described as the spectrum of commuters who would shift their mode from private car trips to transit

trips on the BRT system. The comparative analysis between the extrapolated and actual situations on the level of private car usage due to the impact of Congestion Pricing solution is therefore reported below in Table 8-6. This is used to validate the proposed mode share between public transport and private car trips.

Table 8-6: Comparison between the extrapolated and actual situation on the level of car usage due to the impact of Congestion Pricing

Interventions	Volume of Private Car Trips						Difference between Extrapolated and Actual	
	Existing		Extrapolated		Actual		Percentage Increase	Percentage Decrease
	Number	Percentage	Number	Percentage	Number	Percentage		
No Intervention	71,038	100	-	-	-	-	-	-
BRT Only	-	-	28,415	40	29,836	42	5.0%	-
BRT and TOD	-	-	39,071	55	33,885	47.7	-	13.2%
BRT, TOD & Congestion Pricing	-	-	53,279	75	34,844	49.05	-	34.6%

Source: Author's Analysis, 2013.

In view of the analysis presented in Table 8-6 above, the difference between the demonstrated situation and the actual situation is put at -25.9% which represent a 34.6% decrease from the extrapolated level of private car usage to be achieved from the demonstrated reform with the congestion pricing solution. It therefore means that the extrapolated reduction in private car usage by commuters in private cars could fall-short or be imprecise by 34.6%. In aggregate, the application of the congestion pricing solution creates disincentives for commuters in private car towards increase car usage cost and the reduced level of private car usage, this therefore provide evidence of impacts that consolidate the impacts of the efficiency of the BRT system and TOD on the reduction of private car usage. The congestion pricing solution therefore represents additional impact towards the reduction of private car usage even though there is short-fall in the extrapolated level.

8.4.3.4 Statistical Analysis of Users' Perception Survey of Commuters in Private Cars on the Reforms with Congestion Pricing

This section presents a statistical analysis and explanation of the responses from the perception survey using the Chi-Square analysis. This is to elicit association between introduction of congestion pricing and desire of commuters to leave their cars at home to ride on the BRT system. Therefore, a hypothesis has been put forward to show the impact of the introduction of congestion pricing on the number of motorists who may leave their cars at home and shift to become riders on the BRT system.

The hypothesis is stated thus:

(i) H_0 : There is no significant association between desire of motorists to leave their cars at home to ride on the BRT system **and** the introduction of congestion pricing in Abuja.

Results of the Statistical Analysis from the Users’ Perceptions Survey

The assumed level of significance for this analysis has been set at 0.05. Accordingly, when the computed p-value is greater than the assumed level of significance (α) of (0.05), the null hypothesis is accepted and vice versa.

Table 8-7: Chi-Square Analysis of decision of commuters in private cars to leave their car at home and ride on the BRT system due to the introduction of congestion pricing

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	77.266 ^a	4	.000
Likelihood Ratio	80.821	4	.000
Linear-by-Linear Association	14.641	1	.000
N of Valid Cases	722		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 38.23.

Source: *Author’s Analysis (2013)*.

As evident from the results of the analysis displayed in Tables 8-7 above, the test of the hypothesis shows that commuters’ support for the introduction of congestion pricing and the desire of commuters to leave their cars at home to ride on the BRT were crosstabulated; $X^2 = 77.266$, $df = 4$, $p = 0.000$. Since the computed p-value is less than the assumed level of significance (α) of 0.05 (i.e. $p < 0.05$), therefore, the null hypothesis is rejected. It is therefore concluded that there is association between the two variables under consideration. Simply put, it can be stated that there exist association between commuters’ support for the introduction of congestion pricing, and the desire of motorists to leave their cars at home to ride on the BRT system in Abuja.

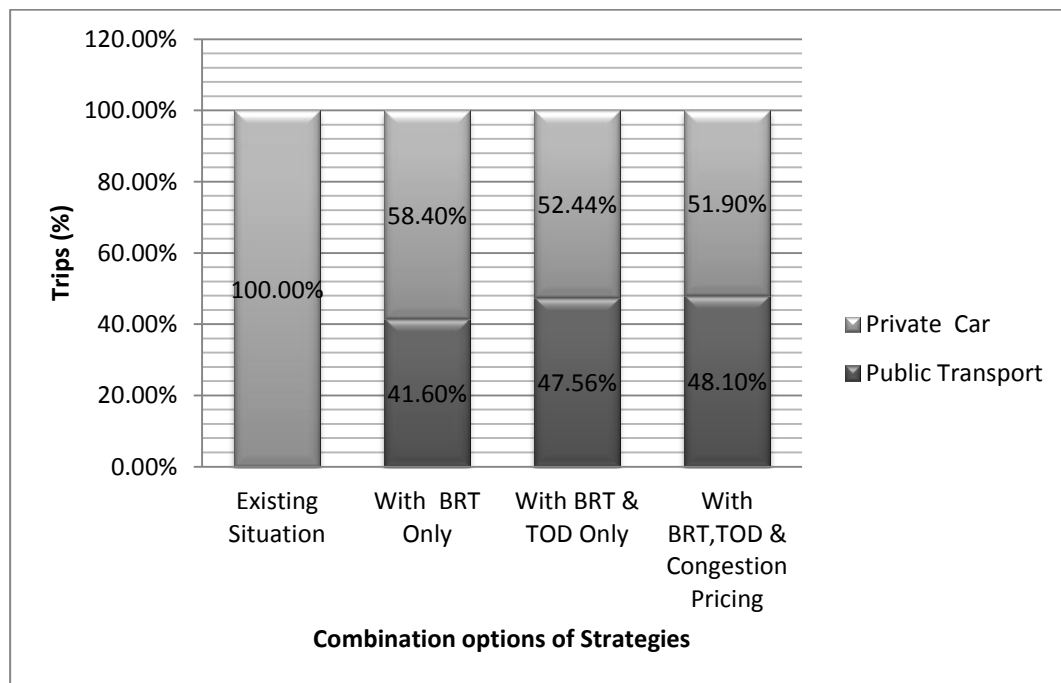
To sum up, the association detected between the two variables may have been due to the efficiency gains attributable to the combination of BRT, TOD and Congestion Pricing strategies which includes reduced travel time, reliable travel time, effective bus scheduling, improved living in transit communities, proximity to BRT station, and increased cost of car usage. These may also include dissatisfaction with the routine stress connected with prolong driving in traffic jam, fuel wastage, wear and tear of cars due to prolong driving and frequent acceleration and deceleration in traffic congestion. This therefore suggest that the introduction of the combination of BRT, TOD and Congestion Pricing

strategies may impact on the reduction in car usage level by commuters, the consequent reduction in traffic congestion, and the achievement of efficiency in passenger mobility in Abuja. In addition, by addressing the level of congestion and sprawl, the related externalities may also be reduced, if not eliminated.

8.5 Final Structure of Modal Share based on the usage level of the Spatial Planning Strategies

The analysis in this section focuses on the impacts of the spatial planning strategies of BRT, TOD, and congestion pricing on the specific reductions of the existing level of private car trips, (in that, the existing public transport trips are envisaged to be transformed into the new BRT system).

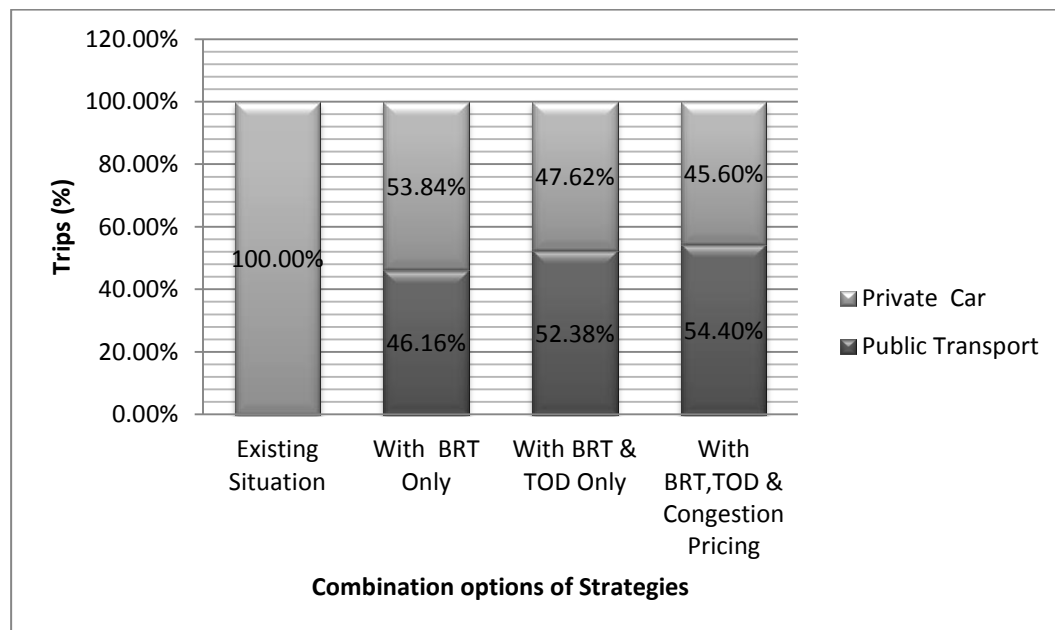
Following the analysis of the responses concerning the level of usage of the BRT system, TOD and the congestion pricing regime as shown in Figures 8-3, 8-10, 8-15, and Table 8-5 the modal share of daily private car commuter trips along the three routes under consideration in Abuja could be recalibrated to reflect a structure that is in favour of public transport usage. The Figures 8-16 – 8-19 below illustrates the different level of modal share achievable based on the impacts of the demonstrated reform with the spatial planning strategies (BRT system, TOD and the congestion pricing) along the three routes under consideration in Abuja (See Appendix VIII for detail computation).



Source: Author's Analysis, 2013.

Figure 8-16: Modal share impact on car trips on the Airport Road axis due to reform with the spatial planning strategies

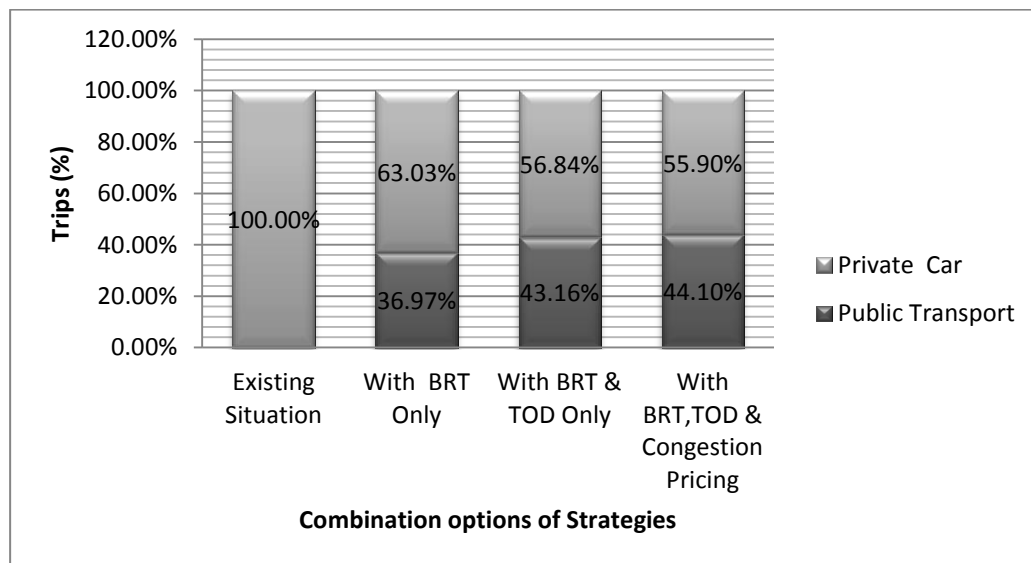
As evident from the analysis in Table 8-6 and Figure 8-16 above, there is evidence of gradual reduction in the level of private car usage towards transit trips along the Airport Road axis; this therefore shows a trend of incremental shift of the mode share in favour of public transport. The analysis above shows that the share of commuters in private cars who are willing to leave their car at home and ride on the transit (BRT system) equal 41.60% when the BRT system only is used to make reforms; 47.56% when the BRT system and TOD only are used to make reforms, and 48.10% when the BRT system, TOD and congestion pricing are used to make reforms. In comparison, the extrapolated reduction prescribed in the demonstrated solution equal 40.00% when the BRT system only is used to make reforms; 55.00% when the BRT system and TOD only are used to make reforms, and 75.00% when the BRT system, TOD and congestion pricing are used to make reforms (See Table 7-11). This therefore reveals some discrepancies between the extrapolated and actual levels of reduction in private car usage especially when the BRT system and TOD only are used to make reforms, and when the BRT system, TOD and congestion pricing are used to make reforms (See Table 8-5 on comparison between demonstrated and actual situation). Importantly, regardless of the gap in the extrapolated levels, the impacts of the reform with the spatial planning strategies of BRT, TOD and congestion pricing indicate a reduction to about half of the existing level of private car usage, and importantly, a gradual shift in modal share in favour of public transport.



Source: Author's Analysis, 2013.

Figure 8-17: Modal share impact on car trips on the AYA-Nyanya axis due reform with the spatial planning strategies

Similarly, the analysis presented in Figure 8-17 above shows evidence of gradual reduction in the level of private car usage towards transit trips along the AYA-Nyanya axis, this indicate a trend of incremental shift of the mode share in favour of public transport. The analysis above shows that the share of commuters in private cars who are willing to leave their car at home and ride on the transit (BRT system) equal 46.16% when the BRT system only is used to make reforms 52.38% when the BRT system and TOD only are used to make reforms, and 54.40% when the BRT system, TOD and congestion pricing are used to make reforms. In comparison, the extrapolated reduction prescribed in the demonstrated solution equal 40.00% when the BRT system only is used to make reforms; 55.00% when the BRT system and TOD only are used to make reforms, and 75.00% when the BRT system, TOD and congestion pricing are used to make reforms (See Table 7-11). This therefore reveals some discrepancies between the extrapolated and actual levels of reduction in private car usage especially when the BRT system and TOD only are applied, and when the BRT system, TOD and congestion pricing are used to make reforms (See Table 8-5 on comparison between demonstrated and actual situation). Notwithstanding the shortfall in the demonstrated levels, the performance from making reforms with the combination of these spatial planning strategies of BRT, TOD and congestion pricing indicate a reduction to more than half of the existing level of private car usage, and importantly, a gradual shift in modal share in favour of public transport.

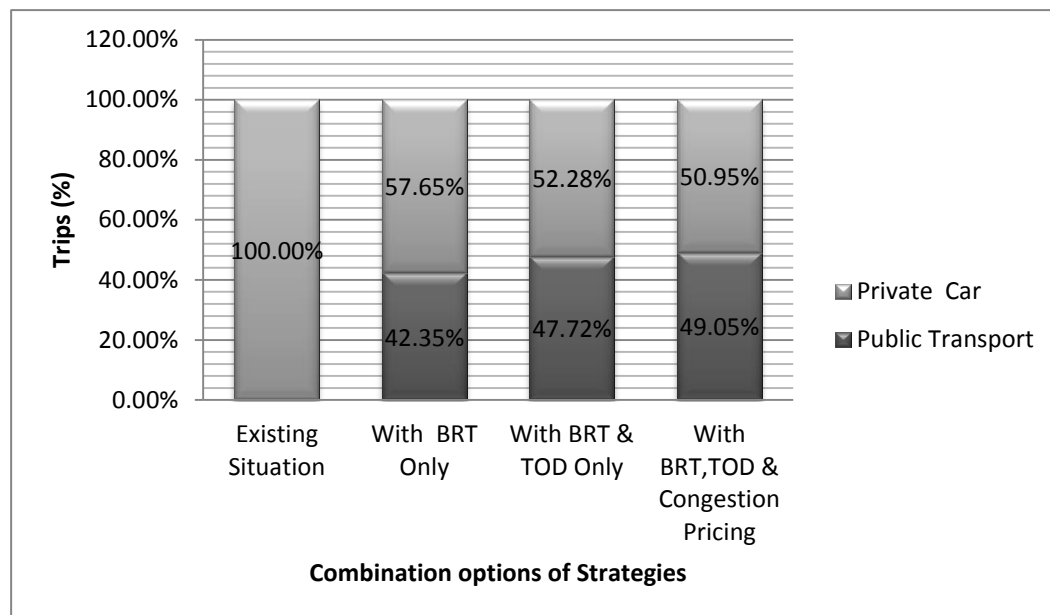


Source: Author's Analysis, 2013.

Figure 8-18: Modal share impact on car trips on the Kubwa-Bwari axis due to reform with the spatial planning strategies

In the same light, the analysis in Figure 8-18 above, reveals a trend of gradual reduction in the level of private car usage towards transit trips along the Kubwa-Bwari axis, this therefore shows a trend of

incremental shift of the mode share in favour of public transport. The analysis above shows that the share of commuters in private cars who are willing to leave their car at home and ride on the transit (BRT system) equal 36.97% when the BRT system only is used to make reforms; 43.16% when the BRT system and TOD only are used to make reforms, and 44.10% when the BRT system, TOD and congestion pricing are used to make reforms. In comparison, the extrapolated reduction prescribed in the demonstrated solution equal 40.00% when the BRT system only is used to make reforms; 55.00% when the BRT system and TOD only are used to make reforms, and 75.00% when the BRT system, TOD and congestion pricing are used to make reforms (See Table 7-11). This therefore reveals some discrepancies between the extrapolated and actual levels of reduction in private car usage especially when the BRT system and TOD only are implemented, and when the BRT system, TOD and congestion pricing are used to make reforms (See Table 8-5 on comparison between demonstrated and actual situation). Aside the underperformance in the speculation levels, the level of performance from making reforms with the combination of these spatial planning strategies of BRT, TOD and congestion pricing indicate a reduction to about 45% of the existing level of private car usage, and importantly, a gradual shift in modal share in favour of public transport.



Source: Author's Analysis, 2013.

Figure 8-19: Aggregated Modal Share impact of reform with the spatial planning strategies on commuters in private cars along the three routes

As evident from the analysis in Figure 8-19 above, the mode share on private car trips shows a trend of incremental shift of the mode share in response to making reforms with the spatial planning strategies of BRT, TOD and congestion pricing. The analysis above shows the aggregation of the existing share

of the volume of commuters in private cars along the 3 axes illustrated above as 100% in the existing situation. The analysis above shows that the share of commuters in private cars who are willing to leave their car at home and ride on the transit (BRT system) equal 42.35% when the BRT system only is used to make reforms; 47.72% when the BRT system and TOD only are used to make reforms, and 49.05% when the BRT system, TOD and congestion pricing are used to make reforms. Whereas, the extrapolated reduction prescribed in the demonstrated solution equal 40.00% when the BRT system only is used to make reforms; 55.00% when the BRT system and TOD only are used to make reforms, and 75.00% when the BRT system, TOD and congestion pricing are used to make reforms (See Table 7-11).

This therefore reveals some discrepancies between the extrapolated and actual levels of reduction in private car usage especially when the BRT system and TOD only are used to make reforms, and when the BRT system, TOD and congestion pricing are used to make reforms (See Table 8-5 on comparison between demonstrated and actual situation). Notwithstanding the underperformance in the extrapolated levels, the level of performance from making reforms with the combination of these spatial planning strategies of BRT, TOD and congestion pricing indicate a reduction to about half of the existing level of private car usage, and importantly, a gradual shift in modal share in favour of public transport.

Hence, there is a trend of gradual shift in modal share by commuters in private cars skewed towards public transport trips in response to making reforms with the combination of these spatial planning strategies of BRT, TOD and congestion pricing, this trend may continual shift over time. In these situations, the impact of each individual strategy may not be markedly outstanding. But it is important to note that this is consistent with the findings in earlier study by Litman (2012) which suggest that the efficacy of the impact of an individual strategy is a function of how efficiently they are combined as complementary initiatives. It, therefore, becomes imperative to appropriately and efficiently combine these strategies in order to achieve the optimal outcomes. By this, the role of synergy amongst the spatial planning strategies is recognized; as such, it may, therefore, be imperative to treat these strategies as complementary rather than as mutually exclusive in making the reforms to the explicated problem in global south cities.

As a result of the nature of the peculiarity of the challenges of traffic congestion and suburban sprawl, and the extra institutional barrier to the effective deployment of urban planning intervention in the case-city, this has led to developing an innovative strategic response package consisting of BRT, TOD

and Congestion Pricing strategies encapsulated within a spatial planning framework. The impacts that the developed package of strategies could have in terms of policy outcomes was extrapolated with focus on reduced level of car usage and modal share. This includes impacts in terms of reduced travel time, transport-related CO₂, fuel and man hour loss. The responses of commuter group on how they will shift from car commuting to transit commuting was used to extrapolate the impacts the package of strategies could have in terms of these policy outcomes. In specific terms, the analyses of commuter group revealed that in view of the impacts of the combined strategies, the present car usage level can be reduced by 49%. Further, this outcome was used to extrapolate the related impacts on reduction in transport-related CO₂, fuel and man hour loss levels during daily commuting.

The methodology for testing whether the inclusion of Congestion Pricing strategy within a package of strategies is likely to be effective was premised upon the analysis of both the individual and cumulative effect of each strategy within the package of strategies. Accordingly, the effect from each strategy and combination of the three strategies was established from the responses of commuter group on the reduction in car usage level due to the impact of each strategy. This help to show the effect in terms of reduction of car usage level attributable to the addition of the strategy into the package. This therefore provide the premise to establish the level of effectiveness of each of the strategies in terms of the resulting modal share when compared to the situation without the intervention, and also when compared to efficiency level found in best practice case reviews.

The potential impact of the spatial planning framework was tested by presenting it before expert groups in interview and FGD sessions in order to gauge their opinion on what the spatial planning framework can do differently from the existing master planning approach. The analyses of responses from the expert groups therefore provide the premise to predict the perceived impact that the spatial planning framework could have in terms of overcoming the barrier to effective deployment and implementation of the package of strategies in the case-city context. In specific terms, while 32% and 17% of the responses of expert group in interviews and FGD sessions respectively suggest that the spatial planning framework is alien and may not be effective, 68% and 83% of the responses of expert group in interviews and FGD sessions respectively opined that it would be effective, and produce optimal outcome even though progress may be slow and would be an evolutionary process.

In practice, this result suggest that the decision of the commuter groups to leave their car at home to ride on the BRT due to either BRT intervention, BRT and TOD intervention, and BRT, TOD and

Congestion Pricing intervention and the resulting modal share is associated with the deployment of the package of strategies.

Therefore, the deployment of the package of strategies which include BRT, TOD and Congestion Pricing has the capacity to likely spur reduction in the level of daily motorized trip, reduced level of traffic congestion and related reduction in travel time, transport-related CO₂, and reduction in fuel loss in daily commuting. Further, the result suggest that when the package of strategies is deconstructed in order to identify the impact of each strategy, and to elicit on which strategy may require prioritizing, it was discovered that BRT intervention account for 42% predicted reduction in car usage, while the addition of TOD pushes/up the reduction of car usage level to 47%, while the addition of Congestion Pricing up the reduction of car usage level to 49% with just 2% marginal increase. It may be argued that when the costs, social, economic and political implication of implementing Congestion Pricing is considered, the marginal effect of deploying Congestion Pricing strategy may be considered not worthwhile. Therefore, in the instance where the deployment of the strategies needs to be prioritized, BRT and TOD strategies are likely to top the agenda with Congestion Pricing strategy being less desirable.

However, while the effect of Congestion Pricing strategy on car usage level appear marginal in the case-city, earlier studies (Penalosa, 2004, Litman, 2014) have argued that, without such disincentive offered by Congestion Pricing strategies, such efficient integration of transit and TOD strategies may not be enough to spur increased transit ridership and reduced car usage level. It is argued that this situation may be marked especially where car usage and ownership (e.g. global south cities) is considered as huge leverage on social credential of people. This may therefore make the deployment of Congestion Pricing strategy desirable.

In practice, the result suggest that the developed spatial planning framework is alien to the case-city and may be slow at achieving the set outcome, however, in view of defining character of the framework, and responses of a large spectrum of the expert group the framework remain a credible platform that can permit innovative reform to address the existing institutional barriers. With this, the capacity to create the enabling environment for inclusiveness, joining-up sectors, sectoral integration, capacity building, removal of restrictive bureaucratic practices to effectively deploy the developed package of strategies and achieve optimal outcomes is likely to be realized in the case-city.

8.6 Summary

This chapter focused on the evaluation of the spatial planning framework and related strategies solution (artefact) of BRT, TOD and congestion pricing developed as the artefact in this study in semi-structured and FGD session, and users' perception surveys. The evaluation is based on interview and FGD sessions, and draws on the experiences and insights which the purposively selected practitioners in government establishments, private consulting firms, and the academia brought to bear in analyzing the relevance and applicability of the identified spatial planning strategies of BRT, TOD and congestion pricing to the explicated problem of traffic congestion in medium-sized global south cities including Abuja.

The summary of findings from empirical evaluation of the developed artefact in interview and FGD sessions with practitioners, and user perception survey of commuters is presented below in Table 8-8.

Table 8-8: Summary of Findings from empirical Evaluation of the Developed Artefact

S/N	Component of the Research Problem	Solutions Accepted as Component of the Artefact	Demonstrated Capability of the Solution to Address the Explicated Problem	Validation of Performance Capability of the Solutions as Component of the Artefact	
				Practitioners	User Group (Commuters)
a.	Huge volume of daily motorized trips traffic congestion and increased travel time for commuters	i. Restructure modal share in favour of transit trips ii. Application of rapid transit system of BRT to reduce travel time and encourage more transit trips	i. Application of BRT as rapid transit system ii. Restructure of modal share in favour of transit trips (40% reduction in car trips) of traffic congestion	i. 82% of practitioners in interview session opined that application of decentralized concentration can contribute to restructuring modal share and balancing of travel across the metropolis. ii. 89% of practitioners in interview and 88% in FGD sessions responded that the application of BRT system can transform existing public transport system, by ensuring convenience and reduced travel time for commuters and also the reduction in the related impacts of man-hour loss, fuel loss, and transport-related CO ₂ emission.	i. 40.86% of commuters in mini-bus across the 3 routes support the introduction of BRT system in the case city. ii. 42% of commuters in private car agree to leave their car at home to ride on the BRT system.
		iii. Application of Congestion Pricing System to deter proliferation of car usage	i. Application of Congestion Pricing (20% reduction of car trips)	i. 78% of practitioners in interview and 82% in FGD session responded that the application of Congestion Pricing can help dis-incentivize private car usage on the routes under consideration. This strategy can help reduce car proliferation and spur choice riders from car trips to transit trips. This includes the reduction in the related impacts of man-hour loss, fuel loss, and transport-related CO ₂ emission.	i. 49.05% of commuters in private cars agree to leave their cars at home to ride on the BRT system due to the introduction of BRT, TOD and Congestion Pricing.
b.	Increasing trend of transport-related challenges such as time loss, fuel loss and CO ₂ emission	i. Application of BRT system and Congestion Pricing System to deter proliferation of car usage	i. Application of BRT as rapid transit system and Congestion Pricing in Abuja can lead to; ii. Reduction in motorized traffic and transport-related impacts by 50% reduction in fuel usage level, 50% reduction in transport-related CO ₂ emission level, 400% reduction in man-hour losses.		
c.	Ineffective public transport characterized by mini-buses which struggles to move commuters daily	i. Application of Rapid Transit System of BRT to reduce travel time and encourage more transit trips	i. Application of BRT rapid transit system high capacity 160-250 articulated and bi-articulated buses. ii. Application of BRT as rapid transit system which leads to reduction in travel time due to dedicated BRT lane	i. 89% of practitioners in interview and 88% in FGD session responded that the application of BRT system can transform existing public transport system, by ensuring convenience and reduced travel time for commuters	i. 40.86% of commuters in mini-bus across the 3 routes support the introduction of BRT system in the case city.

d.	Increasing trend of suburban sprawl and inefficient use of land evident in extensive spatial pattern of development make people live further away from core-city, and increases commuting distances	i. Application of TOD strategy to achieve diverse mixed use commuting with reduced need for long travels, and located along transit corridor to ensure access to rapid transit for long trips (intra-city)	i. Application of TOD strategy can reduce, car trips by 55% and enhances convenience of commuters due to large number of persons living near transit corridor (5-10 minutes' walk to BRT station)	i. 81% of practitioners in interview and 84% in FGD sessions opined that the application of TOD strategy can reform spatial development on the 3 corridors under consideration into smart compact development that can contribute to reduction in the trend of sprawl and land usage, and reduced car usage level due to proximity to BRT station.	i. 89.66% of commuters in mini-buses and 68.36% of commuter in private cars agree to live within high density mixed-use community located within walking distance to a BRT station. ii. 47.7% of commuters in private cars agree to leave their car at home to ride on the BRT system due to the introduction of BRT and TOD strategies.
e.	Ineffective planning system and weak institutional capacities of current urban planning organization which cannot cope with the complex challenges of traffic congestion and suburban sprawl in global south cities	i. Framework for combined application of spatial planning strategies ii. Institutionalization of spatial planning framework to reform the existing urban planning organization and the related planning procedures	i. Framework for the combined application of BRT, TOD and Congestion Pricing spatial planning strategies can reduce private car trip by 75% and reduce travel time for commuter. The planning procedure in spatial planning regime would also ensure stakeholders and inclusive engagement that can permit timely and efficient urban planning outcomes.	i. Majority of the practitioners opined that there is need for reform to the existing planning system in order to provide the enabling environment for the application of the developed artefact. ii. 68% of practitioners and 83% of FGD sessions responded that they are in support of the adoption of spatial planning approach in order to realize the reform prescribed to the existing planning system, this is in view of the demonstrated features of the spatial planning approach.	

The practitioners offered insights and suggestions that validated the demonstrated capabilities, and also suggested some elements required to effectively adapt the developed spatial planning framework to the case area in order to achieve optimal outcomes. Some of the suggestions in the interview and FGD sessions include institutional reforms, enabling legislation, capacity building of practitioners in government establishments, creating new agency and the institutionalization of stakeholder engagement to support the application of the spatial planning strategies. These formed the feedback that provided the premise to modify the artefact to reflect the realities of the existing situation. This provided in specific terms the elements required to achieve the successful reforms in commuter mobility pattern and suburban development with the developed solution of BRT, TOD and congestion pricing in the case area and other similar cities.

The second part of the evaluation provide additional layer of evaluation of the performance of the demonstrated spatial planning strategies. Here, the perceptions of the commuters were investigated to reveal the actual level of the performance of the combination of the BRT, TOD and congestion pricing strategies. The analyses of the responses of commuters on the reduction of car usage by 49.05% due to the impacts of the combination of BRT, TOD, congestion pricing strategies was compared to the extrapolated reduction in private car usage by 75% from the application of the developed artefact. These analyses revealed the actual performance level achievable with this solution and provided the premise to validate or invalidate the extrapolated performance level of the artefact. This therefore provides the basis for generalization of the performance capabilities of the artefact across other similar medium-sized global south cities.

The next chapter focuses on the conclusions drawn from the results and findings presented in Chapter 8 vis-a-vis the objectives and research questions set at the beginning of this thesis. This is followed by recommendations for addressing the research problems in line with lessons from literature and empirical evidence, this include the stated policy and research implications.

CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

9.1 Introduction

The fundamental goal of this research is the development of a novel strategic spatial planning solution (framework) which consists of the unique integration of TOD, BRT and Congestion Pricing strategies. This study sufficiently demonstrate that this new knowledge which has never been implemented prior to this study has the capacity to better optimize urban planning outcomes as compared to the single application of these spatial planning strategies for addressing the intractable challenges of traffic congestion and suburban sprawl in rapidly urbanizing global south cities. This integrated solution therefore provides leverage for planning policies in rapidly urbanizing global south cities with regards to evolving spatial planning strategies for transforming car-dependent mobility patterns and to direct the spatial development of the suburban areas towards achieving sustainable passenger transport.

The research has been designed to address the array of research objectives and questions which were outlined in Chapter 1. The focus of this chapter is to draw conclusions based on the findings reported in this research. Accordingly, this chapter is structured into three major sections: Section 9.2 presents a summary of major conclusions; Section 9.3 presents a summary of main findings that addresses the research questions/objectives. Section 9.4 presents the recommendations on the policy implications of the research findings, while Section 9.5 presents the Limitation to Research and some Suggestions for Mitigation. Lastly, Section 9.6 presents recommendations on areas for further research.

The salient findings from the research are:

- Rapid urban population growth in global south cities has significant consequences such as the trend of growth of sprawling suburban settlements and huge mobility demands as seen in numerous daily motorized trips undertaken by commuters in private cars and in mini-buses.
- The existing Master Plan approach has been inefficient at addressing these growing trends as can be observed in the creation of an enabling environment that permits the growth of the challenges presented above. There has also been a lack of efficient sectoral integration which is required to implement spatial plans.
- The resulting challenges from the current situation in cities in this region impact on the efficiency of the use of land resulting from suburban sprawl, and traffic congestion with related impacts on economic loss (fuel and man-hour) and transport-related CO₂ emission.

- The creation of multiple development hubs that balances population and activities across the metropolis by inter-linking TOD nodes along the transit routes linked by a BRT system, and the application of congestion pricing can ensure that the mobility patterns in, and spatial character of, these cities can be directed to a more efficient pathway that permit sustainable passenger transport.
- The existing institutional set up system requires reform to provide the requisite platform to institutionalize spatial planning and the application of the framework that integrates the relevant proposed strategies in order to realize the expected outcomes vis-à-vis the new leverage and collaboration amongst the relevant sectors.

9.2 Major Conclusions

The result from the analysis of the responses of commuter groups gives an indication that elicits on the policy outcomes of the package of strategies. In practice, this result suggest that, the decision of the commuter groups to leave their car at home to ride on the BRT due to BRT, TOD and Congestion Pricing intervention and the resulting modal share is associated with the deployment of the package of strategies. Therefore, the deployment of the package of strategies which include BRT, TOD and Congestion Pricing has the capacity to likely spur reduction in the level of daily motorized trip, reduced level of traffic congestion and related reduction in travel time, transport-related CO₂, and reduction in fuel loss in delayed travel time. Further, the result suggest that, should the implementation of each of the strategies be prioritized, the BRT and TOD strategies are likely to top the agenda with congestion pricing strategy being less desirable due to its marginal effect on reduced car usage level. However, the need to address the extra barrier of desire for car ownership and usage in global south cities which may still occur regardless of an efficient transit infrastructure and TOD strategies may therefore make the deployment of Congestion Pricing relevant as means to dis-incentivize car usage.

The result from the analysis of the responses of expert groups on the capability of the developed spatial planning framework solution to overcome barrier to effective implementation of the package of strategies in global south cities shows that the spatial planning regime is alien to the case-city, and may be slow at achieving desired outcome. However, it remains a credible platform that can reform the existing barriers and create the reduced enabling environment to permit the effective deployment of the package of strategies and achieve optimal outcomes. The explication of problem in the case-city revealed evidence of barriers and challenges which shows that the package of strategies of BRT, TOD,

Congestion Pricing, and spatial planning framework has not been deployed in the past in the case-city context.

The result from the analysis of the responses of expert groups indicates that the performance capability of the package of strategies is desirable. Further, the results suggest that without reform to the existing planning system, the package of strategies cannot be deployed effectively. The results therefore support the assertion that the features of the developed spatial planning framework can provide the requisite enabling environment to effectively deploy the package of strategies and realize optimal urban planning outcome. These therefore provide the premise to conclude that the spatial planning framework and package of strategies developed in this study is likely to transform the situation and address the challenges in global south cities. The new regime therefore presents a new narrative for optimal urban planning outcome in global south cities especially in sub-Saharan African context.

Evidence from the result provide the premise to conclude that the inclusion of Congestion Pricing along with BRT and TOD strategies will make a significant contribution to reduced level of car usage. This is premised on the recognition that the impact of the sum is greater than the impact of the individual parts of the package of strategies. However, when the package of strategies is deconstructed, the impacts of Congestion Pricing on the reduction in car usage level are marginal and appear less desirable. However, since evidence show that in situation with effective transit infrastructure (such as BRT) and with people living in transit communities (such as TOD), car proliferation may still continue in the absence of such disincentive provided by Congestion Pricing strategy. Nevertheless, Congestion Pricing strategy may still remain relevant on the agenda of reduction of car usage level in situation with strong desire of commuters for car ownership and usage as evident in the case-city. Therefore, with the existence of an effective transit infrastructure and commuters living in proximity of transit, commuters in private car might mostly be the affluent of the commuter group, therefore the concern of equity with how low income commuters may appear to have been addressed.

9.3 Conclusions (Addressing the Research Questions and Objectives)

A summary is presented of the main findings from this research which has resulted from the three research questions emerging from the six research objectives of the study as considered in the following sub-sections.

- i. Rapid urban population growth has implications on suburban development and mobility demand with resulting car-dependent mobility pattern especially where urban planning institutions are weak and un-proactive.

Abuja like other global south cities exemplifies features of a primate city with a dominant core-city, and sprawling extensive suburban development, with suburbs growing faster than the core.

- ii. The sprawling spatial pattern is using up land inefficiently and generating travel demand. The present numerous travel demand and high motorized commuter trips resulting from private cars and mini-buses culminates into intractable traffic congestion with related impacts of time loss, fuel loss and transport-related CO₂ emissions.
- iii. Present transport sector investment structure is skewed towards road building and expansion with less effort on public transport system, hence indicating enabling environment for private car proliferation, and suggest the presence of predict and provide approach to addressing traffic congestion.
- iv. Present Master Planning system in Abuja did not prioritize linking transit infrastructure to suburbs, consequently commuter trips has been via inefficient public transport system with mini-buses running in mixed traffic with private cars and culminating in daily traffic congestion. Put succinctly, each commuter in the mini-buses and the private cars loses 21.66 and 20.84 days respectively in every year by being on the road in traffic congestion during home-work-home journey along the three routes (AYA-Nyanya, Airport Road and Kubwa-Bwari) in Abuja.
- v. Institutional analysis of the present planning system and organization show the lack of enabling environment for sectorised integration and collaboration on the planning and implementation of urban infrastructure plans.
- vi. Making reforms with individual application of BRT, TOD, and Congestion Pricing spatial planning strategies to address traffic congestion challenges have produce some relief to traffic congestion challenges but has not solved all the deep rooted ills of traffic congestion. This sub-optimal outcome suggests that the combined application of the artefact/strategies may produce optimal outcomes.
- vii. Evolving a strategic vision plan that designates multiple hubs across city region in pursuit of decentralized concentration to balance population and employment activities linked by BRT transit routes/network and the application of TOD and congestion pricing, has the capacity to transform suburban development and car-dependent mobility pattern towards efficient passenger commuting.

- viii. Upon the testing/evaluation of this artefact in the case city Abuja, respondents broadly agreed with the concept of combining the three spatial planning strategies in a unified strategic programme. The analyses of the responses show that making reforms with BRT has enormous potential to improve commuter travel time and spur the reduction in private car trips by 42%; this is as against an extrapolated 40% reduction.
- ix. Upon evaluation in the case city, making reforms with TOD has the capacity for reduction in the trend of sprawling suburban development and the co-benefit of reduction in private car trips by 47%; this is as against the extrapolated 55% reduction.
- x. Upon testing/evaluation in the case city, making reforms with congestion pricing system can serve as disincentive to spur the reduction in private car trips by 49%, this is as against a predicted 75% reduction.
- xi. Notwithstanding the divergence in the performance level of the strategies (artefact) especially with TOD and congestion pricing, the artefact show enormous potential to address suburban sprawl and major traffic congestion concerns as evident in the efficiency gains of reduced car usage levels.

The findings from the evaluation phase with practitioners have highlighted key issues relating to the improvement and modification required in order to realize the optimization of reforms with the artefact. These include;

- ❖ A dedicated agency with real planning powers and willingness to take positive lead to drive the reform with the spatial planning framework needs to be created and backed by enabling legislation.
- ❖ Mechanism that prioritizes re-accommodating existing residents in reformed TOD community is imperative, this is to avoid housing gentrification that may displace current residents of areas designated for TOD needs to be put in place.
- ❖ Location of BRT station needs to be close to planned LRT and other transit network is imperative to ensure model integration.
- ❖ Need for alternative power source (e.g. solar power) to power lift in high rise TOD buildings.
- ❖ Effective traffic enforcement regulation mechanism is required to be put in place to avoid contravention on the BRT lane.
- ❖ Bike share facility may be slow at producing result because of the desire for car ownership and usage, and the lack of bike culture in the case area.

- ❖ The higher cost in scenario 1 for congestion pricing should be adopted in order to achieve effective compliance and outcome of reduced car usage.
 - ❖ Stakeholder engagement and enlightenment is imperative and should be pursued at every level of the reform and application of the framework.
- xii. The BRT, TOD, and Congestion Pricing strategies need to be treated as complimentary strategies, not as mutually exclusive initiative, in order to realize optimal outcome in addressing the explicated problem of traffic congestion of suburban sprawl.
- xiii. Institutional reform is required to create the enabling environment for institutionalizing spatial planning approach, and the framework for application of spatial planning strategies of BRT, TOD, and Congestion Pricing.
- xiv. It is an important initiative to transform the planning system to a pathway that is pro-active rather than reactionary; eliminate restrictive bureaucratic practices, foster sectoral integration and joining-up of government and sectors for effective realization of optimal outcome with regards to planning objectives.
- xv. Capacity building is required to leverage the capacities of the crop of practitioners in government establishments to be able to effectively make-innovative and informed decision to derive the reforms with the spatial planning framework to address the explicated problem.

9.4 Recommendations and Policy Implications

The solution from the stream of analyses in this study has been articulated into a spatial planning framework that encapsulates spatial planning strategies with recommended guide for policy makers and urban planners. Consequently, lessons can be learnt from the illustration of the application of spatial planning strategies, as a guide for reducing the volume of motorized travel, to encourage sustainable modes such as transit (BRT) for passenger transport and to retrofit the extensive sprawling spatial developments in the suburban areas and in the city at large in global south cities.

(a) Decentralized Concentration

By adopting the concept of decentralized concentration to envision the spatial form of the city, a platform has been created to structure the city into hierarchies of nodes which shall balance population and activities across the city-region. This described balance can serve to distribute passenger mobility demands across the city and between the different levels of nodes. By evolving enabling legislation to serve as a policy thrust for designating identified settlements as nodes along BRT routes in line with the

envisioned spatial form of the city, this has the capacity to create a platform for reforming the spatial form and redistributing travel demand across the city.

(b) Rapid Transit

In line with the vision plan, the designated hierarchy of nodes and the planned redistribution of mobility demands require an efficient rapid transit mode. In line with empirical examples and the research findings, the impact of adopting BRT as the rapid transit option has been adequately demonstrated. Evidently, the social, economic and environmental objectives of a passenger mobility system can, therefore, be achieved by application of a BRT system. A comprehensive transit plan backed by an enabling policy to designate BRT routes to link all the hierarchies of the designated nodes should be implemented. The resulting policy should spell out the role of relevant sectors and stakeholders in the development of a BRT system. With this, a platform for transforming the passenger mobility pattern in the city towards a pathway of mode share that is skewed towards public transport usage and transit-dependence, and the reduction in the level of automobile-dependence, should be guaranteed.

(c) Transit Oriented Development (TOD)

Concerning the designated hierarchy of nodes, and the demonstrated development of these nodes along the transit corridors as TODs, the findings reported in this research are consistent with findings in earlier studies on the potential co-benefit and impacts of applying the TOD strategy for transforming mobility and retrofitting the extensive sprawling spatial pattern of development in cities. By engaging all relevant sectors and stakeholders and using planning instruments to evolve planning codes, regulations and guides for the development of the TODs in line with the prescriptions in this study, the character of spatial development in these nodes can become recalibrated to reflect diverse, high density, mixed-use communities. The application of this character of development should be pursued because it can permit more people to live near BRT stations in mixed-use communities and, therefore contribute to reducing the level of demand for travel, Additionally, the majority of travel, when it is necessary, can be made via the BRT. In a similar vein, the spatial character of these TOD communities serve as a mechanism to firm-up the character of spatial form in order to use land efficiently and reduce the rate of sprawl in the suburban areas of global south cities. With the planning codes, regulations and guides in place, the characteristics of the developments along the BRT corridors can become transformed and, therefore, contribute to shifting spatial development in suburban areas in cities in this region towards a pathway that is efficient and sustainable.

(d) Transport Demand Management

Upon the application of an efficient BRT infrastructure and mixed-use, high density transit communities using TOD to achieve a shift towards transit-dependent mobility pattern, it is indeed imperative to identify and apply measures that can serve as disincentives to the present proliferation of private car usage. This is because findings in earlier studies show that, without such disincentives, the proliferation of private car usage would soar. The soaring level of car use leads to soaring levels of related impacts from the huge motorized mobility pattern as illustrated by findings in this research (and by empirical evidence and evidence in the literature).

In line with findings in earlier studies, the findings from the research reveal that the application of congestion pricing is a viable measure to reduce the private car travel demand in cities and can be pursued. Also, it has the potential to generate revenue which should be used to expand investments and further engender the efficiency of the transit operation. By engaging the relevant stakeholders and sectors, and by evolving enabling legislation to permit the application of the prescriptions for a congestion pricing system, commuters in private cars can therefore, become deterred from excessive private car usage in Abuja. Even though the potential reduction of car usage due to application of congestion pricing in Abuja is below conceptual specification, it still showed capabilities for the reduction of private car usage. The application of this strategy should be pursued because of the additional impact of modal share in favour of public transport trips and the reduction in the trends of private car proliferation.

(e) Institutional Reforms

Based on the identification and analysis of the deficiencies in the existing Master Planning system and the related urban planning organization, the existing planning system evidently lacks the requisite capacities to drive the application of the changes and shifts suggested by this study. The sub-optimal performance of the existing planning system (illustrated by the findings from the analysis of the perceptions of the practitioners from the interviews) indicates the need for reforms in the areas of bureaucracy, sectoral integration, and timely/scheduled implementation of plans, capacity building and political interference.

Accordingly, the relevant sectors and stakeholders should be engaged in the reform process so that reform becomes stakeholder-driven and so that the emerging results can be situation-specific. The suggested reforms should not lose sight of the key features required in the planning system in terms of achieving a sustainable development agenda. These described features include pursuing sectoral

integration to permit a framework for internalizing social, economic and environmental objectives that shape the process and implementation of spatial plans and urban infrastructure plans in global south cities including Abuja. By backing-up these reforms with enabling legislation as a policy thrust, the existing planning system and urban planning organizations become reformed to reflect the characterizations of a spatial planning regime. With the institutionalization of spatial planning framework and its related strategies, and the creation of a dedicated agency in these cities, the planning system becomes leveraged with the requisite capacities and platform to engage the relevant sectors and stakeholders to drive the application of the spatial planning strategies in order to achieve the envisioned sustainable transformation in global south cities.

9.5 Limitation to Research and some Suggestions for Mitigation

(a) Traffic Survey Data

The extrapolation of externalities from the existing passenger mobility patterns are data demanding and require up-to-date data in order to make comprehensive, accurate and beneficial analyses, these dataset are limited in the case city. The FCT Transport Secretariat, the DRTS and the FRSC should collaborate on conducting regular traffic surveys and also expand the scope of the surveys to include household travel patterns, vehicle type and age, and fuel intensity. This pool of data can be shared amongst the relevant agencies and as the basis for establishing and comparing trends in mobility and travel patterns, and to provide platforms for research and evidenced-based policy-related informed decisions.

(b) Marginal differences in the extrapolation of vehicle fuel consumption level due to age of vehicle

The extrapolation of impacts relating to fuel consumption and the CO₂ emission levels are based on the fuel intensity of vehicles. The extrapolation in this study has been based upon the indices of 2.4 kg CO₂ per litre of PMS fuel consumed by a vehicle and 2.7kg CO₂ per litre of diesel fuel consumed by a vehicle. These indices are based on the assumption that vehicles on the Abuja roads are new. However, the vehicles in Abuja area are mostly used cars imported from North America and Europe. It may therefore be safe to posit that the extrapolated fuel consumption levels and CO₂ emission levels are beyond the levels reported in this study by the margin created by the age of vehicles. It is, therefore, imperative to integrate within the extrapolation methodology an allowance that control for the margin of difference in fuel intensity resulting from the age of the vehicles in order to allow for an increased level of accuracy in this extrapolation.

(c) Complexities of the Developed Artefact

The developed artefact is made up of three sub-components of spatial planning strategies of BRT, TOD, and Congestion Pricing; in addition, these strategies are alien to most global south cities and may not be well understood by research participants. Understanding the combination of these three strategies into a single strategic programme and making informed contribution in the Evaluate Artefact phase by respondents may not be challenging, by this, the contribution/feedback from the respondents may be based on deep understanding of the intricacies of the strategies.

However, this limitation was mitigated by initially de-constructing the artefact into three sub-components in the interview and FGD Sessions so that respondents can understand and offer informed contributions/feedbacks in the Evaluate Artefact sessions. This was followed by the contribution of the three strategies into a single unique strategic programme using a spatial planning framework and therefore provided the premise for better understanding that led to informed contribution/feedback on the appropriateness and applicability of the artefact by the respondents. Hence, the reliability of the research findings.

9.6 Recommended Areas for Further Research

This study has examined the character of an existing mobility pattern and the extensive sprawling spatial pattern of development in the suburban areas of global south region cities using Abuja as the case city. As illustrated in the relevant chapter (Chapters 7), the development of the solution (artefact) forms a stream of informative intelligence for Researchers, Urban Planners, Sustainability Experts and Decision Makers. Consequently, the methodology and findings of this study can provide a platform for further research studies in the field of core-city-suburban areas commuting patterns in order to guide and shape research, policy and programmes for transforming mobility patterns and sprawling suburban spatial development toward a sustainable pathway. The researcher suggests the following themes for research in order to further expand an in-depth understanding of the themes covered in this research.

(a) First/Last Mile Commute

Planning and designating a mode to address the first/last mile commute when implementing rapid transit is critical to ensuring the convenient travel of commuters from their residence to the BRT station, and getting from the BRT station to the destination end-point. This vacuum is presently filled in Abuja by mini-buses, commercial motorcycles and walking via unsafe walking paths. Further research in this area may focus on the provision of a bike share facility to especially cater for passengers on the BRT system that have to walk for more than 10 minutes to a BRT station. This facility should be located at BRT stations and also at entry and exit points to the major suburban and core-city

residential areas and communities located within the BRT corridors. The bikes should operate on safe segregated lanes linking the BRT station and these entry/exit points of the residential areas; this is to guarantee the safety of riders and motorists. The bike share facility should also have a tracking device in each bicycle so as to prevent bikes being used beyond designated points or beyond an established cycling cordon. This further study can also illustrate the externalities from motorized trips that are avoided by implementing such non-motorized trips for this first/last mile of commute.

(b) Externalities from the Mobility Patterns

In this study the areas covered by the analysis of the externalities resulting from the existing mobility patterns (characterized by numerous daily motorized trips) have been limited to traffic congestion and consequent fuel consumption, man-hour losses and transport-related CO₂ emissions. Other implicit externalities from the current mobility patterns can include traffic accidents, particulate matter air pollution, and the cumulative effect of these impacts on persons living in areas adjoining these routes. The emerging findings from further studies may expand an understanding of the wider ramifications of these mobility patterns and the additional potential corresponding savings that are realizable from the application of the chosen spatial planning strategies developed in this study.

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APPENDICES
APPENDIX I

The List of Conference Publications by the Author

Razak, S. Y. (2014) The Imperatives of Transit Oriented Development (TOD) and integrated transport in achieving smart suburbia in fast growing cities: Case of Abuja, Nigeria.
2014 World Symposium on Transport and Land Use Research June 24-27, 2014 - Delft, the Netherlands.

Razak, S. Y. (2013) An Analysis of Spatial Planning Strategies in Reducing Automobile Dependent-related CO₂ emissions and related co-benefits in Cities. A Case of Abuja, Nigeria.
Papers presented at the International Post-Graduate Research Conference (IPGRC) 2013, Page 216-229. School of the Built Environment, University of Salford, Manchester, United Kingdom.

Razak, S. Y. (2013) Classical Modernist Planning and the Menaces of Automobile Dependence in Cities. A Case of Abuja, Nigeria. *Nineteenth International Conference on Urban Transport and the Environment 2013. Urban Transport XIX – Editor C.A. Brebbia. International Journal of Sustainable Development and Planning. Wessex Institute of Technology eLibrary Volume 30, Page 317-328. Built Environment (ISSN-1743-3509). Papers presented at Urban Transport 2013. Kos, Greece.*

Razak, S. Y. (2012) The Role of Urban Spatial Forms in Building Resilience to Population Stress in Cities: A Case of Abuja, Nigeria. *Papers presented at the Annual Town Planners Day Conference, Abuja, Nigeria, 2012.*

APPENDIX II

Computation for Spatial Sprawl in the Suburban Areas and the Core-city of Abuja

Rate of Spatial Sprawl in the Suburban areas

The total area of land cover in 2006 equals **73.7km²** in 2009 it grew to **81.2 km²**, and in 2012 it grew to **91.0km²**.

Using the **Compound Annual Growth Rate (CAGR)** formula, the annual growth rate of the land cover over the time period of 2006 – 2009, and 2009 – 2012 is dis-aggregated as computed below:

$$\text{CAGR} = (\text{ending value} / \text{beginning value})^{(1 / \text{number of years})} - 1$$

This result / product here is therefore multiplied by 100 to obtain the percentage.

(a) Between the time- period of 2006 – 2009

The Land cover in 2006 equal 73.7 km²

The land cover in 2009 equal 81.2km²

The number of years between 2006 and 2009 = 3 years

$$\text{CAGR} = (81.2 \text{ km}^2 / 73.7 \text{ km}^2)^{(1/3)} - 1$$

$$= (1.1017)^{0.33} - 1$$

$$= 1.0324 - 1$$

$$= 0.0324 \times 100 = \underline{\underline{3.25\%}}$$

(b) Between the time period of 2009 – 2012

The Land cover in 2009 equal 81.2 km²

The land cover in 2012 equal 91.0 km²

The number of years between 2009 and 2012 = 3 years

$$\text{CAGR} = (91.0 \text{ km}^2 / 81.2 \text{ km}^2)^{(1/3)} - 1$$

$$= (1.1207)^{0.33} - 1$$

$$= 1.0383 - 1$$

$$= 0.0383 \times 100 = \underline{\underline{3.83\%}}$$

The Mean of annual growth rate is computed thus;

$$\text{Suburban area: } 3.25\% + 3.83\% / 2 = \underline{\underline{3.54\%}}$$

Rate of Spatial Sprawl in the Area of the Core city

The total area of land cover in 2006 equals **89.5km²** in 2009 it grew to **92.5 km²**, and in 2012 it grew to **95.0km²**.

Using the **Compound Annual Growth Rate (CAGR)** formula, the annual growth rate of the land cover over the time period of 2006 – 2009, and 2009 – 2012 is dis-aggregated as computed below:

$$\text{CAGR} = (\text{ending value} / \text{beginning value})^{(1 / \text{number of years})} - 1$$

This result / product here is therefore multiplied by 100 to obtain the percentage.

(a) Between the time- period of 2006 – 2009

The Land cover in 2006 equal 89.5 km²

The land cover in 2009 equal 92.5 km²

The number of years between 2006 and 2009 = 3 years

$$\text{CAGR} = (92.5 \text{ km}^2 / 89.5 \text{ km}^2)^{(1/3)} - 1$$

$$= (1.0335)^{0.33} - 1$$

$$= 1.0109 - 1$$

$$= 0.0109 \times 100 = \mathbf{1.09\%}$$

(b) Between the time period of 2009 – 2012

The Land cover in 2009 equal 92.5 km²

The land cover in 2012 equal 95.0 km²

The number of years between 2009 and 2012 = 3 years

$$\text{CAGR} = (95.0 \text{ km}^2 / 92.5 \text{ km}^2)^{(1/3)} - 1$$

$$= (1.0270)^{0.33} - 1$$

$$= 1.0088 - 1$$

$$= 0.0088 \times 100 = \mathbf{0.88\%}$$

The Mean of annual growth rate is computed thus;

$$\mathbf{\text{Core city: } 1.09\% + 0.88\% / 2 = \mathbf{0.985\%}}$$

Projection of Spatial Sprawl in Abuja

In order to understand the magnitude of the trend/rate of sprawl, under the existing situation/business as usual scenario, the projection of the sprawl was computed. The mean annual growth rate of sprawl is used here to compute the projection over a 10 years and 15 years period, using 2012 as the base year.

Using the simple projection formulae, the spatial sprawl of both the core city and suburban area was computed below:

$$P_o = P_1 (r + 1)^n$$

With P_o = value of land cover for the expected year

P_1 = value of the land cover for the base year

r = annual rate of sprawl/growth of land cover

1 = constant value

n = number of year over which projection is sought

Projections of sprawl/ land cover for the Core city

(a) Between the time period of 2012 – 2022 (10 years)

P_1 = value of land cover for base year 2012 = 95.0 km²

r = Annual rate of sprawl/growth of land cover = 0.985%

n = Number of years over which projection is sought = 10 years

Therefore:

$$\begin{aligned} P_o &= 95.0 \text{ km}^2 \\ &= 95.0 \text{ km}^2 \times 1.10298 \\ &= \mathbf{104.7831 \text{ km}^2} \end{aligned}$$

Sprawl/land cover in year 2022 equals = 104.7831 km²

Therefore: Between the time period of 2012 – 2027 (15 years) is computed below:

$$\begin{aligned} P_o &= 95.0 \text{ km}^2 (0.00985 + 1)^{15} \\ &= 95.0 \text{ km}^2 \times 1.15838 \\ &= 109.6138 \text{ km}^2 \end{aligned}$$

Sprawl/ land cover in year 2027 equals = 109.6138 km²

Projections of sprawl/ land cover for the Suburban areas

(b) Between the time period of 2012 – 2022 (10 years)

P_1 = value of land cover/sprawl for base year 2012 = 91.0 km²

r = Annual rate of sprawl/growth of land cover = 3.54%

n = Number of years over which projection is sought = 10 years

Therefore:

$$\begin{aligned} P_o &= 91.0 \text{ km}^2 (0.0354 + 1)^{10} \\ &= 91.0 \text{ km}^2 \times 1.4160 \\ &= 128.856 \text{ km}^2 \end{aligned}$$

Sprawl/land cover in year 2022 equals = 128.856km²

Therefore: Between the time period of 2012 – 2027 (15 years) is computed below:

$$\begin{aligned} P_o &= 91.0 \text{ km}^2 (0.0354 + 1)^{15} \\ &= 91.0 \text{ km}^2 \times 1.16851 \\ &= 158.3441 \text{ km}^2 \end{aligned}$$

Sprawl/ land cover in year 2027 equals = 153.3441 km²

Table IA: Profile and Projection of Spatial Sprawl in Abuja

Year	Land Area in km ²	
	Core-city Area	Suburban Area
2006	89.5	73.7
2009	92.5	81.2
2012	95	91
2022	104.7831	128.856
2027	109.6138	153.3441

APPENDIX III

1. Rate of Growth of Motorized Trips (Mini-buses and Private Cars)

(a) Mini – buses

Firstly, the rate of growth of motorized trips along the three axes namely AYA, Kubwa and Airport road routes are computed, the mean of the rates are computed thereafter.

The total of daily mini-buses trips in 2008 along AYA, Kubwa-Bwari and Airport road routes are 3245, 2883, and 1331 respectively. In 2011, along AYA, Kubwa-Bwari and Airport road routes the daily mini-buses trips are 4297, 3800, and 2078 respectively.

Using the Compound Annual Growth Rate (CAGR) formula, the annual growth rate of the mini-buses trips over the time period of 2008 – 2011 is as computed below:

$$\text{CAGR} = (\text{ending value} / \text{beginning value})^{(1 / \text{number of years})} - 1$$

This result / product from above are therefore multiplied by 100 to obtain the percentage.

(i) AYA Route

The volume of daily mini-bus trips in 2008 equal 3245

The volume of daily mini-bus trips in 2011 equal 4297

The number of years between 2008 and 2011 = 3 years

$$\text{CAGR} = (4297 / 3245)^{(1/3)} - 1$$

$$= (1.3242)^{0.33} - 1$$

$$= 0.0971 \times 100 = \underline{\mathbf{9.71\%}}$$

(ii) Kubwa – Bwari Route

The volume of daily mini-bus trips in 2008 equal 2883

The volume of daily mini-bus trips in 2011 equal 3800

The number of years between 2008 and 2011 = 3 years

$$\text{CAGR} = (3800 / 2883)^{(1/3)} - 1$$

$$= (1.3181)^{0.33} - 1$$

$$= 0.0954 \times 100 = \underline{\mathbf{9.54\%}}$$

(iii) Airport Road Route

The volume of daily mini-bus trips in 2008 equal 1331

The volume of daily mini-bus trips in 2011 equal 2078

The number of years between 2008 and 2011 = 3 years

$$\text{CAGR} = (2078 / 1331)^{(1/3)} - 1$$

$$= (1.5612)^{0.33} - 1$$

$$= 0.1584 \times 100 = \underline{15.84\%}$$

Therefore the mean annual growth rate of mini- bus trip equals:

$$\underline{9.71\% + 9.54\% + 15.84\% = 11.695\%}$$

3

(b) Private Cars

Firstly, the rate of growth of motorized trips along the three axes namely AYA, Kubwa and Airport road routes are computed, the mean of the rates are computed thereafter.

The total of daily private car trips in 2008 along AYA, Kubwa-Bwari and Airport road routes are 16950, 18,109, and 17,174 respectively. In 2011, along AYA, Kubwa-Bwari and Airport road routes the daily private car trips are 24,874, 23,688, and 23,476 respectively.

Using the Compound Annual Growth Rate (CAGR) formulae, the annual growth rate of the private automobile vehicles trips over the time period of 2008 – 2011 is as computed below:

$$\text{CAGR} = (\text{ending value} / \text{beginning value})^{(1 / \text{number of years})} - 1$$

This result / product from the above computation are therefore multiplied by 100 to obtain the percentage.

(i) AYA Route

The volume of daily private automobile vehicles trips in 2008 equal 16,950

The volume of daily private automobile vehicles in 2011 equal 23,874

The number of years between 2008 and 2011 equals 3 years

$$\text{CAGR} = (23,874 / 16,950)^{(1/3)} - 1$$

$$= (1.4085)^{0.33} - 1$$

$$= 0.1197 \times 100 = \underline{11.97\%}$$

(ii) Kubwa – Bwari Route

The volume of daily private automobile vehicles trips in 2008 equal 18,109

The volume of daily private automobile vehicles trips in 2011 equal 23,688

The number of years between 2008 and 2011 = 3 years

$$\text{CAGR} = (23,688 / 18,109)^{(1/3)} - 1$$

$$= (1.3081)^{0.33} - 1$$

$$= 0.0927 \times 100 = \underline{9.27\%}$$

(iii) Airport Road Route

The volume of daily private automobile vehicles trips in 2008 equal 17,174

The volume of daily private automobile vehicles trips in 2011 equal 23,476

The number of years between 2008 and 2011 = 3 years

$$\begin{aligned} \text{CAGR} &= (23,476 / 17,174)^{(1/3)} - 1 \\ &= (1.3669)^{0.33} - 1 \\ &= 0.1087 \times 100 = \mathbf{10.87\%} \end{aligned}$$

Therefore the mean annual growth rate of private automobile vehicle trip equals:

$$\underline{11.97\% + 9.27\% + 10.87\% = 10.70\%}$$

3

2. Fundamental Assumptions for computing the profile of existing and proposed mobility pattern

This section explains the underlying assumption made in the computation of the potential savings on man-hour, fuel and CO₂ emissions implicit to the intervention proposed by this study.

Table IIA: Existing volume of Mini-bus and Private cars across the three axes

Route	Bus System		Private Automobile	
	Volume of Vehicles	Percentage	Volume of Vehicles	Percentage
Airport Road	3385	27.47	23,476	33.05
AYA	4297	34.88	23,874	33.61
Kubwa-Bwari	4638	37.65	23,688	33.34
Total	12,320	100	71,038	100

Source: Author's Analysis, 2013.

Occupational and income status of commuters in mini-buses and private cars

1. Savings on Man-hour

It is assumed that the existing 18-passenger capacity mini-buses that run in mixed traffic and in traffic congestion will be replaced by 160-passenger capacity articulated buses, which will run in exclusive segregated lane devoid of traffic congestion.

Mini-Buses and Articulated Buses

In order to compute the economic cost of the man-hour loss, it is important to discern the occupational structure (income level) for each typical mini-bus trip. Therefore, an interview of a total of 15 randomly selected mini-buses (5 mini-buses on each of the 3 routes under consideration) was conducted (A total of 75 structured interviews). In line with the findings, it was therefore assumed that in each typical 18-passenger mini-bus trip contains; 7 Civil Servants, 4 Private Sector Employees, 6 Self-employed Persons, and 1 Unemployed Person.

The following assumption was therefore made regarding the income level of the respective group as it was difficult for respondents to reveal their exact income level, thus, the employment status was used to infer their respective income level.

The income level of the civil servant group was inferred from the approved national minimum wage of ₦18, 000, and since the commuters of the existing mini-buses are not choice riders but riders belonging to the low income spectrum. It was assumed that these commuters are the low income cadre and lower-middle income cadre. Therefore the assumed estimated average income level for the respective group stated below in Table IIB.

Table IIB: Employment status and income level for commuters in mini-buses and private cars.

Employment Status	Assumed Income Level			
	Commuters in mini-buses		Commuters in private cars	
	Monthly	Hourly	Monthly	Hourly
Civil Servant	N 30,000	N125	N 50,000	N 208.3
Private Sector	N 24,000	N88.89	N 35,000	
Self Employed	N 18,000	N60	N 30,000	
Unemployed	Nil			

Source: Author's Analysis, 2013.

These values were therefore computed with the volume of passenger during peak hour to obtain the monetary value for the man-hour loss in traffic congestion for passengers in mini-buses.

However, since these commuters in the mini-buses are expected to be transferred into the articulated buses, which will run on exclusive lane devoid of traffic congestion and time loss. All the time loss and consequent man-hour wastage in the mini-buses will result into savings in the proposed regime (BRT system).

Private Automobile Vehicles

It was assumed that commuters in private car on these routes under consideration are the upper middle income cadre persons employed in the civil service, private sector and self-employed sector. The basis for this assumption is that majority of persons in the high income spectrum prefer to live in the core-city because this can be supported by their income level. Therefore the assumed estimated average income level for these car group as shown in Table 6 is put at; Civil Servant – ₦40,000; Private Sector – ₦35,000; Self-employed – ₦30,000 (see Table 6 below).

Based on these income categories, the per-hour income loss for the respective spectrum was further disaggregated in order to arrive at the income loss due to time wastage in traffic congestion in the present situation. This value was therefore computed with the volume of passenger during peak hour to obtain the monetary value for the man-hour loss in traffic congestion for passengers in private cars.

However, based on the proposed re-calibration of daily motorized trips and planned reduction in the existing volume of private automobile trips by 40%, this spectrum of private automobile trips will be transferred to trips in the articulated buses. Hence, the difference between the volume of man-hour loss and consequent income loss from the existing situation and the proposed re-calibration shows the expected savings on man-hour and income from the proposed situation.

2. Savings on fuel

It is assumed that the existing 18-passenger capacity mini-buses will be replaced by 160-passenger capacity articulated buses.

Mini-Buses

The per capita fuel usage/consumption of the mini-buses has been computed by dividing the 18 passengers over the amount of fuel used by the mini-buses to commute passengers to work and back home during peak congestion period (6am-11am and 3pm – 6pm) and off-peak non-congestion period (11am – 3pm). The per capita fuel usage during peak congestion period equals 0.243 litre per passenger and 0.194 litre per passenger during off-peak non-congestion period.

Non – Congestion Scenario (Non-Peak Period)

Each bus travel with 70 litres over 12 km, and make 20 trips

Therefore litres per trip = 70 litres/20 trips = 3.50 litres per trip (12km)

Therefore litres per passenger = 3.50 litres / 18 passengers = 0.19444 litres per passenger

Hence, per capita fuel consumption equals **0.19444 litres**

Congestion Scenario (Peak Period)

Each bus travel with 70 litres over 12km and make 16 trips

Therefore litres per trip = 70 litres / 16 trips = 4.375 litres per trip (12km)

Therefore litres per passenger = 4.375 litres/ 18 passengers = 0.24305 litres per passenger

Hence, per capita fuel consumption equals **0.24305 litres**

This value was therefore computed with the volume of passenger during the respective peak and non-peak periods to obtain the volume of fuel used in the existing mini-bus system. The computation for the savings on fuel usage has been disaggregated into peak and off-peak period in order to ensure accuracy of computation because it is evident that fuel usage during congestion and non-congestion period varies because of difference in journey time and period of operation of vehicles.

Articulated Buses

The per capita fuel usage/consumption of the proposed articulated buses has been computed by dividing the number of passengers over the fuel used by the articulated bus to commute passengers for the same journey (home-work-home trip). Since the articulated buses would run on exclusive segregated lanes devoid of congestion, the computation of the per capita fuel consumption was done with the assumption that the articulated buses would not run in congestion in both peak and non-peak period, as such, fuel consumption would be uniform across peak and non-peak periods. Hence, the per capita fuel consumption for the articulated buses is put at 0.078 litre per passenger.

Each bus travel with 250 litres over 20 trips

Therefore, 250 litres/ 20 trips = 12.5 litres per trip

Since the new bus is 160 passengers capacity bus

Per capita fuel consumption equals 12.5 litres/160 passenger = 0.078125 litres/passenger

This value was therefore computed with the volume of passengers currently plying the mini-buses; as they are envisage to be transferred into the articulated bus in the proposed BRT system. Hence, the differences between the aggregated fuel usage for the total volume of trip during peak and off-peak in the mini-buses, and the fuel usage from total volume of trips in the articulated buses reveal the savings on fuel.

Private Cars

In line with proposed recalibration of mode share, it is proposed that the present private car trips be reduced by 40% and transferred to trips in the articulated buses. The proposed estimated re-calibration of 40% is deemed as a realistic ambition because it represent the average prescribed in literature and empirical examples of 20% - 60% reduction in private car trips due to the impact of implementing a transit system.

The available data show that private cars plying these routes are majorly single occupant vehicle with an average of 2 passengers. The per capita fuel usage of these private cars have been computed by dividing the two passengers over the amount of fuel used by the vehicle to commute passengers to work and back home (home-work-home trip) during peak congestion period (6am – 11am, and 3pm – 6pm) and off-peak non-congestion period (11am – 3pm). The per capita fuel usage during peak congestion period equals 1.285 litres per passenger and 0.644 litre per passenger during off-peak non-congestion period.

A typical car travel on this route over 260.5 km = 42.98 litres

12km (home – work trip) = 2.571072319 litres per trip

Therefore per capita fuel consumption = 2.571072319 litre per trip/ 2 passenger = 1.28553616 litres

Hence, the difference between the aggregated fuel usage for the total volume of trips during peak and off-peak periods in the private car trips, and the fuel usage from the reduced volume of private car trips implicit to the proposed re-calibration of total daily motorized trips mentioned above shows the expected savings on fuel usage in the proposed situation.

3. Savings on CO₂ Emission

The assumptions for the computation of savings on CO₂ emission was made in line with the indices of 2.4kg CO₂ emission per litre of petrol, and 2.7kg CO₂ emission per litre of diesel burnt by a given vehicle. These indices are applicable to new car, however because majority of the fleet of vehicles under consideration in this study are second-hand vehicles imported from Europe and North America, the emission levels of these cars is likely beyond the limit of the above stated indices because of the ageing cars. This study will adopt these indices due to lack of sufficient data age of vehicles. It should be noted that the actual emission value is beyond the value computed in this section by some margin.

Mini-Buses

Using the per capita fuel consumption of passengers in the mini-buses during peak (0.243 litre) and off-peak (0.194 litre) hours and multiplied by the total number of daily trips during these respective periods. The product of these is therefore multiplied by 2.4kg CO₂ to obtain the CO₂ emission value. Accordingly, the weekly, monthly and yearly CO₂ emission footprint from the existing mini-buses can be inferred from the total daily CO₂ emissions.

Articulated Buses

Using the per capital fuel consumption of passenger in the proposed 160-passenger articulated (diesel-based) buses, this value of 0.078 litre per passenger was multiplied by the total number of daily trips along the routes under consideration. The product of these is therefore multiplied by 2.7kg CO₂ to obtain CO₂ emission value. Accordingly, the weekly, monthly, and yearly CO₂ emission footprint from the proposed 160-passenger articulated (diesel-based) buses is computed from the total daily CO₂ emissions. Hence, the difference between the volume of CO₂ emission footprint of the existing situation in mini-buses and the articulated buses shows the expected savings from the proposed situation.

Private Automobile Vehicles

The per capita fuel consumption of passengers in the private cars during peak (1.285 litre) and off-peak (0.644 litre) hours was multiplied by the total number of daily trips during this respective periods in this computation. The product of these values is therefore multiplied by 2.4kg CO₂ to obtain the CO₂ emission value. Accordingly, the weekly, monthly, and yearly CO₂ emission footprint from the existing private automobile trips can be inferred from the total daily CO₂ emissions. Hence, the difference between the aggregated volume of CO₂ emission footprint from the total volume of trips during peak and off-peak periods in private cars, and the CO₂ emission from the reduced volume of private car trips implicit to the proposed re-calibration of the total daily motorized trips mentioned above, shows the expected savings on CO₂ emissions in the proposed situation.

APPENDIX IV

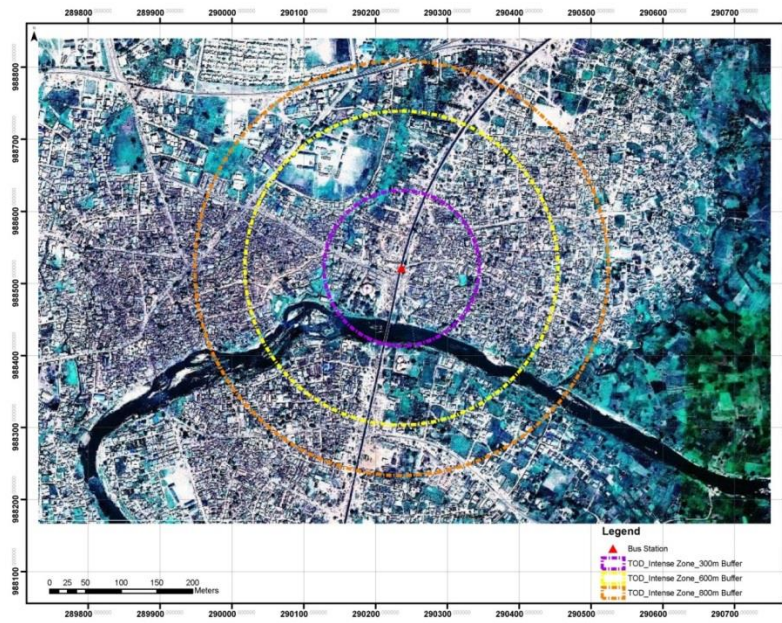
Assumptions for Computation for Savings realized from Transformation of Designated TOD nodes

This section explains all the assumptions made on the indices considered in the computation for savings on land realizable from the transformation of the designated TOD nodes. In view of the character of the nodes as mixed-use high density community, this new development will provide gains in term of accommodating more persons than in less land area in comparison to existing extensive spatial pattern, and also make more people live near transit corridors.

Computation for Land Area and Population in Areas designated as nodes (Suburban areas and Area of the Core-city)

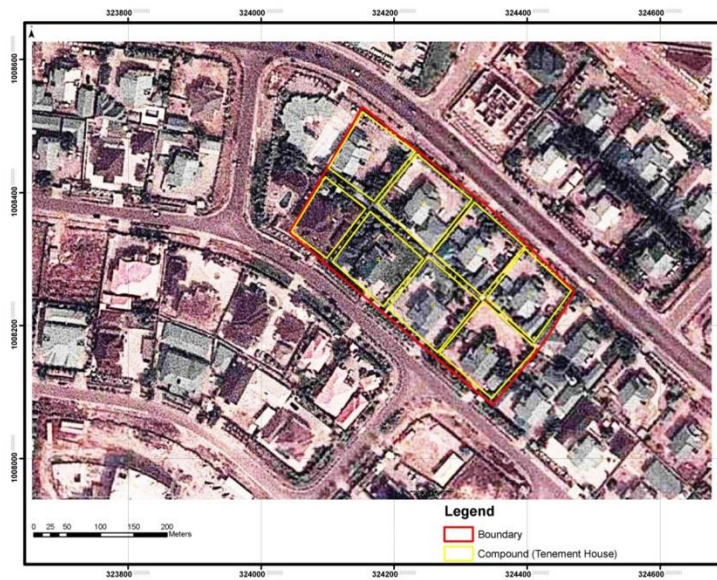
Based on the standard of landuse budget, this computation assumes residential land coverage of 55-60% in a residential district (FCDA, 1979). The land area in each of the 3 zones of influence of the TOD nodes along the BRT corridor in line with Figure IIIA and B below is computed below.

Evidence show that majority of suburban residents in Abuja live in tightly-packed small sub-standard rooms in the suburban areas, thus, showing a lot of persons living in small unit area in per capita terms. It may be inappropriate to compare this high room occupancy ratio with the density prescription in the TOD standards which is stated in dwelling units per unit area since the suburban developments are majorly unplanned, it may therefore be misleading to make comparison between the two situations. Therefore, the standard of dwelling specified in the Abuja Development Control Manual and Regulation in Abuja and its application as seen in the field survey is therefore adopted for the comparison with the standard of the proposed TOD in order to arrive at the computation on the related savings in this section.



Source: Author's Analysis, 2013.

Figure IIIA: A typical designated TOD node along BRT route A typical node in the suburban areas



Source: Author's Analysis, 2013.

Figure IIIB: Existing character of spatial development within a typical node in the area of the core-city along the BRT corridor

Land Area Obtainable

This is computed as a product of the following indices; the character of development is extensive single floor buildings

Zone 1:

Land Area equals: $300\text{m}^2 \text{ (Radius)} \times 3.142 = 28.28 \text{ hectares}$

Therefore, the total land area for residential use equals $28.28\text{hectares} \times 60\% = \mathbf{16.97\text{hectares}}$

Zone 2:

Land Area equals: $(800\text{m}^2 \times 3.142) - (600\text{m}^2 \times 3.142) = 84.83 \text{ hectares}$

Therefore, the total land use area for residential use equals $84.83 \text{ hectares} \times 60\% = \mathbf{50.89\text{hectares}}$

Zone 3:

Land Area equals: $(600\text{m}^2 \times 3.142) - (300\text{m}^2 \times 3.142) = 87.98 \text{ hectares}$

Therefore, the total land area for residential use equals $87.98 \text{ hectares} \times 60\% = \mathbf{52.78\text{hectares}}$

Hence, the total land area equals $\mathbf{201.08\text{hectares}}$.

Therefore, the total land area obtainable for residential use equals $\mathbf{120.64\text{hectares}}$

APPENDIX V

STRUCTURED INTERVIEW GUIDE (Private Automobile Drivers)

Transport User Group:

1. Gender: Male Female
2. Employment Status: Public Sector Private Sector
Self Employed Unemployed Others (specify).....
3. What is the make and model of your car?
4. How many litre is the full tank of your car?
5. How much does it cost to fill the fuel tank of your vehicle?
6. How many trips (km) do you make with your vehicle’s filled fuel tank in congestion and non-congestion situation?
.....
7. How much time is lost during your journey to work due to traffic congestion?
Less than 30mins 40mins 60mins 90mins 120mins-above
8. Do you think this traffic congestion results to economic loss?
Agree strongly Agree slightly Not sure Disagree slightly Disagree strongly
9. Do you think this traffic congestion amount to fuel wastage?
Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure
10. Do you think this traffic congestion results to Carbon dioxide (CO₂) emission?
Agree strongly Agree slightly Not sure Disagree slightly Disagree strongly
11. Rank the following causes of traffic congestion associated with the existing transport system (**put 1 as highest and 5 as lowest rank**)

Factors	1	2	3	4	5
Poor traffic management					
On street parking					
On street trading					
Too many vehicles on the road					
Narrow road width					
Un-trained drivers					
Reckless driving					
Others (Comments):					

STRUCTURED INTERVIEW GUIDE (Transport User Group - Commuters & Drivers)

Commuter on mini-buses:

1. Gender: Male Female

2. Employment Status: Public Sector Private Sector

Self Employed Unemployed Others (specify).....

3. How long does it take you to walk from your house to the existing bus stop?

5-10minutes 10-15 minutes 15-20 minutes 20-30minutes 30minutes-Above

4. How much time is lost during your journey to work due to traffic congestion?

Less than 30mins 40mins 60mins 90mins 120mins-above

5. Do you think this traffic congestion results to economic loss?

Agree strongly Agree slightly Not sure Disagree slightly Disagree strongly

6. Do you think this traffic congestion amount to fuel wastage?

Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure

7. Do you think this traffic congestion results to Carbon dioxide (CO₂) emission?

Agree strongly Agree slightly Not sure Disagree slightly Disagree strongly

8. Do you think this congestion amount to economic Loss?

Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure

9. Rank the following causes of traffic congestion associated with the existing transport system (**put 1 as highest and 5 as lowest rank**)

Factors	1	2	3	4	5
Poor traffic management					
On street parking					
On street trading					
Too many vehicles on the road					
Narrow road width					
Un-trained drivers					
Reckless driving					
Others (Comments):					

STRUCTURED INTERVIEW GUIDE (Practitioners in Government Planning Establishments, Private Consulting Firms, and the Academia)

Analysis of Institutional Deficiencies

Evaluating the capacities of existing planning system / organization

s/n	Checklist	Rating		
		Strong	Weak	Non-Existence
1	<u>Government Bureaucracy:</u> Current restrictive bureaucratic practice			
2	<u>Sectoral Integration and Collaboration:</u> Current framework for sectoral integration and collaboration during planning and implementation			
3	<u>Implementation of Plan:</u> Adherence to Schedule of Implementation			
4	<u>Achievement of Planning Goal:</u> Current long range plan and long term technocratic-driven objectives			
5	<u>Organizational Capacity:</u> Trained human capacity is available and adequate			
6	<u>Relevance of Planning Document:</u> Current Planning document is up-to-date and relevant to existing realities			
7	<u>Political Interference:</u> Current level of political interference in plans and implementation process			

Please tick as appropriate

Semi-Structured Interview Guide:

Section I: Practitioners in Government Planning Establishments, Private Consulting Firms, and the Academia

1. Would you agree to the assertion that the Master Plan Approach has been ineffective at shaping medium-sized global south cities as seen in the growth of unregulated/unplanned suburban settlements, with impacts of physical planning seen majorly in the inner city?
2. Would you say the majority of population growth in these global south cities including Abuja takes place in sprawling suburban settlements as against inner city, Why?
3. Do you agree that sprawling extensive character of spatial development in the suburban areas of Abuja is inefficient?
4. Do you agree that the emphasis of investments on road building and expansion permits the trend of suburbanization and huge commuting volumes?
5. Would you agree that this described situation and deficits of effective public transport system linking the inner city and these suburban settlements (majorly dormitory settlements) has continued to fuel huge daily motorized trips with attendant traffic congestion challenges (time loss, fuel loss, air pollution, transport-related GHG emissions)?
6. With these existing scenarios, of the numerous daily motorized trips, would you agree that if no intervention or reform is done, passenger mobility in these cities may become dysfunctional?
7. Would you describe the existence of sectoral integration between urban planning and other sectors in the implementation of spatial plans as ineffective?
8. With this present scenario, would you say the outcome from the Master Planning approach has been optimal?
9. Would you attribute these challenges and sub-optimal outcomes to the failure of the existing CMP/ Master Planning in these cities?
10. What do you think the Master Planning system should have done differently to achieve optimal outcomes?
11. What change or alternative would you describe as an appropriate and relevant intervention to transforming inefficient of the existing Master Planning System in Abuja?
12. How can these proposed changes be implemented?
13. Why do you think these changes are appropriate and relevant to the existing challenges, and why do you think they will work?
14. Would you agree that with the described challenges, the existing Institutions and its Framework in these cities including Abuja have weak capacities to cope with these complex dynamic challenges?

16. What changes or alternatives would you propose as reforms to transform these described ineffectiveness of the existing institutional capacities?
17. How can these proposed changes be implemented?
18. Why do you think these changes are appropriate and relevant to the existing challenges, and why do you think they will work?
19. Cities with the described similar challenges of sprawling suburban development and automobile-dependent mobility pattern have adopted spatial planning strategies as TOD, BRT/LRT and Transport Demand Management (TDM) (e.g. Congestion Pricing) globally, including global south cities to reform these challenges in order to achieve optimal planning outcomes (See visuals of examples of BRT system, TOD community, Congestion Pricing system and savings/outcomes from empirical case application). Do you agree that the implementation of BRT system as seen in Curitiba and Bogota, and its adaptation to Abuja can transform and improve passenger mobility challenges?
20. What sources of funds will you identify as relevant to the implementation of the BRT system and other related strategies?
21. Do you agree that building high density mixed-use communities along the BRT corridors termed TOD as seen in Curitiba can transform suburban spatial pattern of development and optimize BRT operations?
22. Do you agree that the introduction of congestion pricing can serve as deterrent to reduce private car usage and related traffic congestion in Abuja?
23. Do you think a combination of these strategies will work to produce optimal outcomes in Abuja? (See computed plan for transforming mobility pattern and spatial development in Abuja, and also see visual impression of the character of proposed development of a typical TOD node).
24. What will these strategies do differently from the existing planning system?
25. What do you think is required to successfully implement these strategies to achieve optimal outcomes?
26. How do you think these strategies should be implemented?
27. Why do you think these strategies will work effectively to realize optimal outcome?
28. Cities with evidence of adopting these spatial planning strategies are noted to have shifted from the Master Planning approach (and its predict and provide engineering solution) towards spatial planning system because of the strength of its robust Framework to permit sectoral integration (Vertical / Horizontal), permit outcome focused-approach, avoid restrictive bureaucratic practice, generate planning reforms and solutions from situated experience, and permit integration of sustainable development principles. Would you agree to reforms to the existing planning system by institutionalizing spatial planning and its related features and strategies to produce optimal outcomes in Abuja?
29. What will this spatial planning system do differently from the existing planning system?
30. What do you think is required to successfully implement this spatial planning system to achieve optimal outcomes?
31. How do you think this spatial planning system should be implemented?
32. Why do you think this spatial planning system will work effectively to realize optimal outcome?

Section II - Transit (Bus Rapid Transit)

Agencies:

The Infrastructure Bank Plc.

- 1- How would you describe the efficiency of the existing public transport infrastructure and passengers' daily commuting experience between suburban residential areas and core-city employment areas of Abuja.....
- 2- Would you agree that the existing structure of government investments in the transport sector gives priority to building and expansion of roads at the expense of public transport investments?
Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure
- 3- What would you describe as the appropriate policy response and strategy(ies) for addressing the inefficient public transport system and the present dysfunctional mobility pattern so created?
.....
- 4- Do you think cross-sectoral integration exists amongst relevant sectors as Urban planning, Environment, Transport e.t.c. in implementing urban development and infrastructure plans?
Yes No
- 5- If No, Describe how you think this can be achieved
- 6- If Yes, Explain in detail why transport infrastructure in cities are dysfunctional and contribute significantly to socio-economic and environmental menaces
- 7- What is your opinion of replacing existing mini-buses with Bus Rapid Transit (BRT) system along routes/corridors leading to the core-city employment areas of Abuja.....
.....
.....
- 8- Do you agree that the proposed BRT system will contribute to significant reduction in transport-related challenges, and enable the optimum growth of the economy of Abuja?
Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure
- 9- The existing transport system leads to yearly wastages of fuel (112.6 million litres=N10.9 billion), Man-hour loss (33.3 million hours=N4.88billion), and CO₂ emission (0.27million tones CO₂). The proposed situation of high capacity BRT buses is predicted to reduce the level of yearly wastages of fuel to (50.1 million litres=4.8 billion), man-hour loss to (6.6 million hours=N1.3 billion) and CO₂ emission to (0.12 million tones CO₂). Describe which of the two situations best illustrate efficient mobility system for Abuja?
.....
- 10- Does your institution provide funding facility for public transport infrastructure in cities?
Yes No
- 11- If Yes, describe the type of facility and the scope of transportation infrastructure covered.....
.....
.....
- 12- Describe the enabling environment available in your institution for funding public transport infrastructure.....
- 13- Describe the funding arrangement that you deem appropriate to permit owners of existing mini-buses in Abuja to become owners of the high-capacity BRT

buses.....
.....
.....

- 14- Describe the requirements of your institution which will enable owners of the existing mini-buses become eligible for the stated funding arrangement.....
- 15- Explain in detail the requirement of your institution from cooperatives formed by owners of existing mini-buses in order to access funding facility from your institution towards ownership of high capacity BRT buses.....
- 16- Describe the arrangement that would be appropriate for selling-off existing mini-buses in order to raise proceeds for initial deposits towards the repayment of the funding facility.....
.....
- 17- Explain the supports that your institution can offer towards the selling-off of these mini-buses in order to achieve successful transition to the BRT regime.....
.....
- 18- Describe the funding capacity of your institution for new investments in high-capacity (250 passengers) articulated and bi-articulated buses used in exemplary BRT projects (e.g. Bogota, Curitiba and Johannesburg).....
- 19- What would you suggest as the critical factor(s) pertinent to the successful realization of this BRT model in Abuja.....

Section III - Transit (Bus Rapid Transit)

Agencies:

Directorate of Road Traffic Services (DRTS)

- 1- How would you describe the present commuting pattern between suburban residential areas and core-city employment areas of Abuja.....
- 2- Would you agree that the huge daily motorized trip is skewed toward exceedingly high level of private automobile usage?
Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure
- 3- Do you agree that if the increasing trend of huge daily motorized trip in mini-buses and private automobile use is not reduced, the mobility pattern will become dysfunctional?
Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure
- 4- How would you describe the contribution of the huge daily motorized trips to transport-related CO₂ emissions, man-hour and fuel wastages.....
- 5- Do you agree that the present level of public transport trip via fragmented mini-buses is inefficient because of its contribution to transport-related CO₂ emissions, man-hour and fuel wastages?
Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure
- 6- Would you agree that the existing bias of investments in the transport sector with priority for building and expansion of roads at the expense of public transport investments has created this existing mobility pattern?
Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure
- 7- Are you aware of policy response by the FCT Transport Secretariat towards addressing the existing challenges
Yes No
- 8- Describe what appropriate policy response and approaches that you think are appropriate for addressing this mobility challenges in Abuja
- 9- What is your opinion of the bus system termed (BRT) which run on a dedicated lane; with high capacity articulated buses, not in traffic jam, convenient, and reduces commuting time as in Curitiba, Bogota and Johannesburg?.....
.....
- 10- The existing transport system leads to yearly wastages of fuel (112.6 million litres=N10.9 billion), Man-hour loss (33.3 million hours=N4.88billion), and CO₂ emission (0.27million tones CO₂). The proposed situation of high capacity BRT buses is predicted to reduce the level of yearly wastages of fuel to (50.1 million litres=4.8 billion), man-hour loss to (6.6 million hours=N1.3 billion) and CO₂ emission to (0.12 million tones CO₂). Describe which of the two situations best illustrate efficient mobility system for Abuja?
.....
- 11- Do you agree that this model can transform the challenges of traffic congestion and improve commuting time on these axes (AYA, Kubwa and Airport Road routes) in Abuja?
Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure

- 12- Describe why you think the new BRT system would work in Abuja and improve commute time, eliminate congestion in commuting and enhance efficient mobility experience of passengers?

- 13- Describe how existing Transport Owner Groups can be integrated into the new regime.....

- 14- Explain the role of your institution in re-training drivers of existing public transport in order to ensure compliance with the driving etiquette / rules and regulations of the new BRT regime.....
- 15- Describe what can be done to levy private automobile use to reduce motorized commute during peak-hours into the core-city employment areas of Abuja.....
- 16- Do you think the introduction of congestion pricing would be efficient at reducing commuting via private automobile into the core-city during peak-hours and reduce traffic congestion levels
 Yes No
- 17- Explain in details how your institution will ensure effective control and enforcement mechanism as exemplified by Lagos Traffic Management Agency (LASTMA) in Lagos in order to prevent interference with the BRT infrastructure by motorists and ensure optimal functioning of the BRT operation,

- 18- Explain your opinion on the applicability of congestion pricing as exemplified in Singapore, London and Tehran to levy private automobile use into core-city Traffic Restricted Zone (TRZ) during peak-hours.....
- 19- Do you think the model would work in Abuja?
 Yes No
- 20- Describe how this would be implemented to achieve successful reduction in private automobile usage during peak hours into the core-city employment areas of Abuja.....
- 21- What do you think should be added to the model to make it more effective

- 22- Do you think there is in place the mechanism and comprehensive database of registered vehicles in Abuja that is robust enough to track offending Motorist (Traffic Offenders)?
 Yes No
- 23- If No, what more should be done to enrich the database and make the congestion pricing regime successful?

- 24- Give detail explanation of other critical factor(s) you think is imperative to the achievement of efficient and sustainable mobility in Abuja.....

Section IV - Regulation and Reduction of Transport-related Carbon dioxide emissions

Agencies:

Federal Ministry of Environment (FMEnv)

- 1- How would you describe the present commuting pattern between suburban residential areas and core-city employment areas of Abuja.....
- 2- Would you agree that the huge daily motorized trip is skewed toward exceedingly high level of private automobile usage?
Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure
- 3- Do you agree that if the increasing trend of huge daily motorized trip in mini-buses and private automobile use is not reduced, the mobility pattern will become dysfunctional?
Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure
- 4- How would you describe the contribution of the huge daily motorized trips from the commuting pattern on these axes of Abuja to transport-related CO₂ emissions, man-hour and fuel wastages_____
- 5- Do you agree that the present level/form of public transport trip via fragmented mini-buses is inefficient because of its contribution to transport-related CO₂ emissions, man-hour and fuel wastages?
Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure
- 6- Do you think CO₂ emission from this mobility pattern of proliferation of daily motorized trips is contributing to the CO₂ footprint of Abuja?
Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure
- 7- What is your opinion of the bus system termed (BRT) which run on a dedicated lane; with high capacity articulated buses, not in traffic jam, convenient, and reduces commuting time as in Curitiba, Bogota and Johannesburg?.....
.....
- 8- The existing transport system leads to yearly wastages of fuel (112.6 million litres=N10.9 billion), Man-hour loss (33.3 million hours=N4.88billion), and CO₂ emission (0.27million tones CO₂). The proposed situation of high capacity BRT buses is predicted to reduce the level of yearly wastages of fuel to (50.1 million litres=4.8 billion), man-hour loss to (6.6 million hours=N1.3 billion) and CO₂ emission to (0.12 million tones CO₂). Describe which of the two situations best illustrate efficient mobility system for Abuja?
.....
- 9- Do you agree that this model can transform the challenges of traffic congestion and improve commuting time on these axes (AYA, Kubwa and Airport Road routes) in Abuja?
Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure
- 10- Describe why you think the new BRT system would work in Abuja and improve commute time, eliminate congestion in commuting and enhance efficient mobility experience of passengers?
.....
- 11- What enabling legislation is in place to regulate emission from private automobile usage in Abuja?.....
.....
- 12- What improvement can be done to optimize the capacity of existing framework for enforcing reduction of automobile-related CO₂ emissions in Abuja?

- 13- Do you think this existing framework contain spatial planning strategies?
 Yes No
 If Yes, name them.....
- 14- How would you describe the relevance of urban planning strategy in reducing transport related CO₂ emissions?
- 15- What combination or single option listed below do you think can de-leverage the high level of CO₂ emission from the proliferation of daily motorized trips?
 Fuel efficiency Automobile efficiency Transport and Landuse policy
 Congestion pricing Transit Oriented Development (TOD)
 Effective transit infrastructure (e.g BRT)
- 16- What is your suggestion on tailor-made measures or policy to effectively reduce CO₂ emissions from private automobile proliferation in Abuja?
- 17- Describe how these measures can be implemented successfully in order to achieve sustained reduction of CO₂ emissions in existing mobility pattern in Abuja.....
- 18- What is your opinion of the application of spatial planning strategies that integrate transit infrastructure, landuse and TOD, and congestion pricing to retrofit transport-related CO₂ emissions in Abuja as exemplified in transit-dependent cities of Curitiba and Bogota.....
- 19- Describe how you think BRT system can be implemented in Abuja in order to improve commute time, eliminate congestion in commuting and enhance reduced level of transport-related CO₂ emissions and traffic congestion challenges of man-hour and fuel wastages?
- 20- Do you think sectoral integration between relevant sectors as environment, urban planning, transport e.t.c. spatial planning are imperative and can be effective at reducing transport-related CO₂ emission level in Abuja?
 Yes No
 If No, explain in detail how effective cross-sectoral integration can be achieved by relevant sectors in implementing spatial development and urban infrastructure in cities.....
- 21- Describe how these approaches can be integrated into Clean Development Mechanisms (CDM) in Abuja so that the BRT project can be eligible for climate change finance related funding in order to ensure successful implementation.....
- 22- Give detail explanation of other critical factor(s) you think is imperative to the achievement of efficient and sustainable low carbon mobility system in Abuja.

SEMI-STRUCTURED INTERVIEW GUIDE (Transport Operator Association)

Transport Operator Association:

4. What is the model of your vehicle.....
5. With what fuel type is your vehicle operating? Diesel PMS Others.....
6. What is the capacity of the fuel tank of your vehicle?
7. Explain the number of functional buses in your fleet and state the passenger capacity of the vehicle?
.....
8. How many trips (km) do you make with your vehicle's filled fuel tank in congested traffic situation on each route (AYA, Kubwa and Airport Road).....
9. How many trips (km) do you make with your vehicle's filled fuel tank in non-congested traffic situation on each route (AYA, Kubwa and Airport Road).....
10. Where would you describe as major point(s) of origin of trips on your buses?
.....
11. Where is the major destination of trips on your buses?
City centre Before city centre
12. How long should this trip last when there is no traffic jam?
<30mins 40mins 60mins 90mins 180mins
13. How much time is lost during your commute in congestion situation?
<30mins 40mins 60mins 90mins 180mins
11. How would you describe the causes and problems of traffic congestion associated with this existing mobility system.....
12. Do you agree that continued road expansion towards suburban areas at the expense of functional public transport is permissive to the growth of suburbanization and contributes to the growth of the present huge commuting volume?
Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure
13. Do you agree that the existing high number of commuter buses and private automobile vehicles are contributing to CO₂ increasing traffic congestion challenges of man-hour and fuel wastages on routes leading to the core-city employment areas of Abuja?
Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure
14. Do you agree that if the increasing trend of huge daily motorized trip in mini-buses and private automobile use is not reduced, the mobility pattern will become dysfunctional?
Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure
15. Describe the solution you think is appropriate to addressing these challenges of traffic congestion and increasing commuting time.....
16. Describe in detail the role of each stakeholders in your proposed solution and explain how you think this solution would work.....
17. What is your opinion of the bus system termed Bus Rapid Transit (BRT) which run on a dedicated lane; with high capacity not in traffic jam, convenient, and reduces commuting time as in Curitiba, Bogota and

Johannesburg?.....
.....

18. The existing transport system leads to yearly wastages of fuel (112.6 million litres=N10.9 billion), Man-hour loss (33.3 million hours=N4.88billion), and CO₂ emission (0.27million tones CO₂). The proposed situation of high capacity BRT buses is predicted to reduce the level of yearly wastages of fuel to (50.1 million litres=4.8 billion), man-hour loss to (6.6 million hours=N1.3 billion) and CO₂ emission to (0.12 million tones CO₂). Describe which of the two situations best illustrate efficient mobility system for Abuja?
.....

19. Do you agree that this BRT model can transform the challenges of traffic congestion and improve commuting time on these axes (AYA, Kubwa and Airport Road routes) in Abuja?

Agree slightly Agree strongly Disagree slightly Disagree strongly Not sure

20. Describe why you think the new BRT system would work, and explain how it can be implemented in Abuja, in order to improve commute time, eliminate congestion in commuting and enhance efficient mobility experience of commuters?

21. Would you support the transformation of the existing system to this described BRT system?

Yes No Not sure

22. Describe the ways you hope to participate in the new BRT system?
.....

23. Explain what you know about Euro-IV high capacity bus types with catalytic converter that reduces fuel consumption and emission levels of buses.....

24. Describe the available plans to upgrade the existing bus types to the Euro-IV bus types.....

25. Describe how you think replacing existing high capacity buses/mini-buses with high capacity articulated BRT buses like in Curitiba, Bogota and Johannesburg can be implemented in order to reduce congestion, improve commute time and enhance commuter experience.....

26. Explain how you will ensure the training of your drivers in order to ensure compliance with the driving etiquette / rules and regulations of the new BRT regime in Abuja.....

27. Do you require government support to become part of the new BRT system?

Yes No Not sure

28. Describe the nature and level of supports or subsidies that you require as stakeholders in the existing transport system from the government in order for your group to effectively participate and contribute to the success of the new

transit (BRT)
regime.....

29. What is your opinion of forming groups of cooperatives in order to access facility/funds to become owners of high capacity BRT buses.....

30. Describe how this cooperative can be organized in units and made up of 5-9 owners of existing mini-buses to become owners of new high capacity BRT buses.....

31. In order that initial deposits for the bank facility are paid in a timely manner, describe what decisions you prefer to be taken in order to selling off your mini-buses?
.....

32. Outline in detail how you think these existing fleet of mini-buses can be sold-off off/auctioned in
.....

33. What percentage of the present market value should these mini-buses be sold in order to dispose them off in good time. (By this, the proceeds will serve as initial deposit toward the repayment of the bank facility for the high capacity BRT buses).....

34. What do you think should be added to make this model more effective.....

QUESTIONNAIRE: Commuters in Mini-buses resident in the suburban areas):

PART ONE: COMMUTING CHARACTERISTICS

1. Gender: Male Female

3. Purpose of Trip: Work Leisure Others (specify).....

4. How much time is lost during your journey to work due to traffic congestion?

Less than 30mins 40mins 60 mins 90mins 120mins-above

5. Do you think this traffic congestion results to economic Loss?

Agree strongly Agree slightly Not sure Disagree slightly Disagree strongly

6. Do you think this traffic congestion results to Carbon dioxide (CO₂) emission?

Agree strongly Agree slightly Not sure Disagree slightly Disagree strongly

7. Rank the characteristics of the existing mini-bus system that prevent efficient journey to work experience for passengers? **(with 1 as the highest rank, and 5 as the lowest rank)**

Factors	1	2	3	4	5
Longer journey time					
High cost of transport fare					
Unreliable waiting time for bus					
Lack of comfort in the bus					
Low quality Bus Stop					
On-street parking					
Un-trained drivers					
Reckless driving					
Others (comments):					

8. Rank, in order of importance, the following solutions to traffic congestion and increasing journey to work time **(with 1 as highest and 5 as lowest rank)**

Factors	1	2	3	4	5
Use of high capacity buses					
Road diversion /Alternative Road/By pass					
Road expansion					
Increase number of mini buses					
Enforcement of traffic regulation					
Enlightenment of bus drivers					
Others (Comments):					

9. Would you agree that the introduction of a convenient, high capacity Bus Rapid Transit (BRT) system as in some fast growing cities of the world (see picture below); will be an appropriate solution for addressing traffic congestion challenges in Abuja?

Agree strongly Agree slightly Not sure Disagree slightly Disagree strongly



Private cars in congestion

BRT buses on dedicated lane

An example of BRT Buses in Bogota Colombia

10. Do you agree that this BRT model can transform the challenges of traffic congestion and improve journey time on the AYA Road, Airport Road and Kubwa Road into the city?

Agree strongly Agree slightly Not sure Disagree slightly Disagree strongly

11. Why would you choose to ride on the new BRT system? (Rank your reasons in order of importance; with 1 as the highest rank, and 5 as the lowest rank)

Factors	1	2	3	4	5
Less journey time					
Reliable timing					
Less cost					
Weather friendly bus stop					
Comfort in bus during journey					
Orderly better trained driver					
All day services (24 hours)					
Others (Comments):					

12. Rank the following components of the BRT services in order of your preference (with 1 as highest and 5 as lowest rank).

Factors	1	2	3	4	5
High frequency of buses (high number of buses)					
Nearness of bus stops to major residential entry/exit points					
Effective bus scheduling (Reduced length of waiting time)					
Display board showing bus arrival and departing time at bus stops					
Traffic management system					
Well protected bus stops from sunshine and rain					
Secured bus stops					
Display of route maps on notice board at bus stops					
Others (Comments):					

13. Would you desire to live within 5-10minutes walking distance to a bus stop that serves an efficient public transport system like the Bus Rapid Transit (BRT) system? Yes No

14. How much time would you be willing to spend to walk to a BRT bus stop?

Less than 5minutes 5-10minutes 10-20minutes 20-30minutes 30minutes-Above

PART TWO: CHARACTERISTICS OF EXISTING PLACE OF RESIDENCE AND PROPOSED TOD

15. Status of Occupant of building? Tenant Property Owner (Landlord)

16. Building Type: Tenement/Compound House Bungalow Duplex Storey Building

17. What is the number of households in your compound? 1-2 3-5 6-8 9-11 above 11

18. What is your household size (family size)? 2-4 5-7 8-10 11-13 13-above

19. How long have you lived in your house?

Less than 1 year 2-4 years 5-7 years 8-10 years 10-above years

20. If your present residence/house in this community is to be re-built (redeveloped) into high density 3-10 storey mixed use community, so that you can live within 5-10minutes walking distance to a BRT bus stop, where would you live?



High density mixed-use development abutting the transit corridor

BRT bus stop

Within high density mixed use community of 3-10 storey buildings Further away from high density mixed use community of 3-10 storey buildings

21. If you would live within high density mixed use community of 3-10 storey buildings, which of the floors would you be willing to live in? 1st-3rd floor 4th-6th floor 7th-10th floor

22. What incentive/facilities should be added to this high density mixed use re-developed area in order to make it a better community for you to live in?.....

23. As a resident of the proposed designated TOD, would you ride a bicycle to and fro a BRT station?

Yes No

QUESTIONNAIRE: Commuters in Private Cars resident in the suburban areas):

PART ONE: COMMUTING CHARACTERISTICS

1. Gender: Male Female

2. Rank, in order of importance, the following solutions to traffic congestion and increasing journey time (**1 as highest and 5 as lowest rank**)

Factors	1	2	3	4	5
Use of high capacity buses					
Road diversion /Alternative Road/By pass					
Road expansion					
Increase number of mini buses					
Enforcement of traffic regulation					
Enlightenment of bus drivers					
Others (Comments):					

3. Would you agree that the introduction of a convenient, high capacity Bus Rapid Transit (BRT) system as in some fast growing cities of the world (see picture below); will be an appropriate solution for addressing traffic congestion challenges in Abuja? Agree strongly Agree slightly Not sure Disagree slightly Disagree strongly



An example of BRT Buses in Bogota Colombia

Private cars in congestion

BRT buses on dedicated lane

4. If you agreed, will you support the introduction of the BRT system?

Yes No

5. Would you choose to leave your car at home and ride on the BRT system?

Yes No

6. If yes to 4 above, rank the following components of the BRT services in order of your preference (**with 1 as highest and 5 as lowest rank**).

Factors	1	2	3	4	5
High frequency of buses (high number of buses)					
Nearness of bus stops to major residential entry/exit points					
Effective bus scheduling (Reduced length of waiting time)					
Display board showing bus arrival and departing time at bus stops					
Traffic management system					
Well protected bus stops from sunshine and rain					
Secured bus stops					
Display of route maps on notice board at bus stops					
Others (Comments):					

7. Would you desire to live within 5-10minutes walking distance to a bus stop that serves an efficient public transport system like the Bus Rapid Transit (BRT) system? Yes No

8. Would you desire to leave your car at home and ride on the proposed BRT system because you are resident of high density 3-10 storey mixed use community (TOD nodes) in the suburban areas? Yes No

9. If no to 4 above, why would you not ride on the BRT system (**rank your reasons in order of importance, with 1 as highest and 5 as lowest rank**)

Factors	1	2	3	4	5
Need for privacy					
Overcrowding in the Bus					
Long walking distance to the Bus stop					
Insecurity at BRT station					
Others (Comments):					

10. What can be done to make the use of private cars un-attractive in order to reduce traffic congestion during peak-hours in and out of the city (**Rank your choices in order of importance, with 1 as highest and 5 as lowest rank**)

Factors	1	2	3	4	5
Payment of fine for driving into the city centre during peak hours (Congestion Pricing)					
High level of parking fees					
High cost of PMS (petrol)					
Odd/even Registration number restrictions on given days/period					
Others (Comments):					

11. Do you agree to the potentials of the proposed application of Payment of fine for driving into the city centre during peak hours (congestion pricing) will attract private car drivers to ride on the BRT system?
 Agree strongly Agree slightly Not sure Disagree slightly Disagree strongly

PART TWO: CHARACTERISTICS OF EXISTING PLACE OF RESIDENCE AND PROPOSED TOD

12. Status of Occupant of building? Tenant Property Owner (Landlord)

13. Building Type: Tenement/Compound House Bungalow Duplex Storey Building

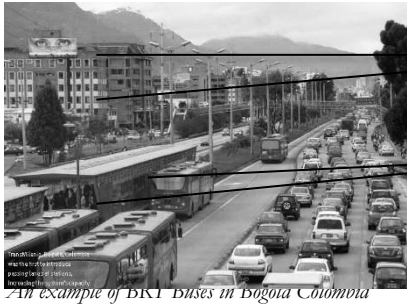
14. What is the number of households in your compound? 1-2 3-5 6-8 9-11 above 11

15. What is your household size (family size)? 2-4 5-7 8-10 11-13 13-above

16. How long have you lived in your house?

Less than 1 year 2-4 years 5-7 years 8-10 years 10-above years

17. If your present residence/house in this community is to be re-built (redeveloped) into high density 3-10 storey mixed use community (TOD), so that you can live within 5-10minutes walking distance to a BRT bus stop, where would you live? Within a high density mixed-use community of 3 – 10 storey building Further away from a high density mixed-use community of 3 – 10 storey building



High density mixed-use development abutting the transit corridor

BRT bus stop

18. If you would live within high density mixed use community (TOD) of 3-10 storey buildings, which of the floors would you be willing to live in? 1st-3rd floor 4th-6th floor 7th-10th floor

19. What incentive/facilities should be added to this high density mixed use re-developed area in order to make it a better community for you to live in?.....

20. As a resident of the proposed designated TOD, would you ride a bicycle to and fro a BRT station?

Yes No

21. As a residents of the proposed designated TOD in the suburban areas, would you desire to leave your car at home and ride on the BRT system when congestion pricing is introduced? Yes No