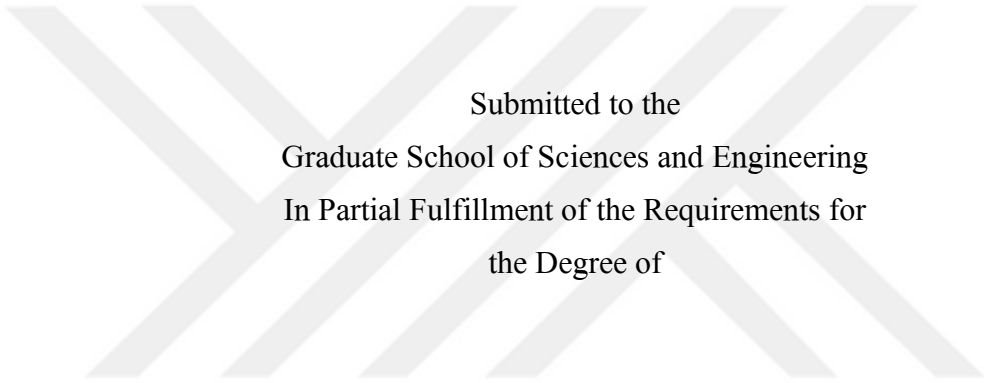


**A STUDY OF STREET NETWORK CONFIGURATION ON THE
DISTRIBUTION OF NON-RESIDENTIAL LAND-USE IN ABUJA, NIGERIA.**

A Thesis

By

Zaharaddeen Saleh Ahmed



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DEDICATION

To my parents.

ABSTRACT

Cities go through various changes in their growth over time, this is both in their physical urban form and in the effects of the form on every day activities. The functionality of the buildings and various land uses are considered artefacts in discerning the urban form. Historically, cities evolve their active centers through agglomeration and growth overtime. However, the middle of the 20th century also introduced new types of cities, from the industrial to the administrative. Abuja the capital city of Nigeria is among the few administrative capitals designed and constructed in that period. Embodying modernist planning ideals and inherited colonial urban policies.

The thesis investigates land use changes from residential to nonresidential functions across two districts developed at different phases of the city, the district of Wuse II and Utako. This is to determine the relationship between land-use changes (functionality) and street network hierarchy as well as how an administrative city is evolving and creating new high streets in hitherto residential neighborhoods.

The study utilized Space syntax methodology through analysis of the road networks at the scale of the city and the districts. Global and local radii of Choice and integration measures determined the probability of a street network to be passed through and the depth of each street to all other streets in the network. By layering the land use changes and the growth of the city between the first phase and completion of most of the second phase the study found a demonstrable relationship (correlation) between land changes from residential to nonresidential changes as well as in the clustering of these activities along streets with high integration in the urban grid. This thesis presents an analytic approach to understanding the changing urban form of a rapidly expanding contemporary African capital.

ÖZETÇE

Şehirler, zaman içinde büyümelerinde çeşitli değişikliklerden geçmektedir, bu hem fiziksel kentsel formlarında hem de formun günlük aktiviteler üzerindeki etkileri şeklinde olmaktadır. Binaların işlevselliği ve çeşitli arazi kullanımları, kentsel formun ayırt edilmesinde eserler olarak kabul edilmektedir. Tarihsel olarak şehirler, zaman içerisinde aktif merkezlerini toplanma/yığılma ve büyümeye evrilmektedir. Bununla birlikte, 20. yüzyılın ortaları, sanayiden yönetime kadar yeni şehir türleri de tanıtmıştır. Nijerya'nın başkenti Abuja, o dönemde tasarlanan ve inşa edilen birkaç idari başkent arasında yer almaktadır. Modernist planlama ilkelerini ve kalıtsal sömürge kentsel politikalarını somutlaştırmaktadır.

Bu tez, kentin Wuse II ve Utako ilçelerinde farklı aşamalarında geliştirilen iki ilçede konuttan konut dışı işlevlere arazi kullanımındaki değişiklikleri araştırmaktadır. Bu da arazi kullanım değişiklikleri (işlevsellik) ve sokak ağı hiyerarşisi arasındaki ilişkinin yanı sıra, bir yönetim kentinin şimdiye kadar yerleşim bölgelerinde nasıl yeni caddeler oluşturduğunu ve yarattığını belirlemek için yapılmıştır.

Çalışmada şehir ve ilçeler ölçeğindeki karayolu ağlarının analizi ile "Space Syntax (Mekan Dizimi) metodolojisi kullanılmıştır. Choice (seçim) ve entegrasyon değerleri, küresel($r:n$) ve yerel yarıçapı ($r:3$), bir sokak ağının kullanılma olasılığını ve her sokağın ağdaki diğer tüm sokaklara göre derinliğini (depth) belirlemiştir. Arazi kullanım değişikliklerini ve kentin, çalışmanın ilk aşama ile ikinci aşamanın çoğunun tamamlanması arasındaki büyümeyi katmanlamasıyla, konuttan konut dışı değişikliklerle ve bu faaliyetlerin kentsel ızgarasında yüksek entegrasyona sahip sokaklarda kümelenmesiyle arazi değişiklikleri arasında belirgin bir ilişki (korelasyon) bulunmuştur. Bu tez, hızla genişleyen çağdaş bir Afrika başkentinin değişen kentsel morfolojisini anlamak için analitik bir yaklaşım sunmaktadır.

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1 INTRODUCTION

Cities have been known either to have grown from small settlement overtime or are created for a particular purpose ranging from defense, commerce to administration, and in some cases a combination of both. Over time some cities grow and become important at different levels, which varies from provincial to global. However, certain cities belong in a central category that serve as the symbolic city of a nation state by being its administrative capital. These are special cities designated to serve as the center for national administrative functions and in some cases economic centers (Gordon, 2006a). The capital city serves as an interface between local and other national governments, this means they have unique planning and land-use elements such as seats of government, monuments and memorials, embassies as well as cultural and symbolic elements (Gordon, 2006a).

A number of cities have been playing the role of capital city for more than a century (prior to the 20th century). However, the 20th century heralded an explosion of new capital cities as a result of the end of the world war, the end of colonial rule and the collapse of the Soviet union which saw the number rise from 40 to over 200 at the beginning of the 21st century (Gordon, 2006b). Some of the new nations that were formed as a result adopted their largest cities to serve as capitals during their early years, and will later build dedicated capital cities. Among these countries included Nigeria which gained its independence from Britain in 1960. It retained its most populous city and commercial center, the port city of Lagos as the national capital. In the 1970's a resolution was made to have a new capital that truly represents the young country. It would also serve as a center and symbol of a multiethnic country like Nigeria.

Abuja was proposed as the future capital in 1976, but did not become the capital until 1991; although its master plan was completed in 1979. This stemmed from factors that ranged from financial to administrative. At the inception of the master plan in the 1970's modernist city planning theories were the prominent planning theories of the period and this had a major influence on the design of the city. The aforementioned theoretical view of cities in that era, which Batty (2012) describes as a system view of the city, i.e. the city as a distinct collection of interactions that are in a state of equilibrium which resulted in a top down approach to planning and management. A system interpretation of the city is supported by various tools with the most widely used being land-use zoning. Zoning serves as a regulatory tool for planners by assigning and

managing various land-use types in a city. The combination of masterplans with zoning ordinances continue to play a role in the design and management of cities especially in countries like Nigeria where these planning models are still being applied.

Zoning is utilized in the designation of what the various parts, blocks and plots of a city will be used for from the district to the plot level. It stipulates the location of various activities, such as work districts, residential and industrial districts, centered around a set number of people buildings or activities. Each plot is also designated a land-use in order to maintain a given character, either based on visual form, program of use or both. The use of zoning is an attractive tool in the quest for well-organized cities, and even more desirable in cities that are identified with a specific function as their identifier. However, in most instances involving master planning at the city scale zoning as a tool on its own continue to fall short; as evolving technologies and economic conditions also have extensive influence how the city functions and develops. The city of Abuja was created as an administrative city, this was reflected in the land-use zoning of the city and the emphasis placed on the zoning framework in urban planning decisions. It is however unavoidable for it to serve the administrative objective alone, like all cities it must cater for multitude of activities; both the ones which it was planned for and those that were not. This means there are continuous evolutions and interactions between the planned and the unplanned; especially in the provision of amenities for a fast-growing population's needs. This is apparent in the morphology of the city's commercial streets and the continuous conflicts between the city administration and property owners.

These conflicts continue to be a regular occurrence in the city. They also highlight issues in terms of fragmentations in policy on one side and user needs, requirements and aspirations on the other. This can be ascribed to urban management processes rooted in planning systems that have been continuously argued against in contemporary urban literature as being unsustainable and lacking in appreciation of the city at the human scale. Although a general theory of the city is yet to be formulated, theories on some of the constituents of how a city functions have contributed in understanding how various layers of cities function; in addition to theories guiding policy and administrative directions. This dissertation will focus on the use of space syntax theory and methodology in understanding the relationship between urban form and land-use changes in Abuja metropolitan area.

Space syntax has been used in studying and understanding how lived space influences human activities. Space syntax theory is a configurational theory of space applied in the study of buildings and urban spaces and their influence on society. It uses configuration as the relationship between spaces keeping in account a third space (Bafna, 2003). The urban street network is broken into a series of lines which are analyzed using various measures that relate to the urban system. This enables a quantitative understanding of lived space and the effects of human decisions on these spaces.

1.1 Problem Statement

In developing countries like Nigeria, the masterplan drawn by the planning authority of a city still serves as the only reference tool/document for making planning decisions. A system developed on modernist and colonial planning that endures at major decision-making levels. The capital city of Abuja designed on a clean slate still uses its original plan design from 1979, which is yet to be fully reviewed. This has led to a deficiency in sustainable approaches in adapting to contemporary urban needs along with inadequate fixes to problems and conflicts arising from the exploitation of the urban space to meet those needs. Foremost conflicts because of this have been land-use changes. Primarily, residential land uses provided in the masterplan being changed to commercial uses in certain neighborhoods and streets, leading to marking and demolition of infringing properties in order to restore the city to its original masterplan. The primary aim of which is to avoid the densification of the city comparable to the former capital of Lagos.

The masterplan of Abuja provided commercial/retail zones at the neighborhood level in every district. However, these areas have become inadequate. Streets previously designed as residential streets have evolved into non-residential uses in various parts of the city creating active centers unintended by the masterplan. Furthermore, changes in governments and policy directions have contributed to these alterations and reversals, which are based mainly on political partisanship. Resulting in the absence of an analytical approach/understanding of why it is more common in certain streets and neighborhoods of the city. Abuja is one of the fastest growing cities both in Nigeria and on the African continent, and as such, its role as an administrative city and its continued

expansion while navigating the downsides of traditionally built cities through the evolution of its active centers compels a study into.

1.2 Aim and Objectives of the study

The research aims to study the distribution of building and land use changes and the correlation of these changes to the street network configurations of Abuja using space syntax analysis. The research will include a comparison of two districts; one each from the first and second development phases of the city as case studies.

The main objectives of the thesis are three-folds. First, to determine the locations of land use changes at the various development phases of Abuja. This involves collecting data on use change applications and the originally proposed uses across two completed phases of Abuja through historic maps, on-site photographs and satellite imagery. Second, to identify the extent to which the distribution of non-residential land uses is associated with the configuration of street network layout. This involves network analysis of the urban grid through space syntax methodology. Third, to determine which streets in a neighborhood are likely to change first into non-residential when new centers are created. This can determine if use changes are creating new district centers as well as their relationship with the designated centers in the masterplan.

1.3 Scope of the Study

The study is limited to Abuja metropolitan area and does not include adjoining satellite districts as well as undeveloped areas of the masterplan. It covers of two sectors of the city, one from the first phase and another from the second phase. The primary data collected will include all non-residential land-uses as well as mixed use buildings with non-residential ground floor uses. The study does not cover buildings that have been reverted after a use change to its original use designation. While the land use data collected represents that of the two study districts, the space syntax analysis reflects the road networks of the completed phases.

1.4 Research Questions

The questions that this research raises are:

- What is the relationship between land use changes and urban street networks hierarchy in Abuja?

- How does land use change in a mono-functionally designed city lend itself to the creation of urban centers as opposed to predetermined centers?

1.5 Hypothesis

The hypothesis of this research is that nonresidential land uses are influenced by street network configuration in a city designed on a blank slate.

1.6 Contributions

Urban theory both in its conceptual and empirical approaches for the most of the 20th century was stuck in the study of a limited number of western cities (Edensor & Jayne, 2012; Watson, 2014). The gradual transition in the last few years towards cities considered to be in the global South have been because of factors such as the rapid growth of populations, the mass migration to urban areas and debilitating environmental conditions in those parts of the world. This thesis can contribute to the growing knowledge of cities most especially in understanding the correlations between configuration and social activities in African countries. This thesis can also contribute in the development of analytical processes to replace the older colonial-modernist planning approaches that have proven inadequate for fast changing urban dynamics challenging the continent. While a few studies on Abuja have focused on the aesthetics of the city and the role of urban planners, also housing development and social exclusion. There has been a limited number of studies on how the form of the city is being influenced by them. The growing population of the city is also exacting pressure on the city towards fast tracking the development of the third phase of the city. This phase is being developed as a series of large gated estates granted to private developers. This thesis can contribute to an alternate approach towards flexible zoning and guidelines for these new districts.

1.7 Thesis Structure

The outline of the thesis is as follows: Chapter one provides a general overview of the thesis; the problem statement, research aim and questions, in addition to expected outcomes. The second chapter is divided into two sections. The first section is a review of urban planning and design theories of the 20th century as well as the roles of colonization and these theories in determining land uses zoning in Nigerian. The section also includes a review of land use zoning and the effects of zoning on the morphology

of cities. The second section discusses space syntax theory, its methodology and the use of space syntax in urban research. The third chapter is the background chapter. It discusses the background and history of the city of Abuja including the design concept and development of the city. A second section describes the form and characteristics of the districts of the city selected for the study. The fourth chapter is the study design including data collection and analysis methods. While the fifth chapter comprises the analysis of the urban grid and land-use data, chapter six presents the findings and conclusion of the thesis.



2 LITERATURE REVIEW

2.1 Urban Planning Theories

The urban space in the last two centuries became, and continues to play the role of major centers of human activities. The rapid development in human innovation in the ensuing period made urban areas exceedingly attractive, and as a result, the urban/city became a major interest for researchers in terms of how to solve a large number of problems that derived from such growth. The earliest urban problems that efficient planning was suggested to solve were in preventing disasters such as fires and the spread of diseases (Gordon, 2006b). Subsequently, urban planning refocused on managing population growth, and the rise of the automobile and industrialization in the 20th century. This chapter discusses the major urban form/planning theories of the 20th century and their effects/influence on planning in Nigeria.

2.1.1 Early Urban planning theories.

In the late 19th and early 20th century, urban planning transitioned from managing the spread of disease and the extensive effects of disasters to the management of rapid growth of cities as a result of industrialization. Although some of the earliest urban modelling plans of the period pursued ways to streamline the city, the way factories were organized and to find suitable locations for workers to utilize maximum production. These plans usually had the relocation of the factories to a central location in the city for easy access by arterial roads from the workers housing in the periphery. Ebenezer Howard's "Garden city of tomorrow" and Raymond Unwin's "Town planning in practice" were the prominent ideas of the period and the precursors of the New Towns development by the middle of the 20th century in England. These milestones in urban planning, although considered as utopic models and theories of the city, began the shift towards methodical development and management of cities with masterplans.

It was at this period the *CIAM* was formed, with the aim of designing cities and buildings of the future. The *CIAM* strived for a guideline for a design approach that sheds away its ties to the past through the simplification of forms, confidence in technology and creation of an international style. The movement promoted the agenda of the modernist avant-garde in architecture and also produced a significant theoretical contribution in the form of the functional city (Mumford, 1992). The resulting

manifesto for the functional city known as the charter of Athens called for a city with appropriate zoning of four main functions; Dwelling, working, recreation and traffic. The movement's influence as a result of its members and contributors was widespread. By the 1950s, the charter's ideas were being implemented in America and planning schools across the world (Rodwin, 1981).

At the time, the functional city was being discussed by the CIAM, sociologist at the Chicago University studying the relationship between the history of the city and land use, developed models that would become significant for city planning. The most prominent model was the Ullman and Harris model, which combined the concentric zones model of Burgess and the sector models of Hoyt before them. Harris and Ullman (1945) suggested the city as a series of nodes with similar activities clustered while separating activities that were considered to repel one another. Their model separated residential zones into classes with corresponding distance to either industry or business district. Their model, though developed around the sociology of American cities, would become prominent in planning schools around the world. As Rodwin (1981) underscores, planners in developing countries were trained in these schools and have continued to implement these models and planning approaches.

2.1.2 Institutionalized top-bottom master planning

As industrialization intensified in Europe and America, most countries in Africa were under colonial rule. As such, the urban form in colonized countries was molded mainly in the best interest of the colonialist through segregation policies. While there are variations in planning amongst African colonies, mainly between the French and the British, this section highlights the influence of British planning on Nigeria.

The colonial city in Nigeria was usually divided into four sections: A Government reserved area for the foreigners and their staff, an area for the original inhabitants of the place (this was excluded in cities built as a result of rail services). An enclave reserved for workers that come from other communities across the country, and an area designated as the central commercial area.

This segregation of the city can be argued as the earliest form of functional delineation of the city in Nigeria, before that, towns were built around the primary function of defense. The resulting ordinances utilized in the organization of the urban form was later combined with the 1945 British town and country plan and became the dominant

planning policy document post-independence, until the introduction of the Town planning decree of 1992. Both planning approaches maintained the ownership of land to the state and the decisions on how to utilize this land at the discretion of the planning authority.

This has also contributed to a divergence in terms of what is needed by users of the city and what city planners aspire for the city function like. It is more so when paired with the historical influence of colonial decision making and subsequent military rule. The principles of a centralized urban planning approach were further enforced with the continued creation of urban masterplans well into the 1980s by the federal government. Although this approach is considered detrimental as time goes, another demerit of large-scale centralized planning is the time that is required to develop them at the metropolitan scale leading to such plans obsolete by the time they are implemented. This rigidity embedded in modernist/colonial masterplan approaches and urban models paired with similar rigid decision-making processes highlights a significant point of departure in the quest for a physically functional city while ignoring the social subsystems that the physical form shapes.

2.2 Land Use Planning

2.2.1 Urban Land Use Planning

Urban land use planning, which has its roots in 19th century Europe, can be traced to the rapid industrialization and population growth of that era, which also stemmed increased concerns in terms of health and structure of cities. At the turn of the century, these risks were at their peak, as such rules and guidelines were thus needed to curb them. These rules enabled local administrators the opportunity to control the height of buildings, reduce plot subdivisions and restrict certain commercial and small scale industrial activities especially in tenement buildings (Talen, 2012). This also overlapped with intensifying use of the automobile as the perception of distance to amenities changed. By developing land use regulations and plans these cities were able to gradually move industries from the center to the periphery as well as contributing to the improvement in the management of sewage and water to reduce the spread of diseases.

The evolution of land-use zoning in the 20th century from managing urban problems to a vital decision-making tool is well documented in urban literature (Ellickson, 1973; Gauthiez, 2004; Gordon, 2006b; Talen, 2012; Watson, 2014). Land-use zoning has also

become challenging in many instances, especially when there are disproportionate limitations for land uses to continuously evolve and reflect the changing spatial requirements/needs of the city. The internalization of zoning in planning agencies, although needed in the management of public land, has also led to the creation of codes and rules for problems that have either ceased to exist or do not apply to where they are implemented. As Talen (2012) argues this leaves urban areas devoid of considerations in terms of character, form and how these places are actually experienced. Municipalities embraced the master planning approach to their cities as it enables them to make decisions on what urban spaces should function like and in most cases with no recourse for changing ways of living and technology.

The high levels of rationality put in place for the achievement of master plans through specified plot sizes and functions as well as the creation of precise density figures for urban areas tend to create both cultural and economic segregation in cities. As Watson (2009) explores, urban planning is increasingly shaped by the real estate industry and markets which usually align with the planning ambitions of the municipal administrators. While the relationship between the planning authorities and property owners is mutual in terms of large-scale developments, conflicts do arise at the community and building levels when they do not reflect a stipulated zoning ordinance. These conflicts/violations are often resolved through enforcement powers granted to the planning authority, arbitration or legal actions. This, however, can be regarded as restrictive in the evolution of a city and its changing needs.

2.2.2 Retail/Commercial land-uses

A significant driver of activities in urban areas has always been the presence of retail as well as the agglomeration of non-residential and industrial activities. It forms a nexus for activities unrelated to work, industry and residential. These activities serve as attractors of people through the various services they provide, and as such is an essential influence on how the contemporary urban space is experienced. They also form part of the basis for the assessment of the urbanity of a place. Retail activities range from small scale hawking to large scale malls and shopping districts. While the scale of retail may vary, it is driven by the presence of people that participate in the interactions. As such, retail activities tend to be situated in locations that are considered optimal due to the traffic it attracts. The attraction retail provides makes it a coveted land function in cities.

Retail land use, therefore, becomes a focal point. This way cities try to control this growth by limiting how these functions are allocated around the city.

Historically, urban planners approach retail land-uses mostly as catchment area-based solutions especially for new urban developments and as the continuation of historical street patterns. The use of catchment areas for the provision of urban services and facilities can be considered a priori; it provides a valuable approach for planners to patch together the various demands of urban areas. However, this deterministic approach has mostly ignored the contingent nature of activities in cities as argued by (Carmona & Tiesdell, 2007). This is more so in street front and mix-use locations where economic and social factors serve as contingent activities in constant flux with predetermined factors of administrative planning.

While centralized urban planning does make provisions for increased non-residential activities, it still faces challenges of agglomeration and intensification, as well as the effects of a decline in these activities. Agglomeration may occur through the surge of certain forms of activities such as restaurants and small retail shops or the colocation of higher-level activities such as small-scale offices. The control of this agglomeration may become vital when it pushes out other activities such as residential functions, and calls into question the role of these activities in the city due to economic and environmental consequences of their presence. Retail agglomeration as argued by is the driving force of growth in the contemporary city.

However, a foremost containment process for retail agglomeration is planning administration through enforcing and implementing land-use management rules such as increasing/decreasing land rates and the use of zoning guidelines to control or manage appropriation by mono-functional land-uses. Similarly, contemporary planners have also endorsed strict zoning to promote the development of other centers, and with the fast growth of urban areas and progress in knowledge relating to the polycentric nature of cities. Strict zoning can have a reverse effect on new centers when they fail to integrate into the general framework of the city. As such, constraining the development of new centers to master plans also results in restriction of growth to only specific sections of the city. This can be said to hinder growth and exploration of opportunities, especially those opportunities that have been earlier stated to be deterministic.

2.2.3 Planning in Nigeria

The 1960s began the surge in the criticism of modernist planning and the influence of its universal principles on both scale and social interactions in cities. While these criticisms were on the top-down approach to planning decisions, it later included the stretching of the city with the rapid development of suburbs. The declining popularity of modernist planning in Europe and North America in the subsequent years had a resurgence in newly independent countries in Africa. In these countries of the global south, the ideas of modernism thrived and continued to be part of urban planning with minor revisions (Watson, 2009). In Nigeria, the planning legislation still being used was developed from 1950s-60s British planning law with revisions in the form of military decrees in 1976 and 1992. This resulted in entrenched top-down spatial planning management and design that continues to create conflicts in both social and spatial requirements which are different from the original intent. The large city masterplan with mono-functional zoning is the reference document for cities in Nigeria. Since most of these plans are decades old, they continue to be challenging to implement and maintain. However, the zoning component of master planning continue to play an important role.

Zoning is mostly a selective tool when it comes to its application in urban areas. Although, certain guidelines may be applied at large scales such as a city or metropolitan area. Zoning ordinances are tailored to meet local requirements with other subdivisions such as Health, fire and building codes. As a result, zoning ordinances have large effects on the provision of amenities and on land values which further makes it attractive to municipalities as a quantifiable policy approach (Ellickson, 1973). In the case of Nigeria, individual states develop their urban masterplans through a planning and development agency, which is then approved by the state legislature. The national capital is the exception to this and has an administrative agency supervised by a minister appointed by the president. The capital is a completely designed new city and with a non-elected administrative body has resulted in its planning policies being distinctive from other cities in the country.

As described in the last section the effects of the pre- and post-colonial master planning for cities has become embedded in planning policy across Africa. For instance, a change of use permit may be granted to the owner of the land but can be revoked by the municipality citing a violation of the original masterplan when there is a change of

management. This, as noted by Watson (2009), is a particular problem faced by planners especially in countries like Nigeria where urban managers view the city in terms of control and development based on the notions of modernization and the creation of ‘proper communities’ living and working in ‘proper urban’ environments. As such the objectives for land use zonings become skewed towards that of the ‘proper’ city.

The pursuit for the proper city, however, does not take into consideration the morphological nature of cities over time. The various active centers of the city are formed as a consequence of the concentration of several land-uses in a particular location. Non-residential land uses such as businesses and offices attract people, which usually lead to agglomeration of these activities. The resulting agglomeration becomes a focal point or a landmark for both location-finding and discernment of the general character of a city. Similarly, as agglomeration leads to peak activities in centers, these centers can also decline or evolve through gentrification and growth in the city through the development of new centers or changing economic conditions.

The contrasting effect of old zoning laws and significance giving towards a ‘proper’ city on the one hand and that of the morphology of the city due to inputs by users have become a challenging prospect for planning in Nigeria. This is more so in the reasons for creating the new capital city of Abuja and in other major cities tackling the challenges of rapid urbanization. Abuja embodies the ambitious planning ideas of a ‘proper city’ with designated land uses functioning as designed at the conception of the master plan. As Ebo (2006) concludes on the planning of the city—underscoring it as the continuation of colonial development and representing a contradiction of intentions behind its creation.

A major argument for the strict regulations of how the city of Abuja is designed and managed is credited to the military decrees leading to the creation of the city, and the resulting loop it created in terms of the need for changing the framework for the city on one hand and city users continuously readapting the existing urban framework. With decision making exclusively placed on the office of the minister of FCT, creating a lack of consistency in city management and decision making. For instance, land-use change guidelines only came into effect in the year 2007(appendix) after years of demolishing buildings because of land use changes that were approved but later considered unfit and not suitable to the original masterplan of the city (COHRE, 2008).

Although regulations provided for changes to land use such as; the various administrative committees and assent by residents within 100 meters of the plot, it also provided a percentage fee structure based on the intended land-use (appendix). However, there isn't any evidence of the processes being followed as well as including those of notifications of public hearings for assents.

2.3 Space Syntax as a Methodology for Analytical Understanding of Cities

Space syntax theory is based on a set of techniques developed by Bill Hillier & Julienne Hanson that began in the 1980s. It was developed based on the prior works on perception and functioning of urban spaces, such as Lynch (1960) and Alexander et al. (1977) as well as network theory, a part of graph theory developed in the 1970s. These sets of techniques are used in the analysis of buildings and urban spaces, by proposing an approach to the development of a theory of form and function (Hillier, Penn, Hanson, Grajewski, & Xu, 1993). Space syntax is primarily the analysis of the spatial configuration of buildings and cities and how they influence social life (Hillier et al., 1993; Karimi, 2012). The major propositions of space syntax are; space is intrinsic to and not a background to human activity, making it a non-discursive element, and that space is principally configurational (Hillier, 2010). Configuration in space syntax, as outlined by Hillier et al. (1993) is the relation between two spaces taking into account a third and at most, as the relations among spaces in a system taking into account all other spaces in the system. However, it is distinct from space relations which can be viewed as the interaction between a pair of related spaces alone. This provides for an analytical understanding of certain complex interactions/activities in cities.

The complexity of cities has existed in urban literature for a substantial amount of time. Although earlier in the 20th century the objective had seemed to be the simplification of how the city is viewed and designed, the latter half of the century saw an increased momentum for the understanding of the city and the complexity that comes with living in it. Complexity is underscored in the interrelationship of various elements of the city both in terms of its social interactions and in its spatial configurations. Space syntax seeks to be a quantifiable method for understanding these relationships (Al Sayed, Turner, & Hanna, 2009); That is, the underlying effects of spatial configurations on social interactions and vice versa.

The subsequent sections discuss various tools and measures, their development and importance in space syntax studies and a review of urban studies conducted using space syntax.

2.3.1 Axial lines

The axial line is the primary unit of analysis in space syntax. It is a series of fewest and longest lines passing through a *convex* space or street making the axial line principally based on a line of sight or unobstructed movement (Penn, 2003). The axial line of each space intersects with adjacent axial lines resulting in an axial map of the area. Each line represents a node as opposed to the use of intersections as nodes in network graphs, making it an inverted graph. This inverted nodal graph in space syntax utilizes a different type of graph developed by Hillier and Hanson (1984) called justified graphs or J-graphs. J-graphs represent the relationship of an initial node/axial line and the degree of control it has on lines that intersect it. Figure 2-1 shows a j-graph where the initial line 1 controls access to the subsequent nodes of the graph. Each subsequent level of the graph is called a *Depth*. As seen in Figure 2-1, Node 2,3,4 and 5 are depth 1 from node 1 and nodes 6 through 10 are depth 3 away.

Lines that are multiple depths away and not intersecting are calculated based on the shortest depths connecting them called step depths. A fundamental property of depth is asymmetry which determines the relative depth of a space with regards to a third space by determining how deep or shallow a space is in the system. However, due to a large number of nodes that can be generated from axial lines in an urban grid, the mean depth of each node to all other nodes is computed to determine the relative mean depth or relative asymmetry. The relative asymmetry of the nodes is then computed with relative asymmetry of a similar diamond graph with the same number of nodes as a consequence of its normal distribution of nodes across all levels (Bafna, 2003). This results in a ratio referred to as the Real Relative Asymmetry (RRA). The inverse of the RRA gives us the space syntax measurement of *integration* which is identical to the mathematical measurement of closeness. This means that the higher the integration values of a node, the more integrated it is in the spatial system. Additionally, it can be said that integration values measure the *to-movement* in the system.

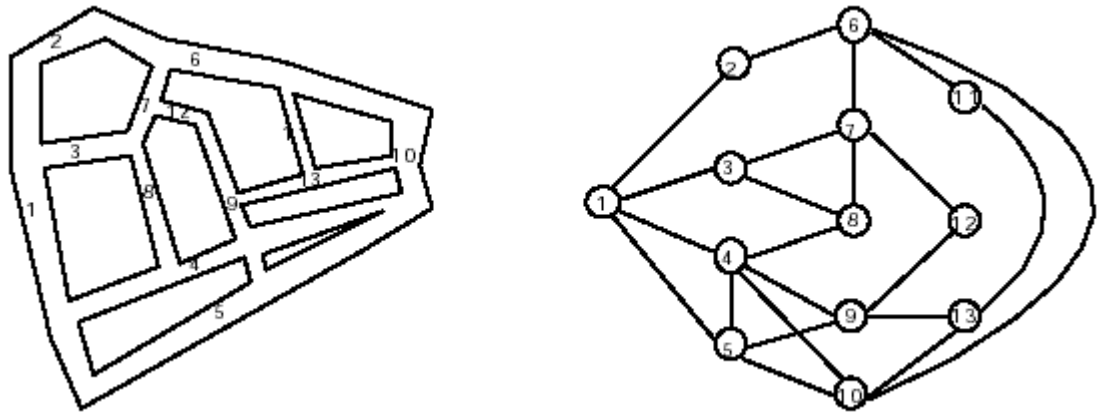


Figure 2-1 Depth illustration. Bill Hillier (1993)

The second measure in space syntax, referred to as Choice, is identical to the mathematical measurement of *betweenness*. Choice measures the probability of an axial line to be passed through on all shortest routes from all spaces to all other space in the system within a set radius. In other words, it measures the potential *through-movement* of the system.

Both integration and choice have consistently shown high correlations with human movement and activities in the spatial system. However, they do not take into account the nature of human movement in space based on subtle changes in turns as is it is perceived in curved streets. An algorithm developed by Turner (2001) introduces a weighing value to axial lines based on their angle of intersection with each other. That way curved streets can be analyzed as one long segment in the whole system instead of a series of individual axial lines, called a segment analysis.

Additionally, Hillier proposed a measure of intelligibility of the urban grid and defined it as a second measure of space syntax base on the correlation between connectivity of the axial lines with the integration and choice measures (Hillier, 2007). He further denotes that by analyzing the scatterplot diagram of the correlation we can abstract the level of intelligibility of a certain area. In Hillier's studies of movement economies and the effect of housing estate structures on security, he concluded that the if the scatterplot points of an area are crossing the regression line of the whole city in a steep angle then the more the area is distinct as well as the area leaning towards greater local integration than global integration. While on the other hand if the points of an area lie on the

regression line of the whole city, then the area is made up of small spaces that do not create a sub-area (Hillier, 2007).

2.3.2 Topological and Metric Weighing.

The topological nature of space syntax is often criticized for its lack of metric weighing, as questioned by Ratti (2004) on whether pedestrians are likely to choose the least number of changes in direction rather than shortest paths. This is however countered by studies in cognition and transportation which have shown route complexity as a higher variable in route choice than metric distances in urban networks (Conroy-Dalton, 2003). The use of these measurements is to further understand the relationship of not just one part of a city to another, but of all parts to all others.

Although, Metric weighting has shown the least correlations when compared with other weightings such as least angle changes which is a topological weighting; metric distance between weighing is also applied to space syntax to determine the distance between the center of a segment and the center of a neighboring segment measured in meters. The use of metric definition of distance creates a shortest path map of both integration and choice. Topological distance, on the other hand, is determined by the changes in direction. Where a value of 0 is assigned to a segment when there is no change in direction between a segment and its neighbor, and a value of 1 when there is. Topological distance, therefore, creates a fewest turns map.

2.3.3 Space Syntax in urban studies

The relative success of space syntax as a tool in urban studies can be attributed to not only its analytical nature of presenting the relationship of the urban grid and the functions that go on it but also in the various scales it can be applied to: from a building to a neighborhood to the whole of a country. This has given rise to theories on the socio-spatial relationships in an urban system. Space syntax has been linked to the creation of places and economic centers (Hillier, 1996; Hillier et al., 1993) and the process of creating these centers (Hillier, 1999), the distribution of inequality (Vaughan, Clark, Sahbaz, & Haklay, 2005), as well as in historical research (Griffiths et al., 2013) and the decline of streets and cities (Griffiths et al., 2013; Psarra, Kickert, & Pluviano, 2013).

Over time, as cities grow, they acquire a dual structure of a dominant foreground (longer lines and linear continuity) and background (shorter lines and less linear

continuity) structures (Hillier, 1999). Hillier also refers to this structure as the deformed wheel; the foreground lines highlight the main arterial roads as well as the major commercial centers. Foreground lines are particularly more prominent in cities that grew organically from around a hub and spread to the edge of the city. The background structure, in contrast, highlights short residential streets and estates representing the least integrated parts in the structure (Figure 2-2). This is reinforced through the inherent linearity in human movement coupled with the concepts that space, movement and their multiplier effects give cities their characteristic structures.

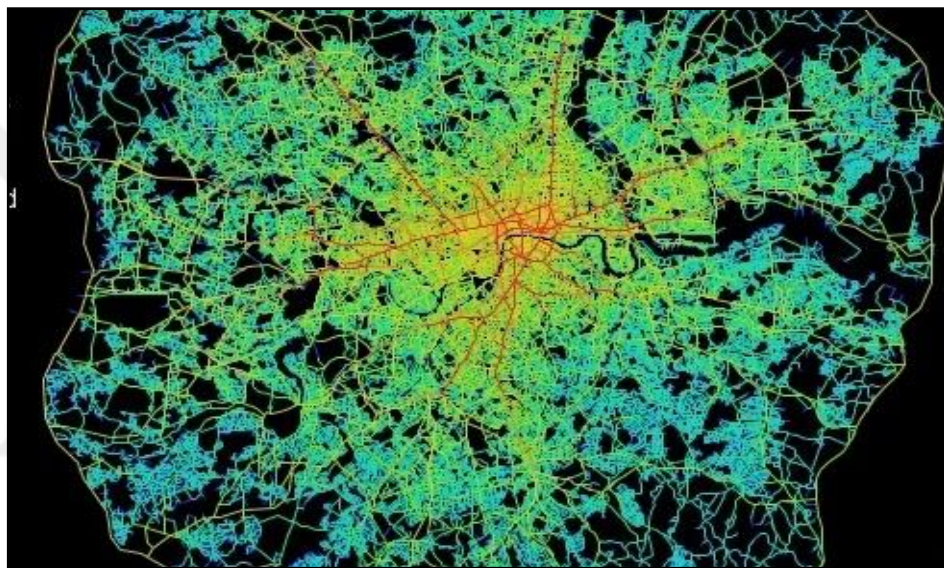


Figure 2-2 Deformed wheel structure of London. Bill Hillier (1999)

The deformed wheel reflects the structure of many cities, notably cities that have grown from small agglomerations that later become the core of the city. In a paper comparing the axial maps of Atlanta, Manchester, The Hague and Hamedan; Hillier (2002) found that the cities had distinct deformed wheel structures despite having different geometry types based on their line lengths and angle of intersections. However, axial studies of an entirely planned city like Brasilia show a different structure and absence of the deformed wheel (Figure 2-3). Two theories put forward by Hillier (2002) explaining this difference between cities that developed organically and planned cities are in the way axial lines are intercepted and in their geometry in terms of line lengths and angle of intersections. When an object is placed in the middle of a line, it interrupts the line of sight and increases distribution on both sides of the line

than when placed at the edge. In organic cities, axial lines are usually short, and lines of sight are interrupted by buildings at small angles. However, in a planned city such



Figure 2-3 Axial map of Brasillia (Wiki Commons)

as Brasilia axial lines are long and interrupted at wide angles. As the lines are longer, they are also intersected by more lines and resulting in a high level of control for long lines in the whole system.

Though space syntax has been used as an analytical approach to the relationship between the urban configuration of cities and the social activities that go on in them. A number of authors have been critical to some of its components, primarily in how the axial line is generated (Ratti, 2004), the exaggeration of correlations which may have been as a result of unrelated forces, the limits of its epistemology in relation to three-dimensionality of built forms (Netto, 2016), as well as its dependence on topological distance rather than metric distances. While the subjective nature of drawing the axial line manually have been argued against it, it has shown to have no significant effects on results when compared with automatically generated lines despite the limitation of computing power in generating lines for large areas such as cities (). Likewise, the urban form in space syntax is explored in the form of accessibility, and as such the role of building height is in how its function(s) impacts movement. Finally, although metric distances are used in space syntax analyses studies have shown that people utilized

topological distance in terms of reducing the number of turns while traveling between destinations (Hillier, 2012).

2.3.4 Street network configuration and Land Use Distribution

Cities across the world and in some cases an entire country often exhibit similar geometrical properties as a result of the configuration of their street networks. However, a major distinction is in how their physical properties at the street scale are created and the functionality they are allocated. The role of both the geometrical and the physical in an urban area can be observed based on their temporality. While the geometrical have long term influence and coupled with a degree of permanence, the physical readapts faster to changes to reflect contemporary functionality. This is chronicled in instances when small scale industrial streets have over time transformed into fully residential or commercial streets while in some others, municipalities have tried to revitalize urban streets with commercial activities through zoning ordinances and incentives without success. Although the economic view of this relies on agglomeration, heterogeneity and traffic, it does not identify why some locations may fail when municipalities try to make them active areas of specific functions.

Additionally, urban space is perceived in three-dimensional form whereas human movement is unidirectional. Space syntax represents the possible movement of humans into a series of networks connecting an origin and all potential destinations. Early urban models and plans usually apportioned the city base on the origin-destination model especially in the allocation of economic centers without consideration for the properties of the connecting street networks. However, these street networks when considered as a collective play a vital role of determining how the origin connects to the destination by influencing human movement.

Space syntax analysis has also shown correlations between the concentration and development of economic activities with the integration of a street in terms of its control of *through-movement* in the network (Hillier et al., 1993). Hillier refers to this as the “movement economy”, where he argues that the most active areas/centers are as a result of settlements creating movement patterns, which influences land uses and the resulting multiplier effects leading to increased intensity in an area. He further extended the argument towards understanding centrality as a process of interaction between street networks and land uses rather than a static function in the city (Hillier, 1999). For

instance, in a study of multiple areas of Atlanta Ozbil, Peponis, and Stone (2011) found the hierarchy of a street in a syntax network has an influence on the distribution of pedestrian traffic in a city. Similarly, in a study of the decline of Detroit tracing from its pre-industrial form, the active centers were located in the most integrated parts of the city even as the city declined later (Psarra et al., 2013). Space syntax has consistently reflected the influence of movement and land-use in the shaping of the intensity of activities in cities especially while reflecting on the effects of time and expansion of the city.

While individual cities have unique spatial structures, they can be influenced by planning decisions that affect their development at multiple phases, as the case of Barcelona and Manhattan, which were compared by Al Sayed et al. (2009). In the case of these cities, both started as organically formed structures, which were then expanded using modernist grid layout concepts. They argued that the grid parts of the cities had to undergo optimization process which deformed the grid and evolved new centers. Though the old centers still had a high integration, the deformed grids of the cities result in long continuous lines that branch and connect the city preserving the continuity of the city pattern and its optimization.

3 BACKGROUND: PLANNING, HISTORY AND URBAN FORM OF ABUJA

3.1 *Introduction to Abuja*

This section introduces a brief history of the development of Abuja. It highlights the effects of certain decisions and circumstances leading to the existing form of the city. It then examines the concept of the city and the influences of other purpose-built capital cities. Finally, it will also look at the forms and characteristics of the case study districts.

Abuja, the purposely designed capital of the federal republic of Nigeria, was founded in 1975 by the then military government based on the need to have an administrative capital city similar to Washington DC and Brasilia (IPA, 1979). The need for a new capital was further reinforced by the increased density and population growth of the port city of Lagos, the then Capital. Also, to serve as a unifying city after a secession attempt led to a four-year civil war.

The government commissioned International Planning Associates (IPA) a coalition of firms that submitted an entry for the masterplan competition to design a new capital city at the heart of the country. The new capital initiated as a result of challenges that were being faced in the then capital Lagos: a coastal city at the southern edge of the country, which also made it further away from the other states of the federation in the far North (Figure 3-1). Lagos being the colonial capital before independence was inherited from the colonial era which made it essential for international trade but unusual for the general administration and multicultural nature of the country (Nwafor, 1980). Lagos was also facing threats from rising sea levels as well as traffic congestions and a very rapid population growth resulting in the need for a Capital city that is more inland.

The selection of the present location of Abuja was made so as it could be more accessible from every part of the country (to be within five hours from the farthest states that comprised the country). As stated in its development guideline, "...to be an administrative capital and a center of unity for all Nigerians" (IPA, 1979). Considered to be among one of the most ambitious planning projects of the 20th century its design needed to reflect the designation. The location of the capital territory was selected to be at almost the center of the country. The actual city was decided to be located in the village of Abuja at the foothills of Aso Rock, a 400m rock outcrop that was selected as the focal point of the city (Elleh, 2016, p. 13).

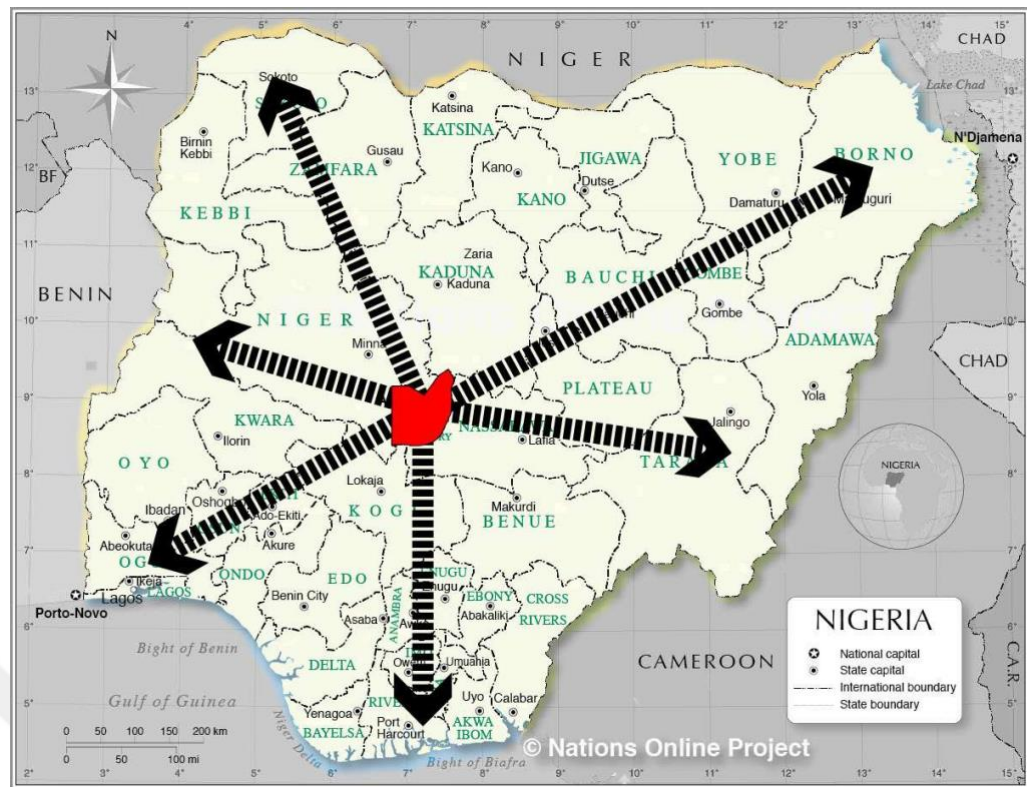


Figure 3-1 Location of Abuja with reference to the whole country.
 (https://www.nationsonline.org/oneworld/map/nigeria_map.htm)

3.2 Concept and planning

While the official declaration for the new capital was made in 1975, preliminary works and creation of the master plan were conducted between 1976 to 1979. The masterplan relied strongly on the ideas of Washington DC, USA; Brasília, Brazil and Islamabad, Pakistan as case studies for its development IPA (1979). The evidence of the influence of those cities as case studies can be seen in the crescent shape of the city, which is similar to that of Brasilia with a central business district and main bodies of the government linked to a natural monument. A lake in the case of Brasília and a rock outcrop in the case of Abuja. While the Abuja design dropped the superblock idea from the Brazilian capital, this was primarily so the city can easily grow along the end of the crescent. The planners did, however, borrow the Sector-District idea of Chandigarh. This comprised of a sector with four districts sharing a common sector center and individual district centers (Figure 3-2). These centers are to serve as active points for their sectors as well as their connection to the rest of the city with the location of transport hubs. It is also primarily based on the multi-nuclei urban form developed by Harris and Ullman (1945).

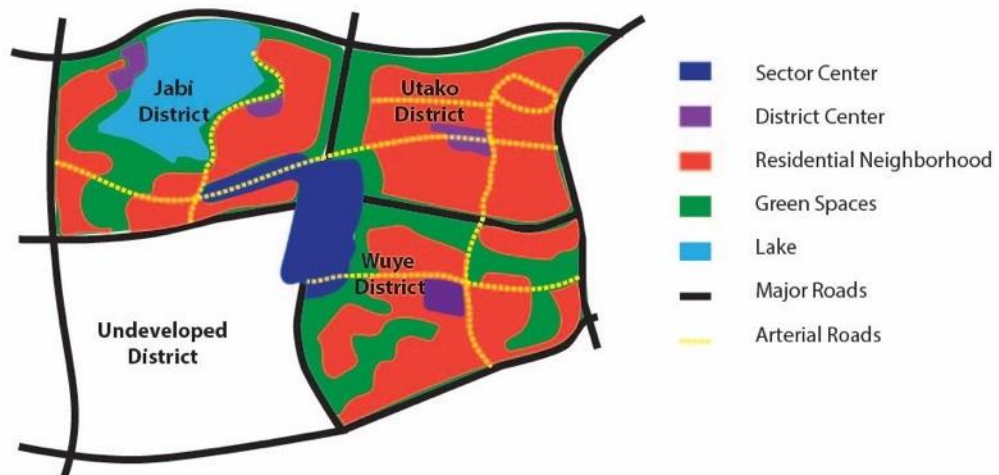


Figure 3-2 Typical sector representation FCDA Land-use map

The masterplan proposed a phased development which was divided into four phases separated by arterial roads and added as the city grows eastwards (Figure 3-3). The first phase covers the central business district with two adjoining sectors north and south of it. Subsequent phases included 4 sectors each in turn containing four districts, a major characteristic influence from Le Corbusier's design of Chandigarh, India.

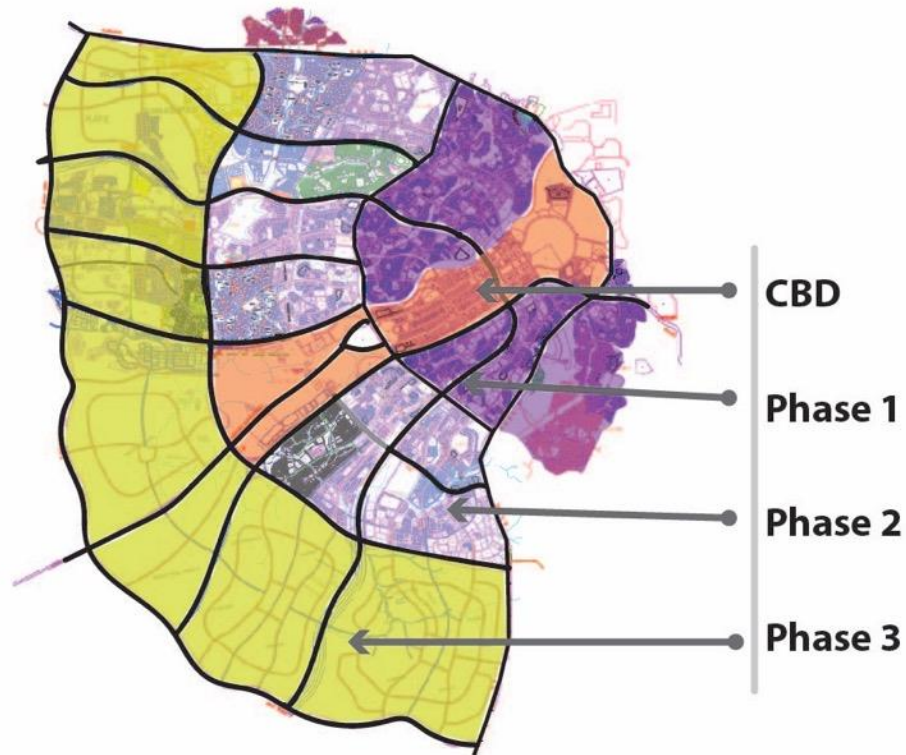


Figure 3-3. Development phases of Abuja.

The design of an entirely new city, although ambitious, usually suffers from the fallacy of utopic ideals as the consequences of design decisions surface as the city grows (Rodwin et al., 2013). A report on new capital cities in Africa (Pfaff, 1988) identified funding to be a major influence in delay and development of new capital cities a few years after they have been planned. Abuja, like its sister cities, faced an identical problem that will go on to inhibit its development. In an interview on the development of Abuja's master plans a designer involved in the project highlighted how Nigerian authorities insisted on "exorbitant demands/requests for the new city by citing the availability of funds for the project" (Take, 1984). However, by the time construction started in the early 1980s the country was struggling in the development of its new capital territory and failing to meet its development goal guidelines. The project was suffering from both political influences and the misconception of modernist urban planning which frames the city in terms of having a set view of how it must eventually look and function, as well as objectively restricting population to a number and a growth at a specified rate.

The masterplan of Abuja was designed with a target population of around three million when it is completed (IPA, 1979). However, the city exceeded these numbers with less than 50% of the city completed and has continued to face these challenges (COHRE, 2008; Nwafor, 1980). A few factors have been attributed to its slow development. These include financial difficulties because of decisions made at its inception when Nigeria was earning a lot from crude oil exports in the 1970s. However, by the 1980s the country was in recession, which led to a military coup d'état in 1983. Among the reasons for the coup was the high cost of constructing the city and the subsequent suspension of its development. The capital was finally moved to Abuja in August 1991 by military decree. And by the year 2000 when the original masterplan was due for a review after 35 years only the first phase of the city had been completed. The population of the municipal area had already grown beyond its designed capacity and had spawned several shanty towns at the periphery of the city, which can be attributed to rising housing costs coupled with the slow development of infrastructure.

In the early 2000 accelerated development of the second phase was initiated. These were residential neighborhoods to complement the four districts from the first phase. In 2003 the minister responsible for the administration of the capital Nasir El-Rufai began a campaign for the restoration of the Abuja master plan. This campaign included the clearing of slums and villages considered illegal in the undeveloped parts of the city as well as the demolition of commercial centers that were not in the original masterplan. This resulted in criticism of the city administration on being fixated on its physical looks while avoiding the underlying social challenges and needs of the city, as well as reliance on a homogenous rather than a heterogeneous approach to the form of the city (COHRE, 2008; Ebo, 2006; Watson, 2014).

The design and development of Abuja was overseen by both local and foreign consultants although, the bulk of the masterplan was developed by international consultants with rooted ideas of modernism and a Western conception of urban form. For instance, Kenzo Tange designed the central business district together with a few government buildings, and as Elleh (2016) maintained, is a replica of some of his works in the Middle East. The influence of Modernism and its Western influences is further reflected in the composition of public spaces, commercial activities and highway systems, achieved through the clear delineation of these activities. The formal separation of these activities, especially at the district and neighborhood scale with

broad boundaries, creates contention for the urban space that has proven difficult to reconcile. This is largely impacted by the design of the districts and the cultural interactions and activities that go on in them.

3.2.1 Urban Form of Wuse II District

Wuse II district forms part of the first phase residential districts of Abuja. It was developed as a medium density district to accommodate the first batch of civil servants that were transferred to the city in the late 1980s. Located North of the Central Business District, the district includes two sectors, each with its amenities and services cluster (Figure 3-4). On the masterplan of the city, the district is designated as a residential district with some selected areas allocated as 'employment' zones. Whereas the employment zones are clustered together and are largely government agencies, the residential plots are grouped based on their density. Medium density plots for semi-detached as well as single family houses and high density for block of residential flats for four to six families.

The district is designed around a street network that is made up of a hierarchy of four-lane arterial roads that connect to other districts, two-lane collector roads that allow movement between sectors and local streets that directly connect to residential properties. Shaded sidewalks complement the roads on both sides and the addition of medians in the case of arterial and collector roads. Buildings on local roads are set beyond a right of way of 21meters from the roads. While their perimeter fencing is restricted to a height of 1.8meters to promote visual continuity. Although the provision of street parking has been made, the increase in density makes them inadequate on the busy streets leading to the use of pedestrian walkways for parking.

The building fabric is a blend of single-family housing units and low rise apartment blocks. It also includes fenced estates assigned to government agencies (Figure 3-5). All developed plots in the district are fenced and gated in one form or another except for retail-based plots on major roads that have been converted from residential use. Fences are eliminated to provide direct access from roads, further incorporating the building into the public sphere by eliminating the buffer fencing provides. The elimination of fences also goes a long with redesigning of the façade of the building to create an aesthetic to identify the new use of the building. However, in some instances some form of cladding or signage is used without tempering with the building itself.

Despite being designated a residential district, the two main collector roads of Aminu Kano and Adetokunbo Ademola crescents in both sectors are among the most active commercial streets in the city. Residential plots on these streets that were previously fenced have the fences demolished when the functions of the buildings on them change to non-residential functions (Figure 3-5b).



Figure 3-4 Land-use designation Wuse (Abuja Development Control Agency, 2017)

Although, the planning code of the city allows for the change of land use, the constant changes in policy objectives with themes such as returning the city to its original masterplan have continuously been a point of contention. Whereas many plots reflect their use functions on recent zoning maps, there are buildings whose uses have been altered and have subsequently been labelled with large red warning markings for their functionality to be reverted to the old zoning functions even when approval had been granted prior to the start of the conversion.

Also, a unique characteristic of land use in the district is that a plot is either commercial or residential with no mixed-use functionality. This is attributable to the original masterplan designating use zoning at the plot level, and subsequent change applications are only approved if the change of use is to a nonresidential function and not a mixture of both. Activities are clustered around the two main arterial roads, and neighborhood

streets as no buildings are allowed by regulation to be accessible from the main arteries that cross through the district.



Figure 3-5 Typical building forms in Wuse (a) Building marked for reversal to previous land-use (b)&(c) Flats changed to commercial building while maintaining residential typology (d) A typical commercial low-rise building. (July, 2017)

Furthermore, the colocation of most of the non-residential land uses on certain streets and the bustle of activities they have attracted also created a second level of informal activities. These activities such as food hawking and sale of goods from car trunks parked on walkways also resulted in blurring of the space meant to delineate the buildings and roads (Figure 3-5d).

3.2.2 Urban form of Utako district

Utako/Jahi/Wuye districts form sector B3 which forms part of the northern axis of the second phase of the city. The sector was designated for completion by the middle of the 1990's, Development however did not start until the year 2003 through an accelerated development program. The sector is located East of Wuse II district and is also bordered by expressways on four sides, with two others dividing it into

neighborhood quadrants of which only two have been fully developed, the third partially built while the fourth is yet to be developed (Figure 3-6).

The design of the district makes provisions for a sector center that is zoned as the central commercial area and the location for public utilities such as the water treatment and electricity distribution plant. It also includes a hub for public transport and a large market. The arterial roads leading to the sector center have land uses zoned as mixed use or commercial use on the masterplan. However, they can only be accessed through the interior of the neighborhood segment they are situated in and cannot be accessed from the arterial roads, although some buildings have over time added pedestrian accesses.



Figure 3-6 Utako land-use map (Abuja Development Control Agency, 2017)

The building fabric of this district comprises of midrise commercial, offices, residential apartments and single-family dwellings. The location of nonresidential uses along arterial roads also resulted in their influence on residential buildings adjacent to them in the neighborhoods. While each neighborhood has a small shopping center to serve the surrounding residences most activities are clustered around the large commercial plots. The impacts resulted in land-use changes occurring largely along these plots (Figure 3-7).

Due to the development of the district by largely businesses and private individuals as opposed to the government in older district, the building typology varies across different types and character. Furthermore, land use changes were often secured before construction commences and as such changes are reflected at the masterplan level and often do not reflect the typological characteristics of a residential building that has been changed to a commercial building.

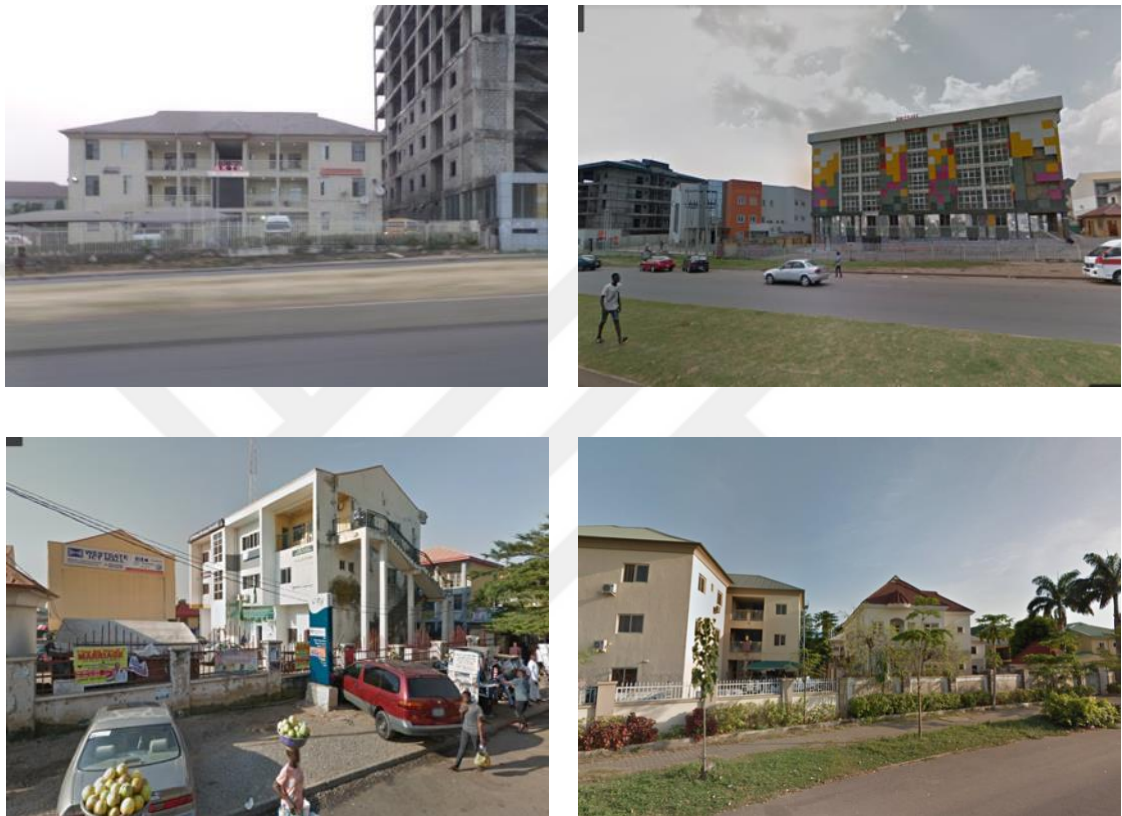


Figure 3-7 Residential themed office in a mix use plot, (b) office buildings (c) Residential plot now commercial (d) Typical residential buildings. (July 2017)

During the development of the district in 2003 the government had to clear out the slums and some of the villages located in the proposed district. While most of the villages were demolished, a few remain with their original organic forms and densities (Figure 3-8). The presence of villages also meant not all development of the master plan of the district was realizable in terms of the targeted density, form and development control. Although considered outside the realm of official planning policy and guidelines, the villages were permitted to occupy their present locations due to the failure of an earlier resettlement process to move the original indigenes of the area. The villages later subdivided their farms which resulted in the creation of a series of low-

income clusters. The presence of these villages also contributes to the presence of high intensity centers and paths as they have a higher density and are more organic as compared to the surrounding planned neighborhoods. As land prices continue to increase and the city expanded some of these cluster of villages have contracted to give way to new developments.



Figure 3-8 Village clusters in Utako District (Google Earth, 2017)

4 STUDY DESIGN

4.1 Study Area

The study area includes two districts of Abuja metropolitan area, one each from the first and second phases of the development of the city developed over a span of 30 years. The district of Wuse II is 8 km² district located between the CBD/National complex and the low density Maitama district. It was among the earliest built districts to provide housing for civil servants transferred to the city from the former capital.

The district of Utako forms part of the second phase of development located West of Wuse II. The district is made up of four neighborhoods with a central service sector. It is 16 km² although mostly made up of a large lake in one of its sectors. The aim is to study the relationship between land use changes and street network configuration representing the two phases of Abuja's masterplan and to identify whether the association is constant or varies according to the different urban form characteristics.

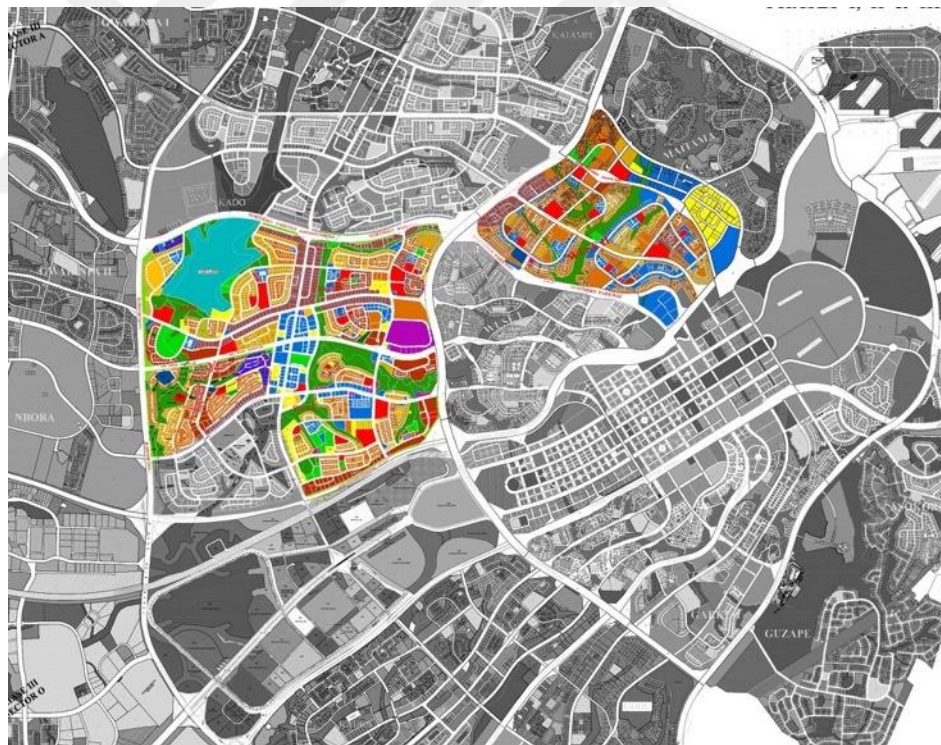


Figure 4-1 Study areas. (Abuja Development Control Agency, 2017)

4.2 Methodology and Data

The research question is on the effect of urban street networks on land-use and it incorporates the use of space syntax tools and measures to analyze the city and the

districts being studied. Axial lines of street networks of the metropolitan area were drawn in AutoCAD from google satellite images for the years 2003 and 2015 to identify the changes in the street network configuration within a 12-year period. The year 2003 is used as the earliest base map as it is the year the development of the second phase began and the limit of clearest and most usable satellite images from google earth.

Space syntax measures of segment choice and segment integration were used to evaluate the configuration of the street layout using Depthmap for QGIS. As highlighted in the literature, segment analysis has been shown to be a more accurate technique to objectify urban networks (Barros, Kneib, Paiva, & Tedesco, 2014; Turner, 2001). The analysis includes the use of angular weighing of turns which reduces the effect of axial lines on curved street networks. Choice measures at radius 500m, 1000m and a global radius were used at the city level. However, only 500 and 1000m radii were applied at the district level of analysis. 500m and 1000m radii reflect the possibilities of passing through a street at the pedestrian level and 10000m radius reflects Choice at the vehicular level. Segment Angular integration was measured using step depths of 3 and 10 for the analysis of local depth and radius n for the analysis of global depth. The results of the analysis are presented graphically using a red-blue color gradient, with red representing the most integrated axial lines and blue to representing the least integrated lines.

The dissertation relies on secondary datasets of land-uses that includes the original land-use map of the first phase designed in 1989 and a revised land use map from 2015. The year 2015 is used as it is the most up to date land-use map of the city that was accessible at the time of the research. A survey of existing uses was also conducted across the study districts of Wuse II in the first phase over a two weeks' period. The 2015 land use map and self-conducted survey of uses were used for the second phase development district of Utako.

The land use zoning data was then layered over satellite images from google maps and AGIS (Abuja Geographic information systems) and the designated use for each plot was identified on QGIS- an open source GIS software. While it is common to designate only ground-floor uses in nonresidential land use studies, this research assigns land uses at the plot level. As the primary unit of analysis, the plot level land-uses was selected as the basis of analysis. The land-use were categorized into Educational, residential, Public and Commercial. The decision to utilize plot level land-uses is supported by the

stringent administrative approach to zoning in the city which is mainly concerned with functions at the plot level.



5 ANALYSIS AND RESULT

This chapter includes space syntax analysis using Depthmap and land-use analysis of the study area as divided into two sections. The first section includes the choice and integration analysis of the whole city of Abuja after the completion of the first phase and the most recent stages of the second phase. The analysis uses axial lines generated from satellite images of the year 2003 and 2015. This to relate the two neighborhoods to the wider context of the city i.e. their role in the global system. The section also includes analysis of each neighborhood to determine its local syntactical properties. The second section compares and analyses the various land use changes in the study districts and the relationship with their original planned uses.

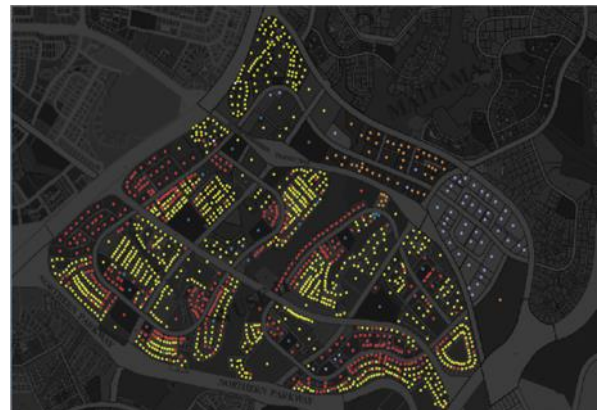
5.1 *Land-use Data*

5.1.1 Wuse II land-use Analysis

Figure 5-1 shows the distribution of land-uses in Wuse District at its inception and as it exists in 2017. In the East there is a cluster of employment zones made of office buildings and government agencies while the North-Eastern cluster is designated as a commercial zone. Additionally, there are small clusters of neighborhood shops in each sector. From Figure 5-1 it can be observed that there is an increase in commercial activities around the main arterial roads of Aminu Kano Crescent and Adetokumbo Ademola crescent. In Table 5.1 it can be observed that no new plots were added in the district there is however a significant drop in residential plots from 83.19% to 65.96% while on the other hand there was an increase in commercial plots from 11.69 to 29.12% of all plots in the district. However, there were no observable changes in both government and educational plots.



(a)



(b)

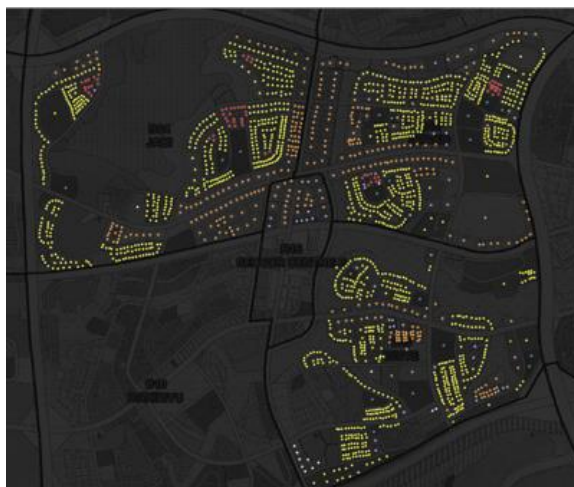
Figure 5-1 Wuse II land use data 2003 (a) & 2017 (b)

Land-use type	2003	%	2017	%
Residential	1252	83.19	992	65.96
Commercial	176	11.69	438	29.12
Educational	27	1.79	23	1.53
Public	50	3.32	52	3.46
Total	1505	100	1504	100

Table 5.1 Land-uses changes

5.1.2 Utako Land-Use Analysis

Figure 5-2a shows the distribution of land-uses in Utako according to the masterplan while Figure 5-2b shows the land-use distribution as it exists. The of land-uses in such a way that the main arterial roads in the district have already been designated as mixed-use zones. However, in the Jabi sector of the neighborhood, the neighborhood shopping cluster have become residential plots while in the Utako neighborhood there are plots that have changed from residential to commercial plots. In Table 5.2 it can be observed that the was only a slight increase of residential plots from 73.82% to 74.68%, there was a more discernable increase in retail plots from 3.75% to 5.03% while mixed use plots lowered from 19.47 to 17.47.



(a)



(b)

Figure 5-2 Utako land-use Masterplan (a) & Existing (b)

Land-use type	Masterplan	%	Existing	%
Residential	1475	73.82	1513	74.68
Commercial	75	3.75	102	5.03
Mixed-use	389	19.47	354	17.47
Educational	19	0.95	19	0.94
Public	40	2.00	38	1.88
Total	1998	100	2026	100

Table 5.2 Utako Land-use changes

5.2 Segment Map Analysis

5.2.1 Integration Analysis of The Whole City

The integration analysis of the axial maps of Abuja (Figure 5-3) reveals the structure of the streets at a metric radius of 500m (Figure 5-3a) and a global radius (Figure 5-3b) of the whole city from the 2003. At the radius of 500m the grid shaped Central Business district is the most integrated zone. However, a few arterial roads in residential neighborhoods are also highly integrated in the system while the main expressways are fragmented because of their lower integration values. Conversely, at the global radius the long expressways delineating the city into districts and sectors are the most integrated lines. Arterial streets connecting through neighborhoods form the second order in terms of integration at global level. While the least integrated streets are short internal streets and districts that are at the periphery outside the first phase.

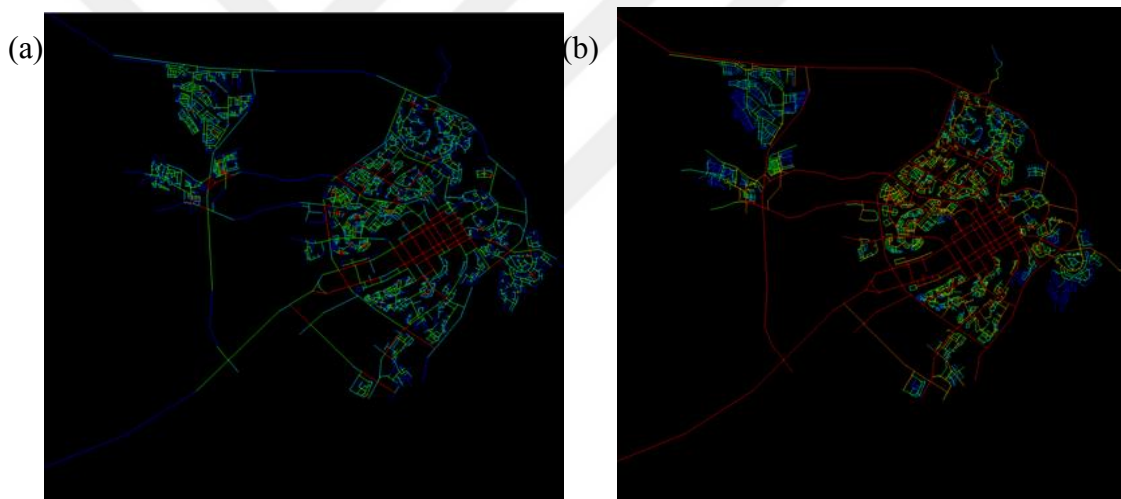


Figure 5-3 Integration analysis radius 500m (a) and Global radius (b) 2003

As the city expanded the integration at radius 500 (fig 2.a) can be observed to have averaged out while the Central Business Districts still maintains the most integrated lines. Pockets of high integration can be observed in almost every district with the district of Wuse having the most integrated streets after the CBD. Integration at global radius (fig 2.b) has the central business district and the expressways as the most integrated axial lines as well as arterial roads delineating neighborhoods. The doubling of axial lines between 2003 and 2017 also resulted in the doubling of maximum integration values with a slight increase in minimum integration values (Table 5.3). Finally, the intelligibility of the system which measures the correlation between the

most connected streets and integration values at the global level shows a drop in from 0.3697 to 0.3146.

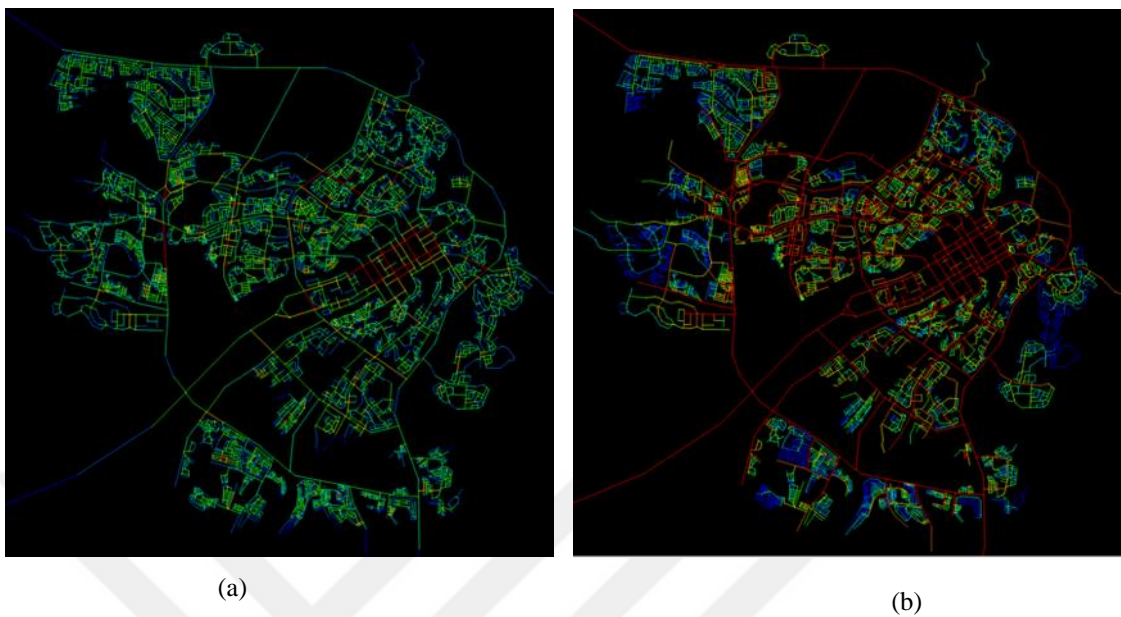


Figure 5-4 Integration analysis radius 500m (a) and Radius Global (b) (2017)

	Global Integration (2003)	Global Integration (2017)
Axial Lines	4980	10081
Min NaIn	0.2854	0.3378
Max NaIn	1.0453	2.0355

Table 5.3 Min-Max Global Integration values

5.2.2 Choice Analysis of The Whole City

Choice analysis measures the likely hood of passing through a street segment through the shortest route in the system. From the (Figure 5-5) it can be deduced that the early stages of the city, the Central Business District has the most control of access at radius-3 while the line intersecting Wuse II and its bordering expressway have the most control of access amongst the residential neighborhoods. Conversely, the choice analysis at radius-n shows almost all streets in the city are within the radius of a segment with a high choice measure. The most prominent segments after the expressways are the

arterial roads that connect from the center of the city to the periphery. Similarly, by 2017 there is a noticeable drop in high choice measure segment at radius-3 with pockets of short segments catering for neighborhood clusters (Figure 5-6). The global choice measures on the other hand highlights all the segments representing expressways and arterial ways together with long segments in the districts. However, there was just a marginal change in maximum choice measures between the two periods.

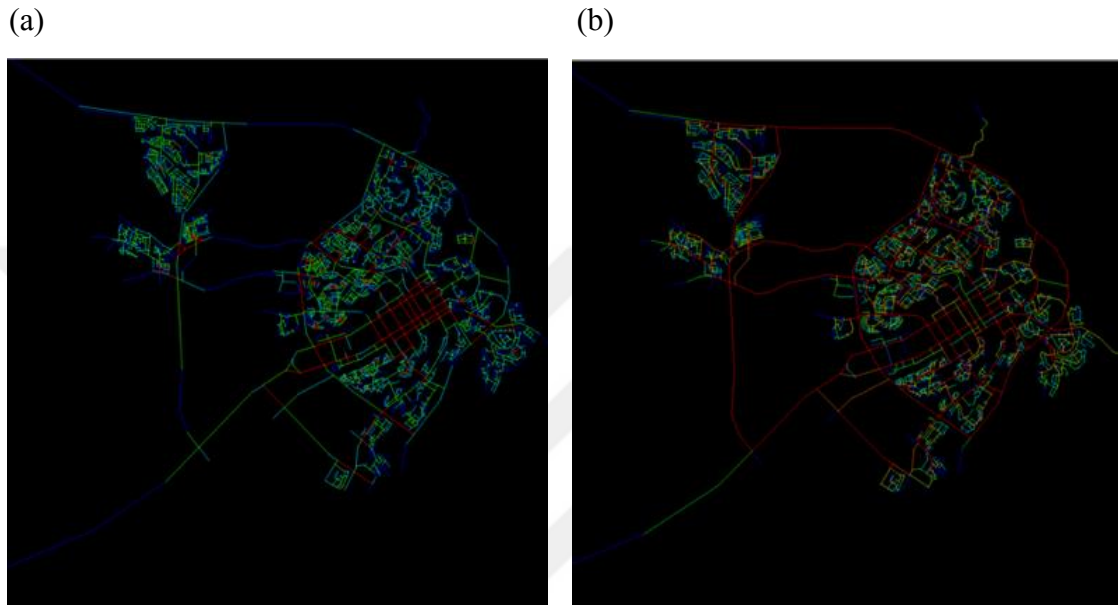
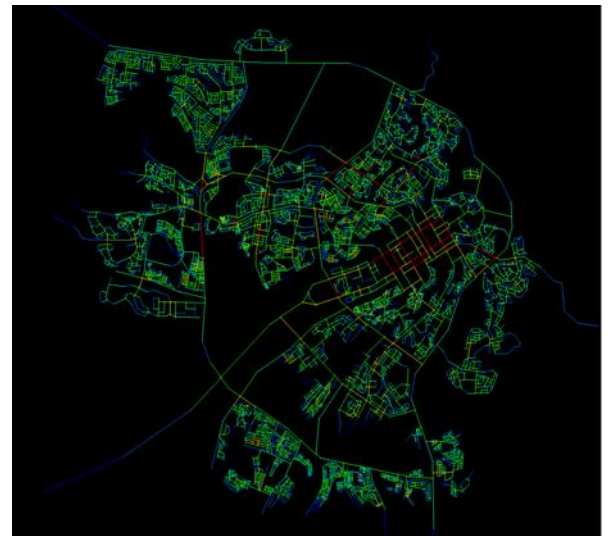


Figure 5-5 Choice Analysis Radius-3 (a) & Radius-n (b) 2003

Figure illustrates the intelligibility of the street segments in terms of the correlation between connectivity and choice measurements between the two periods. The correlation results show only a marginal decrease in terms of choice intelligibility of the segments from 0.5529 to 0.5321.



(a)



(b)

Figure 5-6 Choice Analysis Radius-3 (a) & Radius-n (b) 2017

	Global Choice (2003)	Global Choice (2017)
Axial Lines	4980	10081
Min NaCh	0.0	0.0
Max NaCh	1.4685	1.6452

Table 5.4 Min-Max Global Choice 2003 & 2017

5.2.3 Wuse II District Analysis

Figure 5-7 represents the various integration measures of Wuse district relative to non-residential land-use distribution. In terms of both metric and topological integration at the global level the expressways passing through the district are the most integrated segments. Although there is already a commercial plot cluster on Aminu Kano crescent new large clusters have also been formed on Adetokunbo Ademola crescent where most of the street segments are well integrated.

Additionally, at the local radius the district is not well integrated both on the topological and metric weightings. Although, the main arterial crescents form the most integrated segments of the district.

Figure 5-8 shows the analysis of choice measures, which is a likelihood of passing through a street segment using shortest paths. At the global radius there are no observable changes in both metric and topological analysis. However, at radius-500m the main expressways have the lowest choice measures at both temporal scales. While Aminu Kano crescent and some segments of Adetokunbo Ademola crescent have the highest choice values in 2003, this is lower compared to 2017 which average choice measures across the district. At topological radius-3 the preliminary masterplan has short segments with high choice values around the neighborhood shop clusters by 2017 radius-3 choice values are highest in internal residential streets.

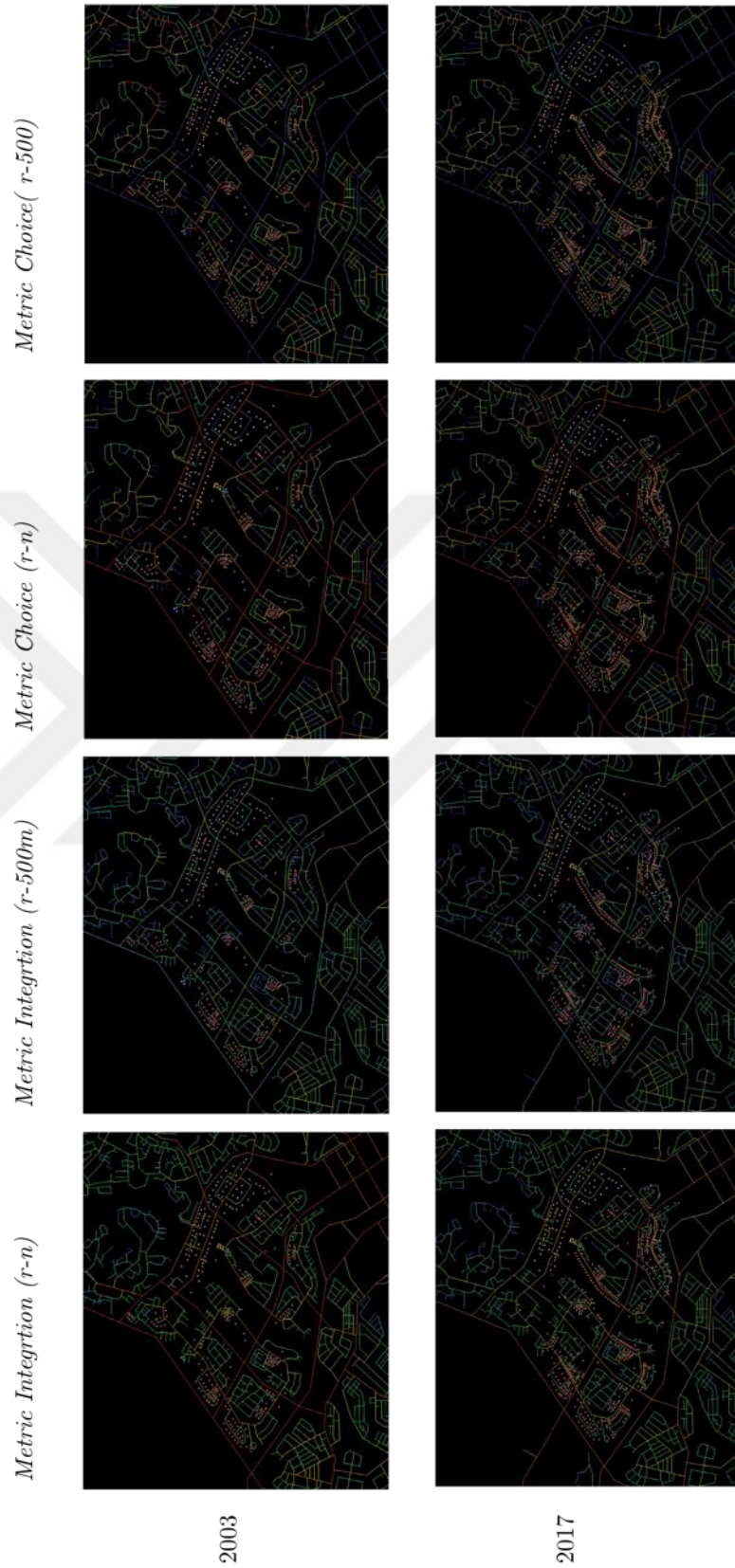


Figure 5-7 Metric and Topological Integration of Wuse II 2003 and 2017

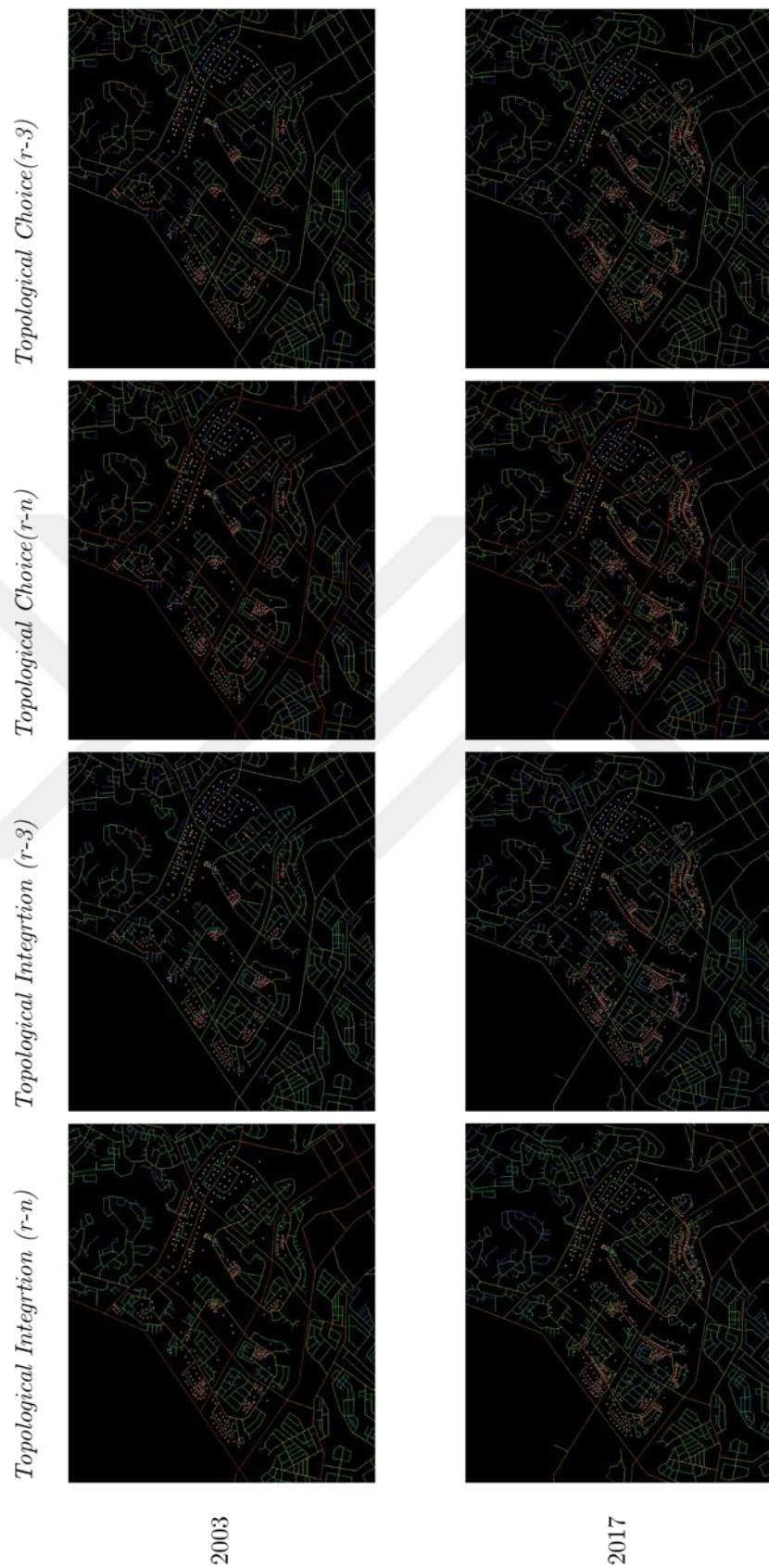


Figure 5-8 Metric and Topological Choice of Wuse II 2003 and 2017

5.2.4 Utako District Analysis

Figure 5-9 illustrates the metric analysis relative to nonresidential land-uses of Utako district. Although the most integrated streets are the radius-n are the arterial roads dividing the district into neighborhood quadrants. Retail activities by virtue of their entrances are located on third order neighborhood streets while the designated neighborhood shops are segregated away from the main commercial clusters. Additionally, at a radius of 500m the district is very segregated as most segments are on the lower end of the integrations scale. However, global choice analysis highlights a significant portion of the neighborhood arterial roads while the local radius measures highlights the cluster of high-density low-income neighborhood with the most local accessibility.

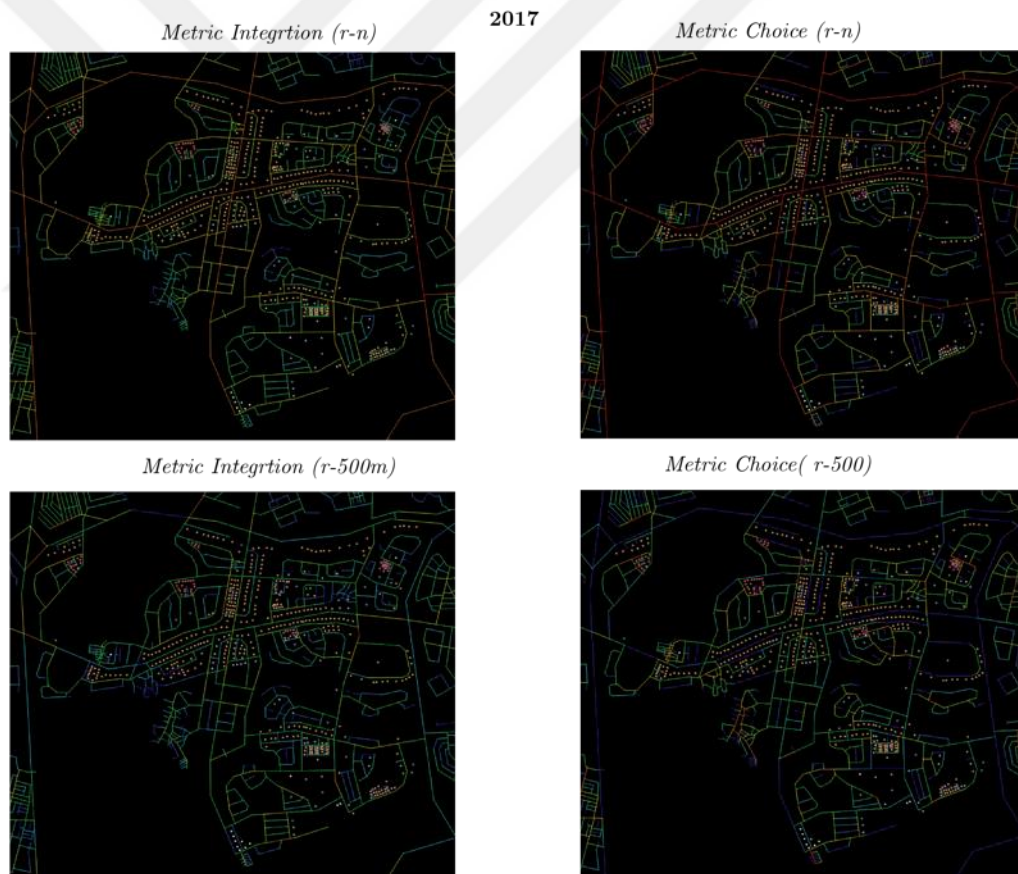


Figure 5-9 Metric and Topological Integration Analysis of Utako

Topological Integrtrion (r-n)

2017

Topological Choice(r-n)



Topological Integrtrion (r-3)

Topological Choice(r-3)



Figure 5-10 Metric and Topological Choice Analysis of Utako

6 DISCUSSION AND CONCLUSION

6.1 Discussion

From the analysis in the previous chapter, it showed that overall the city of Abuja upon the completion of the first phase did not exhibit a defined foreground and background properties of urban street segments. However, as the city expanded the foreground structure of the street segments became highly defined and integrated, with the least integrated segments at the periphery. Although, expressways that create borders around the district, as well as the whole city, are the most integrated components of the city. The grid structure of the Central Business District has also shown to be a major component of the structure of the city, creating a concentration of high integration street segments. Furthermore, the segment analysis of the city conforms to Hillier's theory of deformed grid cities (Hillier, 1999).

The analysis of Wuse II demonstrates that there is a high degree of relationship between the street segment analysis and plots that have changed to non-residential functions in the district. The relationship is further highlighted based on the similarities between metric and topological weighings distinguishing the same street segments with a significant number of land-use changes. Additionally, these changes occurring on Aminu Kano crescent and Ademola Adetokunbo crescent as well as streets that are 1-step depth away. From the analysis, agglomeration around designated commercial plots also highlights a pull effect on the commercialization of previously residential plots in the district, especially on parts of Aminu Kano crescent where large multilevel shopping complexes are located. However, on segments with just neighborhood shopping areas, there were no agglomeration effects observed, as land-use changes did occur on street segments away from them.

On the other hand, the more recent nature of the development of Utako district has ensured that land-use changes are marginal with stricter approaches to land-use management. As such, instances they occur have, however, been around street segments with high Choice and Integration values. Although, the location of entrances to plots are through internal neighborhood streets. Agglomeration of other retail non-residential buildings only occurred in areas where there are designated neighborhood commercial areas adjacent to the main mix-use plots.

However, while there have been a few retail land-uses designated as neighborhood commercial areas that have been changed to residential uses in the district, these changes have occurred on street segments with low Integration and Choice values at both Global and Local scales.

6.2 Conclusion

This thesis has aimed to study the distribution of building and land-use changes and the correlation of these changes to street network configurations of Abuja. The thesis discussed the influence of colonial urban planning policy combined with 20th-century modernist design approaches that play a significant role in determining the urban form of Abuja, from its inception to its present state. Specifically, the issues studied are based on reliance on the original masterplan by administrators while neglecting the influence of the structure of the city, contributing to these changes.

The study utilized the use of space syntax as an analytical tool that has shown empirical evidence towards predicting various human activities and interactions with the city. Furthermore, the thesis focused on the use of Choice and Integration units of measurements to analyze the urban structure: the topological and metric distance at a global and pedestrian radius provided for additional analysis at different scales.

Land-use changes from residential-commercial in the districts of Wuse and Utako were analyzed because of them being developed at various phases. The span of development between the first and second phase provided a framework towards understanding how the Spatio-temporal relationship has created new commercial centers.

The two main research questions of the thesis were; What is the relationship between land-use changes and the street network configuration, and How does the mono-functional planning of the city lend itself to these changes. It was shown that there was a relationship between land-use changes in the city and the street networks configuration as most changes, especially in the district of Wuse II, have occurred in second-order streets that are not arterial roads as the city expanded. Although, the changes in Utako were minimal compared to Wuse II and mainly as a result of differences in approach to zoning designations. The changes occurred on second-order streets as well as adjacent plots that have been designated as commercial plots.

Finally, the syntactical measures of integration and choice of the whole city also highlighted that as the city expanded the main expressways became more prominent in

the structure of the city. Additionally, most of the second-order neighborhood streets using global measures also have the highest syntactical values at the pedestrian scale. It was shown that although districts were designed as enclaves with distinct borders, the creation of high activity commercial streets has a high correlation with the global and local structure of streets.

6.3 Further Research

The opportunities for further research can be realized by expanding the study area towards the third phase of the city, which has a different development plan than the first two phases. Also, in this study, the combination of Integrated and Choice measures with topological and metric weighing were used. Future research can include angular weighing and increased the number of radii. Pedestrian and vehicular traffic data can also be incorporated in future studies to understand their effects on active street centers as well as studies in similar post-independence capital cities. There also the effect of increasing population densities on retail/commercial activities.

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