CONTRIBUTORS TO SUSTAINABILITY OF PUBLIC OPEN SPACES IN NAIROBI, KENYA: AN EVOLUTIONARY APPROACH

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Contributors to Sustainability of Public Open Spaces in Nairobi, Kenya: An Evolutionary Approach

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

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DEDICATION

This thesis is dedicated to my mother and sisters. This thesis is dedicated to Jesus Christ.

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LIST OF ABBREVIATIONS

ANOVA	Analysis Of Variance
CBD	Central Business District
COK	Constitution of Kenya
GOK	Government of Kenya
JICA	Japan International Co-operation Agency
KNSP	Kenya National Spatial Plan
NCC	Nairobi City County
NIUPLAN	Nairobi Integrated Urban Development Master-plan
NUDP	National Urban Development Policy
SDG	Sustainable Development Goals
SPSS	Statistical Package for Social Sciences

ABSTRACT

Public open spaces play a significant role in the life, form, and human experience of cities. Growth of towns and cities results in greater urbanization within countries. Urban growth means increased numbers of people in cities who require access to social amenities. These social amenities include public open spaces in cities such as Nairobi. In Nairobi's case, multiple public open spaces in its Central Business District (CBD) are under-utilized. These spaces do not fully perform their role as publicly accessible areas for commerce, transportation, transit, and recreation. There is therefore a dichotomy comprising an increased demand for public open spaces on one hand and a non-optimal use of such existing spaces on the other. This research focused on elements of urban form and usage that entailed study of public open spaces and surrounding environments. Fifteen public open spaces in the Nairobi CBD were investigated. Six key variables were identified for analysis namely connectivity, density, enclosure, land use, space size, and tree cover. Through these, the research established the spatial evolution of public open spaces in the CBD from 1963-2015. It then established the social, economic, environmental, and governance factors that influence the sustainability of public open spaces. Thirdly it established the relationship between spatial evolution and sustainability of public open spaces in the CBD. The thesis hypothesized that the sustainability of public open spaces in Nairobi CBD is influenced by social, economic, environmental, and governance factors. A descriptive and quantitative approach was employed in this research. Therein, social, economic, environmental, and governance variables were used to measure characteristics of public open spaces. Observation forms and interview schedules were the instruments used for data collection. Maximum variation sampling was used to determine sample size and selection of subjects of study. Photographs and maps were reviewed to pattern spatial changes over the 1963-2015 timeframe. From these, base maps, figure-ground maps, land use maps, and 3-Dimensional (3D) models were developed and analysed for each space. Research results indicate that from 1963-2015, CBD public open spaces have become more sustainable with regards to connectivity, enclosure, density, mixed use, and tree cover. They have however become less sustainable in terms of space size. Results also indicate that social sustainability is influenced by spatial and economic factors. The specific predictors of sustainability are the number of services in ground floors of buildings facing space, number of connectors to the space, and number of users of sidewalks surrounding the space. Results further indicate that environmental sustainability and governance sustainability are influenced by spatial factors. The former predictors are the area of the space and the longest distance of the space, while the latter predictors are proximity of space to the public transport hub, the number of parking spaces in the space, and area of paved pathways in the space. Lastly, results indicate that economic sustainability is influenced by social and economic factors. The number of users of the space, number of service businesses in the space, and number of retail shops in ground floors of buildings facing the space are its predictors. Research conclusions indicate that the social, economic, and environmental sustainability are not necessarily concurrent but that one aspect of sustainability can be dominant at a time. In addition, improvement in social sustainability means economic, environmental, and social improvement of public open spaces in Nairobi CBD. Also concluded was that achievement of socially sustainable spaces is the most complex and comprehensive of the four aspects of sustainability. Research recommendations are that more mixture and diversity of uses be encouraged around public open spaces. In addition, in order to enhance social sustainability, creation of environments that enhance economic activities are recommended. Also recommended is that efforts to enhance sustainability of spaces can be undertaken in phases. Lastly, as spatial factors are significant predictors of three aspects of sustainability, spatial interventions should be prioritized in improvement of the sustainability of public open spaces.

Key Words: spatial evolution, sustainability, public open spaces, urban form.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Problem

This research investigates urban form in Nairobi with particular focus on the public open spaces in its Central Business District (CBD). As a morphological study, it analyses the changes that these spaces have experienced over time. It reviews theories in urban development, urban design, urban planning, and evolutionary biology which guide in establishing factors that contribute to making public open spaces in the CBD sustainable.

The research theoretical and conceptual framework comprises two concepts from the natural sciences. First is Charles Darwin's Theory of Evolution by Natural Selection that states that change comes through production of variation in each generation (Darwin, 1859). Like an organism, urban space evolves over time and has the ability to retain advantageous variations and characteristics. Second is the concept of atrophy that recognises that organs atrophy with disuse (Mill, 1865). It refers to a cellular wasting away or gradual decline in effectiveness or vigour due to neglect or underuse. Spaces that are neglected or underused likewise degrade and decrease in terms of vitality, functionality, and attractiveness. The third framing concept of sustainability guides analysis of the city's public open spaces from social, economic, environmental and governance perspectives. These four inter-connected issues have been considered imperative for achieving sustainable development in Africa (UNECA, 2012).

The thesis posits that because a space has survived over a period of time does not necessarily mean that it is sustainable. A public open space can survive or be retained within the urban fabric as an unused, abandoned, or environmentally polluting space. The research provides better understanding of the configurations of open spaces in

Nairobi today, and makes recommendations concerning public open spaces for the future.

The population of the East Africa sub-region was estimated at 292.7 million in 2011, of which 63.5 million lived in urban areas. Nairobi is Kenya's capital and largest city accommodating more than one-third of Kenya's total number of urban dwellers (UN Habitat, 2014). Popular rhetoric on urbanization has left the impression that cities are currently growing too fast and that growth should be limited or somehow diverted (Cohen, 2006). Kenya's National Urban Development Policy (NUDP) notes that in view of the rapid growth of urban populations, existing open public spaces are inadequate (GOK, 2015). The policy also recognises that public open spaces play a central role in the formation and consolidation of urban culture. The Urban Advisory component of the NUDP highlights the importance of education, health, and open spaces in national urban development (UMDD, 2016). Open spaces are critical because they provide opportunity for people from diverse socio-economic, age, gender, and cultural groups to equitably engage with the city. Despite government efforts at national and local level, Nairobi's development plans have not adequately met the needs created by rapid urban growth. This has in part resulted in misuse or misallocation of public open spaces away from public use. This presents an immediate concern because 60 percent of Africa's and Kenya's population will be urban by 2050 (UN-Habitat, 2010), demanding shelter, and basic services.

Unplanned urban growth has multiple consequences. Among them is depletion of natural vegetation cover as human settlements increase. In Nairobi, increments in settlement footprint size and densities result from inadequate housing supply and unregulated urban sprawl. The unregulated growth of settlements has occurred on riverbanks and other public land resulting in less open space available for public recreational use (Plate1.1 and Plate 1.2). Tree coverage and social amenities such as parks and playgrounds thus become insufficiently available.

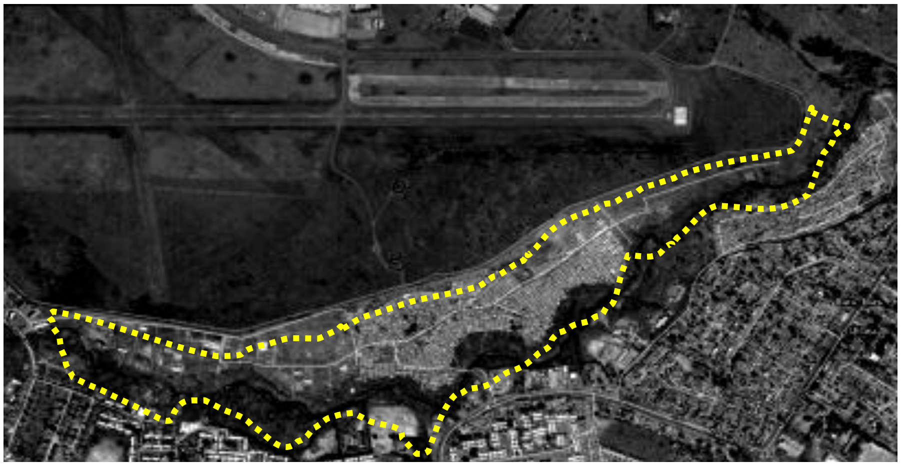


Plate 1.1: Encroachment on Nairobi River bank, Eastleigh (2003). **Source: JICA Study Team, 2014.**

Plate 1.2: Encroachment on Nairobi River bank, Eastleigh (2012).
Source: JICA Study Team, 2014.

In Kenya public land has been privatized particularly since the 1980s (GOK, 2012). In some city neighbourhoods, open spaces for public use have been acquired illegally for private commercial development. In instances, the public has adapted public open spaces to suit their own social and economic functions that are often incongruent with those envisioned by urban planning authorities. These realities illustrate the decrease in number and size of public open spaces that has been experienced in Nairobi for more than three decades.

Public space includes parks, playgrounds, riverbanks, squares and streets. According to UN-Habitat (2012), urban areas should ideally allocate 45-50% of land to public space, including streets. Nairobi presently has about 20% of its land allocated to public space. This means that public space allocation in the city is below recommended United Nations (UN) global standards. Beyond the quantity of public open space, the quality, function, and access to public space by citizens is important. According to Jacobs (1961) open spaces should be created with multiple, relevant, and complimentary functions in mind. If not, they become redundant spaces and bleak vacuums between buildings as opposed to spaces for ordinary people to use and enjoy.

The problem of inadequate public open spaces in cities has been tackled in diverse and innovative ways throughout urban history. In the mid 19th Century for instance, the centre of Paris was overcrowded, dark, unhealthy, and with poor circulation of traffic. During that period civic planner Baron Eugene Hausmann was charged by Emperor Napoleon III to give Paris air, open space, and improved road connectivity and networks. In response Hausmann created a network of public open spaces comprising boulevards, parks, and gardens that significantly improved the appearance and function of the city (Figure 1.1). Key to this massive spatial urban reconfiguration was political goodwill, enabling legislation, and innovative financing models. Its negative consequences however included social disruptions and displacement due to increased rents and speculation in real estate markets. Hausmann’s interventions illustrate the role that parks, boulevards, and other public open spaces can play in greening and connectivity of cities (Figure 1.2). It also highlights the unintended consequences of plan implementation that can have negative social and economic impact, particularly on the most vulnerable groups.

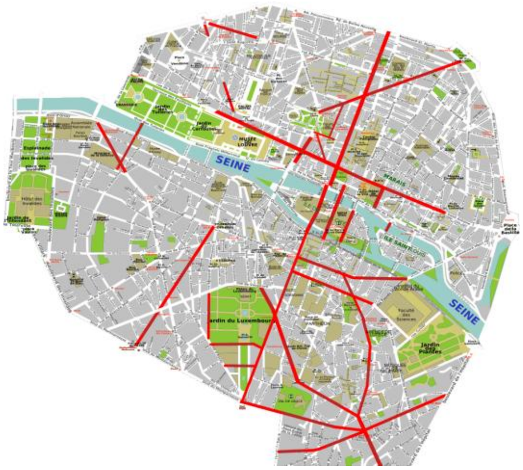


Figure 1.1: Boulevards by Haussmann. Source: www.museumofthecity.org

Figure 1.2: Improved Connectivity by Haussmann in Paris. Source: www.arthistoryarchive.com

In Osaka, Japan, public open spaces have been created by innovative means. Osaka took the closure of a baseball stadium as opportunity for redevelopment of a commercial district that included a park. Namba Parks was completed in 2003 as a natural park in Osaka's dense urban environment. As shown in Figure 1.3, the project features a commercial centre and tower with a multi-level rooftop park. The park connecting to the street promotes the natural environment comprising trees, waterfalls, ponds, and outdoor terraces. Namba Parks exemplifies innovative intervention in a high-density neighbourhood and design strategies to increase public open space. It also indicates the impact of public-private partnership, highlighting the role that governance can play in the enhancement of environmental sustainability.

Figure 1.3: Natural environment in dense neighbourhood, Namba Park, Osaka. Source: www.inhabitat.com

Legislatively, there have been laws to guide urban development that have had limited success. Prior to the Constitution of Kenya (COK) enactment in 2010, Kenya's urban development was conducted in the absence of a comprehensive legislative framework. The Local Government Act (CAP 265) and the Physical Planning Act (CAP 286) of 1996 were the main legislative instruments guiding development in urban areas. According to the NUDP as at 2012, only 30% of urban areas were planned settlements. Most of the planned urban areas employed out-dated physical development plans (GOK, 2012). The lack of a well-coordinated framework prior to the key legislation and policy of 2010 and 2012 respectively meant that public open spaces were among the spaces for which overall, insufficient planning was done. This has proved disadvantageous because good public open spaces contribute to the spatial, social, and economic excellence of cities. In addition, their protection and sound management enable them to perform their functions as places of gathering, movement, and recreation.

1.2 Problem Statement

The rate of urbanisation in Kenya continues to challenge national and county governments to meet the needs of its growing urban populations. Such needs include development of infrastructure and services, protection of the natural environment, and provision of suitable public open spaces. The pressures of urbanization such as encroachment on land for informal settlement, increased formal property development, and construction of infrastructure have adversely impacted public open space in Nairobi. This has resulted in a decrease in the number of open spaces, reduction in size of existing open spaces, and change in the function of open spaces in the city. This means that as Nairobi's population has increased, social amenities such as public open spaces have become insufficient for its citizens.

In the CBD of Nairobi several public open spaces are neither well-suited nor attractive for use. These spaces do not allow for free and easy movement of pedestrians into, within, and around them. Circulation and access are made difficult by chain barriers, dead-ends in the space, and roads enclosing the spaces (Plate 1.3). As indicated in Plate1.4, orientation, location, and design of sitting areas negatively contribute to the level of activity of the space. In several instances there is low visual and functional interaction between buildings and the surrounding environment (Plate 1.5). Some instances also have conflicting land uses within the space. Many public open spaces in the CBD are not well maintained; they feature litter, broken pavements, and non-functional streetlights. Some public open spaces in the city have low use not as a deliberate expression of milieu, but rather as a result of poor spatial design and inappropriate activities within the spaces (Plate 1.6).

Plate 1.3: Multi-land highway enclosing public open space at Globe Cinema Roundabout. Source: Author (2013)

Plate 1.4: Seating facing away from park at Hilton Hotel Circle.
Source: Author (2013)

Plate 1.5: Low visual and functional interaction between buildings and park at John Michuki Park.
Source: Author (2013)

Plate 1.6: Low park use at Hilton Hotel Circle.
Source: Author (2013)

Kenya's NUDP indicates that land for long term urban development should be surveyed, planned and registered. In many instances, public open spaces in urban areas have neither been surveyed nor secured. This puts them at risk of unregulated change of use, illegal acquisition, and encroachment (GOK, 2012). Nairobi is no exception to this inadequacy of surveying and securing of its land. The city therefore risks losing public open spaces that have been allocated for public use, to private interests. Indeed, social infrastructure and services are critical to the development of sustainable urban communities. The city of Nairobi has however in the past failed to sufficiently provide this social infrastructure and services, which include public open spaces.

Social facilities including public open spaces are affected by poor maintenance, low appreciation of the role of open spaces in enhancing quality of urban life, and inappropriate physical settings (GOK, 2012). These settings are spatial in nature and include connectivity, enclosure, and neighbourhood densities. Some buildings adjacent to open spaces fail to incorporate interaction with people, accessibility, and aesthetic appeal into their design and function. This failure contributes to underutilization of open spaces, negative spatial adaptation, or abandonment of spaces altogether. Efforts to deliver quality public open spaces consistently by the county government in terms of design, use, and management of open spaces has had limited success. By analysis of the spatial evolution of public open spaces and components of sustainability, this research is geared towards establishing factors that could help create spaces that are better and more suitable for its users.

In particular, this research undertakes a systematic, comparative analysis of spatial changes in the CBD. Through credible data, it provides information on the increase and decrease of sustainability of city public open spaces over time. For Nairobi public open spaces, there has not been a clear understanding of the connection between spatial evolution and sustainability. This research fills that gap in knowledge and understanding by articulation of spatial elements as they relate to social, economic, environmental, and governance aspects of sustainability. Apart from typical illustrations of the concept of sustainability, this research provides appropriate models that capture sustainability and its drivers for the African context.

1.3 Study Objectives

This thesis aims to establish the factors that have contributed to the functioning and vitality of public open space in Nairobi since 1963. The specific study objectives are to:

1. Establish the spatial evolution of public open spaces in the Nairobi CBD from 1963- 2015.
2. Establish the social, economic, environmental, and governance factors that influence the sustainability of public open spaces in the Nairobi CBD.
3. Establish the relationship between spatial evolution and sustainability of public open spaces in the Nairobi CBD.
4. Make recommendations that can enhance sustainability of public open spaces in the Nairobi CBD.

1.3.1 Research questions

- How have public open spaces in Nairobi CBD evolved spatially from 1963-2015?
- What factors contribute to making public open spaces sustainable?
- What is the relationship between spatial evolution and sustainability of spaces?

1.3.2 Hypotheses: H_o and H_a

Research Hypothesis (H_a): Social, economic, environmental, and governance factors contribute to the sustainability of public open spaces in Nairobi CBD.

Null Hypothesis (H_o): Social, economic, environmental, and governance factors do not contribute to the sustainability of public open spaces in Nairobi CBD.

1.4 Study Assumptions

The study makes the assumption that spatial evolution can be observed in the Nairobi CBD from 1963-2015. Evolution refers to a transformational change that is gradual, identifiable, and process-oriented. Evolutionary changes can occur over varying durations of time and thus differ among organisms, systems, inventions, and ideas. For public open spaces in the Nairobi CBD therefore, it has been assumed that gradual changes that are observable have occurred over the 52 year period since 1963.

A second assumption is that the spaces selected for this research exhibit a measure of sustainability. This means that to varying degrees they have displayed ability to keep up their vitality, functionality, and attractiveness as public open spaces as expressed in their endurance over time. These three elements captured under the broader aspects of sustainability, namely social, economic, environmental, and governance, have been upheld and thus provide data for the study.

1.5 Study Significance

Evolutionary thinking transformed biology, philosophy, metaphysics, and theology. It has been applied to diverse fields including politics, sociology, and design but not to cities and urbanism in such a significant systematic sense as in recent years (Marshall, 2012). It is only in the 21st Century that organic analogies and their implications for 19th Century evolution theories have reached the point of theoretical influence on cities and city planning (Batty & Marshall, 2009). This thesis is thus significant as it applies the evolution theory to urban transformation of public open spaces in Nairobi CBD. It highlights that the evolutionary arguments cannot apply wholesale to developing city contexts and that local considerations are required. This contributes an additional approach to dealing with sustainability in Africa and other regions of the developing world.

This study articulates the link between evolution and sustainability with regards to public open space in Nairobi CBD. The former is guided by the theory of evolution and the latter by the concept of sustainability. The research identifies and expounds on the type of relationship between the two theoretical references. The study urges that in order to correctly grasp the sustainability of spaces, systems, organisms and so on in the present day, understanding of evolutionary changes undergone in the past is vital.

Sustainability is often described as an interconnection of circles representing its social, economic, and environmental components. This research however indicates that its interconnectedness cannot be all-inclusive and indiscrete, but that it is only certain elements that influence the different sustainabilities as exemplified through the spatial studies conducted. The research indicates that even one set of factors can influence an entire aspect of sustainability. In addition the study presents an alternative conceptual understanding to the interconnected circles as a more accurate depiction of the concept of sustainability.

The core of many approaches to sustainability of cities is the management of the city rather than the configuration and design of urban form. This thesis introduces aspects of urban form such as connectivity of roads, vegetation cover, and buildings adjacent to public open spaces as being influential in the sustainability of open space as elements of urban form. By so doing, it contributes knowledge related to sustainability by providing quantitative data on the social, economic, governance, natural and built environment influencers of sustainability of public open space in Nairobi CBD.

1.6 Study Justification

According the NUDP (2012), utilization of urban land has not been optimal and available land has not been put to the best use. It has been proposed that national and county governments shall therefore promote optimal utilization of land to yield the best results. This thesis is therefore important because it seeks to establish what makes public open spaces sustainable. Further justification to the thesis lies in the objectives of NUDP, which is a fundamental driver of national urban development in Kenya. Objectives include provision of a framework for sustainable urban development in Kenya for the benefit of all (UMDD, 2016). Focusing on making public open spaces more sustainable therefore aligns with broader national mandate and goals on delivering sustainable urban development to Kenyans.

Sustainable public open spaces are important because if spaces do not have the ability to keep up their vitality, functionality, and attractiveness, then public open spaces which are a critical urban resource underperform, not being able to deliver services to citizens. In addition, sustainable spaces are desirable because there is understanding that resources such as land, non-renewable energy, and human capacity are limited and must be used efficiently, responsibly, and with accountability. Establishing the factors that can make public open spaces more sustainable is key as it leads to improved social amenities and promotes stewardship of human and natural resources. The thesis establishes factors that promote more effective and suitable use of land, which is an important and limited resource in Nairobi.

Many older cities especially in Europe and North America are unsustainable from environmental and economic consumer-based perspectives. Gehl ("Making Healthy Cities", 2016) underscores the importance of finding new ways of building cities and in so doing, ensuring that they do not replicate the errors committed by big cities in Europe and America. This research is justified because it exploits the opportunity to guide development of public open spaces in future for Nairobi, making it possible to correct and avoid mistakes resulting from a non-sustainable approach to urban development. Increased urbanization means that cities continue losing green urban spaces as a result of weak development control and densification of settlements; urban areas have been increasingly converted from green spaces to built-up areas (GOK, 2012). Worth noting is that Nairobi CBD has both soft and hard surfaced public open spaces. The diminishing of green and indeed all public open space presents the need to design, manage, and maintain existing spaces in such a way as to encourage their full and compatibly diverse utilization.

The city has experienced a decrease in open space enjoyable by the public due to factors such as encroachment. There is a demand for publicly accessible open spaces that are currently inadequate while at the same time it seems that existing open spaces may have low levels of activity and may not be utilised as much as they possibly could. This thesis is therefore significant because given urbanization trends in developing country cities such as Nairobi, pressures on land availability, land use, and service provision is set to increase. This research is timely because it will provide information useful in mitigating this urban challenge in practical ways.

1.7 Study Scope

This research is guided by a theoretical framework focused on urban design, urbanism, and evolutionary biology from the 19^{th} – 21^{st} Century. These include review of Linkage Theory, Place Theory, Garden City Concept, Broad-acre Concept, Smart City Concept, Compact City Concept, and New Urbanism. The Theory of Evolution, the Concept of

Atrophy, and the Concept of Sustainability are conceptually fundamental in guidance of research instrument design, data analysis and data interpretation.

This research employs qualitative and quantitative approaches in response to the study objectives. Data collection is through observation, interviews, maps, photographs, and review of archival documentation. Data analysis and interpretation is informed by comparative mapping and computer modelling. The variables identified for comparative analysis are connectivity, density, enclosure, land use, tree cover, and space size. Models identify predictors of social, economic, environmental, and governance sustainability of public open spaces in the CBD.

Geographically, the research focuses on public open spaces in the Nairobi CBD area, which is the oldest commercial part of the city. The study area is delineated by City Hall Way to the north, Uhuru Highway to the west, Haile Selassie Ave to the south, and Racecourse Road and Nairobi River to the east. The study spaces are located within and adjacent to the CBD boundary roads. They comprise recreational parks, promenades, car parks, bus termini, pedestrian accessible roundabouts, and markets. As Kenya's largest and most populated urban centre, Nairobi has experienced acutely the challenges related to urbanization that include strain on social amenities such as public open spaces in the CBD. This makes it an appropriate area of study.

1.8 Study Limitations

The ability to compare characteristics of public open spaces over time using detailed maps and aerial photographs was key to documentation of evolution in Nairobi CBD. Since 1963 consistent and comprehensive information regarding public open space in the CBD was unavailable. Non-spatial data for the spaces regarding social, environmental and economic uses and characteristics was therefore not available and could not be analysed comparatively. To ensure adequate availability and access to photographic and cartographic information therefore, the thesis focused its analysis on spatial characteristics that could be observed and measured from 1963 – 2015.

1.9 Study Organization

The thesis is organized into seven chapters. Chapter 1 contains the background to the research problem and the problem statement. It indicates the study objectives, research questions and study hypothesis. In addition, it articulates the study's assumptions, significance, justification, scope, and limitations. Chapter 2 deals with urban theories, concepts, and paradigms. It contains the theoretical and conceptual framework that has guided this research and explains the research variables, key concepts and operational definition of terms.

Chapter 3 is focused on the area of study. Therein national and city physical, social, and economic conditions are highlighted as is demographic information. The development of Nairobi from a historic and spatial perspective is captured and lastly the legal and institutional framework for urban development is outlined. Research Methodology is captured in Chapter 4. The research design, approach, area and research method are explained. Also herein is explanation on matters of sampling namely its method, frame, and size. Data collection and data processing are discussed and ethical considerations highlighted.

Chapter 5 is organized into three sections as informed by the research objectives. The first section deals with determinants of evolution, presenting space size, connectivity, tree cover, enclosure, densities, and space use as measurements for spatial evolution. The second section deals with determinants of sustainability, in particular the social, economic, environmental, and governance models of sustainability. The third section handles the relationship between spatial evolution and sustainability by analysing correlations between selected variables. Chapter 6 thereafter presents systematic discussion of the data presented in the preceding chapter.

Chapter 7 is focused on conclusions and recommendations based on information presented from chapters one to six. It outlines general conclusions and reiterates key elements from preceding chapters. It tests the research hypothesis, indicates implications of the research, and identifies areas for further research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter introduces significant urban theories, concepts, and paradigms that comprise modern-day discourse on matters related to urban design and urban development. The theoretical framework that has guided this research with regards to evolution, atrophy, and sustainability has been critically investigated. Variables used to determine sustainability have been descriptively identified. In addition, key concepts, definition of terms, research questions, and study hypotheses have been introduced and expounded.

2.2 Urban Space and Public Open Space

In order to gain clarity on public open space, a range of spatial definitions have been reviewed. According to Peterson (1980) space is measurable, having definite and perceivable boundaries. It is also described as the medium of the urban experience, providing the sequence between public, semi-public, and private domains (Trancik, 1986). Low (2017) notes that space can be described as something that is absolute and real, thus a ‘thing’ that allows us to position our bodies. She also notes that it can conversely be described as existing only in relation to time, experience, thought, objects, and events on the other.

Lynch (1960) argues that open spaces are regions in the environment which are usable for the freely chosen and spontaneous action of people. In tandem with Lynch, Rapoport (1977) observes that open space allows people to act freely, providing freedom to enter and move without restriction and obstruction. According to Banerjee and Southworth (1990) open space refers to large areas under public or quasi-public ownership, natural areas that are not built-up, or places of outdoor assembly. They further suggest that open space is the uncommitted complement to the system of committed land uses that make up a city region. Although this definition is insightful, it is misleading as it erroneously implies that open spaces are typically uncommitted or un-allocated space. Recreational and open space is a type of land use as identified in spatial planning. Open spaces are routinely designated as parks, linear greenways along roads or rivers, and natural reserves in the planning and design of cities. Spreiregen (1965) opines that the sidewalk is the elementary open space of a city. He further notes that open spaces range in size and comprise vast reserves of natural land, the urban park, the urban plaza, and the street.

Marshall (2012) posits that public spaces are those where anyone may go to interact and that public places are the most inclusive. In addition, public space encompasses all those parts of the built and natural environment where the public has free access (Makworo, 2012). Indeed, public space is described as the living room of a city or space that brings different members together and fosters community (Oppliger, 2015).

Krier (1979) defines urban space as space within a city or town that is external, geometrically bound by various elevations, and usually open and unobstructed with public, semi-public, or private realms. There are two main types of urban spaces: ‘streets’ that include roads, paths, avenues, lanes, boulevards, alleys, and malls and ‘squares’ that include plazas, circuses, places, and courts. In principle, streets are ‘dynamic’ spaces with a sense of movement, while squares are static spaces with less sense of movement (Tisdell, Carmona, Oc, & Heath, 2003). According to Moirongo (2011) public urban spaces comprise front yards or courts that are considered public, arcades, streets, greenery islands, passages, lanes, malls, squares and open spaces. In the urban setting, open or soft spaces provide opportunities for recreation or retreat from the built environment. Some public open spaces are designed to have vitality in terms of space use while others are designed to be calm and serene (Trancik, 1986). Both types of spaces are important as they create different spatial and social experiences for users thereby influencing the overall diversity and contrast within the city.

In comparing the city plan scale, site plan scale, and the people scale, the people scale is the most important when it comes to creating good urban spaces (Cilento, 2011). Good cities are not created merely because they have good form or good buildings. The more important thing is the interaction between the city's buildings, form, and people. He further posits that the relationship between components of the city is what influences the quality of cities and urban spaces. One aspect that is important but not emphasized in these definitions of public open space is the issue of ownership and management of the spaces. Generally, by definition public spaces are those managed by public entities including national government, county governments, local authorities, municipal councils, and state corporations. This consideration presents a more complete and accurate definition of public open spaces.

Against this backdrop of definitions therefore, this research operationally defines public open space to be space that is under the jurisdiction of a public agency, predominantly exposed to the natural elements, accessible to members of the public, and free for pedestrians. Public open spaces are governed by public agency regulations that dictate terms of operation and rules of use. Public open spaces can be recreational such as parks and sports grounds, commercial such as car-parks and markets, and utilitarian for instance cemeteries.

2.3 Urban Space Theories, Concepts, and Techniques

In order to analyse urban space various theories, concepts, and techniques of urban design and urbanism have been reviewed to help contextualize and interpret urban form, inter-relationships, and function.

2.3.1 Linkage Theory

Linkage Theory is an urban design theory that emphasizes the connection of one spatial element to another through lines of movement. These lines are formed by streets, pedestrian ways, linear open spaces, or other linking elements that physically connect parts of the city. The theory seeks to organize a system or network of connections that establishes a structure for ordering spaces. Emphasis is placed on circulation between buildings and spaces as opposed to the solid-void relationship between buildings and spaces. Movement systems take precedence over patterns of defined open space (Trancik, 1986). The 19th Century rebuilding of Paris demonstrates the use of boulevards as principle paths of movement. These become strong axes for the ordering of buildings and public open spaces (Plate 2.1).

Linkage Theory can provide a good basis for spatial development and redevelopment in cities that experience acute traffic congestion exacerbated by their street patterns. Prioritization of movement systems that the theory advocates can however be destructive to urban form and function. This is if implementation occurs without due consideration to the architectural heritage, social ties, and economic inter-relationships that contribute to making neighbourhoods successful. This danger is seen in the interventions of Robert Moses, a New York City official from 1930s-1960s. Moses' embraced modernist thinking that favoured cars over people. Many of his projects destroyed vibrant urban neighbourhoods as expressways, roadways, and bridges were built in order to improve vehicular movement.

Plate 2.1: Linkage Theory Illustrated – Paris Boulevards as Ordering Principles.
Source: Adapted from www.worldpress.com

In order for application of the Linkage Theory to be equitably beneficial to city users, pedestrian traffic must be regarded as important as vehicular traffic. Reacting to the work of Moses, Jacobs (1961) challenged the thinking of Moses towards city development. A strong critic of Moses, she decried modernist planning, instead emphasizing the importance of good densities, short urban blocks, and mixed use of buildings.

2.3.2 Place Theory

As described by Trancik (1986) Place Theory recognizes the importance of reflecting historic, cultural, and social values in urban open space. It seeks to give physical space additional richness by incorporating unique forms and details to local settings. It advances the idea of making space to creating place through a synthesis of components of the environment.

Parallels are evident between Trancik's Place Theory and the concept of genius loci that was introduced into the architecture and built environment discourse by Christian Norberg-Schulz in the 1980s (Habib & Sahhaf, 2012). Norberg-Schulz (1980) describes a place as something that is non-abstract and that is a totality of things that have material substance, shape, texture, and colour. Described as the 'spirit of place' (Norberg-Schulz, 1980), genius loci represents the sense people have of a place, understood as the sum of all physical as well as symbolic values in nature and the human environment. Genius Loci is concerned with topography, natural conditions, buildings, and symbolic meanings in the cultural landscape (Jiven & Larkham, 2003).

In comparison, another urban design process that emphasizes the role of social and public participation in the creation of places is Placemaking. Emerging in the mid-1950s, this approach ranges from advocacy to citizen input through public dialogue in everyday urbanism, to town planning principles and civic design (Future of Places, 2014). Civic engagement in design, planning, and management of urban areas is an expression of governance. Through various processes therefore, members of the public contribute to creating the 'sense' or character of a place. Public participation in city development process is underscored as being important by Lynch (1984). This participation can be in formal or informal ways. The public can contribute to the character of a place by use and adaptation of urban space based on need, economy, and convenience. Appropriation of spatial elements such as sidewalks by city users can introduce a distinct character or sense of place into a street or neighbourhood, diversifying the urban fabric in terms of appearance and function.

2.3.3 Figure-Ground Mapping

Figure ground maps show the footprints of buildings and the pattern of unbuilt voids in urban space. Compared historically they reveal the erosion of the public realm over time and provide an analytical basis for repair of urban tissue (Hebbert, 2016). In the 18^{th} Century Giambattista Nolli, an Italian architect and surveyor undertook figure-ground studies in Rome, Italy that revealed the topographic and spatial structure of the city (Figure 2.1). These studies illustrated the relationship between the public open space and the built form of the city, showing the interaction of public building interiors and streets.

Figure 2.1: Public streets and urban structure in Nolli's Map of Rome (1748)
Source: www.informativeplatforms.blogspot.co.ke

Figure-ground mapping is a very useful technique for recording public space in the city then analyzing its distribution and connection (Moughtin et al, 2003). With this understanding, this research employed figure ground mapping of urban spaces for spatial change analysis of densities and enclosure as aspects of urban form. Trancik (1986) has identified six key typological patterns of solids and voids as grid, angular, curvilinear, radial concentric, axial, and organic (Figure 2.2). He has argued that the qualitative judgement of quality of design of a space comes from its function and the extent to which its physical shape accommodates social needs.

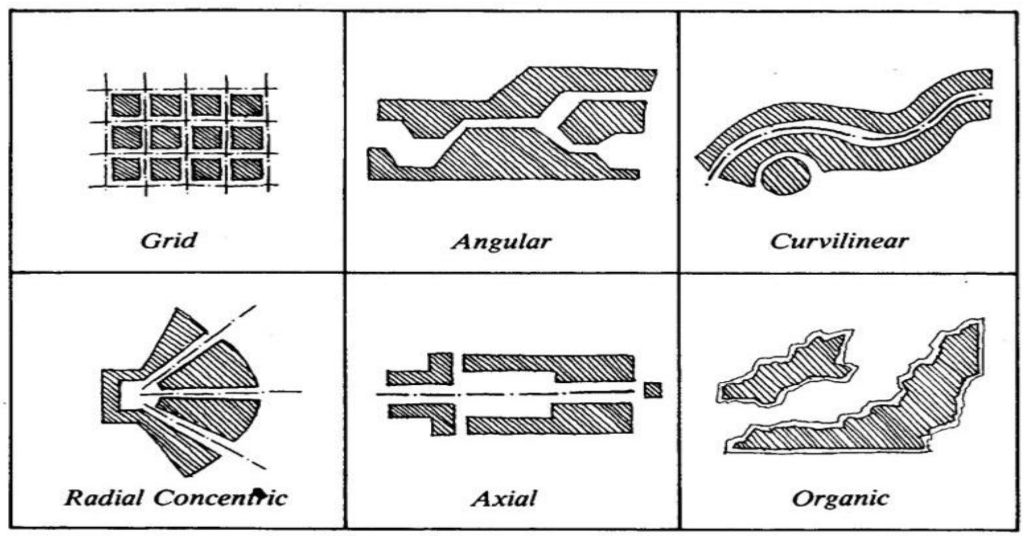


Figure 2.2: Key Typological Patterns of Solids and Voids. Source: Trancik 1986.

2.3.4 Garden City Concept

Garden City Concept was developed by Ebenezer Howard in the 19th Century. It proposed a post industrial revolution urban form envisioned to shape and reflect the ideals of modern life. It aimed to bring together the benefits of town life and country life through a town-country model of city development. Michalos (2014) indicates that the town planners, designers, and developers who promoted this concept hoped to replace the crowded, dirty, and dismal housing districts of the industrial city with green and open landscapes that would improve the quality of life for working families.

The concept presented an alternative to the large and polluted industrial cities of England through a network of cities comprising a hierarchical centre called a 'central city' connected to sub-centres (Figure 2.3). Each sub-centre would be situated in an environment comprising pastureland, forests, and agricultural land. Each was designed to have a central park and concentric rings of land with houses and gardens, interspersed with roads and boulevards. All land was owned co-operatively, which meant that all the open spaces such as the aforementioned comprised the common good. This promotes sense of community and co-operation that are beneficial to the achievement of joint goals of societies. However, as Moirongo (2011) indicates open space must be controlled otherwise it becomes 'no-man's land' that can produce environmental problems. As shown in Figure 2.4 the garden city concept aimed at controlling the overall size and growth of each urban centre. Employing parameters from the garden city could make 21 Century cities more sustainable by compelling a compactness of form and thus reduced sprawl.

Jacobs (1961) decried the garden city for its definition of wholesome housing only in terms of suburban physical qualities and small-town social qualities. These qualities did not encourage mixing of uses, which was an important characteristic of good neighbourhoods, according to Jacobs. The social and environmental aspects of the town-county model were well articulated but proved inexplicit regarding location of commercial activities within the garden city. Compatible mixed use of spaces is a key consideration for sustainable cities (Danish Architecture Centre, 2008). The garden city concept pronounces the interdependence between the environmental and social but fails to spatially articulate the role of enterprise, commercial centres, and markets as economic aspects of a town-country settlement. In practical terms application of the concept to Nairobi City that covers 695sq. kms (172,000 acres) with a population of approx. 3.1 million inhabitants as of 2009 (KNBS, 2015) yields the following: approx. 820,000 acres would be required to create a garden city as per this model. For this, Nairobi would have to make a five-fold expansion in land coverage alone. The concept as presented by Howard may thus have been ideal in 19-20th Century England, but would impractical in many 21st Century developing country cities.

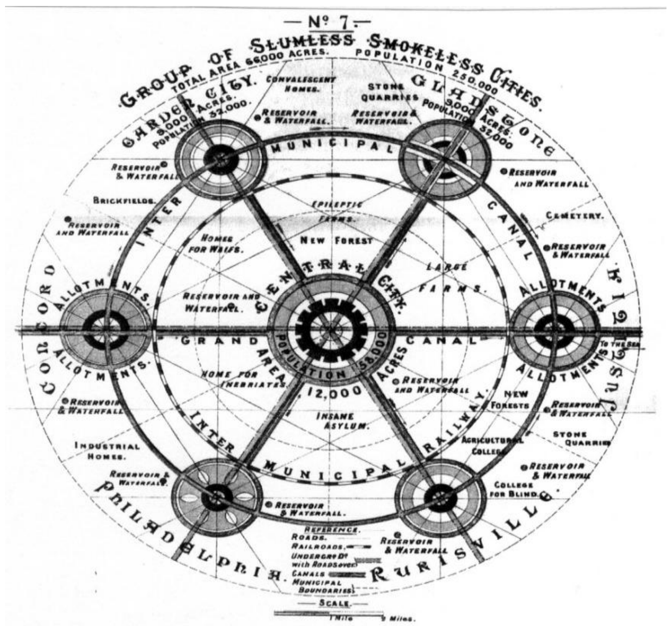


Figure 2.3: Howard's Garden City Concept. Source: Ward, 1992

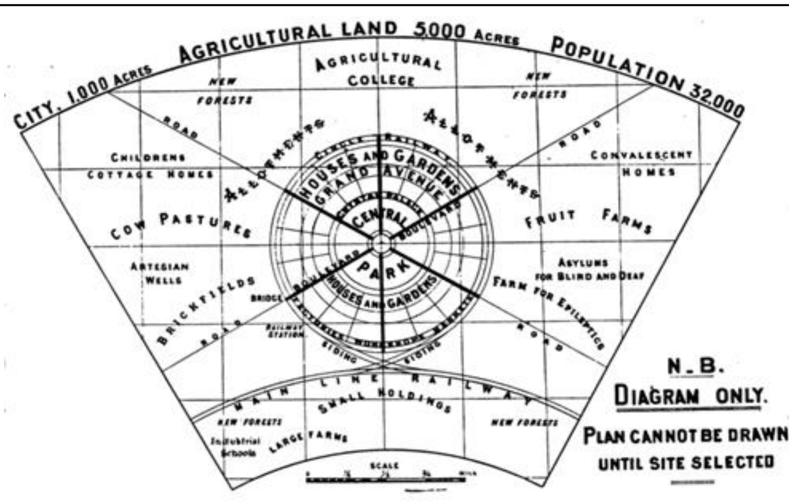


Figure 2.4: Garden City Segment with sub-centre and communal open spaces. Source: Ward, 1992

2.3.5 Radiant City Concept

Swiss modernist architect Le Corbusier developed the Radiant City concept in the 1920s, and like Howard's Garden City, it was designed to improve urban forms following the industrial revolution. The Radiant City was informed by modernist concepts in architecture and planning that consider the building to be an autonomous object in space.

The concept aimed to decongest city centres, enhance densities, increase and improve vehicular movement and increase parks and open spaces in urban neighbourhoods. Although these goals were sound enough, the methods advocated by planners, architects, public officials, and private developers to achieve them were sometimes socially alienating, environmentally degrading, and economically costly. According to Jabareen (2006), the Radiant City was to be a solution to the Victorian city. It advocated clearance of existing buildings, spaces, and roads and erection of high-density tower blocks. In order for a new post-revolution model to be embraced and sustainable in cities, participation of local residents, businesses, and property owners in the older parts of the city would be fundamental. Le Corbusier's neighbourhood plan for Paris inspired

Figure 2.5: Le Corbusier Paris Plan Model (1925). Source: Riley, 1994

The Radiant City supported logical and neat massive public open space that failed as public spaces due to their large size, orientation, poor relationship to buildings, and lack of diversity of functions. Moirongo (2011) has argued likewise that the massive open space was one of the most attractive elements of Le Corbusier's plan and yet one of its greatest failings because such open space rarely support any kind of truly active or functional uses. In view of creating sustainable neighbourhoods therefore, public open spaces need to be of different and appropriate scale, distributed within neighbourhoods, and varied in terms of functions, services, and spatial characteristics.

Multi-storeyed buildings can contribute to compact and densified development, both characteristics of sustainable settlements. Richardson, Bae, and Baxamusa (2000) observe that compact cities of developing countries are neither planned nor the result of design, but rather have a compactness that has emerged spontaneously. This marks a departure from the manner in which compactness was to be achieved in the Radiant City concept. It is thus evident that compactness is achievable through the Corbusian formal, modernist planning on one hand or through informal and spontaneous development on the other.

Associated with urban compactness is the use of personal vehicles as a preferred mode of transport. In the Radiant City concept, cars were esteemed and prioritized as enablers of efficient and speedy movement. This idea contrasts with the thinking of architects and urban designers like Danish architect-designer Jan Gehl who argues for the need to promote non-motorized means of mobility in order to create livable streets, and indeed settlements (Oppliger, 2015). Prioritization of personal vehicles versus public mass transportation tends to promote traffic congestion and air pollution, both of which detract from economic and environmental sustainability of cities.

2.3.6 Broad-acre City Concept

In the wake of the Great Depression of the 1920s, architect Frank L. Wright proposed the Broad-acre City concept at a time of migration to cities in search of employment. This concept aimed to decongest cities by emphasizing a living, working, and farming of land away from urban areas as a solution to unemployment and poverty.

Wright predicted that large cities as dominant economic, social, cultural, political, and administrative centres would become irrelevant in future years. On this premise, a reversion to rural areas and lifestyle was considered a suitable pre-emptive approach to this implosion of cities and towns. Drawing from Wright's agro-centric, 'back-to-the-land' approach, Wise (2013) has argued for the incorporation of agrarian design into models of urban growth. It is notable that she argues for promotion of the agrarian within an urban environment as opposed to the distinctly non-urban focus that the Broad-acre concept espoused.

The allocation of land for work, domestic, and recreational purposes away from existing cities meant that massive investment in infrastructure would be required for the new settlement (Figure 2.6). Due to absence of limitations to population and size of the city itself, the Broad-acre concept would encourage settlement sprawl. Sprawl which is a characteristic of many cities in developing and developed nations can be countered in several ways. For instance, Wise (2013) observes that planning approaches focused on recentralizing development, such as Smart Growth and New Urbanism, have emerged in response to the ills of sprawled development. Sprawl means that there is a lack of urban compactness which requires greater resources for development and maintenance of infrastructure. Da Silva, Raia, and Ferraz (2000) note that where urban growth is not matched by investment towards increased infrastructure demand, problems are bound to arise. They further indicate that the benefits of a compact urban form include more efficient utility and infrastructure provision.

Considered the most effective street pattern, Broad-acre employed the basic grid as the primary ordering principle for the new city. Its widespread use implied another example of intended cost effectiveness in the building of roads and utilities infrastructure.

Figure 2.6: Broad-acre Concept Model (1934-5). Source: http://hyperallergic.wpengine.netdna-cdn.com

The Broad-acre concept advocated that each household would own at least one acre of property and households would comprise farm, workshops, and residence. The Broad-acre Model in (Figure 2.7) indicates the numerous and inter-related land uses proposed. Its open spaces were designed with clear functions and diverse activities to encourage a maximized use of resources. This reflects a compatible mixed use that is a characteristic of sustainable settlements. In this regard, Nabil and Eldayem (2015) argue that mixed land-use enhances social capital. They further emphasize that social capital is an important resource of sustainable development and that increased social capital leads to increased sustainability. Common areas for recreation, assembly, and learning provided avenues for enhancement of social capital and thus for the improved sustainability of the Broad-acre city.

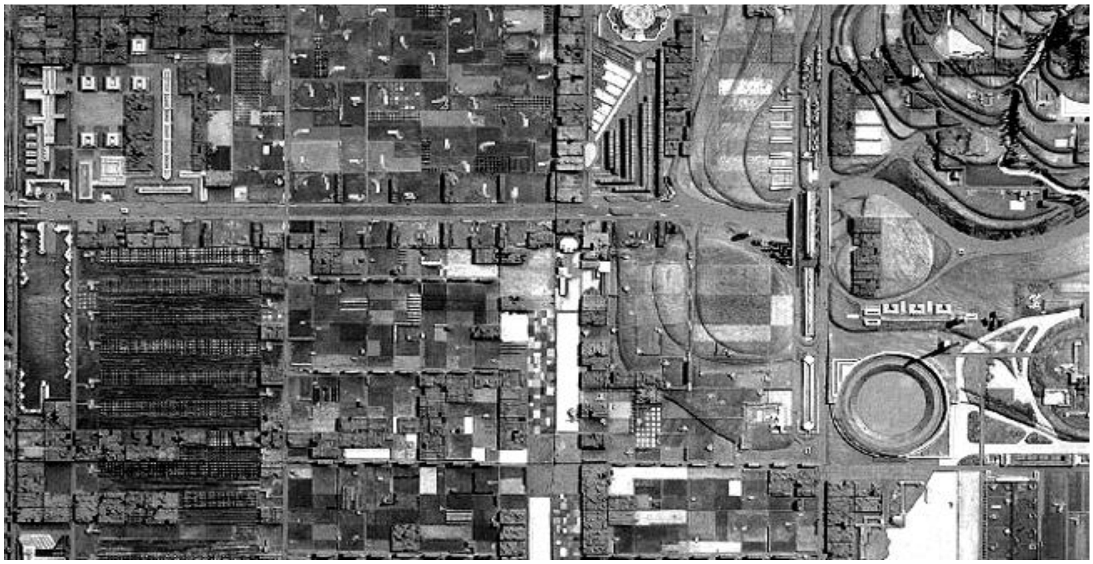


Figure 2.7: Broad-acre Plan with Land Allocation for Work, Domestic, and Recreation. Source: www.metropolismag.com

2.3.7 Smart City Concept

Smart Cities is a concept that has gained prominence in urban discourse in the 21st Century. It is a concept that applies information technologies to facilitate the planning, construction, management and service delivery through the internet of things, cloud computing, big data and geographical information integration (IEC, 2014). The two overarching benefits of smart cities are sustainability and efficiency (High, 2015). Additional benefits of smart cities include equipping of the city to collect data about different aspects of the city. This equipping requires installation or upgrade of Information and Communication Technology (ICT) systems and infrastructure, an investment that can be undertaken by governments independently or in partnership with private sector and other entities.

As an aspect of Smart Cities, smart governance includes automation that enables functions to be delivered reliably and effectively, without the need of direct human intervention, which is considered an advantage of the Smart City concept. Indeed automation could result in greater accountability and transparency of systems but it could also adversely influence employment levels in cities. In line with smart governance, Nairobi City County has initiated e-governance systems through its Information, Communication, and E-Government Sector to improve efficiency of service delivery. These include an e-wallet system that introduced cashless parking fee payment in 2014. This mode of payment aimed to reduce ticketing time and to boost revenue collection by sealing loopholes presented by manual collection of fees (Nairobi City County, 2017).

2.3.8 Compact City Concept

The Compact City concept aims to increase built area and population densities, to intensify urban activities, and to manipulate urban size, form, structure, and systems in pursuit of sustainability (Jenks & Burgess, 2000). As much as compactness is described as an indicator of sustainable urban form, establishment of a global standard for compactness is elusive due to differences between countries and regions of the world. Indeed, Zillman (2000) posits that the compact city is often conceived as having a specific urban form, with its important dimensions of high buildings densities and mixed uses. Regions however often have distinct differences, as do formal versus informal settlements. Social and cultural particulars further challenge efforts at a common standard of compactness. These realities call for re-definitions of compactness from conceptual and practical perspectives with regards to the ways in which compactness is understood and can be achieved in practice.

Rapid urban population growth is evident throughout sub-Saharan Africa (Potts, 2012). Its related growth of settlements renders as redundant the focus on increasing compactness through increased building and population densities. Rises in densities are already taking place as a result of urban population growth and in-migration. Richardson, Bae and Baxamusa (2000) note that city centre densities tend to be much higher in developing countries and that the ratio of central city to suburban densities tends to be much higher in cities in developing countries, reflecting compactness.

Linkage of urban areas by public transport systems is a key characteristic of compact cities (OECD, 2012). Compactness however without adequate road networks and efficient mass transit systems can produce chaotic, congested, and inefficient cities. In light of this, cities around the world are dedicating increasing amounts of public space to pedestrians, cyclists, and public transit (UN Habitat, 2013). Pursuit of the Compact City concept would therefore require creation of public open spaces and mobility systems in step with the densification of urban form. Kenya's National Spatial Plan (KNSP) recognises the importance of urban containment and compact cities. It requires that local plans strive to control urban growth in order to protect agricultural land, mitigate urban sprawl, and reduce cost of infrastructural provision (GOK, 2017).

2.3.9 Eco-City Concept

The Eco-City concept is focused on the rebuilding of cities and towns based on ecological principles for the long term sustainability, cultural vitality, and environmental wellbeing of the earth (Register, 2006). It advocates finding a balance between urban centres and nature, where cities do not continue to develop without deliberate incorporation and co-existence with nature. In tandem with Register, Wolch, Byrne, and Newell (2014) argue that urban green spaces provide critical ecosystem services and promote physical activity, psychological well-being and health of urban residents. Promoting the natural environment and urban greening can therefore contribute to environmental sustainability of urban settlements.

2.3.10 Ecosystem Concept

Cities are complex systems whose infrastructural, economic and social components are strongly interrelated and therefore difficult to understand in isolation. This allows the growth of cities in a continuously adaptive manner (Bettencourt & West, 2010). Cities comprise many spatial and non-spatial parts that are required to work alongside each other in order to achieve sustainable neighbourhoods.

Like an ecosystem a city appears to be a coherent whole with inter-relationships where all components are interdependent. The individual components including public open spaces have their own agendas partly in cooperation and partly in competition (Marshall, 2012). Competition of space or other urban resource can sometimes add to the vitality and innovation of city life. Jostling for space between pedestrians and street traders may for instance result in cleaning and lighting of alleyways for trading in cities or formulation of bylaws that legalise orderly and time-based trading on city streets.

2.3.11 New Urbanism

Initiated in the 1980s, New Urbanism calls for organizing development in cities that are compact, walkable, mixed-use, transit friendly, with diversity of housing. It argues that changes in physical form are a necessary precondition for urban economic, social, and ecological change (Knapp & Talen, 2005). This urbanism thus aims to meet social, economic, and environmental needs through the physical design of the urban fabric. This highlights conceptual linkages with the sustainability discourse in which the social, economic, and environmental have featured prominently since the early 1990s (UNESC, 2013). The idea of physical environment influencing social order is not a new phenomenon. In the 19th Century the idea of physicalism emerged that advocated solving of social problems by influencing the physical built environment (Batty & Marshall, 2009).

Though touted as ‘new’, some of its principles such as compactness and walkability have characterised civilizations in Africa, Asia, Mesopotamia, and Central America from the Neolithic and Mesolithic eras. In agreement, Jabareen (2012) describes New Urbanism as an advocator of design strategies based on traditional urban forms and an approach to neo-traditional planning and development. Durack (2001) similarly criticises New Urbanism as reviving the traditional village prototype, deemed constrictive and contradictory to sustainability in the urban context.

New Urbanism has birthed Sustainable Urbanism that serves as an umbrella term for architecture, urban planning, and urban design that focuses on several issues including sustainability, resilience, human health and safety, eco-system dependency, mobility, and green economic growth (Haas, 2012). Marshall (2012) argues that from an evolutionary perspective, sustainable urbanism implies urbanism that is viable at present. Since this urbanism explores sustainability and urban design in a rapidly urbanizing world, this approach could prove suitable for cities in developing countries.

2.3.12 Green Urbanism

Green Urbanism is another eco-centric approach to cities and town development that advocates for zero-emission and zero-waste urban design (Lehman, 2012). It arose in the 1990s promoting compact, energy efficient urban development, seeking to transform and re-engineer existing city districts and regenerate the post-industrial city centre. This urbanism focuses on interaction between its three main pillars of energy and materials, water and biodiversity, and urban planning and transport. Hammarby Sjostad in Sweden exemplifies application of the principles of green urbanism and transit-oriented development. This redevelopment produces 50% of its power for heating, cooling, and electricity from recycled waste water and domestic waste (Cervero & Sullivan, 2012). Regarding smart and green urban growth in Kenya, KNSP indicates that spatial plans are required to promote sustainable use of energy, create green spaces, reduce the need for car travel, and to promote use of local materials (GOK, 2017).

2.3.13 Landscape Urbanism

In Landscape Urbanism, landscape rather than architecture is regarded as more capable of organizing the city and enhancing the urban experience. According to Waldheim (1997) the origins of Landscape Urbanism can be traced to postmodern critiques of modernist architecture and planning. Although a common methodology for the concept remains elusive, Landscape Urbanism examines the implications of the city in the landscape and the landscape in the city (Gray, 2011). Such examination can contribute to the design and function of public open spaces as landscape spaces that balance and integrate the built and natural environment of towns and cities.

2.4 Theoretical Framework

The theoretical part of this research is framed by the theory of evolution, the concept of atrophy, and the concept of sustainability. By employing an evolutionary perspective in the analysis of spatial change, there is the assumption that spaces are becoming more organised or more complex with time, or that they are decreasing or degrading with time depending on their relevance in the urban ecosystem. An evolutionary perspective finds appropriate application here because as some urban spaces improve and become better organised over time, others become less organized, inferior in composition, and degraded in quality over time.

Thus, informed by the Darwinian approach expounded hereafter, evolution is a right and acceptable lens of interpretation because it accommodates both trajectories and eventualities. It recognizes that organisms, systems, and spaces and parts thereof can become more complex and better over time. It also recognises that organisms, systems, and spaces and parts thereof can become less organised and worsen over time, depending on their relevance and the importance attached to them.

2.4.1 Cities and Evolution

According to Marshall (2012) evolutionary thinking has influenced biology, philosophy, metaphysics, and theology. It has been applied to politics, sociology, and design but not to cities and urbanism in such a significant systematic sense as in recent years. Except for the newest planned creations, cities are products of evolution as opposed to products of simple design. Evolution describes transformational change that is gradual and process-oriented. Figure 2.8 illustrates this change in urban footprint, block patterns, and density as captured through figure-ground mapping. Lozano (1989) argues that the evolution of urban systems continues because cities, urban complexes, and precincts are not static organizations but have a critical dynamic dimension. He further posits that the effect of time on urban systems is as important as the effect of space on the same urban systems. Indeed the above highlights that variation of urban components and their relationships give rise to similarities and differences in urban forms, over space and time.

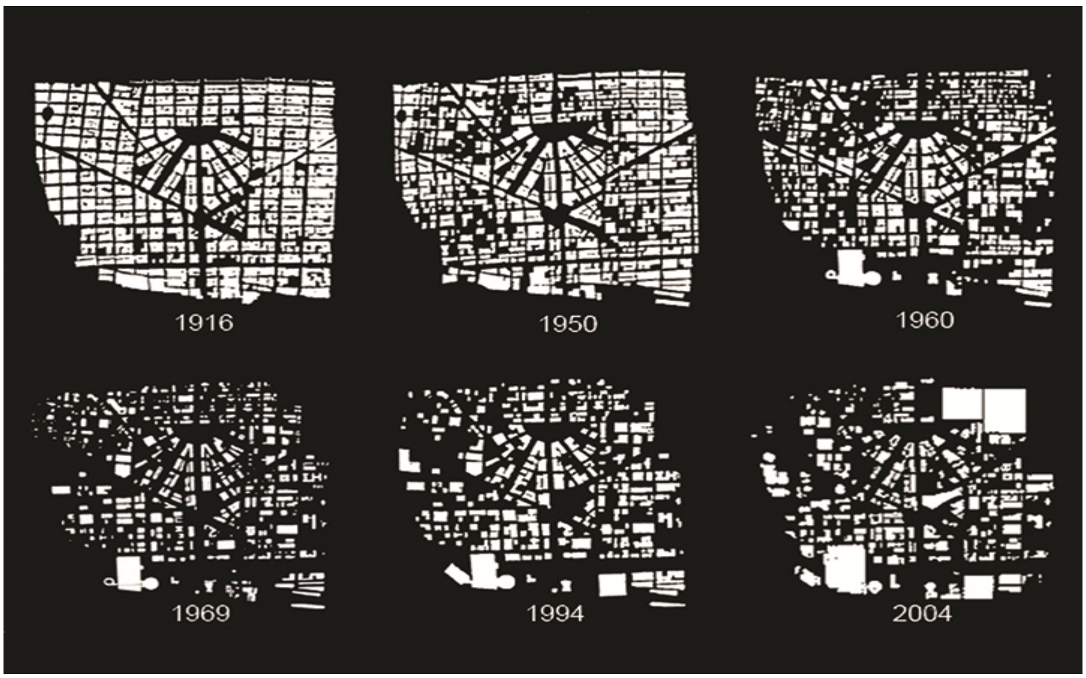


Figure 2.8: Detroit, USA: Evolution from industrial metropolis to high-vacancy city.
Source: Thomas and Bekkering, 2015

2.4.2 Theory of Evolution

The purpose of studying evolution is to see if an evolutionary perspective can help bring understanding on urban change and hence inform future planning and design (Marshall, 2012). Several evolutionary theories have been profiled in this section ranging from Lamarckism to Mutation Theory to Neo-Darwinism. The Darwinian Theory of Evolution that forms an integral part of the theoretical framework is of central focus herein.

Naturalist Jean-Baptise Lamarck developed the Theory of Inheritance of Acquired Characteristics, also called Larmarckism, in the 19th Century. Lamarck believed that evolution was driven primarily by non-randomly acquired, beneficial phenotypic changes especially those affected by use of organs (Koonin & Wolf, 2009). Larmarck advanced the idea that environmentally induced behavioural changes lead the way in species change (Burkhardt, 2013). According to Larmarck, inheritance of acquired characteristics referred to the changes developed in an organism from normal characteristics in response to changes in the environment during its own lifetime.

The Mutation Theory was also proposed in the 19th Century by botanist Hugo de Vries. His theory posited that new species arose by single mutational events (Nei & Nozawa, 2011) and that evolution is a discontinuous process in which there is a shift of characteristics and features from one species to another. This shift enabled new species to arise from pre-existing species in a single generation and not a gradual process as proposed by Lamarck and Darwin.

Neo-Darwinism also called the Modern (Neo-Darwinist) Synthesis or the Synthetic Theory of Evolution is a modification of Darwinian Theory of Evolution. Developed from the mid 1940s Neo-Darwinism is a gene-centred theory of evolution (Noble, 2013) that distinguishes the importance of populations as the units of evolution. It also emphasizes the central role of natural selection as a mechanism of evolution.

Evolutionary biologist George Williams outlined a gene-centred view of evolution thus disputing notions of evolutionary progress and group selection. Zoologist Richard Dawkins in turn coined the term the ‘selfish gene’. He demonstrated that evolution was not concerned with the organism but rather with genes which survive unscathed through eons by transference from one body to another (Yanai & Lercher, 2016). Weighing into the discourse, Agren (2016) has argued that the gene’s-eye view or selfish gene theory describes the gene as the ultimate beneficiary and fundamental unit of selection. Like Dawkins, in the 19th Century biologist and town planner Patrick Geddes proposed that changes in an organism were caused by internal conditions as opposed to external ones (Batty & Marshall, 2009).

As indicated, this research focuses on the Theory of Evolution developed by Charles Darwin (1809–1882). He was the first scientist to articulate the notion that biological life proceeds through natural selection, with the 'survival of the fittest' being the mechanism that guides development (Figure 2.9). Darwin published the book entitled "On the Origin of Species by Means of Natural Selection or 'the Preservation of Favoured Races in the Struggle for Life'" in 1859. His thinking on origin of species was inspired by world travel as a naturalist. Darwin's Theory of Evolution draws from observation of plant and animal biological life (Darwin, 1859).

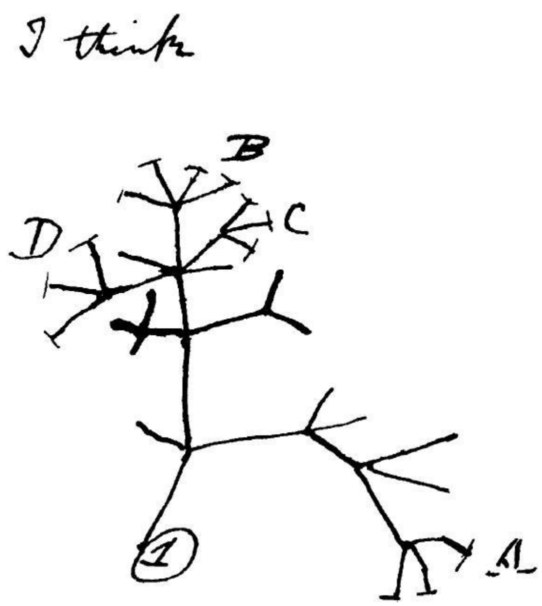


Figure 2.9: Sketch of Darwin's Evolutionary Tree.
Source: Darwin's Notebook B: Transmutation of species from www.biology.stackexchange.com

In order to apply the evolutionary lens to this research, it is important to identify the connection between biological life and cities. Samaniego and Moses (2008) argue that as blood vessels of the vascular network distribute energy and materials to cells in an organism, road networks distribute energy, materials, and people in an urban area. From this perspective, a city can be likened to an organism with interdependent parts that are spatial but also include social, economic, and ecological aspects. Patrick Geddes describes the city in terms of several parts namely place, work, and folk that correspond to the geographical, historical, and spiritual aspect of the city (Welter, 2003). Cities thus display a variety of functions and yet an interdependence among their constituent parts. A city can thus be regarded as being a singular entity and a collection of diverse entities. It is geographically and administratively defined as one urban centre yet comprised of numerous smaller units including constituencies, districts, and wards. Without appreciation of the part-to-whole relationship among elements of cities, urban fragmentation tends to occur. Indeed Borsdorf and Hidalgo (2009) observe that fragmentation and segregation are influenced by orientation towards individualism and private initiatives. This fragmentation often results in inequitable spatial and socio-economic development, non-optimal use of resources, and citizen dissatisfaction.

Similar to living beings, cities are birthed and grow. Like organisms, they can also become sick and die, the latter concept being well articulated in the seminal work of Jane Jacobs entitled ‘Death and Life of Great American Cities’. In line with ailing of cities, Habraken (2012) argues that if indeed the built environment is an organism, then it can be expected to remedy that which ails it. Description of cities in organic terms is also demonstrated by Alexander (1966) who defines natural cities as those that have arisen spontaneously over many years. As an example of this urban life and death cycle is Ancient Greece. As a classical civilization, it pioneered systems of government and politics, architecture and art, culture, and philosophy. Ober (2015) observes that Greek efflorescence peaked about 300BC and lasted from the archaic (c.900BC) to the Hellenistic eras of Greek history (c.100AD). He further notes that by the 2nd Century Greece was a pale shadow of its former glory, and by the 21st Century it had become the poorest country in Europe.

Certainly ancient Greek Civilization does not exist today as it did in the past, with buildings such as the Temple of Athena in Athens recollected through ruins. During the 5th Century however, the Athenians and the Spartans were the most powerful political and cultural powers in Greece (Rubarth, 2014). Once-powerful city-states such as Sparta, Corinth, and Argos have been eclipsed in terms of size and significance by other cities in present day Greece. This shifting in significance illustrates cities are not static but are rather creations that are born, flourish, decline and die with time. Illness of cities can be described as a persistent malfunctioning of the city on administrative, political, social, environmental, and economic levels. It can manifest as an exodus of citizens from inner cities to suburbia as in the case of Detroit in USA shown in Figure 18 previous, or health-hazardous levels of air pollution as in the case of Shanghai and Beijing in China. Air pollution in China contributes to 1.6 million deaths per year, with intense pollution in the corridor from Shanghai to Beijing areas. This accounts for approximately 17% of all nationwide deaths (Rohde & Muller, 2015).

The essence of Darwin's theory is natural selection, which provides the basis of adaptation and speciation. It was regarded as the principle by which each slight variation, if useful, is preserved (Darwin, 1859). According to the theory, species that displayed the most traits that were most useful had the greatest capacity for survival through inheritance. There was the consequent destruction or abandonment of species with less fit traits, which prompted the introduction of the phrase 'survival of the fittest' by biologist Herbert Spencer (Howerth, 1917).

Darwin (1859) noted that there are sometimes many more individuals of each species born than those that can possibly survive, leading to a frequently recurring struggle for existence. A struggle for existence thus follows from the high rate at which organic beings tend to increase (Jones, 2000). Any species therefore that varies however slightly in any manner profitable to itself will have a better chance of surviving and thus be naturally selected. Any selected variety will tend to propagate its new and modified form. Natural selection is therefore the preservation of favourable variations and the rejection of non-beneficial characteristics (Figure 2.10).

In addition to establishing the connection between biological life and cities, it is also important to articulate the connection between variation in species and cities. Darwin (1859) argued that evolutionary change comes through the production of variation in each generation. Profitable variations are the precursor to natural selection. Biology defines variation as a slight departure or divergence from a typical or original form or a heritable change in an organism. Individuals with characteristics which increase their probability of survival will have more opportunities to reproduce. Offspring will also benefit from the advantageous character, so over time these variants will spread through the population. Since variation can be caused by genes or by the environment, urban variation can be caused by adverse environmental or contextual circumstances that compel development of variants. Variation can be in the form of new systems or modus operandi that enable the city to function better. Variants comprising beneficial features are thus replicated and spread through the city. These could include the introduction of an innovative hybrid structure incorporating street lighting and informal trading or introduction of time-based use of public space.

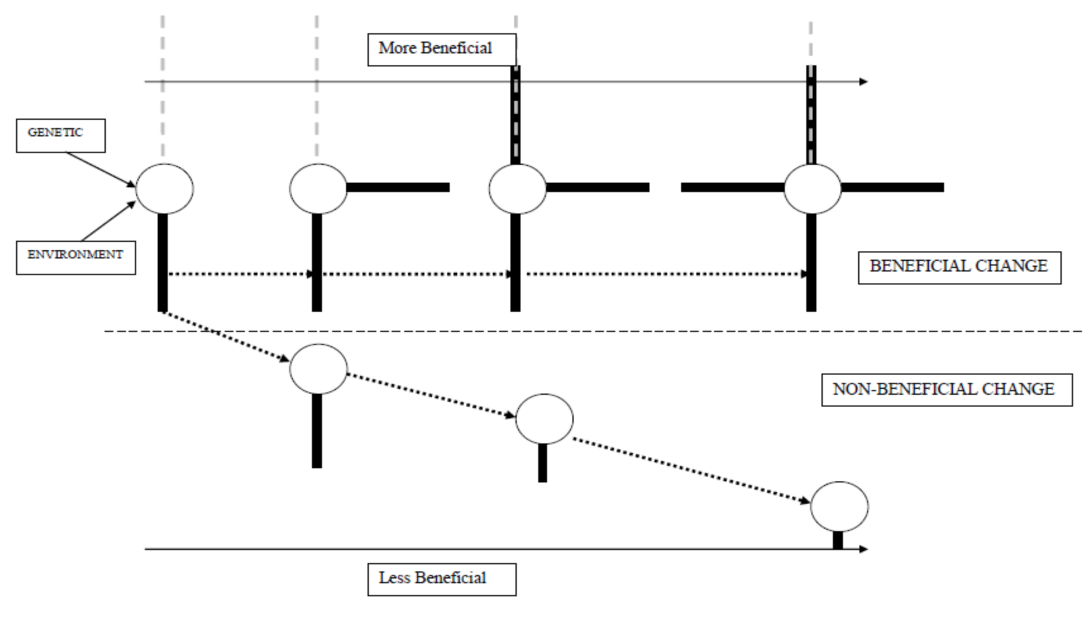


Figure 2.10: Summary of Key Elements of Darwinian Theory of Evolution. Source: Author

consequently be beaten in the race for life by commoner species. On the contrary, because of their rarity and uniqueness, it is expected that greater value will be attached to such species and effort made to preserve them from extinction. This can be likened to practice and attitudes concerning spaces in cities and neighbourhoods for instance. If a neighbourhood has only one large tree in its public park, it is probable that citizens of the neighbourhood will treasure the tree, seek to use it responsibly, and protect it if necessary. The tree is rare and therefore highly valued, making it a feature that is worthy of preservation rather than extinction.

It is important to identify the link between the theory of evolution and the design, form, and function of public open spaces. To do so, vibrant and popular public open spaces such as the 12th Century Piazza San Marco in Venice, Italy and the 19th Century Central Park in New York, USA are considered. Such public open spaces have persisted and performed as socially interactive recreational and transit-mobility spaces for centuries. The piazza for instance has been an integral part of Italian cities since medieval times. Nowadays it performs a complex set of functions as a market, neighbourhood park, gathering space, and automobile parking space (Fusch, 1994). Designed in the 1800s, Central Park still generates a happiness that is a product of geography, landscape architects, human choice, and people whose efforts have sustained the park over the years (Haybron, 2011). Both spaces therefore have several spatial, social, economic, and ecological characteristics that contribute to their function, vitality, and appeal.

Darwinian Theory intimates that it would be due to their advantageous characteristics that these spaces have remained relevant, responsive, and attractive to users and therefore survived or 'been naturally selected'. The favourable or advantageous spatial characteristics (variations) that enhance performance of public open spaces and indeed their likelihood to survive are retained while unfavourable or injurious characteristics are rejected. Some fundamental spatial elements have therefore remained generally consistent in public open spaces and have contributed to the sustained appeal and vitality of the spaces. Characteristics of such public open spaces are retained or in other words become reproduced or inherited, carrying on those characterstics that increase their chances of enduring as good public open spaces. Emphasizing the link between survival and function, Burke (1976) has argued that buildings from the past survived largely on their own merit and chiefly because they continued to serve useful purposes.

Aspects of Darwin's theory are reinforced by Lynch (1960) who indicates that the city is an object which is perceived by millions of people of widely diverse class and character, and also the product of many builders who are constantly modifying the structure for reasons of their own. Further, he indicates that while it may be stable in general outlines for some time, it is ever-changing in detail, and only partial control can be exercised over its growth and form. According to Marshall (2009) evolution refers to the effect of adaptive transformation over time. There is no final result, only a continuous succession of phases. It is through evolution that successful adaptations that urban order appear. The theory of evolution presents ideas on the origin and evolution of species. It is however criticised for leaving unexplained some pertinent issues for instance why it is that there are no species in various forms of evolution or 'linking forms' evident at any given time.

Critics of the Darwinian approach include Patrick Geddes, a key contributor to British town planning, geography, civics and sociology in the 19th Century. Batty and Marshall (2009) support that Geddes rarely invoked Darwin when applying evolutionary ideas to the social and urban context. This is because he considered natural selection as too mechanistic and too reliant on competitive struggle. Consistent with Dawkins, Geddes interpreted evolution as being primarily driven from within the organism, rather than by external drivers. Another area of divergence from Darwinism is that Geddes emphasised cooperation among species as being more important than competition between them. The notion of inter-species cooperation is in turn contrary to the perspective of Jones (2000) who argues that many of nature's most attractive features result from rivalry among cells of species.

21st Century critics of Darwinian evolution include anthropologist Jeffrey Schwartz. Schwartz does not dispute Darwin's theory that humans, animals and plants evolved from other species. He however contests two key parts of traditional Darwinian thinking namely gradualism and adaptation (Roth, 2006). Similar to aforementioned Geddes and Dawkins, Schwartz contends against natural selection. In particular, he posits that new organisms are probably generated by random changes in developmental genes and not as a result of natural selection. He argues that any new features will remain in existence as long as they don't hurt the creatures' chances of survival hence there is no natural selection and retention of characteristics due to advantage. These and other alternative views continue to be presented that challenge Darwin's theory of evolution. Lynch (1972) on the other hand agrees with Darwin as he argues that the passage of time in the urban environment is experienced through progressive and irreversible change. Urbanist Marshall (2012) argues that a city is evolutionary in the sense that urban change is gradual, incremental, adaptive, and ultimately transformative. Both urbanists thus concur on the progressive and transformative nature of urban evolution.

In support of the Darwinian principle of variation and selection, public open spaces in many cities are regarded as being beneficial, advantageous and profitable to the city. They have therefore been retained and protected by legislation and regulations governing the allocation and use of public open space. The fact that the spaces have persisted means that they have been 'selected' because of the environmental, social, economic, and spatial benefits that they provide to cities. According to Darwin (1859) those species that displayed the most traits that were most useful had the greatest capacity for survival through inheritance with the consequent destruction or abandonment of those less fit traits. Unlike Darwin's variation however, not only the advantageous but also the disadvantageous characteristics are passed on in public open spaces over time. Less fit traits are not always destroyed or abandoned; they in fact in some cases get replicated elsewhere. The profitable and the unprofitable are therefore retained in the spaces. Negative characteristics are not 'naturally' or automatically rejected by designers, managers, and users of the space, which is why cities have public spaces that can be improved. Contrary to the viewpoint of Jones (2000) therefore, selection may be inexorable and efficient, but in the context of urban spatial evolution, it is not simple.

2.4.3 Concept of Atrophy

Primarily referred to in biology and medicine, Barton and Morris (2003) indicate that skeletal muscle mass is modulated by muscle load, utilization, and regenerative capacity. They describe atrophy as the loss of muscle mass that can be accute or chronic. They further explain that accute atrophy refers to rapid mucle mass loss due to disuse or lack of loading, while chronic atrophy involves muscle loss related to aging, associated with impairments in muscle repair.

Atrophy can thus be described as a gradual wasting away or decline in effectiveness or vigour due to underuse, neglect or aging. This research is framed by the idea that public open spaces may decline in function, vitality, and atrractiveness due to lack of demand (load), use (utilization), and maintenance (regenerative capacity).

Likened to the concept of atrophy and referenced in Larmarckism, when discussing variation Darwin (1859) suggests that use strengthens organs while disuse weakens and diminishes them. Disuse aided sometimes by natural selection will often tend to reduce an organ or a feature when it has become useless by changed habits or under changed conditions of life. In the urban context, spatial and non-spatial features and activities such as enclosing fences, benches, and services can generally degenerate or ‘waste away’ if they are under-used. As the whole public space is a combination of inter-related parts and features, this would constitute an atrophying or wasting away of the space.

Regarding urban degeneration, Lozano (1989) argues that the built environment is never completed, never balanced, and the threat of decline is always present. Jacobs (1961) observes that if parks lie idle, it is bad for them and their neighbourhoods but they do not disappear as a consequence. Such spaces become neglected and often dangerous spaces whose intended role as recreational space for the public is often overtaken by illicit anti-social activities, parking, dumping or illegal acquisition. Trancik (1986) argues that some urban spaces are 'lost'. He describes them as undesirable urban areas that are under-utilized, deteriorating, and in need of re-design. He further argues that their under-use and condition are caused in part by their location in the city.

2.4.4 Concept of Sustainability

There has been much debate and multiple definitions of sustainability since it was first coined in the 1980s. According to Yanarella and Bartilow (2000), sustainability can have different definitions depending on which user and in what context it is being used. Marshall (2012) for instance, describes sustainability as being about time. He further describes it as a dynamic reality related to the life of a building, town, or community comprising change and decay. Magee et al (2013) similarly identify it as the endurance of systems and processes over time. Sustainability literature has followed two distinct yet alternate philosophical assumptions that underpin the sustainability definitions namely as a state of well-being and as an evolutionary process (Dimitrov, 2010).

Marshall (2012) questions the existence of a target sustainable future state, partly because the future is inherently unpredictable. Mankind cannot be sure what will be sustainable or not, as seen in the extinction of once-successful species or obsolescence of once-viable technologies. That which is deemed sustainable today may not be sustainable tomorrow. Strangas, a city in Sweden, exemplifies this change and unpredictability of the future. Soderlind (2012) describes it as a medieval town built on a lake shoreline that is attractive, socially, and culturally successful. He indicates that part of its attractiveness and vitality is its closeness to the shore and interconnection with the lake. In conclusion, he opines that in the 21st Century, if nothing had ever been built in its location, a new Strangas with the same layout and location would be illegal as its proximity to the shoreline would render it environmentally precarious and unsustainable.

Cross-disciplinary concepts that are central to discourse on sustainability include adaptability, ability to evolve, robustness, resilience, regulation, and conflict (West, 2009). Sustainability is also defined as being about improving the quality of human life while living within the carrying capacity of supporting eco-systems (IUCN, 1991). Curran (2009) vaguely describes it as a destination that mankind aspires to reach while Bagheri and Hjorth (2007) note that definitions of sustainability are expected to become even more complex and sophisticated over time, with increased knowledge. West (2009) highlights failure to come to grips with the essence of the long-term sustainability challenge, described as the interconnectedness of energy, resources, ecology, economic, social, and political systems. It has thus emerged that no overarching, global conceptual framework has been developed uniting the many highly inter-related themes underlying sustainability.

Therefore referring back to its underpinnings as defined by the UN Brundtland Commission of the 1980s, the concept of sustainability was derived from that of sustainable development. Sustainable development has been described as that which meets the needs of the present without compromising the ability of future generations to meet their own needs (UN, 1987). It seeks to create a desirable tomorrow that is socially inclusive and equitable; protects environmental resources; and follows sustainable production and consumption for current and future generations to meet their own growth and development needs (UN, 2013). Aligned to this perspective, Durack (2001) posits that sustainable development satisfies the choices of the present, without compromising the ability of furture generations to make choices of their own. Kenya's National Spatial Plan in turn identifies sustainable development as a balancing of social, economic, and environmental dimensions of development and catering for current and future generations (GOK, 2017). Fowke and Prasad (1996) however argue that the concept of sustainable development runs the risk of becoming meaningless due to a lack of consensus of the concept itself.

By the 1992 UN Conference on Environment and Development there was consensus that the concept of sustainability encompassed interrelated ideas drawn from economic, social, and environmental realms thereafter known as the ‘three pillars of sustainability’. Indeed, the UN has identified economic, social, and environmental protection as informing its sustainable development goals (UN, 2005). Economic sustainability entails optimal economic efficiency regarding use of scarce resources. It involves renewable energy development and minimization of resource depletion. Environmental sustainability focuses on the stability of biological and physical systems that entail natural ecosystems and biodiversity. Social sustainability is people-oriented, focused on stability of social and cultural systems, access to social services, and engagement of women and youth (UNECA, 2012).

In response to this tri-fold approach, the IUCN (2006) has argued that the pillars cannot be treated as equivalent. It argues that the economy emerges from society and that the environment should be treated differently since unlike the economy, it is not created by society. Kuhlmann and Farrington (2010) argue that describing sustainability as encompassing three dimensions, namely social, economic, and environmental wrongly separates the social and economic aspects, which in reality are one and the same. Gibson (2001) opines that a cultural and a political pillar should be added to the three sustainability pillars, in line with Curran (2009) who proposes a broadening of scope to comprise economic, social, environmental and institutional aspects.

In addition to the economic, social and environmental factors, institutional sustainability is an imperative for achieving sustainable development in Africa. In order to enable sustainability to happen, the economic, social, and environmental dimensions needs to be balanced within an environment of good institutional and strategic frameworks. Institutional sustainability significantly involves matters of governance (UNECA, 2012). For the Africa region therefore, governance and institutions, taken together as a component element, is fundamental to sustainable development. Respect for rule of law and enforcement of local legislation are matters of governance that impact the way in which urban space is experienced and used for developed and developing countries.

Good urban design is essential for delivering places that are sustainable on all counts specifically places that create social, environmental, and economic value (Marshall, 2012). Sustainable cities of the 21st Century are described as being lively, safe, and healthy (Danish Architecture Centre, 2008). They would be people-friendly, compact in form, and have good public spaces that invite people to walk and bicycle as much as possible. In tandem, Worpole and Greenhalgh (1996) argue that public space is of central political importance to questions of sustainable, equitable and enriching urban life. Banerjee (2001) further posits that public spaces are an essential ingredient to the sustainability of cities for political, social, economic, public health and biodiversity reasons.

The Sustainability Value Map is a tool for evaluating sustainability that divides ecological, economic, and social elements of sustainability into equal segments (Butters, 2012). The Value Map measures sustainability levels ranging from situations with poor standards to those of average quality, those above average, and finally conditions for a fully sustainable situation. Figure 2.11 indicates a settlement with low energy consumption, compact land use, adequate health services and recycled materials use. This tool however lacks a governance or institutional segment, which is vital in design and evaluation of sustainability in developing country contexts.

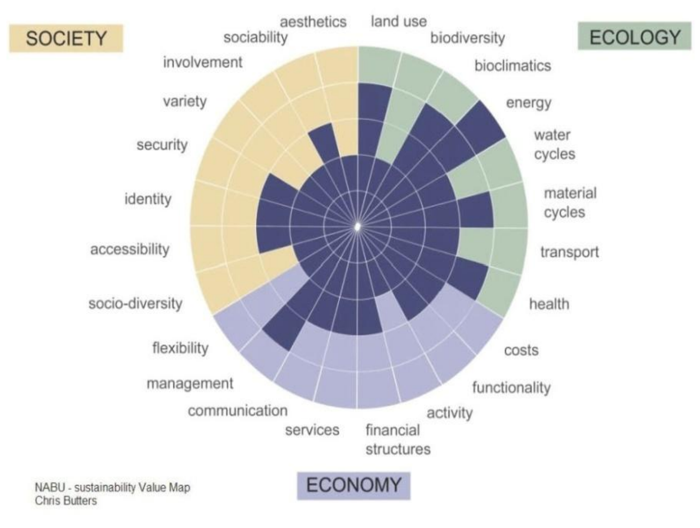


Figure 2.11: Sustainability Value Map **Source: Butters, 2012**

A second tool for measurement of sustainability particularly at the neighbourhood level is LEED-ND. Based on Leadership in Energy and Environmental Design (LEED), LEED-Neighbourhood Development (LEED-ND) is a sustainability certification tool for large-scale land developments that is proving essential for sustainable urbanism (Farr, 2012). As indicated by Farr (2012), green building concerns identified in LEED include natural vegetation, hydrology, energy efficiency, water conservation and recyclable materials. Ellin (2012) has however criticized sustainability indicators like LEED for not adequately acknowledging site and cultural aspects, thereby failing to respond to local conditions and adaptations over time. She proposes a Sustainable Built Environment Tool (SuBET) that comprises social, cultural, economic and environmental indicator of sustainability. This notwithstanding, Farr (2012) still argues that by setting a common standard for municipalities and developers LEED-ND is expected to be a dominant tool for certifying and promoting sustainable communities in the 21st Century.

A third set of tools for measurement of sustainability is the UN Sustainable Development Goals (SDG) whose agenda was adopted in 2015 (UN-Habitat, 2016). The 17 goals aim to end poverty, fight inequality and injustice, and tackle climate change by 2030. In order to measure and evaluate progress towards achieving the SDGs, targets and indicators have been identified for each of the goals. Of relevance to this research, is Goal 11 that seeks to make cities and human settlements inclusive, safe, resilient and sustainable. Target 2 aims to provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities by 2030. Target 7 in turn, aims to attain a recommended level of open space in the built-up areas of cities for public ownership and use.

In this thesis, sustainability is defined as the ability of a public open space to uphold or to keep up its function, vitality, and attractiveness. Sustainability has four major aspects namely the social, economic, environmental, and governance aspects. A public open space is deemed sustainable if it enhances its function, attractiveness, and vitality.

2.4.4.1 Aspects of Sustainability and Public Open Spaces

The Theory of Evolution, the Concept of Atrophy, and the Concept of Sustainability guided selection of variables and subsequent development of research instruments. Literature reviewed a range of theories including Linkage Theory, Place Theory, Garden City Concept, Broad-acre Concept, Smart City Concept, Compact City Concept, and New Urbanism. From the Theory of Evolution, the Concept of Atrophy, and the broader literature review, spatial characteristics were identified that would enable determination of the evolution of public open spaces from 1963-2015. Of necessity, these characteristics required to be observable and measurable from maps and aerial photographs.

Guided by the Concept of Sustainability and the broader literature review, variables to determine the social, economic, environmental, and governance influencers of sustainability in public open spaces were identified. The following gives an overview of the measurable characteristics used to establish factors that contribute to sustainability of public open spaces in the CBD.

Public Space Variables - Built and Natural Physical Environment

Regarding the *size* of space, Alexander et al (1977) have argued that public open greens should have an area of at least 5,575 sq. m. Influenced by size of space, the ability of the layout, activities, and parts of the city or urban space to be easily recognized and understood is described as its *legibility*. Defined by Lynch (1960) as apparent clarity, legibility of cityscape is about the ease with which parts of the city can be organized into a coherent pattern. A legible city or urban space therefore, would be one whose districts, landmarks, or pathways are easily identifiable and are easily grouped into an overall pattern. Although legibility is not the only important property of a beautiful city, it is of special importance when considering environments at the urban scale of size, time, and complexity. According to Moughtin, Cuesta, Sarris & Signoretta (2003), legibility of the urban structure refers to the ways in which people perceive, understand, and react to the environment. It concerns those qualities of a place which give it an identity and is common to the old European city, which is easy to spatially understand and thus favourable to navigate. As shown in Figure 2.12, in such cities the important public and religious buildings were the tallest and imposing, while the main public squares and streets were used for movement, parade, and meeting.

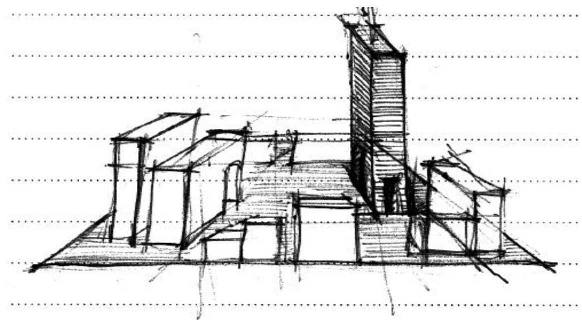


Figure 2.12: Sketch showing legibility of a public square. Source: Author, 2017

Sim, Yaliraki, Barahona and Stumpf (2015) argue that great cities connect people, while failed cities isolate people. Connection can be of different types such as social, cultural, or spatial. Spatially, the arrival at public open spaces of the city is influenced by the *connectivity* of the space. Connectivity thus refers to the level of penetration of pedestrian and vehicular paths of movement that lead to the space through designated linear spatial connectors. Connectors link to the space itself or to a perimeter roadway enclosing the space. Marshall (2005) describes connectivity as the capacity of connections to carry people or vehicles to and from a particular destination. This connectivity influences the volume and frequency with which people can arrive at and thus use the space whether through highways, streets, roads, or alleys Jacobs (1961) argues that the problematic parks are those located where people do not pass by and likely never will. She further notes that for good connectivity within a neighbourhood, majority of blocks must be short and streets must be frequent (Figure 2.13 and Figure 2.14).

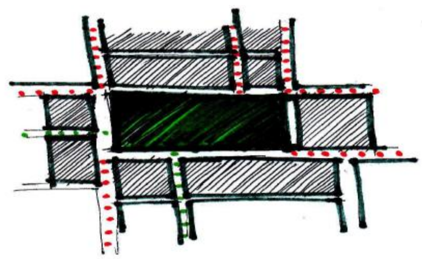


Figure 2.13: Sketch showing vehicular and pedestrian connectivity to space. Source: Author, 2017

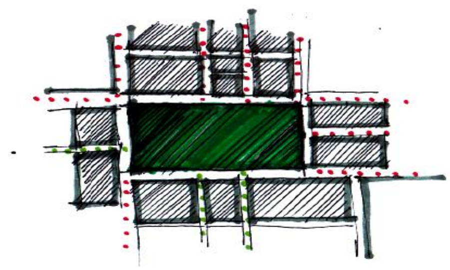


Figure 2.14: Sketch showing effect of increased connectivity on block size and street grain. Source: Author, 2017

According to Moughtin, Cuesta, Sarris and Signoretta (2003) finely meshed grids or finer grain offer different ways to get from place to place within the grid, which is an aspect of good urban form. Coarser, less permeable grids or courser grain offer fewer ways for movement, which is less favourable layout. Of the key elements of the form and layout of urban settlements, street patterns tend to be the most enduring (Tisdell, Carmona, Oc, & Heath, 2003).

In many instances public open spaces are bound by linear elements such as perimeter roads to which connector spaces link. *Boundaries* are typically continuous, defining the limits between sections of spaces (Lynch, 1960). Alexander et al (1977) posit that the strength of the boundary is essential to a neighbourhood and weak boundaries negatively affect the neighbourhood’s character. A different point of view has suggested that it is not necessary to have defined edges in order to have an efficient and good neighbourhood (Murrain, 2012) or public open space. Murrain further argues that the edge and neighbourhood have nothing to do with each other, and that an edge is irrelevant with regards to reinforcing separation of urban spaces. Jacobs (1995) argues that boundaries communicate clearly where the edges of the public open space are, and that they keep eyes on and in the space. According to Jacobs (1961) clear demarcation between what is public space and what is private space is necessary. Boundaries or other physical restrictions to the free movement of vehicles and people into space influence its attractiveness and function as a public good. *Frequency of vehicular traffic* on roads surrounding the space can influence the attractiveness of an open space to potential users as it relates to ease and safety in crossing the street. Roads and streets with high volume and high speed traffic if enclosing public open spaces, can deter potential users from accessing the space.

Formal control and monitoring measures are sometimes installed to control pedestrian and vehicular access into urban space. Lynch (1984) identifies control as a criterion to use in order to determine whether or not a city is functioning well. *Entry control* is typically associated with enhancing security and convenience in the use of public open spaces. Control is associated with territorial occupation of space for discharging daily activities and is dependent on ownership. Within the accessed space itself, circulation by use of the network of habitual or potential lines of movement influence its vitality and appeal to users (Lynch, 1960). Lynch argues that paths through the urban complex are the most potent means by which the whole can be ordered. The urban complex includes public open spaces among its constituent parts. Paths through urban space differ in scale and significance. Oktay and Jalaladdini (2016) posit that pedestrian circulation is not only critical but also more important than vehicular circulation in bringing vitality into urban spaces.

Often informing the circulation paths within the open space, *focal points* are notable organizing features that can give prominence to sections of the space (Figure 2.15). Alexander et al (1977) observe that a public space without a middle area is likely to stay empty. They argue that any area in the middle intended for public use will be wasted unless there is some sort of focal point such as trees, seats, a monument or a fountain. They further argue that people place themselves towards a view or vista. In turn, Jacobs (1961) suggests that good small parks typically have a place somewhere within them that serves as a pausing point and climax.

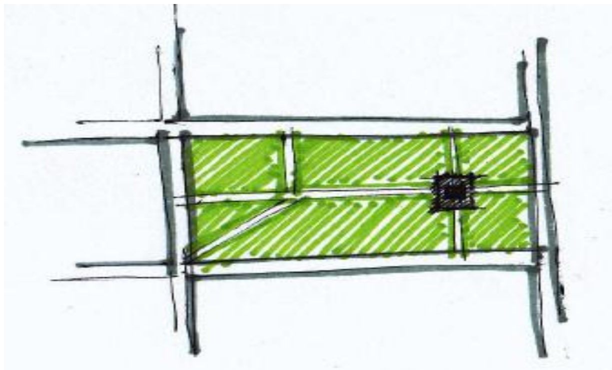


Figure 2.15: Sketch showing focal point in a public open space. Source: Author, 2017

The provision of adequate response to differing microclimatic and weather conditions determines that level of *comfort within the space*. This includes shelter against rain and wind, presence of shade, and pleasantness provided by breeze, coolness, and sunshine. Dobbins (2009) argues that if a place looks good, feels comfortable, and meets its functional expectations, it will attract people and engender their embrace, ongoing interaction, and stewardship. Physical comfort and wellbeing of the users has an influence on the probability of their using the space for extended periods of time or becoming return visitors to these public open spaces. Part of this user comfort is the *provision of fixed sitting areas* within the space that can comprise benches, stairs, and ledges. Vantage point and proximity to activities within public open space influence whether people want to stay in the space or not. Sitting space provides opportunities for users to watch ongoing activities in the space (Alexander et al, 1977). Also related to the comfort of the user is the *cleanliness of the space*. The extent to which the space is clean, void of litter, garbage, and refuse influences its function and attractiveness to users. People's behaviour depends on what you invite them to do (Oppliger, 2015). Sufficient invitation for people to dispose of litter by providing rubbish bins in the space will tend to result in their use of the bins. He further argues that a more attractive public realm will be used by more people.

The presence of natural vegetation such as grass, trees, shrubs, and bushes can influence the level of comfort and attractiveness of the space to users. *Presence of natural vegetation* and greening of the city makes urban places appealing and pleasant (Jabareen, 2006), which is significant for recreational public open spaces. Similarly Lefebvre (1991) notes that green or natural space tends to be attractive and esteemed by people in urban and other environments. Further to this, a sustainable city and neighbourhood would be green, having much natural vegetation (Danish Architecture Centre, 2008). He further emphasizes the need for greener cities with substantial amounts of vegetation to help cool the city and clean its air. *The use of alternative and clean sources of energy* within and surrounding the space can reduce dependence on fossil fuels within a neighbourhood or city. Use of solar power for street lighting and rainwater harvesting and storage systems in public spaces promotes use of renewable energy and thus enhances environmental sustainability.

Density plays a key role in planning, architecture, and urban design. In a spatial sense, density is defined as a number of units per given area, while city density is described as number of units or population divided by the developed area of the city (Boyko & Cooper, 2011). Physical building density is often expressed in number of houses or apartments per hectare, as the ratio of people or dwelling units to land area, or using Floor Area Ratio (FAR). The number of people within a given area becomes sufficient to generate the interactions needed to make urban functions or activities viable (Jabareen, 2006). A sustainable city as one that is compact in urban form (DAC, 2008). Compactness is achieved through size of buildings, height of buildings, and good densities of buildings that encourage walking in between destinations. Attitudes towards high densities cannot be regarded as fixed or homogenous. This is because levels of space consumption and proximity both of which relate to density tend to change within cultures (Jenks & Burgess, 2004). Jenks and Burgess opine that the benefits of densification are questionable where high density settlements also experience adverse conditions including overcrowding and air pollution. They argue that the sustainability gains from further densification will be limited where densities are already very high if unaccompanied by development of infrastructure and provision of socio-economic services and facilities.

In addition to the density, the *external condition of buildings* within and surrounding the space can influence attractiveness, function and vitality. The Broken Windows Theory uses broken windows as a metaphor for disorder within neighbourhoods. The theory links disorder and incivility within a community to subsequent occurrences of serious crime. Prevalence of disorder creates fear in the minds of citizens and reduces use of space because people become convinced that the area is unsafe. Disorder causes crime, and crime causes further disorder and attracts more crime (Britannica, 2016). Lang (2005) argues that in the case of decayed and deserted buildings, often it is not the design itself that was the problem but the surroundings. Whether this is the case or not, it is evident that the condition of the building influences their physical setting and that the surrounding environment in turn also has an influence on the building. Jacobs (1961) argues that in order to promote diversity of use within neighbourhoods it is important to have a mix of buildings, including buildings that are old. Whether old or new buildings, the location of the main entrances to the buildings facing the space is significant in terms of the solid-void relationship. Gehl (1996) observes that buildings assembled with entrances orientated towards pedestrian routes or public space or outdoor areas contribute to assembly of people and events. This assembly of people contributes to the vitality and arises from numbers of users in a space and diversity of uses of spaces, be these for economic, social, cultural, or other activities. Sense of safety and wellbeing of users is influenced be the presence and type of other users in the public space. *Orientation of buildings* towards streets and public open spaces enhances the sense and reality of safety of users of the streets, sidewalks and spaces. Orientation of buildings influences safety of streets, one of four conditions necessary to promote walkability of a neighbourhood (Speck, 2012). Speck identifies the other conditions as comfort, interest, and purpose.

Enclosure can be partial or total and relates to the extent to which a space is defined and surrounded by enclosing elements. It refers to the degree to which streets and other public spaces are visually defined by buildings, walls, trees, and other vertical elements (Ewing, Clemente, Handy, Brownson, & Winston, 2005). Enclosure can be measured by buildings per linear distance surrounding the space and height of buildings surrounding the space. For enclosure, frequency of enclosing elements at the edge of the space is as important as the height of enclosing elements. Width is measurable from one building front to building front or perimeter edge of the other enclosing element. Shi (2012) notes that enclosure is important in public open space design within the context of urbanization and densely developed cities. Too much enclosure in terms of building height and densities may result in users feeling dwarfed or crowded-in within the space, which can result in a quaintness and intimacy of urban space (Plate 2.2 and Plate 2.3). Too little enclosure and there is tendency for users to feel overly exposed and sense that the space is poorly defined.

Plate 2.2: Enclosure of street in medieval York, England.
Source: www. coolplaces.co.uk

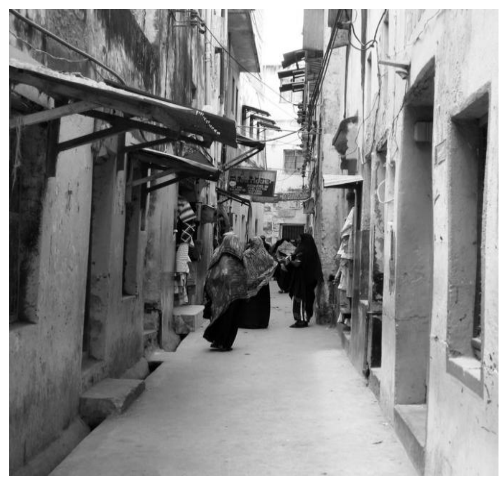


Plate 2.3: Characteristic narrow street of Islamic towns in Lamu, Kenya.
Source: www.walleigh.com

In smaller outdoor spaces such as gardens, parks, walks, plazas, enclosure seems to create a feeling of security (Alexander et al, 1977). According to Camillo Sitte, cited in Kostof (1992) successful European city squares were partly enclosed and opened to one another, so that one led into the next. Of Sitte's many principles, enclosure was the most significant espousing the positive visual and psychological effects of enclosed space in cities. According to Alberti, cited in Kostof (1992), if the surrounding buildings of a square are too low the open space will appear too large. If they are too high, the space will be unduly restricted. A proper height for buildings around a square is one third of the breadth of the open area, or one sixth at the least.

According to Dobbins (2009), buildings are significant in imparting the character and establishing the function of the public realm in several ways. Building on the argument of Jacobs (1961) that the presence of buildings around a park is important in design, their presence around all public open space can be deemed important. This is because buildings, trees or other elements enclose the spaces. They make a definite shape out of the space, so that it appears as a significant event in the city scene, a positive feature, rather than a left-over space of no account. According to Jacobs (1993), the proportion of building heights to street width (Height-to-Width Ratio) should be at least 1:2 (Figure 2.16).

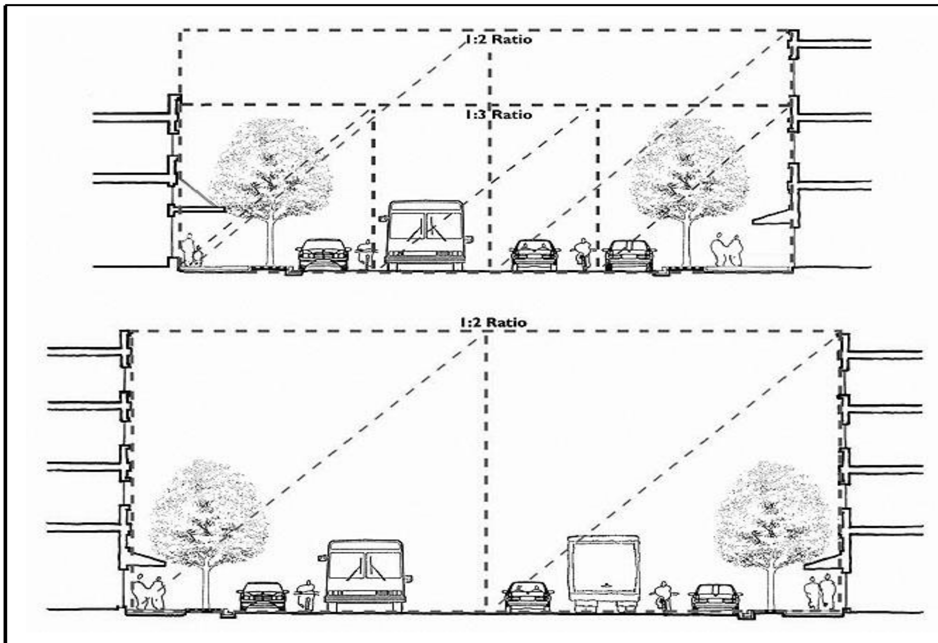


Figure 2.16: Building Height to Width Ratio and Thoroughfare Enclosure.
Source: www.ite.org

Alexander et al (1977) however argue that the total width of the street, building to building, should not exceed the building heights in order to maintain a comfortable feeling of enclosure. Incorrect ratios may lead to feelings of claustrophobia and reduce light penetration into the space (Tisdell, Carmona, Oc, & Heath, 2003).

Visibility is related to sight lines that are enhanced or obstructed by buildings, structures, vegetation, or shifts in ground levels. Since it is about the ability to see what is in and around the space as well as the ability to be seen, visibility relates to security. Streets and other public open spaces become safer for users when natural surveillance is possible enabled by physical characteristics of built form and space. To encourage users of surrounding streets, sidewalks, and buildings to passively watch public life in open spaces, buildings must be oriented towards the space, have minimal obstacles and barriers in between the building and space, and be at a distance where activities within the park are visible and users recognizable. According to Jacobs (1961) open spaces should be created with multiple, relevant, and complimentary functions to avoid becoming redundant spaces, environments for crime, and bleak vacuums between buildings.The mixture of workplaces and residences is encouraged because it tends to ensure that different people at different times of the day keep streets lively and safe with their presence. Oktay (2016) argues that visual accessibility allows people to see and be informed about the happenings within the public open space. He adds that urban public space should invite people to enter the space and use its facilities. Presence of visual connection between the open space and its environs can make potential users feel attracted and welcomed into the space.

The closeness of public open spaces to areas of work or residence has an influence on the probability of people walking to use the spaces. This *proximity of space to public transport hubs* is concerned with distances between hubs and traveller destinations and resulting willingness of people to use public open spaces. Alexander et al (1977) argue that distance can overwhelm the need of people to walk to greens or other recreational public open spaces. He further posits that the most frequent users of these spaces would be those that live less than three minutes walk away from them. City centres with low residential use and users of public open spaces typically have people that commute into the city centre area for work, transit, commerce, recreation or other purposes. The walking distance from a major bus station to public open space may therefore influence the attractiveness, use, and therefore vitality of the public space. In order to create neighbourhoods that are sustainable good public transport plays an important role and that less dependence on private cars will lead to a better, less polluted, and more people-friendly city (DAC, 2008).

Depth of space from carrier space influences vehicular and pedestrian movement within neighbourhoods. Shallow spaces are easily locatable and accessible from principle paths of movement. They tend to be associated with high traffic speed, traffic volume, pedestrian delay time, traffic accidents, noise levels, and pedestrian speeds. They are additionally associated with vehicle-pedestrian conflict and high parking intensity. On the other hand, deeper spaces tend to be associated with waste accumulation and incomplete facades or poor construction (Moirongo, 2011). Neither shallow nor deeper spaces are automatically or particularly safe or attractive environments as they create two extremes of urban space with difference urban problems. The worst problem parks and public open spaces are located precisely where people do not pass by and likely never will (Jacobs, 1961).

The *constitutedness of space* or the relationship between the urban solids and the voids can be an important contributor to enhancement of sustainability of space. It deals with the permeability and transparency of the solids and their proportions in relation to each other and the adjacent urban voids or the space. Permeability and transparency are important in urban design as they initiate interaction between the solids and the voids (Moirongo, 2011). Dobbins (1997) notes that public and private spaces are in constant interaction and that functions of buildings accessibility, visibility, and uses influence the interface between private space and public space.

Public Space Variables - Economic

Mixed use refers to mixture of uses of spaces or buildings that compatibly brings together commercial, social, recreational, residential, and other uses. It is among the principles of New Urbanism as supported within neighbourhoods, within blocks and within buildings. Jacobs (1961) argues that in order to create good neighbourhoods or districts as many of its internal parts as possible must serve preferably more than two primary functions. Thadani (2012) underscores that the best part of all cities have a diverse mix of uses creating neighbourhoods that are alive during the day and evening. In tandem with Thandani, Jacobs (1961) argues that the sidewalk must have users on it fairly continuously. Busy sidewalks ensure street safety and create a vitality that is among the criteria used to measure good urban spaces. She further argues that the parts of cities that literally attract people are seldom in the zones immediately adjoining massive single uses. According to Parker (1994) a mixed-use area containing restaurants, a museum, a theatre, and retail stores has greater potential to generate walking than an area with retail stores alone. He further notes that adding housing to the mix of uses improves diversity of uses significantly. A mixture of uses of buildings can thus produce for adjacent public open spaces a mixture of users that use the space at different times, which contributes to its vitality and function as a space of recreation or transit.

Diversity of use entails use of the space whereby various activities and categories of people function together side by side (Moirongo, 2011). Commercial activities include retail and office space ranging from eateries to mobile-money transaction shops to supermarkets. Mixed use has an important role in achieving sustainable urban form. Mixed-use or heterogeneous zoning locates compatible land close to each other thus reducing travel distances and times between activities (Parker, 1994). Mixed land use indicates the diversity of functional land uses such as residential, commercial, industrial, institutional, and those related to transportation. Mixing uses ensures that many services are within a reasonable distance, thus encouraging cycling or walking (Thorne & Filmer-Sankey 2003). In addition, according to Elkin, McLaren, and Hillman (cited in Jabareen, 2006) mixed use of space can renew life in many parts of the city and in turn enhance security in public spaces for disadvantaged groups. Reinforcing this argument, Cullen (1995) posits that excessive provision of over-specialized facilities weakens vitality of urban areas. For Jacobs (1961), diversity is vital and without it the urban system declines as a living place.

Alexander et al (1977) observe that the sight of action is an incentive for action. Social, economic, cultural, and physical activity within an open space therefore has the potential to attract users into the space as observers, users, or participants. Newman and Kenworthy (1999) note that urban planning has been un-mixing cities through use of rigid zoning that separates single land uses. This has resulted in cities with less diversity and safety, more traffic, and diminished attractiveness of local public open space. Jenks and Burgess (2004) however note that the vitality from mixed use in developing country cities exists in abundance with problems more likely to arise from too much rather than too little mixture.

Public Space Variables - Social

Jacobs (1961) observes that peoples' use of parks make them successful. Not only is the use of the public space fundamental to its success, but also peoples' use of the sidewalks that surround the open space. According to Trancik (1986) people play the most important role in animating public squares. This view is consistent with Shaftoe's (2008) observation that ultimately public spaces are about people. Trancik additionally posits that if the space can attract sufficient activity, it will be perceived as successful in its design. In addition to urban squares, this applies to parks, gardens, promenades and other public open spaces.

Shaftoe (2008) argues that successful spaces have people lingering in them. In addition he advocates that in order for public space to be non-cosmetic it must be functional and used. Alexander et al (1997) posit that places with less than one person per 15- 30sq.m. of paved surface will seem empty. This sense of emptiness reduces the vitality of the space and can influence its attractiveness as people tend to be drawn to places where other people are located. Vitality is related to use of space by people. Vitality in urban public space refers to a safe, desirable, and attractive space with the capacity to offer more choices for social activities and cultural exchanges (Oktay & Jalaladdini, 2016). According to Lynch (1961), vitality as one of the performance dimension of urban design, described as the degree to which the form of places supports the functions, biological requirements, and capabilities of human beings. A mix in the ages and gender of space users introduces active and passive users of space. This introduces or enhances vitality and dynamism of use. Space will therefore be used differently on different days at different times in different ways, increasing the function of the space as one for recreation, trade, and/or transit.

Public Space Variables - Governance

The way in which African cities are growing influences the ability of urban authorities to provide adequate basic infrastructure or services (Cohen, 2006). For Africa in particular therefore, without an enabling governance environment and institutions that provide constitutional, accountable, regulatory and legal frameworks for productive activities to thrive, there will be no basis for sustainable development (UN, 2013). Existence of legislation that promotes good use of urban space and awareness of legislation by the public are critical components of sound governance. The enforcement of regulations and legislation that guides the use of public open space is fundamental towards making urban space sustainable. According to Lynch (1984), efficiency is among the criteria used to determine appropriateness of city form. Efficiency in delivery or access to goods and public services requires stable and efficient public institutions and procedures. Well-defined institutional frameworks dealing with human and institutional capacity are integral to quality service delivery.

2.5 Conceptual Framework

According to Miles and Huberman (1994) a conceptual framework is a visual or written product that explains the main things to be studied in graphical or in narrative form. It refers to the key factors, concepts, or variables and the presumed relationships among them. Following are key concepts and dependant variables that have been identified as measurements for sustainability.

The four aspects of sustainability namely social, economic, environmental, and governance are inter-related, having common viewpoints as emerged from investigation of the theory of evolution and concepts of atrophy and sustainability. The characteristics used to measure spatial evolution between1963-2015 are multiple. Connectivity, density, enclosure, tree cover, space size, and land use were used to measure sustainability. Land use was quantified using indices of commercial, institutional, residential, industrial, and warehouses/workshops (Figure 2.17).

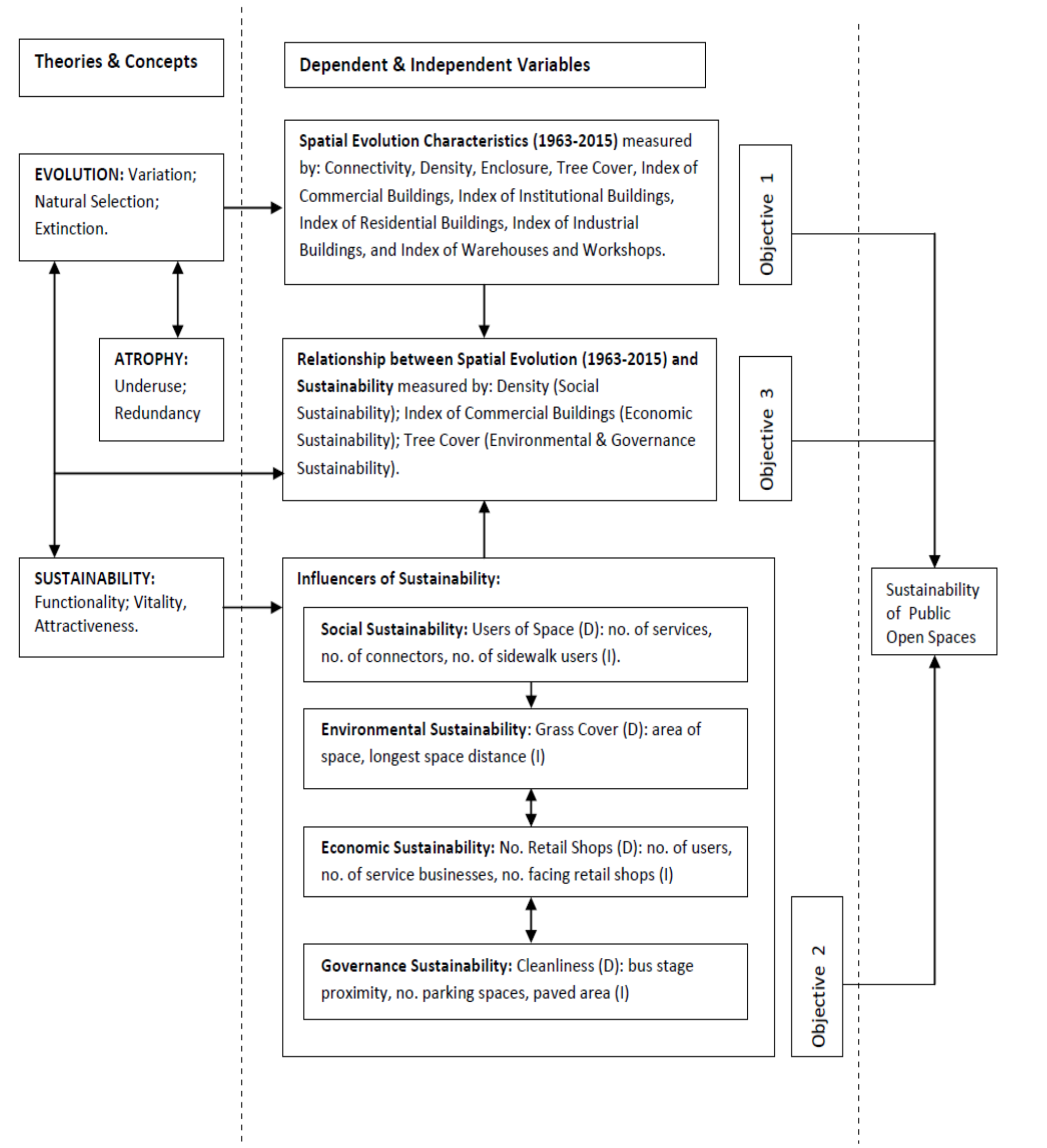


Figure 2.17: Research Conceptual Framework, Source: Author, 2017

2.5.3 Operational Definition of Key Terms

The following are a distillation from definitions of key terms articulated prior in this chapter.

- Sustainability is the ability of a public open space to uphold or to keep up its function, vitality, and attractiveness. Sustainability has four major aspects namely the social, economic, environmental, and governance aspects.
- Function is the purpose for which the public open space was created. This purpose ranges from parks, gardens, and roundabouts whose purpose is recreational, bus termini whose purpose is provision of public transportation, car-parks whose purpose is accommodation of vehicles, promenades whose purpose is provision of pedestrian routes of movement, and markets, which are meeting points for buying and selling of goods and produce.
- Vitality is the capacity and power of the public open space to endure in its environment. It refers to the capacity of the public open space to continue performing its role.
- Attractiveness is the quality of the public open space to be appealing or pleasing to the senses, particularly the visual, olfactory, and audio senses.
- Urban space is external space within the town or city that is measurable. It has definite and perceivable boundaries and can be public, semi-public, or private. It comprises two main types namely streets that include roads, boulevards, and alleys; and squares that include plazas and courts.
- Public open space is space under the jurisdiction of a public agency, predominantly exposed to the natural elements, and accessible to members of the public. It is governed by public agency regulations that dictate terms of use. Public open space can be recreational such as parks and sports grounds, commercial such as car-parks and markets, and utilitarian such as cemeteries.

- Evolution is transformational change that is gradual and process-oriented. It is a process by which transformation occurs in species, organism, or other populations over time through operations that include reproduction, variation, and selection.

CHAPTER THREE

AREA OF STUDY

3.1 Introduction

This chapter articulates Nairobi and its CBD, which is the geographical focus of the research. It captures national and city physical, social, and economic conditions and demographic characteristics. The development of Nairobi from a historic and spatial perspective is outlined, as is the legal and policy framework for urban development at national and county levels.

3.2 Physical and Socio-Economic Conditions

Nairobi is the capital and largest city of Kenya, the seat of national government, and the headquarters of Nairobi City County (NCC) (Figure 3.1). Located to the SW of the country, Nairobi County is approx 696 sq.km., and is divided into nine sub-counties and 27 divisions (NCC, 2014) (Figure 3.2). It is part of the Greater Nairobi conurbation comprising Nairobi City, Kiambu, Kajiado, and Machakos counties (NCC & JICA, 2014). Nairobi serves as a major business, financial, and manufacturing hub in Kenya and East Africa and is the regional headquarters to global organizations and companies (GOK, 2017). The city accounts for 50% of formal employment in Kenya and generates over 50% of the national GDP (NCC & JICA, 2014). From 1948 to 2009 urban centers in Kenya have increased from 17 to 230 urban centres respectively. Presently Kenya's urban population is approximately 12.5million, while Nairobi's estimated population is 3.36 million (GOK, 2017).

Associated with urbanization, this multi-sectoral hub has been characterized by inefficient transport systems, urban decay, insecurity, and governance challenges such as resource mismanagement and poor service delivery (GOK, 2017). As its first integrated and comprehensive plan, the Nairobi County Integrated Urban Development Plan (NIUPLAN) aims to counter the negative effects of urbanization by definition of development priorities and interventions towards achieving sustainable development goals (NCC, 2014).

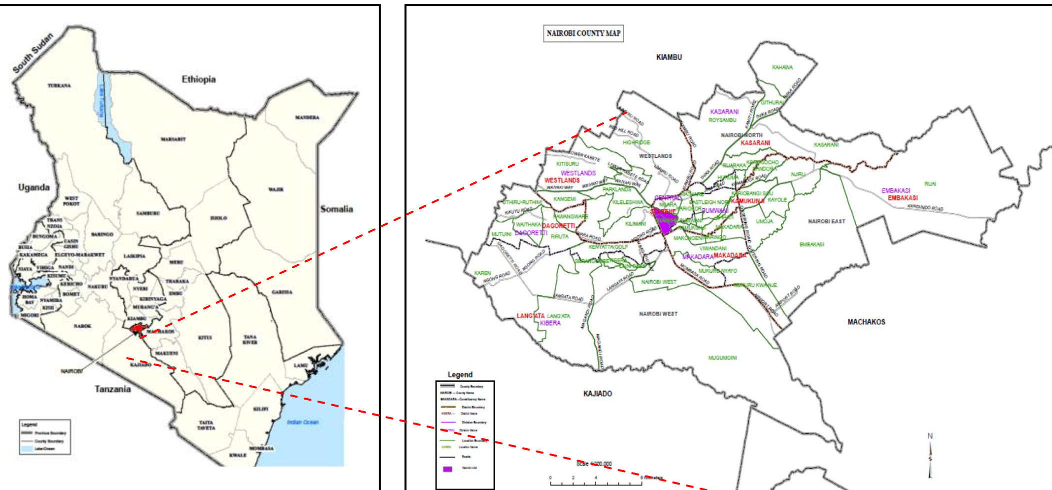


Figure 3.1: Location Map of Kenya and Nairobi City County.
Source: NIUPLAN, 2014

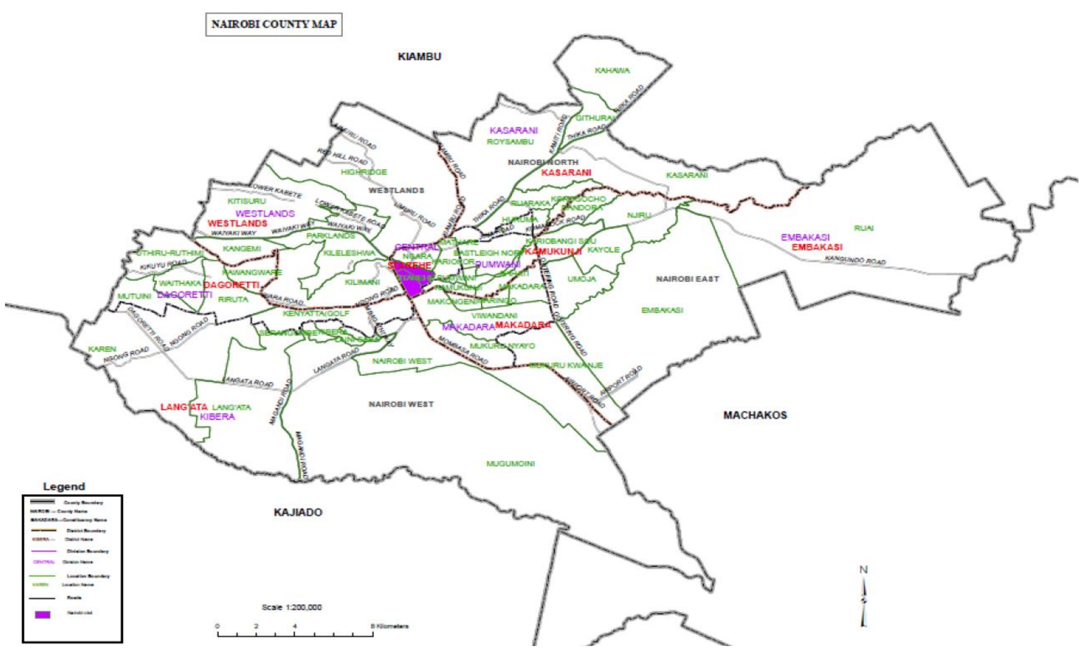


Figure 3.2: Nairobi County Administrative/Political Boundaries Map.
Source: NIUPLAN, 2014

Nairobi lies at an altitude of 1,798 m above sea level, with a fairly cool climate as a result of its high altitude (NCC, 2014). Its lowest elevation occurs around Athi River at its eastern boundary and its highest elevation at its western edge (NCC, 2014). Mean annual rainfall in Nairobi is

786mm. Kenya has a bi-modal rainfall pattern comprising the 'long rains' from March-May (mean rainfall 899 mm) and 'short rains' from October to December (mean rainfall 638 mm) (NCC, 2014). The climate in Nairobi is typically dry and cool between July and August, and hot and dry in January and February. Mean daily maximum temperature by month ranges from 22-28 degrees Celsius and the minimum ranges from 12-14 degrees Celsius (Figure 3.3) (NCC & JICA, 2014).

In Nairobi March, April, May and November are the months with most rainfall, while July and August are the coldest months of the year. These months also have the least hours of sunshine annually (Figure 3.4). These low temperatures and reduced sunshine can make public open recreational spaces less attractive to users during these months. Indeed Gehl (2011) identifies three types of outdoor activities: necessary activities, optional activities, and social activities. Use of public open spaces such as bus termini and parking lots are necessary activities as they are undertaken regardless of weather conditions. Use of recreational public open spaces is an optional activity. It can therefore be less popular during the rainy seasons due to exposure of users to inclement weather.

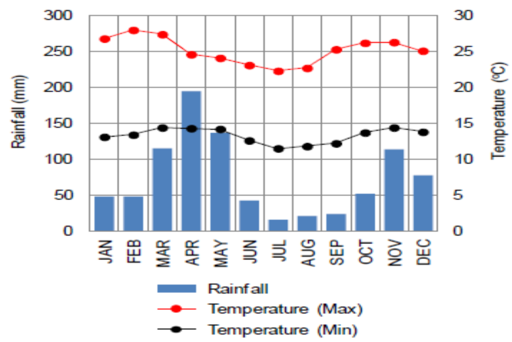


Figure 3.3: Rainfall and Temperature in Nairobi. Source: Kenya Meteorological Department, 2017

Figure 3.4: Average Sunshine-hours in Nairobi. Source: www.weather-and-climate.com, 2016.

3.3 Population and Demography

In 2009, the total population of Kenya was approx 38,610,000. Nairobi's population was approx. 3,138,400, accounting for 8.1% of the national population. The 2009 Kenya Population and Housing Census indicated that Nairobi's population comprised approx. 1.6 million males and 1.5 million females, with a density of approx. 4,500 persons per sq.km (KNBS, 2015). The 2009 population age structure indicates that majority of Nairobi's population is between 20-35 years (Figure 3.5) (NCC, 2014). The CBD is geographically located in Starehe constituency, parts of which have the highest population densities in the city of 500-1200 per hectare (Figure 3.6). The CBD public open spaces are therefore used for recreation, trade, and transit by large concentrations of people. These high population densities require a range of social services and facilities including public open spaces that are adequate, well serviced, and well maintained.

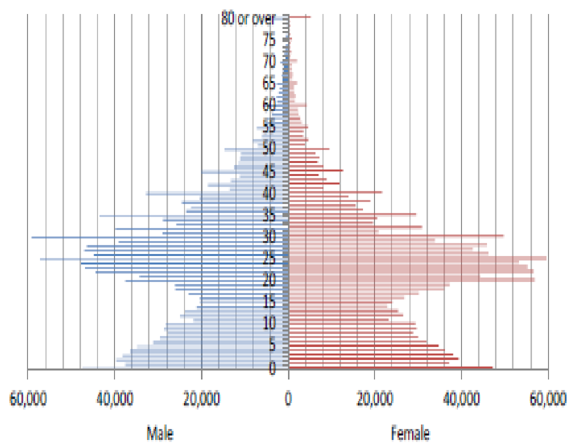


Figure 3.5: Age Structure of Nairobi Population in 2009. Source: Kenya National Population and Housing Census, KNBS, 2009

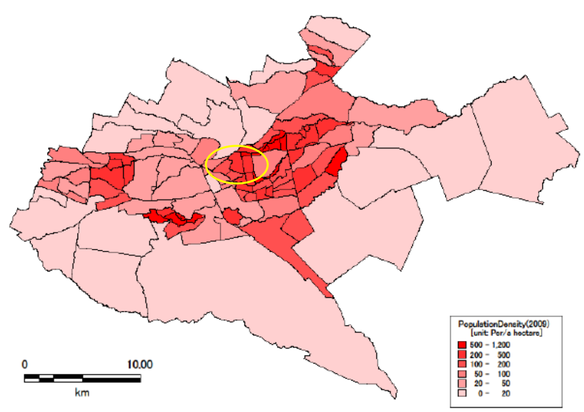


Figure 3.6: Nairobi Population Densities per Hectare. Source: Kenya National Population and Housing Census, KNBS, 2009

3.4 Historic and Spatial Development

Pre-World War 1 and World War 1 Period (1899-1918)

In 1899, Nairobi began as a stop-over for the Kenya-Uganda railway whose construction had begun in Mombasa in 1896. The decision to make 'Enkare Nairobi' the mid-point depot of the Mombasa-Kisumu railway was due to anticipation of challenges in creating a permanent route into and across the Rift Valley by railway authorities (Mehta, 1996). In 1900 the 18 sq.km. around 'Enkare Nairobi' was designated as a town to be the headquarters of the Provincial Administration and the Railway Department yards and workshops (Figure 3.7).

Nairobi, like many other cities in the world, at first grew without a town plan (White, Silberman, & Anderson, 1948). Initially there was plot by plot development as land was subdivided and slowly covered with buildings. In the early 1900s the core of the town comprised a few roads with residential, institutional, and commercial buildings in surrounding landscape (Plate 3.1) and (Plate 3.2). Early settlement patterns comprised European areas in the west of the town, including the area on 'the Hill' that was designated as Railway officers' housing. Part of the Asian population comprising discharged Kenya Uganda Railways workers, established shops to the north of the railway station. This area became known as the Indian Bazaar. Buildings were both commercial and residential for Africans that worked for the Kenya Uganda Railways (White, Silberman, & Anderson, 1948).

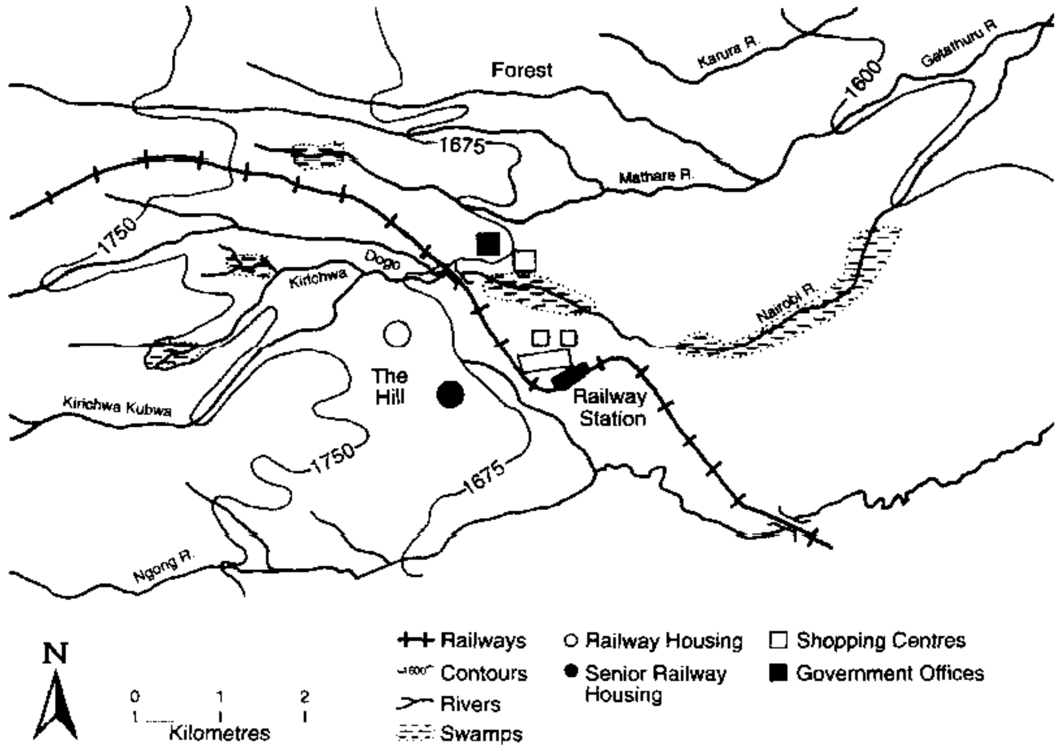


Figure 3.7: Nairobi c. 1900. Source: www.nzdl.org

Plate 3.1: Nairobi Railway Station 1902
Source: www.sikh-heritae.co.uk

Plate 3.2: Nairobi from Upper Hill 1902
Source: www.pininterest.com

An outbreak of plague broke out in the settlement in 1901-2 and 1904. After the first outbreak the Indian Bazaar was burnt down. After the second outbreak strong representations were made to the British government to have the town removed to a healthier site. The Indian Bazaar located towards the NE of the settlement that was damp, dark, unventilated, overcrowded, with poor sanitation (Figure 3.8). It comprised tin sheds used as dwelling houses, shops, stores, sundries, wash-houses, bakeries, and butcheries. As illustrated in Figure 3.9, resulting of the fire, the Indian Bazaar had been moved from its old location to the site south of Government Road (Halliman & Morgan, 1967). The problems experienced with the Bazaar were primarily due to lack of supervisory control of land use (White, Silberman, & Anderson, 1948). By 1905 the Indian Bazaar was thus relocated to its present-day location on Bazaar/Biashara Street which serves as a commercial hub for retail shops and sundries.

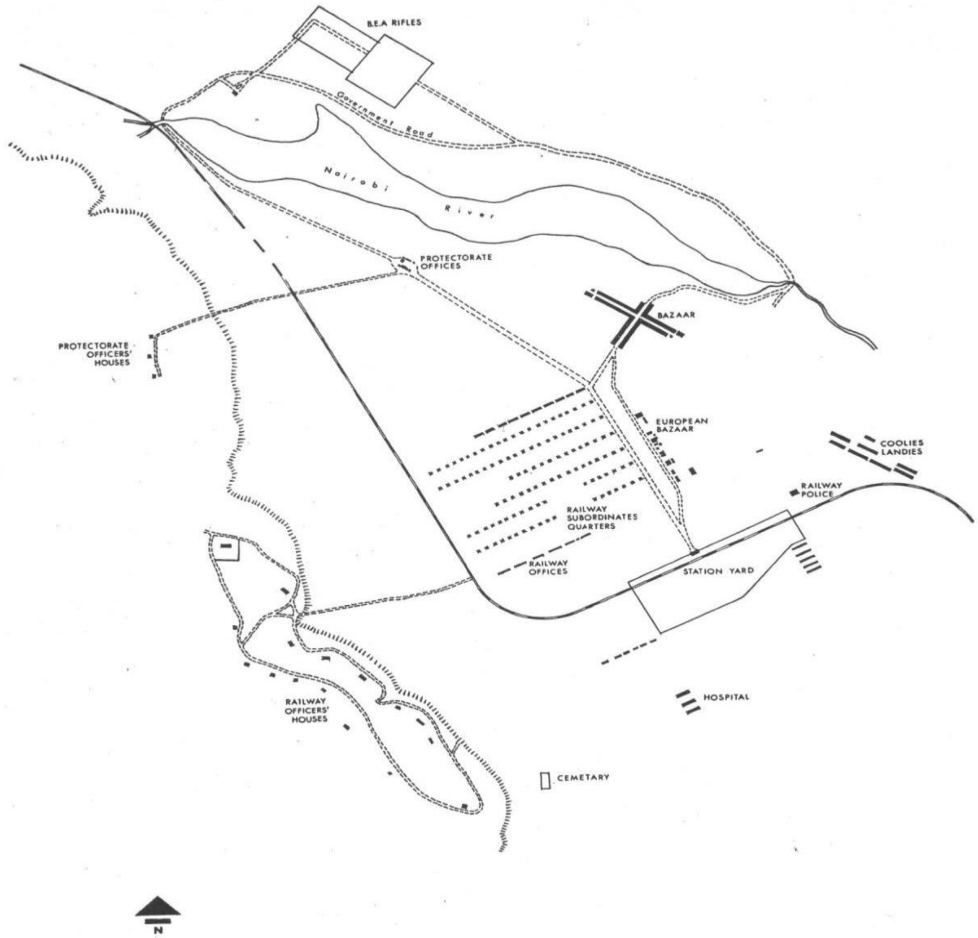


Figure 3.8: Nairobi Indian and European Bazaars, Railway Station, and Residential Quarters c. 1901. Source: Morgan, 1967

The municipal boundary in 1905 enclosed the Railway Station, Government offices, the Railway Quarters, Government Quarters, the Indian and European Bazaars and Parklands, which was the most concentrated suburban district inhabited by Government servants. Flanked by Station Road and the railway lines were 90 acres containing residential bungalows called the Railways Quarters belonging to the railway's subordinate staff (White, Silberman, & Anderson, 1948).

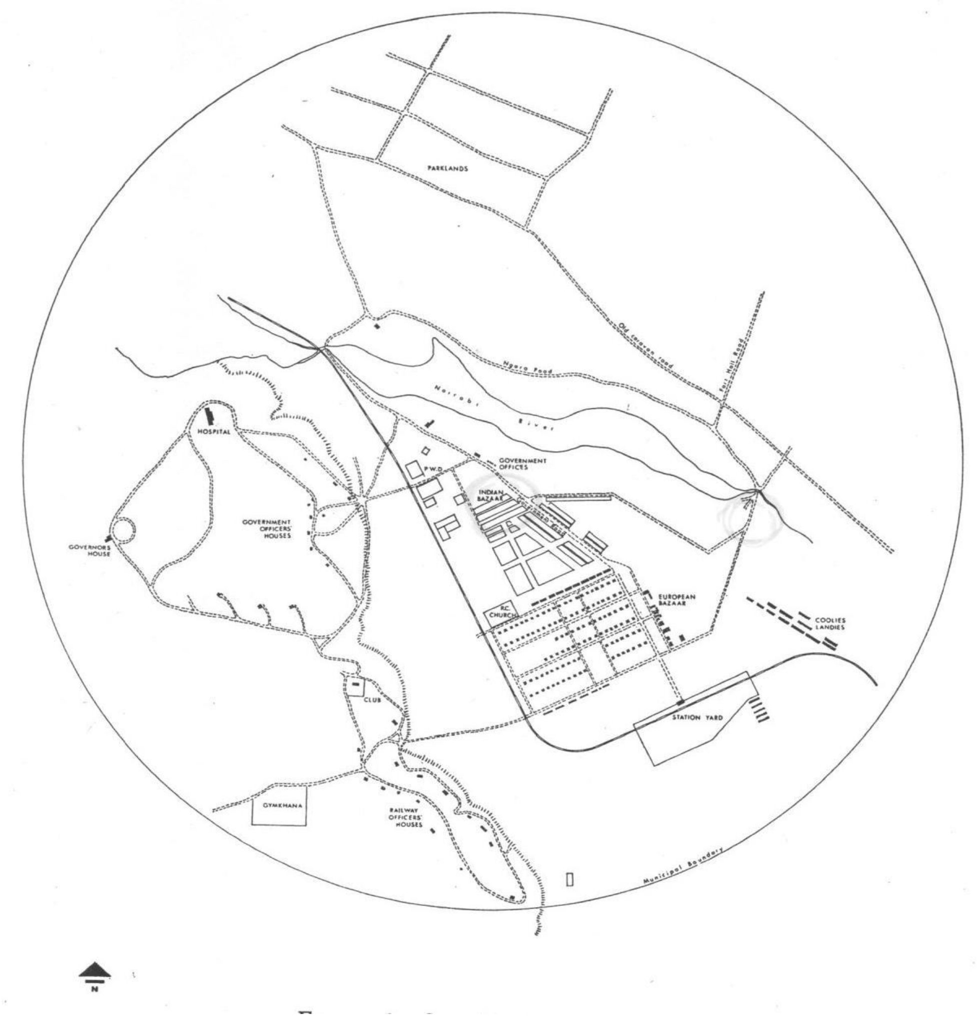


Figure 3.9: Nairobi Relocated Indian Bazaar, European Bazaar, Plot Divisions and Road Networks c. 1905. Source: Morgan, 1967

After completion of the Kenya-Uganda Railway and the influx of more non-African settlers, the town of Nairobi expanded rapidly. Halliman and Morgan (1967) indicate that by 1906 definite land use zones whose patterns underlie 1960s Nairobi had appeared, not through imposed planning, but by chance and the choice of inhabitants. The emerging pattern was thus the result of spontaneous growth. There was no town plan for Nairobi until about 1913 when town dwellers, users, and authorities began to demand a spatial plan (White, Silberman, & Anderson, 1948). By 1909 much of the road network in the central area of Nairobi had been established, and in 1919 Nairobi became a municipality with a corporation that prioritized lower-income public housing schemes. At about the same time the municipal boundary was extended to include some residential estates like Parklands. Among others, Muthaiga residential estate to the north lay outside the municipal boundaries and was considered a township with its own Town Clerk (Halliman & Morgan, 1967).

Inter-War Period (1919-1938)

Until 1919 Nairobi erected no African residential quarters (White, Silberman, Anderson, 1948). The earliest African public housing schemes were Kariokor and Pumwani towards the east of the town. They were nearest its centre, convenient to employment offered by the railway, inner light industrial district, and the industrial area (Halliman & Morgan, 1967). Communal buildings for Africans such as schools, dispensaries, and social halls were introduced in the interwar period. Ziwani was a municipal housing experiment, Starehe a government scheme, and Kaloleni a joint venture of government and municipality with communal kitchens, welfare clinics, and libraries. In addition, these neighbourhoods had sports grounds and the ‘village green’ as their area public open spaces.

After World War 1 European settlers became more influential in colonial administration. The European-dominated municipality introduced town planning with zoning of areas for different purposes (Nevanlinna, 1996). The Local Government Commission of 1926 produced a report concerned with extension of the municipal boundaries to include suburban areas. In 1927 a plan for a settler capital was drawn that expanded the settlement area to approx. 77 sq.km.to accommodate the growing population (Figure 3.10). The plan focused on improvement of drainage, clearance of swamps, regulation of buildings and densities, and traffic regulations (NCC, 2014) The Local Government Ordinance of 1928 laid out the boundary for the old city that corresponds to the CBD of present-day.

From 1919-1938 Nairobi's built form transformed from a 'wild west' appearance into a more urban and culturally more European town. Contributing to this change was the construction of large public buildings in the town centre such as the Law Courts, the Railway Headquarters, the Municipal Offices, the development of the Indian Bazaar, and the construction of the tarmac road system connecting the suburbs to the town centre (Nevanlinna, 1996).

World War 2 and Pre-Independence Period (1939-1962)

By1948 peri-urban estates and villages such as Karen, Spring Valley, Ruaraka and Kibra were growing, prompting the 1948 'Master-plan for a Colonial Capital' to emphasize on development of the neighbourhood unit. The master-plan introduced zoning with institutional and official, business and commercial, industrial, and residential areas, open space, forest reserves, and parks (Figure 3.11). The plan intended that vast portions of land be allocated to open space, describing the planning for open spaces as 'the conscious treatment of that preserved space, its landscaping and utilization for enjoyment' (White, Silberman, & Anderson, 1948).

The master-plan was to guide the general, physical, economic, and social development of the city over the succeeding 25 years. It ultimately aimed to evolve a pattern for balanced growth in view of the growing population and purposes of the town (White, Silberman, & Anderson, 1948). For the most part however, the master-plan remained unimplemented. Indeed Moirongo (2011) underscores that the master-plan neither defined nor provided a concept upon which the city could develop but rather preserved the existing urban structure for practical and economic reasons.

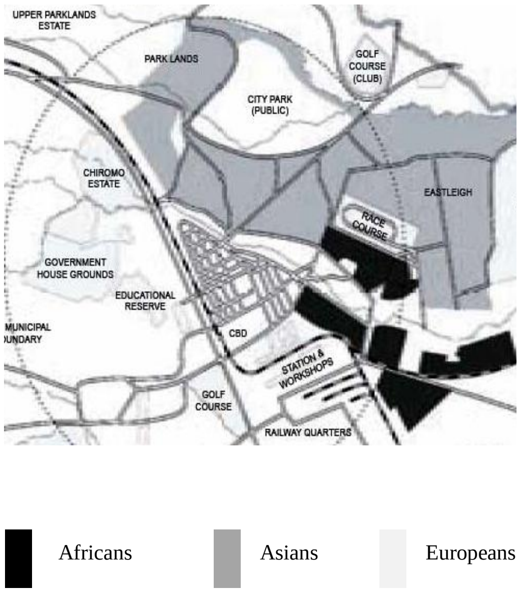


Figure 3.10: 1927 Nairobi Plan for Settler Capital Showing Racially Segregated Zones. Source: ETH Studio Basel Nairobi/Vogel, 2008.

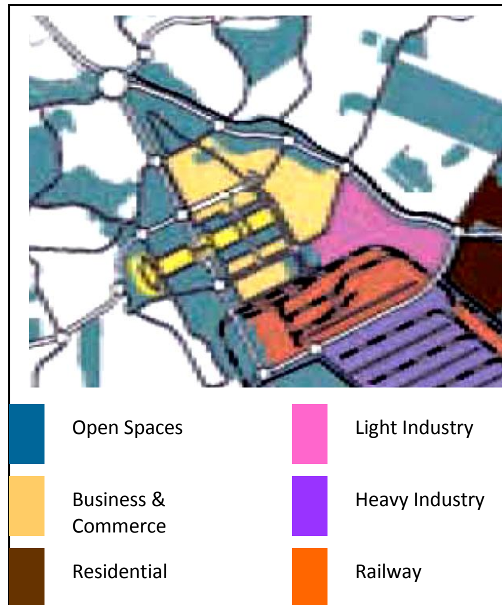


Figure 3.11: 1948 Nairobi Master Plan for Colonial Capital Showing Land Use. Source: ETH Studio Basel Nairobi/Vogel, 2008.

In 1950 Nairobi was elevated to city status by royal charter. In 1952 the up-country railway was re-routed out of town and replaced with the Princess Elizabeth Road, present-day Uhuru Highway (Figure 3.12). This reduced traffic congestion to and from the Industrial Area and protected the greenbelt below 'the Hill' (present-day Uhuru and Central Park) from encroachment by urban sprawl (Morgan, 1967) (Plate 3.3) and (Plate 3.4). In addition to establishing the boundaries for the expansion of the road into the multi-lane major highway, the re-location facilitated the conversion of the area south of the railway station into an extensive industrial zone (NCC, 2014).

Plate 3.3: Greenbelt below 'the Hill': Uhuru Highway and Uhuru Park, 1955. Source: www.sikh-heritage.co.uk

Plate 3.4: Containing Sprawl: Uhuru Highway and Uhuru Park, 1970s. Source: www.sikh-heritage.co.uk

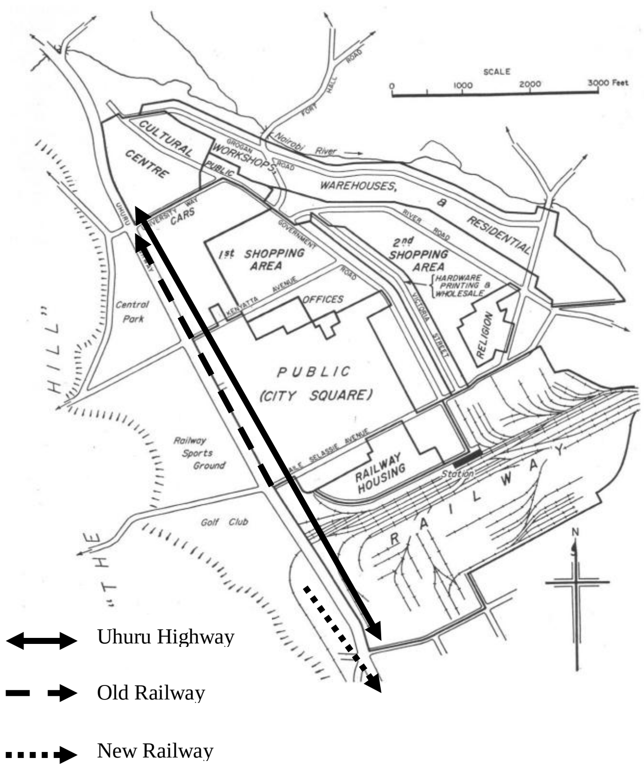


Figure 3.12: Re-routing of the Railway line that Curtailed Sprawl Source: Adapted from Morgan, 1967

Prior to Kenya's independence there had been an influx of people into Nairobi. This was attributed to urbanization caused by industrialization especially after the Second

World War, and the change of the colonial economy from food crops to exportable cash crops. The former attracted people to the city and the latter reduced populations in the rural areas. One of the administrative changes made in Nairobi towards independence was the extension of the city boundary that had been retained since 1928. The 1962 Regional Boundaries Commission included within the city boundary adequate land for future residential and commercial development, peri-urban dormitory areas, and strategic assets while retaining good agricultural land located to the north of the city. The city boundary was thus extended to 690 sq. kms, with 344,000 inhabitants. In 60 yrs Nairobi had grown from a town of 18 sq. kms (1901) to a metropolis with a population of over 1 million inhabitants (1962) (Nevanlinna, 1996).

<u>Post-Independence Period (1963 – 2015)</u>

The period 1963-1973 experienced prolific growth that created pressure on housing and other social services (Figure 3.13). To address this, the 1973 Nairobi Metropolitan Growth Strategy (NMGS) was conceived with the aim of easing pressure from the city's infrastructure by extending its boundaries (Mehta, 1996). The NMGS was designed to create a general frame within which local plans could be executed. In the Strategy, Nairobi was perceived within a regional context that extended beyond the city boundaries, laying emphasis on planning of the city's road network. Although decentralization was introduced in NMGS as the basis of regional planning, the established pattern of functional segregation and zoning persisted (Nevanlinna, 1996).

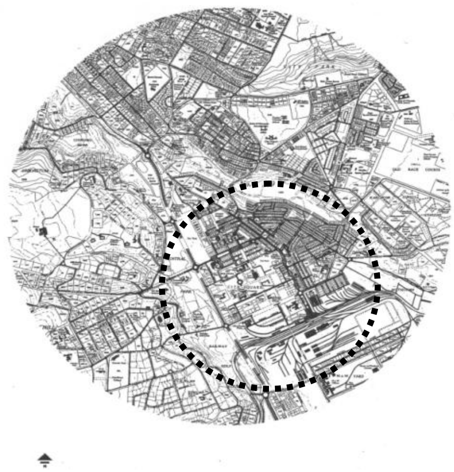


Figure 3.13: Urban footprint and density growth in Nairobi CBD, 1965
Source: Morgan, 1967

In the 1970s urban density and suburban development increased, coupled with major changes in the city's road network such as creation of Globe Cinema Roundabout to the NE of the CBD. In the older commercial centre, high-rise office buildings were being constructed along the major thoroughfares of Moi Avenue and Kenyatta Avenue. By 1983 the urban conglomeration as a whole and its centre had changed. The primacy of the city centre evident in the early 1960s had been replaced by sub-centres in the residential areas. Residential areas spread away from the city core, even beyond the city boundary. The former Asian combined commercial and residential area around River Road still retained its integrated functional character but fewer families lived and worked at the same location.

From the 1990s buildings with services previously found in the commercial centre began relocating outside the core namely west to Upper Hill and east to Ngara. Formulation of the Rezoning Plan for Upper Hill Area in 1993 was motivated by rapid development of multi-storeyed office buildings in a previously residential area. Earlier known as 'the Hill', it was the location for housing for Railways officers. Amongst other improvements, the plan prioritized expansion of infrastructure in particular road networks in the area (NCC & JICA, 2014). Into the 2000s Kenya's urban areas continued to grow supporting estimates that by 2030, 54% of the country's population will be urban. In 2010, approx. 90,000ha of the land in the nation was urban area (GOK, 2017). As its primate city, Nairobi continues to grow in terms of population and size, local and national level plans have been formulated to guide its development. The first of two key plans is the NIUPLAN which is the first County Integrated Development Plan (2013-2015) that identifies priorities, outlines strategic policy thrusts, and identifies projects and programme interventions towards achieving sustainable development in the county (NCC, 2014). The second is the National Spatial Plan (2015-2045) that is a national spatial vision that will guide long term spatial development in Kenya focused in optimal productivity, sustainability, efficiency, and equity in the use of land and territorial space (GOK, 2017).

A Figure-ground Summary of Nairobi Spatial Growth from 1900:

In its early years Nairobi's core town comprised basic residential, commercial office, and commercial retail areas. Densities were low, the settlement was scattered, and its surrounding area expansive. Nairobi River banks comprised the few designated public recreational areas of the early 1900s. By 1920s settlement density had increased and its footprint had extended to the west towards 'the Hill' and east, across the Nairobi River (Figure 3.14) and (Figure 3.15).

Figure 3.14: Nairobi Morphology Map, 1900 Source: Nevanlinna, 1996

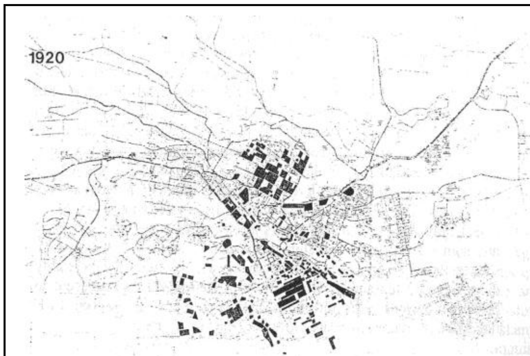


Figure 3.15: Nairobi Morphology Map, 1920 Source: Nevanlinna, 1996

By the 1940s, private and public open spaces were more distinctly defined. These included the Railways Golf Club adjacent to the railway line and present-day Uhuru Park. By this time Nairobi had a distinct commercial centre, suburbs, and a system of public services. The city also reflected Asian and to a lesser extent, African cultures, particularly in the functionally integrated and densely built areas in and near the centre. By the 1960s much of the present urban structure of Nairobi had been established with the beginning of the industrial areas to the south of the core and the erection of the publicly funded residential areas to its east (Figure 3.16) and (Figure 3.17).

Figure 3.16: Nairobi Morphology Map, 1940 Source: Nevanlinna, 1996

Figure 3.17: Nairobi Morphology Map, 1960 Source: Nevannlinna, 1996

During the first two decades following independence, Nairobi emerged as a modern metropolis modeled on western principles of planning. By the first decade densification that had increased within the city core and its environs. Public open spaces such as Uhuru Park, Central Park, Jeevanjee Gardens and the riverbanks continued to be used as recreational spaces. Other public open spaces from the 1960s were commercial municipal markets such as Wakulima Market, the Railways Station Terminus, Kenya Bus Services Terminus, and Globe Cinema Roundabout. The 1970s were additionally characterized by intensification of land especially in and around the centre, the outward extension of the urban structure particularly along the main thoroughfares, and the establishment of new residential areas to the east of the city centre (Figure 3.18) (Nevanlinna, 1996).

Figure 3.18: Nairobi Morphology Map, 1970 Source: Nevannlinna, 1996

3.5 Legal and Policy Frameworks for Spatial Urban Development

Kenya has legislation that guides economic, social, political, spatial, and infrastructure development at national and county levels. Numerous pieces of legislation have been put in place to steer urban development and growth, manage land issues, and address environmental concerns. These include the National Urban Development Policy, Urban Areas and Cities Act 2011, Physical Planning Act 1996, National Land Commission Act, 2012, The Building Code, and the Environmental Management and Coordination Act. The following section outlines aspects of key legislation and policy that influence urban spatial development in Kenya and Nairobi.

3.5.1 Urban Development-related Legislation

The Constitution of Kenya 2010 (COK) is the supreme law that outlines national values and principles of governance (Article 10) that include inclusiveness and attainment of sustainable development. COK Article 60 indicates the importance of sustainable and productive management of land resources, which is a pointer to its optimization. This legislation also establishes the requisite institutional framework to carry out spatial planning functions. National government formulates general principles for land planning and the co-ordination of planning by the counties. County governments are responsible for planning and development, while the National Land Commission monitors and oversees land use planning in the country (GOK, 2017).

The County Government Act (2012) defines the roles and management of the county government and replaces the Local Government Act Cap 265. It aims to effect to matters of devolution in the COK and to provide for the county government powers, functions and responsibilities in delivery of services. The County Government Act articulates a range of political and administrative responsibilities for instance county planning and delivery of county public services, which includes social facilities and amenities such as recreational public open space. This statute mandates county governments to carry out the planning function at the county level (GOK, 2017).

The Urban Areas and Cities Act (2011) is effective for all urban areas and cities in Kenya. It articulates multiple issues including classification, governance, and management of urban areas and cities, delivery of services, and integrated development planning. Since Nairobi City County is categorized as an urban area, formulation of the Nairobi Integrated Urban Development Master-plan (NIUPLAN) was guided by this legislation. The Act specifies that integrated development planning shall inform the provision of physical and social infrastructure and transportation, which includes recreational and social facilities. This statute provides for classification of urban areas and cities, their governance and management, and for integrated development planning (GOK, 2017).

Physical Planning Act Cap 286 (1996 revised 2010) provides for preparation and implementation of physical development plans and connected purposes. It informs physical planning and development control. The Physical Planning Act specifies two types of plans namely Regional Physical Development Plans (RPDP) and Local Physical Development Plans. This Act is the primary statute that provides for administration, types, content, process and approval of the various types of Physical Development Plans (GOK, 2017).

3.5.2 Urban Development-related Policies

Kenya Vision 2030 is the country's long term development blueprint for 2008-2030. It aims to transform Kenya into a newly industrializing, middle-income country providing a high quality of life to all its citizens by 2030 in a clean and secure environment. Vision2030 is anchored in the key pillars of economic, social, and political governance. Matters regarding provision of public open space fall under the social pillar, as such spaces are social amenities (GOK, 2017)

The National Urban Development Policy (2015) was formulated to accelerate economic development, eradicate poverty, promote equity, and to help Kenya realize its Vision 2030. Among others, National Urban Development Policy (NUDP) guides on provision of social and recreational facilities nationally. Until 2012 urban development in Kenya took place without a co-ordinated national urban policy framework. Sector policies therefore did not view urbanization as an opportunity for fostering integrated spatial, social, and economic development. NUDP thus deliberately articulates urbanization as an opportunity for sustainable development for towns and cities in Kenya. The policy attributes under-provision and poor maintenance of social facilities in Kenya to weak governance and constrained human and financial resources (GOK, 2015).

The National Land Policy heavily informed the COK on land matters. Besides identifying land policy principles and guiding values, it set out the goals and direction for the administration and management of land and sets out measures and guidelines for adoption towards achievement of optimal utilization and management of land (GOK, 2017).

3.5.3 Urban Development-related Plans

The National Spatial Plan (2017) is a long term plan that will guide Kenya's spatial development for 30 years (2015-2045). NSP envisions spatial development in a manner that promotes the competitiveness, prosperity, and high quality of life for citizens in line with the aspirations of Kenya's Vision 2030. The plan provides a national spatial planning framework for integration of social, economic, and environmental policies. Through this cross-sectoral coordination framework, it will help the country achieve sustainable development across sectors and mitigate duplication and wastage of resources. In addition, the plan anchors the preparation and implementation of lower-level plans such as County Integrated Development Plans, County Spatial Plans, and Local Physical Development Plans (GOK, 2017).

Respectively, the roles of the lower-level plans are as follows: the County Integrated Development Plans (CIDP) are five-year plans that set out goals for development of counties in Kenya. They are prepared as basis for development budgeting and expenditure. Sectors within counties are required to prepared sectoral plans in line with CIDPs. County Spatial Plans are ten-year Geographic Information Systems-based plans that indicate spatial planning in the counties. These plans that are a component of CIDPs are reviewed every five years. Lastly, Local Physical Development Plans are long or short term plans prepared for a city, town, or urban area for purposes of guiding development and coordination of development of infrastructural facilities and services (GOK, 2017).

CHAPTER FOUR

RESEARCH METHODOLOGY

4.1 Introduction

This chapter outlines the steps, actions, and elements engaged to effectively carry out the research. It explains the sampling of data, in particular its population and sample size, sampling unit, sampling frame, sampling method, and subjects. Also captured herein are the research variables and the tools used for data collection and data processing.

4.2 Research Approach

There are two basic approaches to research, namely the quantitative approach and the qualitative approach. The quantitative approach is based on the measurement of quantity or amount and applicable to phenomena that can be expressed in terms of quantity. The qualitative approach is based on subjective assessment of attitudes, opinions, and behaviour and applicable to phenomena that relate to quality or kind (Kothari, 2013). Mugenda and Mugenda (2003) expound that the quantitative approach includes design, techniques, and measures that produce discrete numerical or quantifiable data. In contrast, the qualitative approach includes designs, techniques, and measures that that do not produce discrete numerical data. In view of the aforementioned, this research engaged a quantitative approach.

Kothari (2013) identifies more than eight basic types of research, one such type is termed as descriptive. Descriptive research determines and reports the way things are, describing behaviour, attitudes, values and characteristics (Mugenda & Mugenda, 2003). Zeisel (1981) underscores that descriptive studies describe and measure one or more characteristics and their relations in a defined group. In this type of research the researcher has no control over the variables, only reporting what has happened or what is happening, through fact-finding enquiries of different kinds (Kothari, 2013). In view of the aforementioned, this is a descriptive type of research.

Fact-finding enquiry can be undertaken in several ways such as through listening, asking, or observing. In an observational study, the current status of phenomenon is determined not by asking but by observing (Mugenda & Mugenda, 2003). Observation is a research method used to collect data in descriptive research. The research principally relies on observation in order to collect and convey information regarding the visible and current state of the study spaces. Through observation the research describes built and un-built characteristics of the study spaces and their immediate surroundings. The observation form was used for collection of this information.

In addition to being descriptive, this research is analytical and historical. Analytical research requires detailed and methodical interrogation of facts or information already available in order to make a critical evaluation of materials at hand. Historical research utilizes historical sources like documents, maps, photographs, and remains to study events or ideas of the past at any remote point in time (Kothari, 2013). Harris, cited in Mugenda and Mugenda (2003) indicates that historical research aims at arriving at conclusions concerning causes, effects, or trends of past occurrences that may help explain present events and anticipate future events.

In this research the descriptive, analytical, and historical types of research converge. Historical aerial photographs, photographs, and maps were reviewed to detect and pattern spatial changes over a period of time. In line with the first research objective, spatial characteristics were thus measured and analysed for each study space for the period 1963-2015. These measurable characteristics (variables) were connectivity, density, enclosure, land use, and tree cover. In order to conduct in-depth evolutionary analyses base maps, figure-ground maps, land use maps, and 3D models were developed for each space. These were informed by aerial photographs, maps, desktop research, and interviews. Interviews are a type of research method discussed alongside other methods later in this chapter. Historical written and photographic documentation was also referenced for information on both spatial and non-spatial characteristics and changes from 1963. This was sourced from the Kenya National Archives, MacMillan Public Library, Nation Newspapers Private Library, and private collections.

The Survey of Kenya (SOK) national database contained aerial photographs of Nairobi CBD for 1963, 1971, 1978, 1998, and 2003. The availability of aerial photographs informed the years analysed in this research. Aerial photographs that represented successive decades beginning in the 1960s were referenced. 1963 was selected as the beginning year of this research's analysis because it is the first year for which a comprehensive aerial photograph of Nairobi CBD area was available. 1963 is also the year of Kenya's independence and so served as a type of baseline for analysis, which has thus been within the context of an independent, post-colonial nation. An aerial photograph for 2015 Nairobi CBD was sourced via online electronic mapping services. A Japanese International Cooperation Agency (JICA) electronic map for 2005 enabled location and accurate mapping of data collected during the reconnaissance study. In addition, aerial photographs for each study space were sourced for 2015 to cross-check with mapping from the reconnaissance study conducted in the same year.

4.3 Research Design

Research design is the conceptual structure within which research is conducted and constitutes the blueprint for collection, measurement, and analysis of data (Kothari, 2013). Based on the research designs categorized by Zeisel (1981) as case studies, surveys, or experiments, this research qualifies as a survey. Cutler, cited by Mugenda (2003) describes a survey as an attempt to collect data from members of a population in order to determine the current status of that population with respect to one or more variables. Mugenda and Mugenda (2003) further explain that a survey is a study that requires collection of quantifiable information from the sample. Surveys can be descriptive, exploratory, or involving advanced statistical analysis.

Kothari (2013) underscores that surveys are conducted when engaging in descriptive studies and useful in finding out about a phenomenon or elements dispersed over a geographic area. The second research objective was to establish the spatial, social, economic, and governance factors that influence sustainability of public open spaces distributed across the CBD of Nairobi. As part of its design, this research employed a pilot survey for testing of research instruments followed by a main survey for collection of field data. The pilot survey was conducted in April 2015. The main survey was undertaken July-September 2015.

Generalizability

According to Kothari (2015) the quantitative approach of research can be sub-classified into inferential, experimental, and simulation approaches. The inferential approach seeks to form a data base from which to infer characteristics or relationships of a population, in this case of public open spaces in the Nairobi CBD. In this research a sample of the population was studied primarily through observation to determine environmental, social, economic, and governance characteristics of the spaces. With the inferential approach adopted for this research, it has been inferred that the population of public open spaces in the Nairobi CBD has the same characteristics of the sample studied. Mugenda and Mugenda (2003) underscore that the researcher must define the population to which they want to generalize their results, which would ideally be the absolute or target population.

The findings, conclusions, and recommendations of this research therefore can be inferred for all public open spaces in the Nairobi CBD that meet the selection criteria. Any generalization of the findings of this research therefore applies to the public open spaces identified in the sampling frame but does not extend beyond the limitation of the frame.

4.4 Research Area

The Nairobi CBD covers an area of approx.7 square kilometres (sq. kms.). It administratively falls within Nairobi City County that is approx. 695 sq.kms. The research investigated public open spaces enclosed by or adjacent to the boundaries of the CBD. For the purposes of this research the CBD is defined by the original built up area of the city. Its boundaries are University Way and Murang'a Road to the north, Haile Selassie to the south, Uhuru Highway to the west, and Racecourse Road and Nairobi River to the east (Moirongo, 2011) (Plate 4.1).

The CBD is an area of particular research interest because it is the oldest part of the city. It thus forms the historic core or city-centre, which is unique and not reproduced elsewhere in the county. The CBD area also uniquely contains a range of different types of public open spaces within its 7 sq.km. It is still considered to be the core of the city that is accessible and used by people from diverse social, cultural, and economic backgrounds. The CBD is thus an inclusive environment, which is appropriate to this research that analyses changes in space and peoples' use of space.

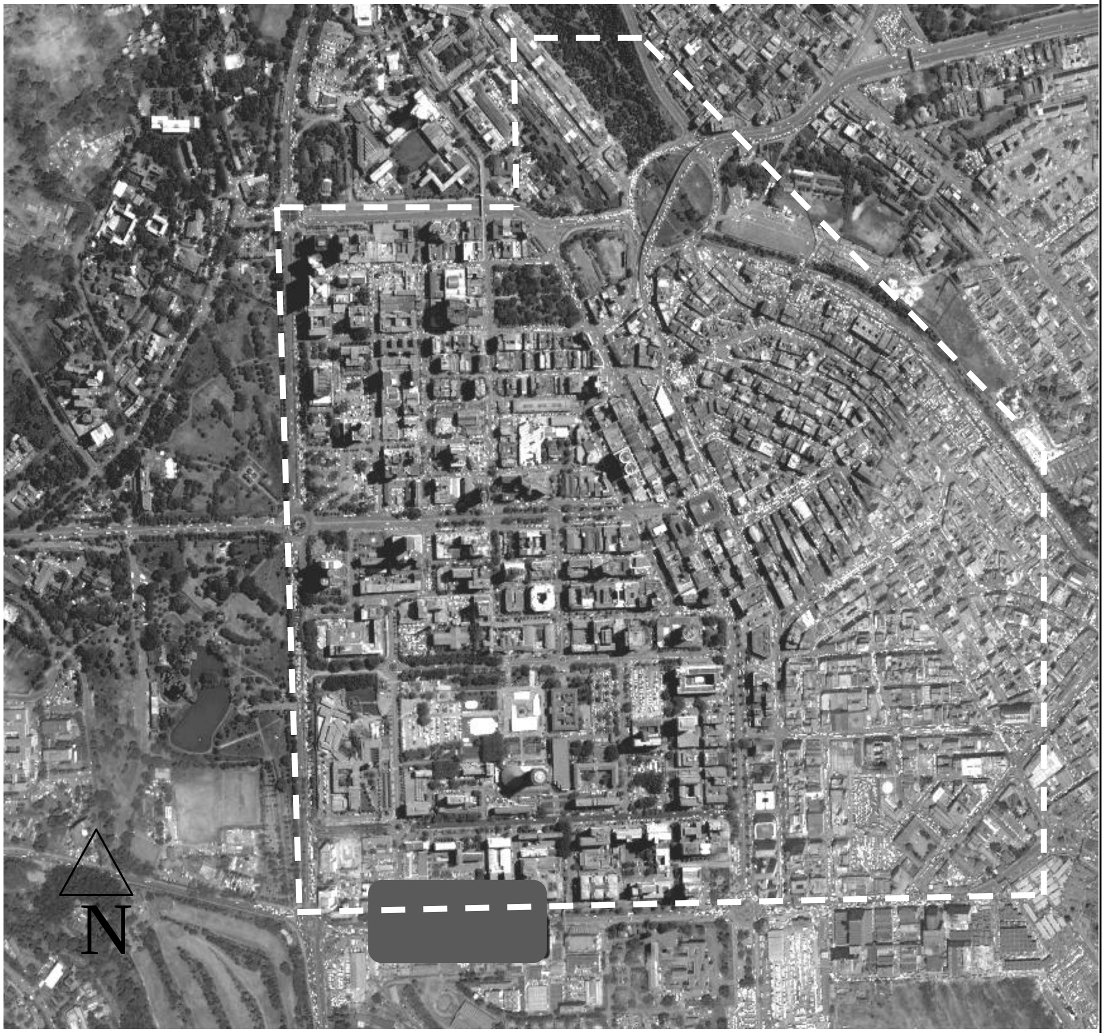


Plate 4.1: Nairobi CBD Research Area Aerial Photograph. Source: Google Earth Pro, 2015

4.5 Research Methods

A research method is the procedure or means that is used to conduct research. It refers to the method used by the researcher in performing research operations. Research methods include observation, interviews, and surveys (Kothari, 2013). They inform the type of research instruments to be used, thus research instruments are derived from the research methods. In social science research, commonly used research instruments are questionnaires, interview schedules, observation forms/checklists, and standardized tests (Mugenda & Mugenda, 2003).

To accurately respond to the research objectives, this research engaged two research methods namely the observation method and interview method. The observation method served to collect objective information based on observation of characteristics of subjects, in this case public open spaces. The information collected through observation is objective as the researcher observes characteristics or behaviour as the basic source of data (Mugenda & Mugenda, 2003). Research instruments for the observation method comprise observation forms, observations schedules, or observation checklists. The research instrument used in this research for data collection was the observation form. The observation form is a detailed document that is organized into categories, through which the researcher records information obtained by observation.

As described in Kothari (2013) the interview method involved presentation of oral-verbal stimuli and reply in terms of oral-verbal responses. Interviews are oral administrations of interview schedules and can be structured, unstructured, or semi-structured. This research used semi-structured interviews that contained both structured and open-ended questions. Mugenda and Mugenda (2003) describe an interview schedule is a set of questions through which the interviewer obtains verbal information from the respondent. The semi-structured interview schedule employed comprised structured questions with categorized responses, and unstructured (open-ended) questions that guided the respondent towards providing required information. Due to the nature of unstructured questions, probing was used by the researcher to extract deeper information from the respondent.

Research variables from the literature review informed the formulation of the research instruments. Both instruments were tested during the pilot survey and thereafter refined for use in the main survey.

4.6 Sampling Design

Kothari (2013) explains that a sample design is a defined plan for obtaining a sample from a given population. It refers to the procedure adopted by the researcher in selecting items for the sample. It comprises definition of parameters of interest, the universe, sampling frame, sample size, and sampling unit. The sampling design for this research is thus articulated hereafter.

4.6.1 Sampling Frame

According to Mugenda and Mugenda (2003) a sampling frame is a list, directory, or index of cases or subjects from which a sample can be selected. Subjects or cases selected from the sampling frame form the units of observation in a study. Also known as the source list (Kothari, 2013), the sampling frame contains the names of all items of a universe (in the case of finite universe only).

This research comprised three phases namely a reconnaissance study, a pilot survey, and the main survey. First a reconnaissance study of the public open spaces in the CBD was conducted through a city map and an exploratory walk. A reconnaissance mission is an initial exploration carried out to find out about the purposes, parts, and relations among parts of the study area (Zeisel, 1981). An inventory of public open spaces in the research area which met the listing criteria was compiled. These criteria required that the spaces were formally designated as public spaces, publicly accessible, free for pedestrians, and owned and/or managed by a government entity. Information for each space such as size, function, ownership, and location was inserted into the inventory from which the sampling frame was derived.

According to Alexander et al (1971) open public greens should be at least 5,575 sq.m. (approx. 1.4 acres). The open spaces studied in this research are not limited to public greens such as parks and gardens but also include promenades, car parks, and bus termini. Due to their function, bus termini grounds are predominantly covered in tarmac and other hard surfaces. Pedestrian accessible roundabouts also differ in terms of size and function. For these reasons, size recommended by Alexander et al for public greens was applied as a guide in setting parameters of the size of spaces to be studied.

In this research the population of public open spaces in the CBD and the sampling frame are the same. Organized according to sub-groups the following table indicates the sampling frame from which the fifteen units of observation were selected (Table 3.1).

Table 4.1: Research Sampling Frame

No.	Space	Primary Space Use	Space Size in. sq.m. & acres	CBD Location
Parks and Gardens				
1	Uhuru Park	Recreational	32.0	West
2	Central Park*	Recreational	77,256 (19.1)	West
3	Jeevanjee Gardens*	Recreational	12,587 (3.1)	North
4	John Michuki Park*	Recreational	6,336 (1.6)	North
5	Hilton Hotel Circle	Recreational	1,552 (0.4)	Central
Pedestrian Accessible Roundabouts				
6	Globe Cinema Roundabout*	Transport	14,721 (3.7)	North
7	Fire Station Roundabout*	Transport/Parking	707 (0.2)	North
Car Parks				
8	Supreme Courts Parking*	Parking	4,856 (1.2)	Central
9	NCC Sunken Parking*	Parking	6,731 (1.7)	Central
10	Railways Godowns Parking*	Transport/Parking	15,000 (3.7)	South
11	KICC Parking*	Parking	8,900 (2.2)	West
12	Nyayo House Parking	Parking	0.5	West
13	Uhuru Park Parking	Transport/Parking	2.0	West
14	Harambee Ave/Parliament Rd Parking	Parking	1.0	West
15	NCC Marikiti Parking	Parking	0.1	East
Bus Termini				
16	Railways Bus Terminus*	Transport/Parking	7,500 (1.9)	South
17	KBS Bus Terminus*	Transport/Parking	4,243 (1.1)	Central
Promenades				
18	Aga Khan Walk*	Connection	6,974 (1.7)	Central
19	National Housing Corporation Walk*	Connection	2,045 (0.5)	South
Markets				
20	Wakulima Market*	Commerce	5,600 (1.4)	East
21	Muthurwa Market	Commerce	29.7	East

Spaces with asterisk (*) selected as units of observation
Source: Author, 2015

4.6.2 Sampling Size

Sampling size refers to the number of items to be selected from the universe to constitute a sample (Kothari, 2013). Also called the population, the universe refers to the set of objects to be studied and can be finite or infinite. In this research, the universe was finite and comprised 21 objects of study (public open spaces) as indicated in the previous table. Gay (1981) emphasizes that ten percent (10%) of the population is sufficient in determining the sample size for descriptive studies. Kerlinger, cited in Makworo (2011) underscores that a sample size of 10% of the target population is large enough as long as it allows for reliable data analysis, provides desired level of accuracy in estimates, and allows for testing for significance of difference between estimates.

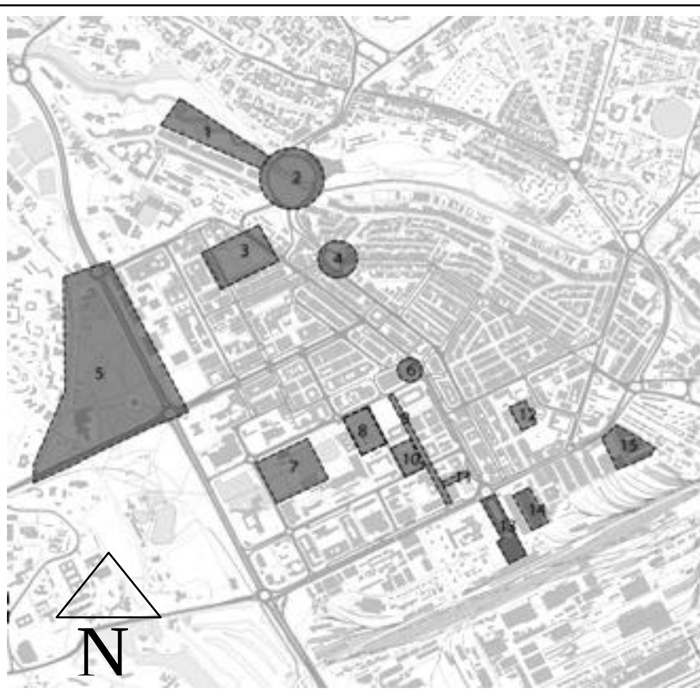
In determining sample size therefore, the 15 out of 21 spaces selected as units of observation constitute 71.4% of the population which far exceeds the 10% recommended threshold. The 15 spaces were selected from the sample frame for the main study based on their size, distribution, and heterogeneity. Informed by these parameters therefore, the sampling method used to determine sample size is both appropriate and adequate.

4.6.3 Units of Observation

In this research the unit of observation, also called the subject or sampling unit (Kothari, 2013) is the individual public open space. For the purpose of this research, public open space is defined as space that is under the jurisdiction of a public agency, predominantly exposed to the natural elements, and accessible to members of the public. The public open spaces investigated herein are recreational such as parks, commercial such as car-parks and markets, transportation hubs, and promenades.

The fifteen (15) subjects or units for observation for this research as indicated in Figure 4.1 are:

- Parks and Gardens: Central Park, Jeevanjee Gardens, John Michuki Park (also weekday open-air market), and Hilton Hotel Circle.
- Pedestrian Accessible Roundabouts: Globe Cinema Roundabout and Fire Station Roundabout.
- Car-parks: Sunken Car-park (also weekend open-air market), Supreme Courts Car-park (also weekend open-air market), Kenyatta International Convention Centre Public Car-park, and Railway Go-downs Parking.
- Bus Termini: Kenya Bus Services Terminus and Railways Bus Terminus.
- Promenades: Aga Khan Walk and National Housing Corporation Walk.
- Markets: Wakulima Market.



Legend

1: John Michuki Park
2: Globe Cinema Roundabout
3: Jeevanjee Gardens
4: Fire Station Roundabout
5: Central Park
6: Hilton Hotel Circle
7: KICC Parking
8: Supreme Court Car-park
9: Aga Khan Walk
10: Sunken Car-park
11: NHC Walk
12: KBS Terminus
13: Railway Station Bus Terminus
14: Railways Godowns Parking
15: Wakulima Market

Figure 4.1: Map of Nairobi CBD Study Spaces Source: Author, 2015

4.7 Sampling Method

The reconnaissance study established that there were 21 public open spaces in the CBD that comprised the sampling frame for this research. Despite the number of spaces, a census was not conducted but rather sampling was done from the population. This was principally informed by commonality among several spaces in terms of their function, size, and CBD location. Cost was a factor that weighed in favour of employing sampling in this research. Sampling is used to cut cost while still obtaining a representative sample of the target population (Vitcu, Lungu, Vitcu, & Marcu, 2007). Indeed this sampling decision is underscored by Neuman (2000) who states that in matters of sampling, not every case of what we are interested in can always be studied. He further emphasizes that scientific enterprise seeks to find out that which will be applicable to everything of a certain kind by studying some examples.

This research employed multi-stage maximum variation sampling, which is a type of purposive sampling. Maximum variation sampling was employed to make sure that conclusions from the sample are as similar as possible to conclusions that would be drawn were the entire population from which the sample was chosen to be studied. Miller (1991) indicates that the essential requirement of any sample is that it is as representative as possible of the population from which it is drawn. Borg et al (as cited in Mugenda & Mugenda, 2003) refer to maximum variation as a method of sampling where effort is made to get a sample containing varied cases.

Purposive sampling is also called judgemental, subjective, or selective sampling and is a method of non-probability sampling or 'non-random' sampling. In non-probability sampling the researcher deliberately selects the items for the sample (Kothari, 2013), with choice informed by determined criteria. Purposive sampling is used as a means of obtaining a representative sample when practical considerations preclude the use of probability sampling (Miller, 1991). Panlinkas et al (2015) emphasize that maximum variation sampling is employed for documentation of unique or diverse variations resulting from adaptation to different conditions and for identification of common patterns across variations. Maximum variation sampling seeks to include extremes in the population and is therefore appropriate for this research because of the diverse variations of public open spaces to be studied. This sampling is based on the knowledge of the population, purpose of the study, with subjects selected because of certain characteristics, in this case the size of space, primary function of space, and location.

This sampling method is called multi-stage because it combines stratification and maximum variation sampling. Based on the reconnaissance study the population of spaces was stratified, which means it was divided into homogeneous sub-groups or strata according to the type of public space before sampling was undertaken. Six (6) sub-groups or strata were identified namely: parks and gardens, car-parks, pedestrian accessible roundabouts, bus termini, promenades and markets. Sub-groups or strata were formed and populated to ensure elements in each stratum were most homogeneous and most heterogeneous between the different strata (Kothari, 2013). The sub-groups/strata contain the subjects from which the units of observation were selected purposively.

4.8 Data Collection

The main research instrument used in the collection of primary data was the observation form that was tested during the pilot study. It comprised variables organized according to the four aspects of sustainability namely environmental aspects (built physical environment and natural physical environment), social aspects, economic aspects, and governance aspects. Observation method required data collection at specific times of the day, in particular observing the characteristics and use of public open spaces and their environs by people and vehicles. Favourable weather during the data collection phase was key so fieldwork was scheduled between July-September. Data thus collected was appropriate as it was gathered during months of relative normalcy and non-extreme weather conditions. A second research instrument used for primary data collection was the interview schedule. Interview schedules were used to source information from county government officials and key respondents with operational and historical knowledge of the study spaces. Data for select variables was collected using interview schedules, which was processed and thereafter statistically analysed. As an additional source of primary data, photographs were taken with a digital camera of each study space and its surrounding environment.

Secondary data was acquired from review of historical printed and photographic documentation from public sources including the Kenya National Archives, the National Museums of Kenya, the Nairobi City County, Macmillan Library, and the libraries of Jomo Kenyatta University of Agriculture and Technology and University of Nairobi. Electronic books and local and international journals in the public domain were sources of vital secondary data. Additional archival information was sourced from private libraries such as from the Nation Newspapers Media Group and private collections of Kenyans of Asian descent that had lived or worked in neighbourhoods in which study spaces were located. Maps and aerial photographs of the CBD for provided key information for comparative spatial analysis for the years of study. These were secured from electronic internet sources and national government institutions namely the Kenya National Archives and the Survey of Kenya. Data was collected using the following main variables contained within the observation form and interview schedules (Table 4.2).

Table 4.2: Primary Data Collection Variables

NO.	ITEM	VARIABLES RELATED TO BUILT PHYSICAL ENVIRONMENT (BPE)
1.	BPE1A:	Length of space in metres
2.	BPE1B:	Width of space in metres
3.	BPE1C:	Diametre of space in metres
4.	BPE2A:	Presence of boundary wall, edge, or fence defining perimeter of the space
5.	BPE2B:	Presence of good sight line from centre of space to main entries/exits of space
6.	BPE2C:	Presence of clearly visible entries/exits to the space
7.	BPE3A:	No. of lockable gate/s into the space per sq.m.
8.	BPE3B:	No. of security barriers into the space per sq.m.
9.	BPE3C:	No. of entries and exits per linear distance of space
10.	BPE3D:	No of wheelchair accessible ramps into space per unit area
11.	BPE4A:	Length of pathways in space in metres
12.	BPE4B:	Width of pathways in space in metres

13.	BPE5A:	No. of connector spaces perpendicular to space boundary per linear perimeter distance
14.	BPE5B:	Width(s) of connector spaces perpendicular to space boundary
15.	BPE6A:	Shortest (narrowest) distance of space in metres
16.	BPE6B:	Longest most direct distance of space in metres
17.	BPE7A:	Height of wall or fence enclosing the space
18.	BPE7B:	No. of roads/streets enclosing the space
19.	BPE8A:	Presence of monuments/statues within space
20.	BPE8B:	Presence of natural or man-made water feature within space
21.	BPE9A:	No. of parking spaces for cars in space per unit area
22.	BPE9B:	No. of parking spaces for PSVs in space per unit area
23.	BPE9C:	No. of public toilets in space per unit area
24.	BPE9D:	No. of drinking fountains in space per unit area
25.	BPE9E:	No. of offices in space per unit area
26.	BPE 9F:	No. of mechanical workshops in space per unit area
27.	BPE9G:	Presence of swings in space
28.	BPE9H:	Presence of dais/space for performances in space
29.	BPE10A:	No. of buildings and structures in space per unit area
30.	BPE11A:	No. of abandoned buildings/structures in space per unit area
31.	BPE12A:	Ground level in space change from surrounding street level
32.	BPE13A:	No. of benches in the space per unit area
33.	BPE13B:	Length of hard, man-made surface used as seating in space in metres
34.	BPE13C:	Width of hard, man-made surface used as seating in space in metres
35.	BPE14A:	Level of Cleanliness in Space
36.	BPE14B:	No. of garbage bins in space per unit area
37.	BPE15A:	Presence of broken or missing paving in space
38.	BPE15B:	Presence of clogged open drains in space
39.	BPE15C:	Presence of trimmed hedges, bushes, and flower beds
40.	BPE15D:	No. of broken benches in space as % of total no. of benches
41.	BPE16A:	Length(s) of built shading canopies in space per unit area
42.	BPE16B:	Width(s) of built shading canopies in space per unit area
43.	BPE17A:	No. of parking spaces for cars per linear distance on surrounding streets
44.	BPE17B:	No. of parking spaces for PSVs per linear distance on surrounding streets & sidewalks adjacent to space
45.	BPE18A:	Total no of floors in buildings facing space
46.	BPE18B:	No. of floors predominantly used as offices in buildings facing space, per total no of floors in buildings facing space
47.	BPE18C:	No. of residences in buildings facing space per linear distance
48.	BPE18D:	No. of learning institutions in buildings facing space per unit area
49.	BPE18E:	No. of banks/financial institutions in buildings facing space per unit area
50.	BPE18F:	No. of religious institutions in buildings facing space per unit area
51.	BPE18G:	No. of bars/night clubs in buildings facing space per unit area
52.	BPE20A:	No. of structures facing space per linear distance
53.	BPE20B:	No. of buildings facing space per linear distance
54.	BPE21A:	No. of abandoned buildings facing space per linear distance
55.	BPE22A:	No. of doors facing space per linear distance
56.	BPE24A:	No. of kms from space to nearest major PSV stage via most direct route
57.	BPE26A:	No. of floors of surrounding buildings per unit area

58.	BPE26B:	No. of trees surrounding space per linear distance
59.	BPE27A:	No. of turns in road connecting space boundary/edge and nearest dual carriageway road
60.	BPE28B:	No. of arcades in buildings surrounding space per linear distance
61.	BPE29A:	No. of vehicular lanes in each roads/streets surrounding space
62.	BPE29B:	No. of zebra crossings on roads/streets surrounding space per linear distance
63.	BPE30A:	No. of windows of surrounding buildings facing space per linear distance
64.	BPE32B:	Width of surrounding streets in metres
		VARIABLES RELATED TO NATURAL PHYSICAL ENVIRONMENT (NPE)
65.	NPE33A:	No. of trees in space per unit area
66.	NPE33B:	Length of space covered in grass in metres
67.	NPE33C:	Width of space covered in grass in metres
68.	NPE34A:	No. of lamp-posts in space per unit area
69.	NPE34B:	No. of operational lamp-posts in space per unit area
70.	NPE34C:	No. of solar-powered lamp-posts in space per unit area
71.	NPE35A:	No. of recycling bins in space per unit area
72.	NPE37A:	No. of street lights in surrounding space per linear distance
73.	NPE37B:	No. of operational street lights in surrounding space per linear distance
74.	NPE37C:	No. of solar-powered street lights in surrounding space per linear distance
		VARIABLES RELATED TO SOCIAL ASPECTS (SA)
75.	SA39A:	No. of people using the space per unit area
76.	SA40A:	No. of men using the space as % total population of users
77.	SA40B:	No. of women using the space as % total population of users
78.	SA40C:	No. of children using the space as % total population of users
79.	SA41A:	No. of vehicles on surrounding streets/roads per unit time
80.	SA42A:	No. of men using surrounding sidewalks adjacent to space per unit area
81.	SA42B:	No. of women using surrounding sidewalks adjacent to space per unit area
82.	SA42C:	No. of children using surrounding sidewalks adjacent to space per unit area
83.	SA42D:	No. of people using surrounding sidewalks adjacent to space per unit area
		VARIABLES RELATED TO ECONOMIC ASPECTS (EA)
84.	EA43A:	No. of retail shops in space per unit area
85.	EA43B:	No. of service businesses in space per unit area
86.	EA43C:	No. of produce/newspaper/magazine vendors in space per unit area
87.	EA43D:	No. of restaurants and eateries in space per unit area
88.	EA44A:	No. of vendors on surrounding sidewalks adjacent to space per linear distance
89.	EA44B:	No. of kiosks on surrounding sidewalks adjacent to space per linear distance
90.	EA44C:	No. of restaurants and eateries on surrounding sidewalks adjacent to space per linear distance
91.	EA45A:	No. of retail shops on ground floor of buildings facing space per linear distance
92.	EA45B:	No. of service businesses on ground floor of buildings facing space per linear distance
93.	EA45C:	No. of restaurants and eateries on ground floor of buildings facing space per linear distance
94.	EA45D:	No. of hotels/lodgings lobbies on ground floor of buildings facing space per linear distance
95.	EA46A:	No. of privately owned buildings facing space per linear distance
96.	EA46B:	No. of government owned buildings facing space per linear distance
		VARIABLES RELATED TO GOVERNANCE ASPECTS (GA)
97.	GA47A:	Presence of by-laws, rules or regulations signage in the space

98.	GA48A:	No. of garbage bins with overflowing garbage per unit area
99.	GA50A:	No. of active sponsors of space per unit area
100.	GA51A:	No. of NCC groundsmen assigned to space per unit area
101.	GA52B:	No. of NCC supervisors supervising space per unit area
102.	GA53A:	No. of hours lampposts operational in space per day
103.	GA53B:	No. of hours surrounding streetlights operational per day
104.	GA54A:	No. of times bins in space emptied per week

Source: Author, 2015

In order to establish the factors which influence the sustainability of public open spaces in the CBD (research objective 2), four dependent variables out of the 104 variables indicated in the table previous were selected. These dependent variables used to measure the aspects of sustainability are as follows:

Y_1 = number of users of space (social sustainability);
Y_2 = number of retail shops in the space (economic sustainability);
Y_3 = area of space covered with grass (environmental sustainability);
Y_4 = cleanliness of space (governance sustainability).
In order to determine the combination of independent variables that influence each dependent variable and the nature of relationship between the dependent and independent variables, multiple linear regression models were generated using SPSS.

In order to establish the relationship between spatial evolution and sustainability of public open spaces in the CBD (research objective 3), another set of dependent and independent variables were identified based on data for the period (1963-2015). The dependent variables were:

$Y_{1\ (1963\text{-}2015)}$ = density (social sustainability);
$Y_{2\ (1963\text{-}2015)}$ = index of commercial buildings (economic sustainability);
$Y_{3\ (1963\text{-}2015)}$ = tree cover in space (environmental & governance sustainability);
Correlations were used to explain the relationships between the dependent and independent variables for each space as illustration of the link between evolution and sustainability. The aforementioned is further articulated under data analysis and interpretation in Chapter 5 and discussed in Chapter 6.

4.9 Data Processing

Data processing involved editing, coding, classification, tabulation, and calculation of data. For the comparative spatial analysis of select variables for the years of study, Microsoft Excel was used for production of graphs.

Prior to fieldwork as captured in the observation form, data to be collected had been organized according to the environmental, social, economic, and governance variables. Some data such as that dealing with number of users of space and vehicular movement was collected and tabulated in an Observation Form Periodic Tally Table. Information from the observation forms, interview schedules, and tally tables was then tabulated and calculated so that the values of the variables would be comparable and usable for subsequent statistical analysis.

Following the processing of data as indicated, Statistical Package for Social Sciences (SPSS v. 16) was employed for the quantitative analysis of data. Multiple linear regression was performed to describe the relationship between identified dependent and independent variables of the four models namely social, economic, governance, and environmental sustainability. Linear relationships and predictions among variables would be best determined using Pearson's correlations. Taking each aspect of sustainability individually and beginning with social sustainability, bivariate correlations of variables were determined. This indicated the nature of the correlation of variables and variables whose correlation, as shown by the p value, was significant at 95 percent confidence level (p <0.05). From correlation coefficients which range from -1.0 to +1.0, variables with strong negative or strong positive correlations that is, values ranging from -0.5 to -1.0 or 0.5 to 1.0 respectively, were identified.

Multiple linear regression is an extension of simple linear regression. Simple linear regression is used to predict the value of a variable based on the value of one other variable. Multiple linear regression is used to predict the value of a variable based on the value of two or more other variables. The variable to be predicted is called the dependent variable (also called outcome, target, or criterion variable). The variables used to predict the value of the dependent variable are called the independent variables (also called predictor, explanatory or regressor variables). Four prediction models were thus obtained for each of the four aspects of sustainability.

In multiple linear regressions, the actual regression model is of the form: $Y=B_0+B_1X_1+B_2X_2+.....B_nX_n+€$

Where Y= dependent variable; X_{1-n}= independent variables; B_0= constant; B_{1-n}= regression coefficients; €= error. In multiple linear regressions, the predicted model which is also called the expected model (of the actual model) is of the form: Y predicted = $\beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3$

4.10 Ethical Considerations

The main research instrument for data collection was the observation form. This means that verbal interaction with persons in and surrounding the spaces was not fundamental and therefore non-essential. The other instrument employed was the interview schedule. Interview of county officials and other key actors provided additional information especially regarding governance and spatial management issues. Interview schedules contained confidentiality clauses indicating responses were voluntary and would be kept confidential. Respondents were protected by keeping information received confidential as per the clauses. The research team accurately disclosed the purpose of the research to respondents and government authorities that granted research permits and authorizations.

As outlined by Kothari (2013), research assistants were carefully selected, briefed, and trained on objectives and procedures through a series of workshops. Occasional field checks were done to ensure that research assistants worked with integrity and did not deviate from instructions for data collection. Every effort has been made to guard against plagiarism and fraud by the researcher and the research team during the course of this academic work.

CHAPTER FIVE

DATA ANALYSIS AND INTERPRETATION

5.1 Introduction

This chapter is organized into three parts as informed by the research objectives. The first part deals with determinants of spatial evolution. The second part is focused on determinants of sustainability. The third section establishes the relationship between spatial evolution and sustainability.

5.2 Determinants of Spatial Evolution

This section is focused on analysis of collected field data and analysis of a series of variable-specific maps. Its structure and content target the first research objective that deals with the establishment of the spatial evolution of public open spaces in Nairobi CBD from 1963 – 2015. In order to investigate the evolution of each space from 1963-2015, six variables were identified. It was fundamental that these variables could be observed, measured, and compared among the spaces and over the stated period. The variables therefore are all concerned with the built and natural physical environment. Base maps, figure-ground maps, density maps, land use maps, and 3D models were generated for each space based on aerial photographs, electronic maps, digital photographs, desktop research, and interview responses.

<u>Evolution of Spaces</u>

Aerial photographs and electronic maps for 1963, 1971, 1978, 1998, 2003, and 2015 and maps from 1962-2012 provided the main sources of reference. The six identified variables were size, connectivity, density, enclosure, tree cover, and land use. These characteristics informed the spatial analysis undertaken, in particular the changes experienced by each variable between 1963 and 2015.

5.2.1 Size of Space

As shown in Table 5.1, the size of space (area) was measured in square metres. Majority of the spaces did not change in size from 1963-2015. Of the four spaces that exhibited change in size, three decreased in area and only Aga Khan Walk increased in size (Figure 5.1).

Table 5.1: Changes in Space Size (1963-2015)

STUDY SPACE	1963	1971	1978	1998	2003	2015	1963-2015 % change
Space Size(sq.m)							
Central Park (CP)	83656	77256	77256	77256	77256	77256	-7.7
Jeevanjee Gardens (JG)	12586	12586	12586	12586	12586	12586	-
John Michuki Park (JMP)	6336	6336	6336	6336	6336	6336	-
Hilton Hotel Circle (HHC)	18750	1552	1552	1552	1552	1552	-91.7
Globe Cinema Roundabout (GCR)	N/A	14721	14721	14721	14721	14721	-
Fire Station Roundabout (FSR)	707	707	707	707	707	707	-
Supreme Courts Parking (SCP)	4856	4856	4856	4856	4856	4856	-
NCC Sunken Parking (NSCP)	6730	6730	6730	6730	6730	6730	-
Railways Godowns Parking (RGP)	15000	15000	15000	15000	15000	15000	-
KICC Parking (KICC)	11400	11400	11400	11400	7400	8900	-21.9
Railways Bus Terminus (RBT)	7500	7500	7500	7500	7500	7500	-
KBS Bus Terminus (KBST)	4243	4243	4243	4243	4243	4243	-
Aga Khan Walk (AKW)	3960	3960	6975	6975	6975	6975	76.1
National Housing Corporation Walk (NHC)	N/A	2045	2045	2045	2045	2045	-
Wakulima Market (WM)	5600	5600	5600	5600	5600	5600	-

Source: Author

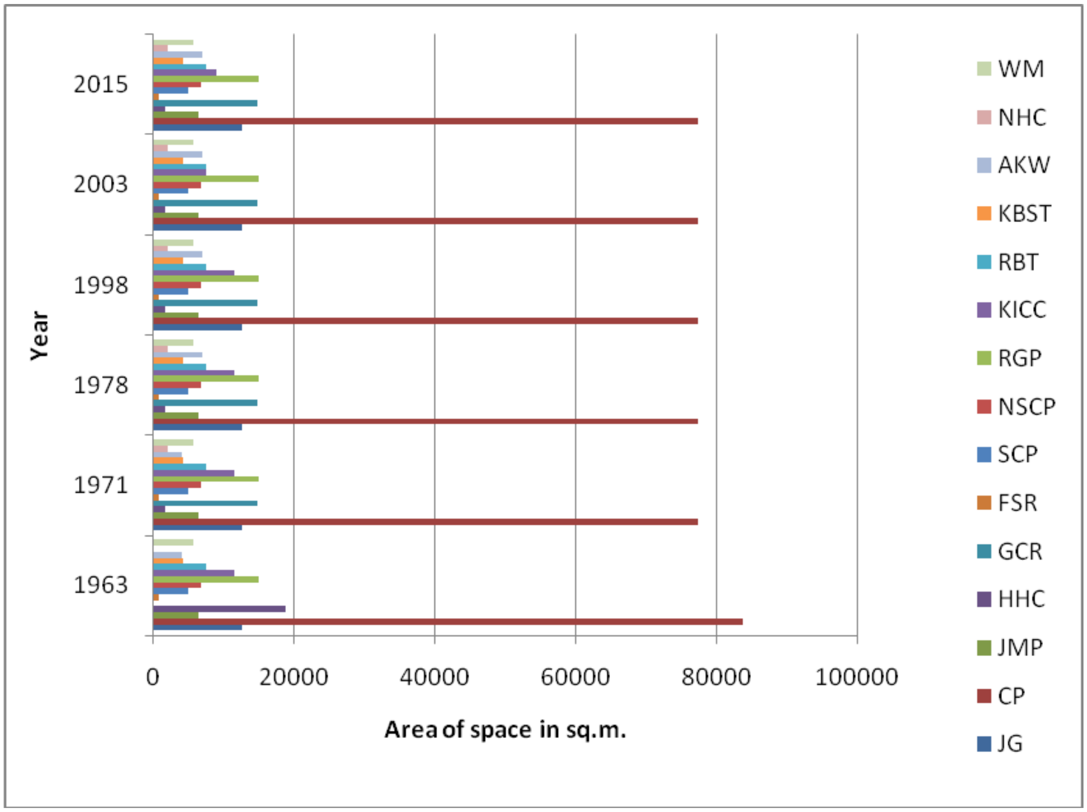


Figure 5.1: Space Size Changes (1963-2015) Source: Author

Table 5.2 indicates changes in all six variable calculated as averages for each year. On space sizes, Table 5.2 and Figure 5.2 show a decrease between1963-1971, an increase between1971-1978 and a consistency in size between1978-1998. This was followed by a decrease to the

lowest overall average size in 2003 and an increase thereafter in 2015 to an average space size similar to that of 1971.

Table 5.2: Space Size Averages (1963-2015)

YEAR	**AVERAGE SIZE**	AVERAGE CONNECTIVITY	AVERAGE ENCLOSURE	AVERAGE DENSITY	AV. TREE COVER	AV. COMM INDEX	AV. INSTIT INDEX	AV. RES INDEX	AV. INDST INDEX
1963	**12088.2667**	7.57E-06	0.022853	2.28836	0.1	7.805867	2.918867	0.115533	0.286733
1971	**11632.8**	9.53E-06	0.030713	2.9934667	0.15	15.93193	6.132	0.135533	0.301467
1978	**11833.7333**	9.42E-06	0.034766	3.5122667	0.22	20.3476	9.9348	0.135533	0.3088
1998	**11833.7333**	9.47286E-06	0.035054	3.8637345	0.24	24.99213	10.20187	0.111867	0.2492
2003	**11567.0667**	9.41486E-06	0.035054	3.9144	0.24	25.3528	11.01907	0.111867	0.250533
2015	**11667.0667**	9.41486E-06	0.035394	4.1724	0.32	25.43813	10.84907	0.108533	0.096867
DELTA	**-421.2**	1.8406E-06	0.0125	1.88	0.22	17.6	7.9	-0.007	-0.191
% DELTA	**-3.5%**	24.3%	54.50%	82.1%	220.0%	225.6%	272.4%	-6.03%	-66.6%

Source: Author

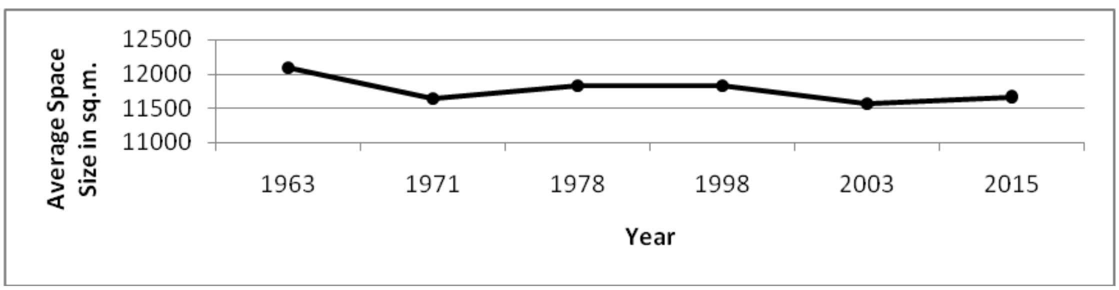


Figure 5.2: Average Space Size of All Spaces (1963-2015) Source: Author

As indicated in Table 5.1, most of the spaces remained the same in terms of size from 1963-2015. However, Central Park, Hilton Hotel Circle, and KICC Parking decreased in size by 7.7%, 91.7%, and 21.9% respectively while Aga Khan Walk increased in size by 76.1%.Organized according to space type, space size changes for 1963-2015 were recorded as follows.

Central Park: This was a public park before 1963, bordered by the Dutch Reformed Church to its north. In the early 1970s the church's land increased, thus reducing the park size. By 1998 the GOK Ministry of Transport Road Safety Centre and the Lutheran Church complex had been constructed. Figure 5.3 indicates that from 1998-2015 the space size remained the same.

Hilton Hotel Circle: Before 1963 the space was a bus terminus (Plate 5.3). Two contributors to decreased space size were the creation of a street and construction of Hilton Hotel. The resultant space outside the hotel became a recreational park (Plate 5.4). From 1971-2015 the size of the park remained the same, its area determined by surrounding street patterns. Changes in space size are captured in the series of comparative maps in Figure 5.4.

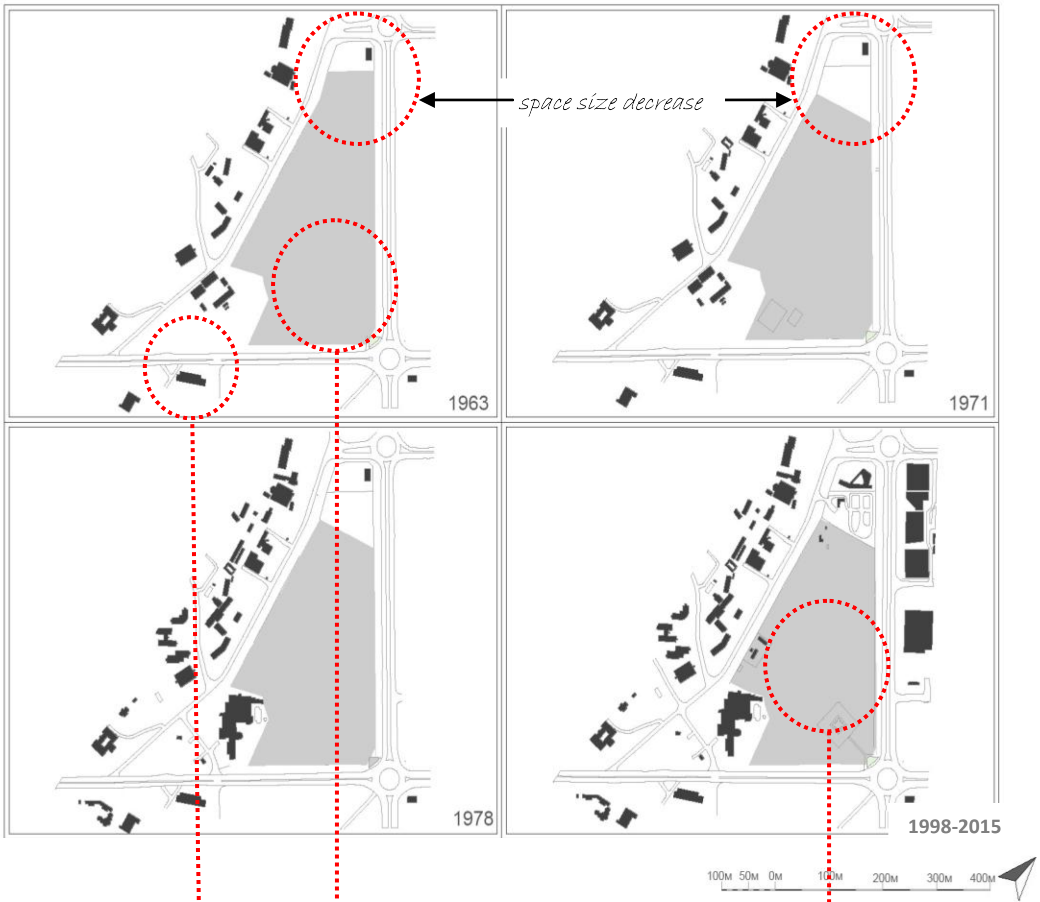


Figure 5.3: Central Park Size Maps (1963-2015) Source: Author

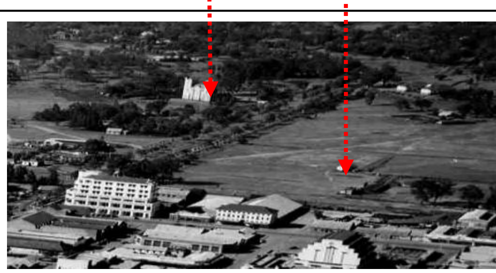


Plate 5.1: All Saints Cathedral & Central Park, 1960s.
Source: www.skyscrapercity.com

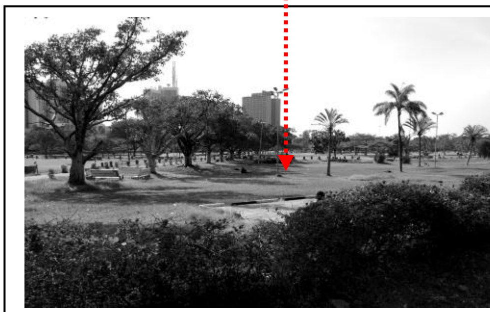


Plate 5.2: Central Park, 2015
Source: Author

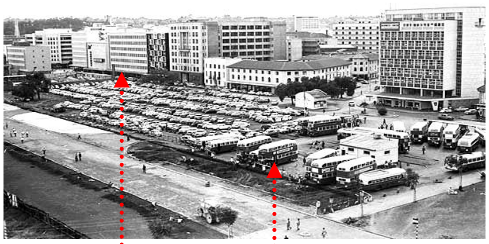


Plate 5.3: Hilton Hotel Area 1950s
Source: www.sikhheritage.co.uk

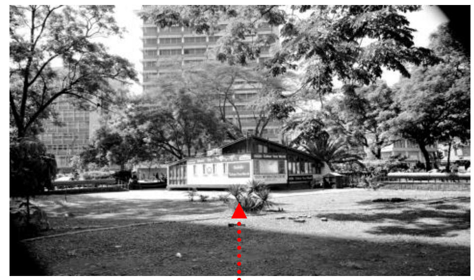


Plate 5.4: Hilton Hotel Circle, 2015
Source: Author

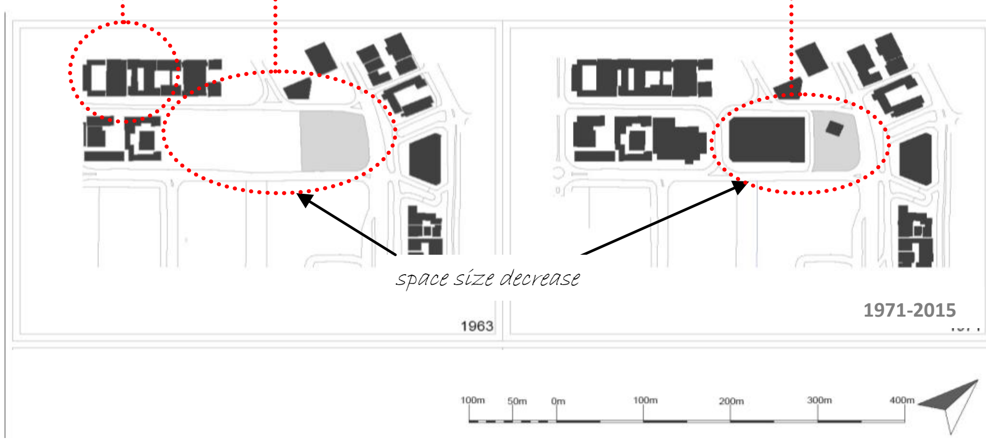


Figure 5.4: Hilton Hotel Circle Size Maps (1963-2015) **Source: Author**

KICC Parking: Plate 5.5 shows that in 1963 the area was covered with natural vegetation and was not a distinct open space. As shown in Plate 5.6 in 1971 the space was enclosed within clear boundaries, remaining the same size until 2003. From 2003-2015 the size of the car park increased due to the inclusion of land at its north boundary. Changes in space size are captured in the series of comparative maps in Figure 5.5.

Aga Khan Walk: Plate 5.7 shows that before 1978 the promenade was covered with natural vegetation. It did not exist as a defined public space. In 1978 the space lengthened to become the only fully pedestrianized promenade in the city centre and a major path of movement between two key west-east paths of vehicular and pedestrian movement. As shown in Plate 5.8 and Plate 5.9, this size remains in 2015. Changes in space size are captured in the series of comparative maps in Figure 5.6.

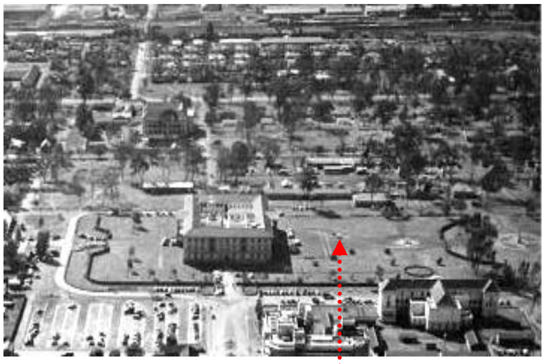


Plate 5.5: High Court Buildings and future KICC site, 1960s Source: www.skyscraper.com

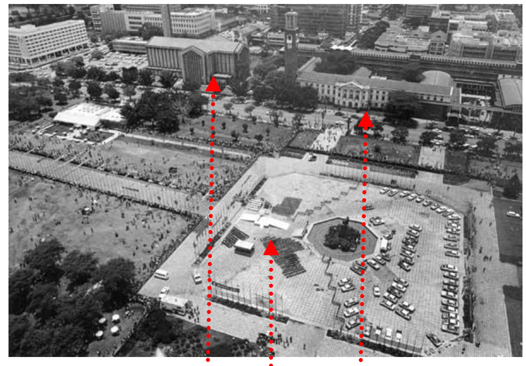


Plate 5.6: KICC Plaza and Parking, 1970s Source: www.sikheritage.co.uk

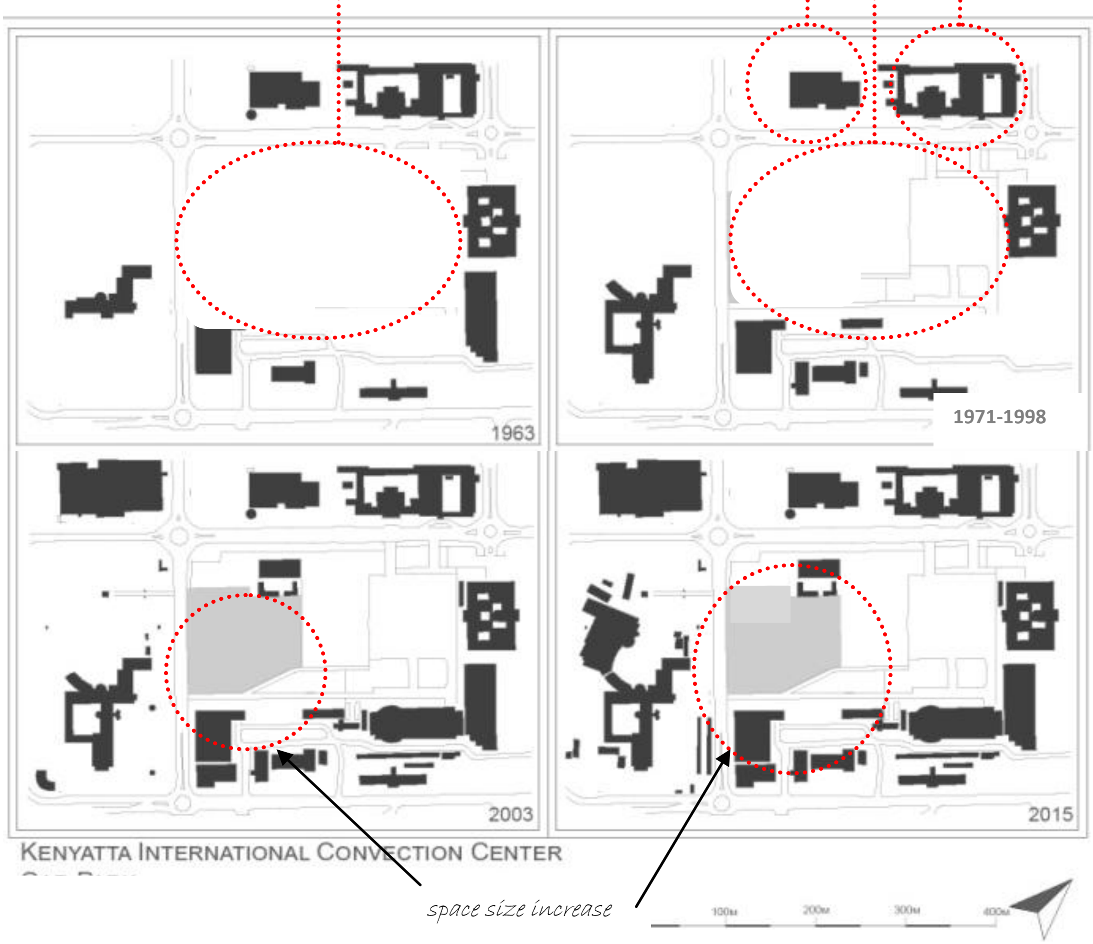


Figure 5.5: KICC Parking Size Maps (1963-2015) Source: Author

Plate 5.7: Nairobi 1960s showing Aga Khan Walk Future Site Source: www.skyscraper.com

Figure 5.6: Aga Khan Walk Size Maps (1963-2015) Source: Author

Plate 5.8: Aga Khan Walk, 2015
Source: Author

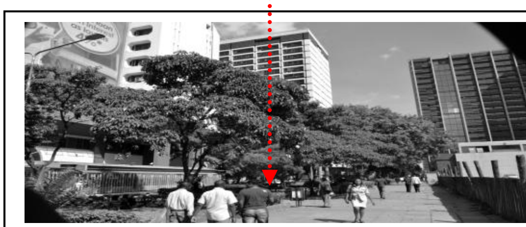


Plate 5.9: Aga Khan Walk, 2015
Source: Author

5.2.2 Connectivity of Space

The second variable was connectivity of the space measured by the number of streets per linear metre/square metre of space. Table 5.3 indicates 46.7% of the spaces experienced increased connectivity from 1963-2015. Connectivity for 33.3% of the spaces did not change over the same period. John Michuki Park, Kenya Bus Terminus, and the National Housing Corporation Walk experienced decreased connectivity of 27.8%, 25.7% and 21.6% respectively from 1962-2015. Figure 5.7 further illustrates the changes in connectivity of each space from 1963-2015.

Table 5.3: Changes in Connectivity (1963-2015)

STUDY SPACE	1963	1971	1978	1998	2003	2015	1963-2015 % change
CONNECTIVITY (No. streets/m/sq.m.)							
Central Park	$6.8e^{-8}$	$6.8e^{-8}$	$6.8e^{-8}$	$9.09e^{-8}$	$9.09e^{-8}$	$9.09e^{-8}$	44.4
Jeevanjee Gardens	$1.69e^{-6}$	$1.69e^{-6}$	$2.03e^{-6}$	$2.03e^{-6}$	$2.03e^{-6}$	$2.03e^{-6}$	17.6
John Michuki Park	$1.75e^{-6}$	$1.31e^{-6}$	$1.31e^{-6}$	$1.31e^{-6}$	$1.31e^{-6}$	$1.31e^{-6}$	-27.8
Hilton Hotel Circle	$1.0e^{-6}$	$2.74e^{-5}$	$2.74e^{-5}$	$2.74e^{-5}$	$2.74e^{-5}$	$2.74e^{-5}$	2600.0
Globe Cinema Roundabout	$4.75e^{-7}$	$1.58e^{-6}$	$1.58e^{-6}$	$1.74e^{-6}$	$1.74e^{-6}$	$1.74e^{-6}$	254.2
Fire Station Roundabout	$9.02e^{-5}$	$9.02e^{-5}$	$9.02e^{-5}$	$9.02e^{-5}$	$9.02e^{-5}$	$9.02e^{-5}$	-
Supreme Courts Parking	$6.59e^{-7}$	$6.59e^{-7}$	$6.59e^{-7}$	$1.32e^{-6}$	$1.32e^{-6}$	$1.32e^{-6}$	100.0
NCC Sunken Parking	$8.77e^{-7}$	$1.31e^{-6}$	$1.31e^{-6}$	$1.31e^{-6}$	$1.31e^{-6}$	$1.31e^{-6}$	47.7
Railways Godowns Parking	$4.0e^{-7}$	$4.0e^{-7}$	$4.0e^{-7}$	$4.0e^{-7}$	$4.0e^{-7}$	$4.0e^{-7}$	-
KICC Parking	$4.65e^{-7}$	$4.65e^{-7}$	$4.65e^{-7}$	$4.65e^{-7}$	$4.65e^{-7}$	$4.65e^{-7}$	-
Railways Bus Terminus	$6.67e^{-7}$	$6.67e^{-7}$	$6.67e^{-7}$	$6.67e^{-7}$	$6.67e^{-7}$	$6.67e^{-7}$	-
KBS Bus Terminus	$3.49e^{-6}$	$3.49e^{-6}$	$3.49e^{-6}$	$3.49e^{-6}$	$2.62e^{-6}$	$2.62e^{-6}$	-25.7
Aga Khan Walk	$1.16e^{-6}$	$2.30e^{-6}$	$2.15e^{-6}$	$2.15e^{-6}$	$2.15e^{-6}$	$2.15e^{-6}$	83.3
National Housing Corporation Walk	$8.8e^{-6}$	$8.8e^{-6}$	$6.85e^{-6}$	$6.85e^{-6}$	$6.85e^{-6}$	$6.85e^{-6}$	-21.6
Wakulima Market	$2.80e^{-6}$	$2.67e^{-6}$	$2.67e^{-6}$	$2.67e^{-6}$	$2.67e^{-6}$	$2.67e^{-6}$	-

Source: Author

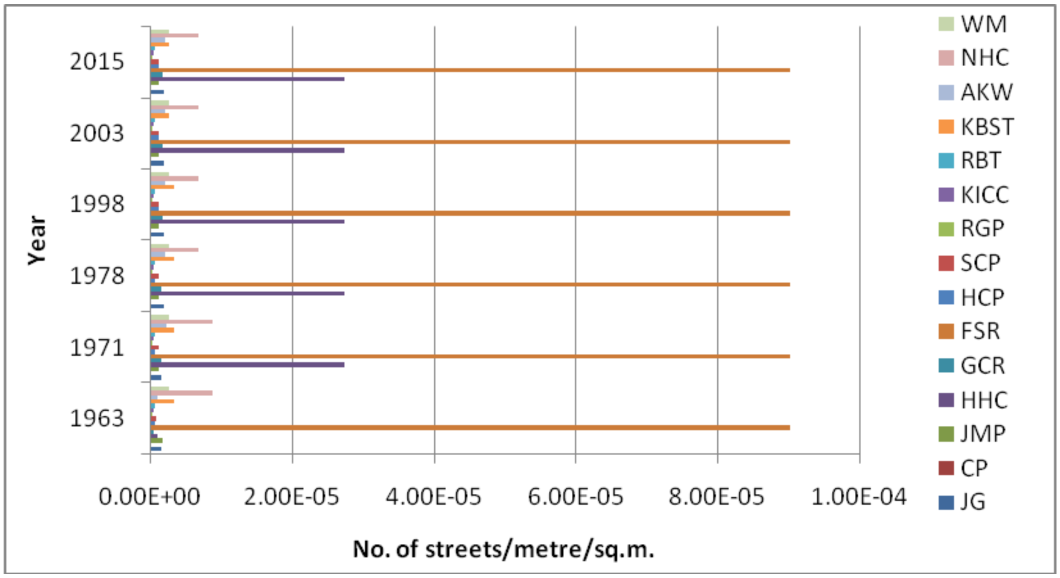


Figure 5.7: Graph of Connectivity Changes (1963-2015) Source: Author

Table 5.4: Space Connectivity Averages (1963-2015)

YEAR	AVERAGE SIZE	**AVERAGE CONNECTIVITY**	AVERAGE ENCLOSURE	AVERAGE DENSITY	AV. TREE COVER	AV. COMM INDEX	AV. INSTIT INDEX	AV. RES INDEX	AV. INDST INDEX
1963	12088.2667	**7.57E-06**	0.022853	2.28836	0.1	7.805867	2.918867	0.115533	0.286733
1971	11632.8	**9.53E-06**	0.030713	2.9934667	0.15	15.93193	6.132	0.135533	0.301467
1978	11833.7333	**9.42E-06**	0.034766	3.5122667	0.22	20.3476	9.9348	0.135533	0.3088
1998	11833.7333	**9.47286E-06**	0.035054	3.8637345	0.24	24.99213	10.20187	0.111867	0.2492
2003	11567.0667	**9.41486E-06**	0.035054	3.9144	0.24	25.3528	11.01907	0.111867	0.250533
2015	11667.0667	**9.41486E-06**	0.035394	4.1724	0.32	25.43813	10.84907	0.108533	0.096867
DELTA	-421.2	**1.8406E-06**	0.0125	1.88	0.22	17.6	7.9	-0.007	-0.191
% DELTA	-3.5%	**24.3%**	54.50%	82.1%	220.0%	225.6%	272.4%	-6.03%	-66.6%

Source: Author

Table 5.4 and Figure 5.8 indicate changes in connectivity for all space sizes, calculated as averages for each year 1963-2015. Based on the average connectivity for all spaces per year, Table 4 indicates that connectivity increased by 24.3% from 1963-2015. This increase was due to a combination of increased infrastructure, more building construction, and increase in size of space.

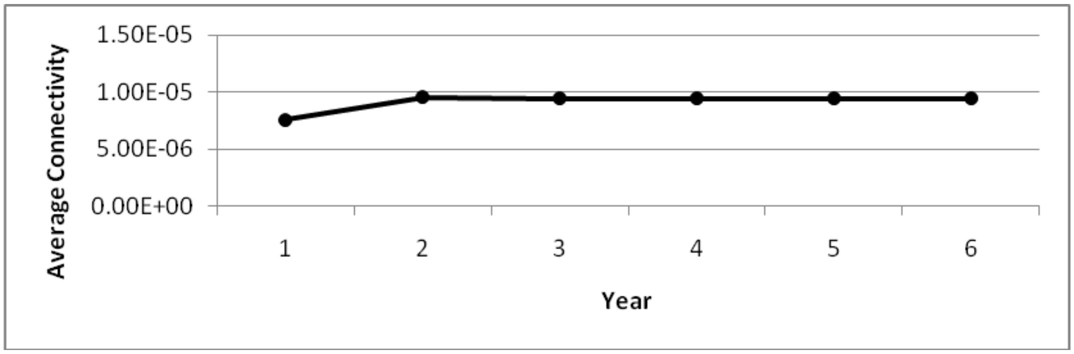


Figure 5.8: Average Connectivity of All Spaces Source: Author

Organized according to space type, connectivity changes for 1963-2015 were recorded and analysed as follows:

Central Park: Table 5.3 indicates that between 1963-2015 connectivity for Central Park increased by 44.4%. This increase is illustrated in Figure 5.9. As shown in Plate 5.10 and Plate 5.11 connectivity via dual carriageway roads remained consistent at $6.8e^{-8}$streets/m/sq.m. from 1963-1978. 1998 it increased due to addition of a pedestrian connector, and remained consistent thereafter at $9.09e^{-8}$ streets/m/sq.m. until 2015. Majority of connectors to the park carry pedestrian and vehicular traffic. Central Park is bordered by Kenyatta Avenue and Uhuru Highway, both wide and high-traffic highways (Plate 5.12) and the double lane Nyerere Road (Plate 5.13). Their speed, volume, and lack of provision of drop-off or parking zones at the park edge decrease the convenience of arrival at the park.

Opposite the park on Uhuru Highway plot patterns impede development of connectors between buildings. Buildings on these plots also have their main entrances located away from the highway. Connectivity is further hindered by a fence that separates majority of the buildings from the highway, limiting direct access to the park.

Jeevanjee Gardens: 1963-2015 indicates increase in connectivity of 17.6% (Table 5.3). This is illustrated in Figure 5.10. The space became a public park in 1906 and its boundaries, enclosing, and connecting streets were established early in the layout of the city. The number of pedestrian and vehicular connectors increased from 1963 – 1998 from $1.69e^{-6}$ streets/m/sq.m. to$2.03e^{-6}$ streets/m/sq.m.(Plate 5.14 and Plate 5.15). This was due to an increase in the number of buildings facing the park that resulted in emergence of alleys connecting onto Monrovia St and Muindi Mbingu Rd as shown in Plate 5.16 and Plate 5.17. From 1998-2015 however, the number of alleys connecting onto Moktar Daddah St decreased due to development of buildings on previously vacant land. This indicates that increase in number of buildings sometimes results in decrease in alleys in-between buildings.

Plate 5.10: Valley Rd, 1960s. Source: www.mccrow.org.uk

Plate 5.11: Nyerere Rd & Kenyatta Av Intersection, 1960s

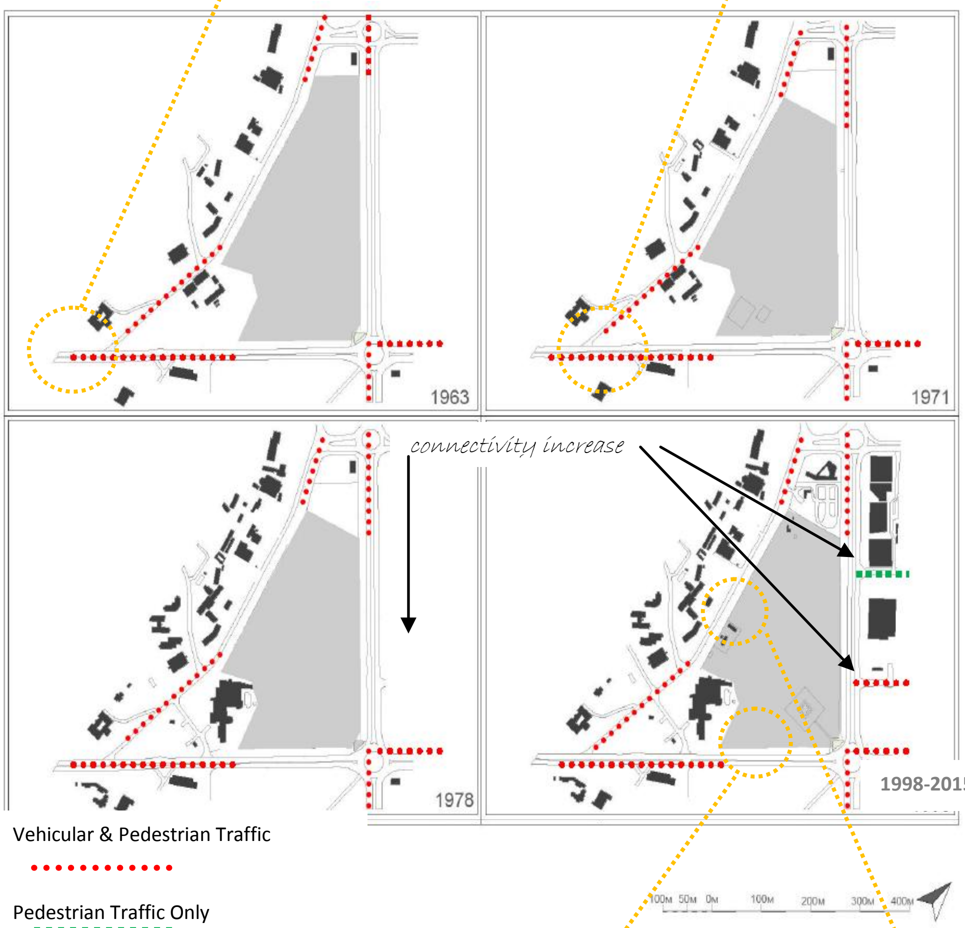


Figure 5.9: Central Park Connectivity Maps (1963-2015) Source: Author

Plate 5.12: Kenyatta Avenue, 2015. Author

Plate 5.13: Nyerere Road 2015, Author

Plate 5.14: Moi Avenue at Jeevanjee Gardens, 1983 tps://twitter.com/ma3route

Plate 5.15: Bazaar St from Khoja Mosque, 1970 Source: www.sikh-heritage.co.uk

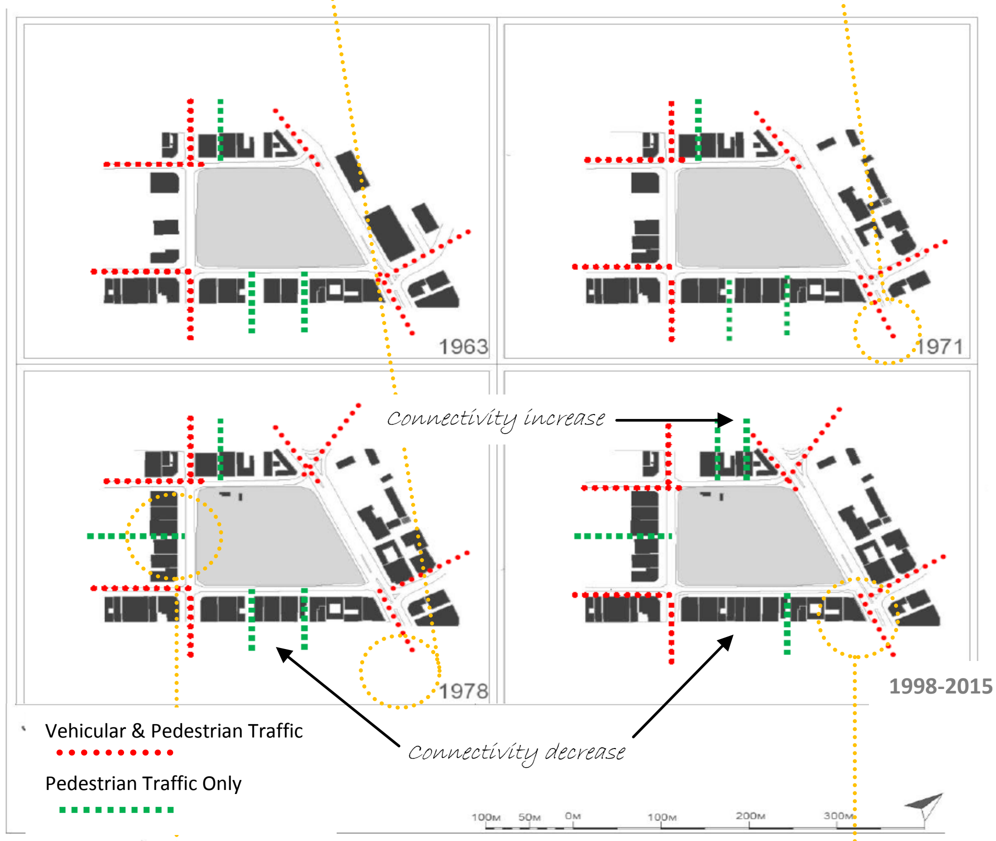


Figure 5.10: Jeevanjee Gardens Connectivity Map (1963-2015) Source: Author

Plate 5.16: Muindi Mbingu Rd, 2015 Source: Author

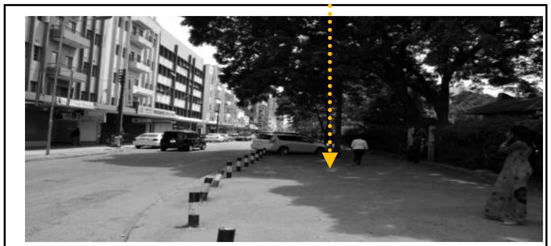


Plate 5.17: M. Daddah St., 2015 Author

John Michuki Park: Table 5.3 indicates a decline in connectivity between1963-1971 of 27.8% from 1.75e^{-6} streets/m/sq.m. to 1.31e^{-6} streets/m/sq.m. This was due to construction of a building that blocked an alleyway. Combined pedestrian and vehicular access routes however remained the same from 1971-2015 (Figure 5.11). As shown in Plate 5.18 the street between the backside of the warehouses and the park is dusty with few pedestrians except on market days. Streets connecting to the space have a combination radial and grid pattern radiating from Globe Cinema Roundabout and Kijabe Street respectively (Plate 5.19).

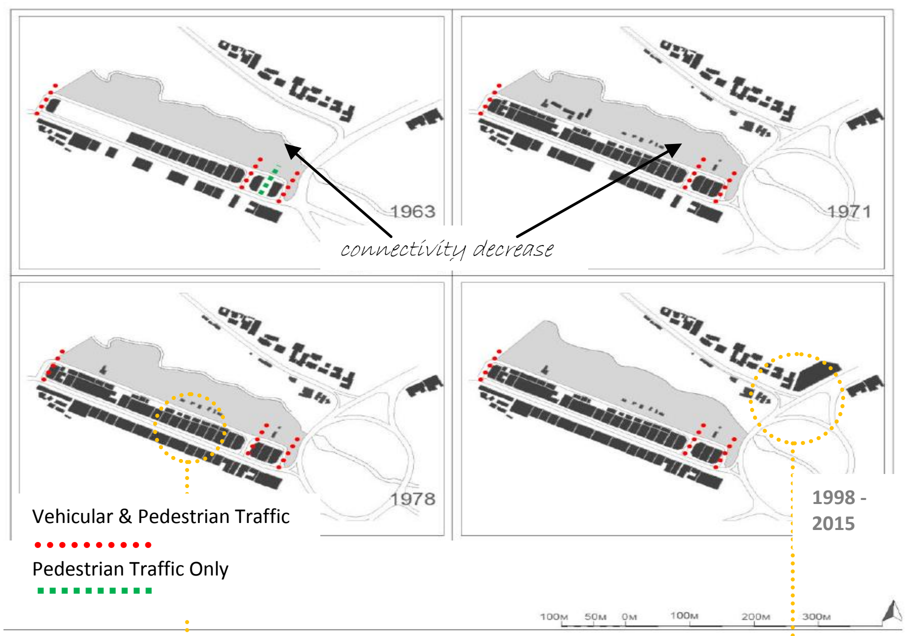


Figure 5.11: John Michuki Park Connectivity Maps (1963-2015) Author

Plate 5.18: Street adjacent to John Michuki Park, 2015 Source: Author

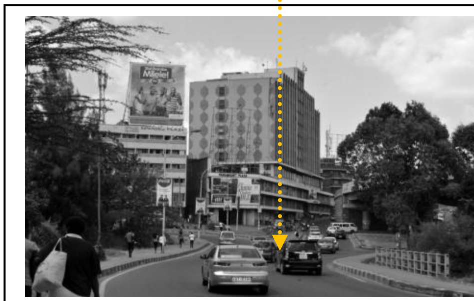


Plate 5.19: Globe Cinema Roundabout, 2015. Source: Author

Hilton Hotel Circle: connectivity increased from 1963-1971 from $1.0e^{-6}$ streets/m/sq.m. to $2.74e^{-5}$ streets/m/sq.m. (Table 5.3) and thereafter remained the same from 1971-2015 (Figure 5.12). This endurance of street pattern underscores the Conzenzian view that out of the basic elements that comprise urban form and layout, street patterns are least likely to change (Plate 5.20, Plate 5.21 and Plate 5.22). Moi Avenue borders the eastern boundary to the space and is a main connector also serving as a major south-north vehicular and pedestrian artery in the city centre (Plate 5.23)

Plate 5.20: Hilton Hotel Circle Connectors, 1960s Source: www.skyscrapercity.com

Plate 5.21: Hilton Hotel Circle Connectors, 1960s.
Source: www.sikh-heritage.co.uk

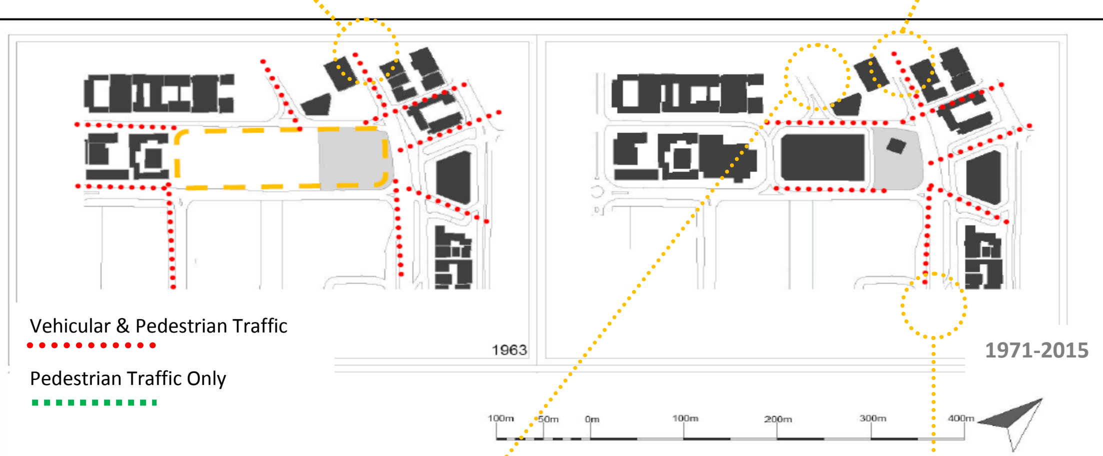


Figure 5.12: Hilton Hotel Circle Connectivity Maps (1963-2015) Source: Author

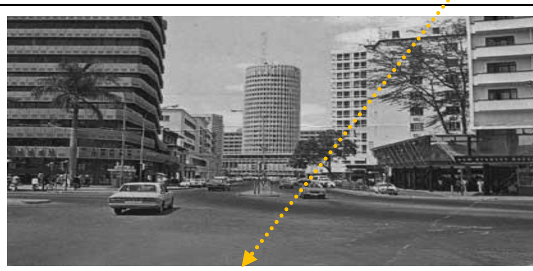


Plate 5.22: Connectors to Hilton Hotel, 1980s
Source: www.network54.com

Plate 5.23: Connectors to Hilton Hotel, 2015 Source: Author

Fire Station Roundabout: from 1963-2015 connectivity remained consistent at $9.02e^{-5}$ streets/m/sq.m. (Figure 5.13). As shown in Plate 5.24 the roundabout connected to the Murang'a Road vehicular artery was formed early in the layout of the city. Neighbourhood building footprints, street patterns and plot patterns have changed minimally from 1963-2015. Indicated in Plate 5.25, direct access to the enclosing road is limited by change in levels and a retaining wall.

Figure 5.13: Fire Station Roundabout Connectivity Maps (1963-2015) Author

Plate 5.24: Murang'a Road Connector, 2015
Source: Author

Plate 5.25: Restrictive Wall and Ground Level Change at Murang'a Rd., 2015
Source: Author

Globe Cinema Roundabout: Table 5.3 indicates that from 1963-2015 connectivity increased by 254.2% from $4.75e^{-7}$ streets/m/sq.m. to $1.74e^{-6}$ streets/m/sq.m. From 1998-2015 it remained the same at $1.74e^{-6}$ streets/m/sq.m. (Figure 5.14). This means that the ability of users to arrive at the space also increased. The function of the roundabout as a public recreational amenity and its enclosure by a major road informed the creation of underground walkways for safe pedestrian passage (Plate 5.26). Neglect and poor maintenance have rendered them crime-prone and unusable. The radial street pattern from the roundabout draws focus to the space itself. This pattern means that the space is accessible from multiple directions that can enhance its convenience to users (Plate 5.27). It also means that access to the space can be impeded in the event of heavy vehicular traffic.

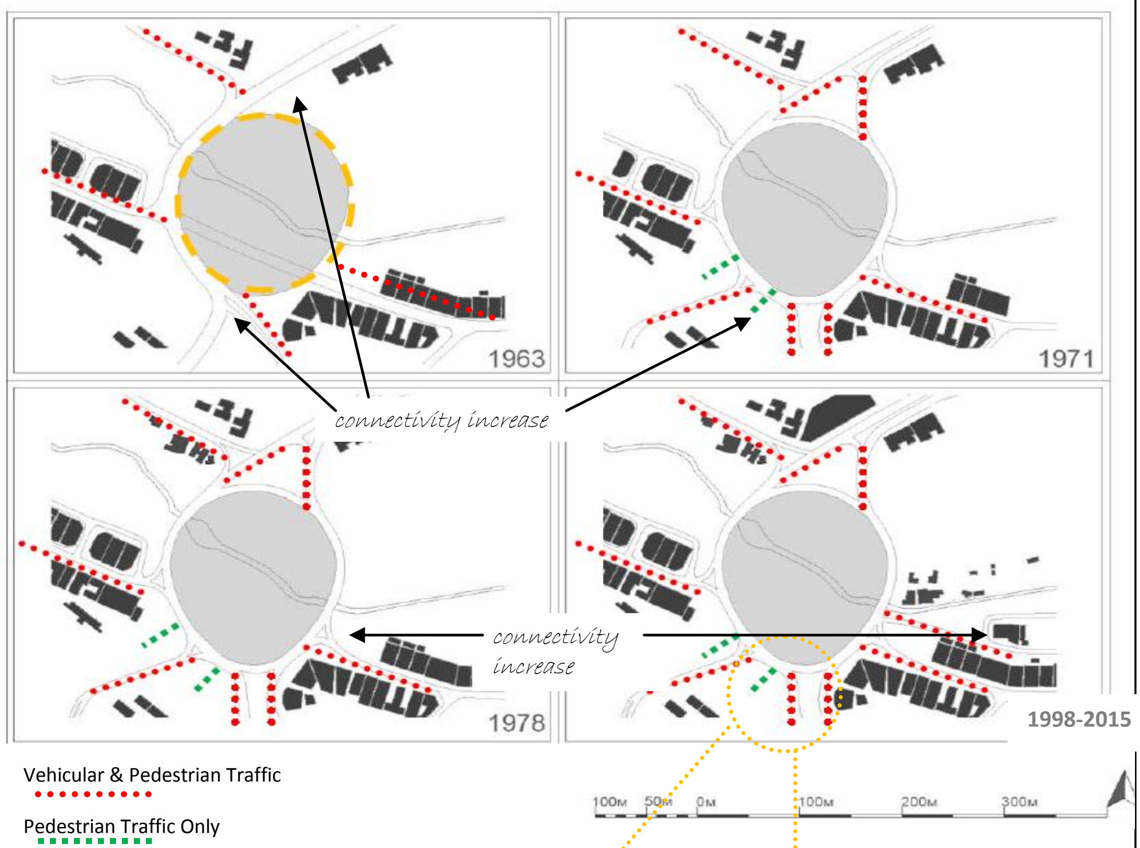


Figure 5.14: Globe Cinema Roundabout Connectivity Maps (1963-2015) Source Author

Plate 5.26 Underground Connector Walkway, 2015 Source: Author

Plate 5.27: Slip Road Connector at Roundabout, 2015 Source: Author

Sunken Car-park: Table 5.3 indicates that from 1963-2015 connectivity increased by 47.7% from $8.77e^{-7}$ streets/m/sq.m. to $1.31e^{-6}$ streets/m/sq.m. Figure 5.15 indicates that from 1963-1971 space connectivity increased and thereafter remained unchanged until 2015 as shown in Plates 5.28 and Plate 5.29. Increased connectivity is increased carrying capacity of connectors and thus greater vehicular and pedestrian access to the car-park.

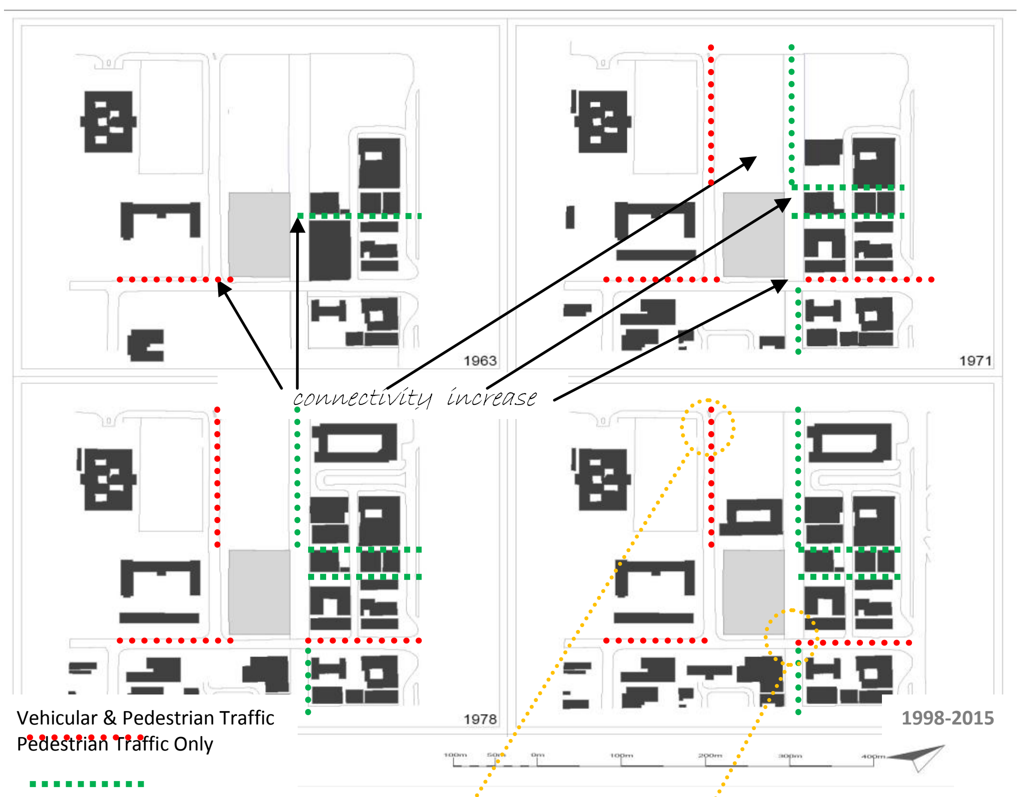


Figure 5.15: Sunken Car Park Connectivity Maps (1963-2015) Source: Author

Plate 5.28: Taifa Road towards Harambee Avenue, 2015 Source: Author

Plate 5.29: Harambee Avenue towards NHC Walk, 2015 Source: Author

Supreme Court Car-park: Table 5.3 indicates that from 1963-2015 connectivity increased by 100% from $6.59e^{-7}$ streets/m/sq.m. to $1.32e^{-6}$streets/m/sq.m. (Plate 5.30). Connectors increased from 1963-1998 but remained unchanged from 1998-2015 (Figure 5.16). The 1982 construction of Reinsurance Plaza shown in Plate 5.31 created new connectors to its basement parking and Taifa Road. The main connector to the space is City Hall Way, a key east-west CBD vehicular and pedestrian axis (Plate 5.32).

Plate 5.30: Supreme Court Parking Area, 1960s Source: www.skyscrapercity.com

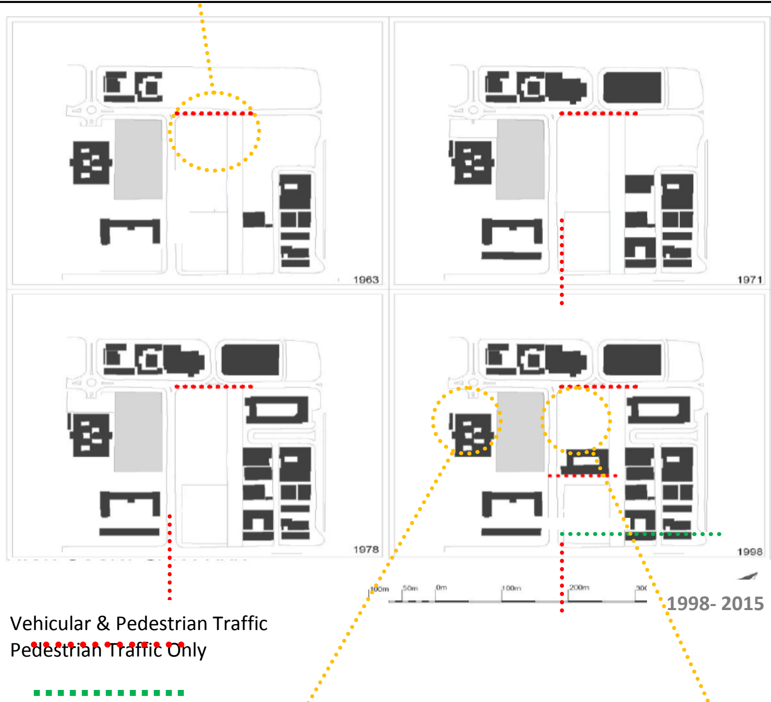


Figure 5.16: Supreme Court Parking Connectivity Maps (1963-2015)

Plate 5.31: Taifa Road, 2015
Source: Author

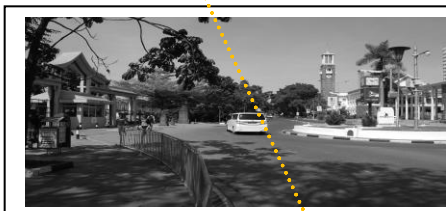


Plate 5.32: City Hall Way, 2015
Source: Author

Kenyatta International Convention Centre Car-park: Table 5.3 indicates that from 1963-2015 connectivity has remained consistent at $4.65e^{-7}$ streets/m/sq.m. (Figure 5.17). Plate 5.33 and Plate 5.34 show the space location at the corner of two prominent streets namely Parliament Road and City Hall Way, which has contributed to the consistency in connectivity. Proximity to the Parliament Buildings and City Hall has also contained property development in the area and retained the footprint and densities of buildings surrounding the space.

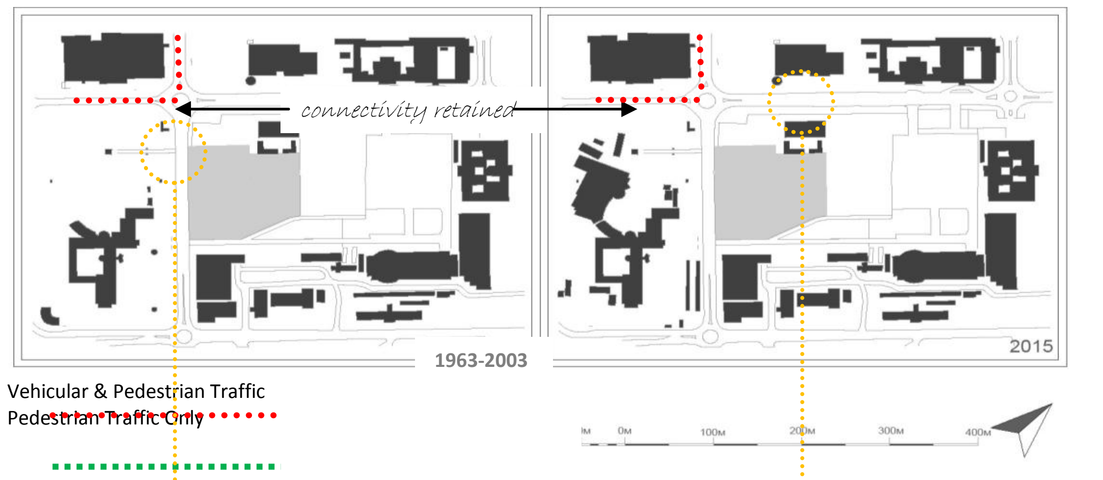


Figure 5.17: KICC Connectivity Maps (1963-2015) Source: Author

Plate 5.33: Parliament Rd towards Harambee Ave. Source: Author

Plate 5.34: City Hall Way towards Moi Ave., 2015 Source: Author

Railway Go-downs Parking: located adjacent to the epicenter of the city's origin, the space has not changed in connectivity from 1963-2015 as indicated in Table 5.3 and Figure 5.18. Street and block patterns have not changed over the period, thus affecting opportunity of new connectors to emerge. As shown in Figure 5.18 and illustrated in Plate 5.35 and Plate 5.36, connectors Haile Selassie Avenue and Moi Avenue are among the oldest roads in the city.

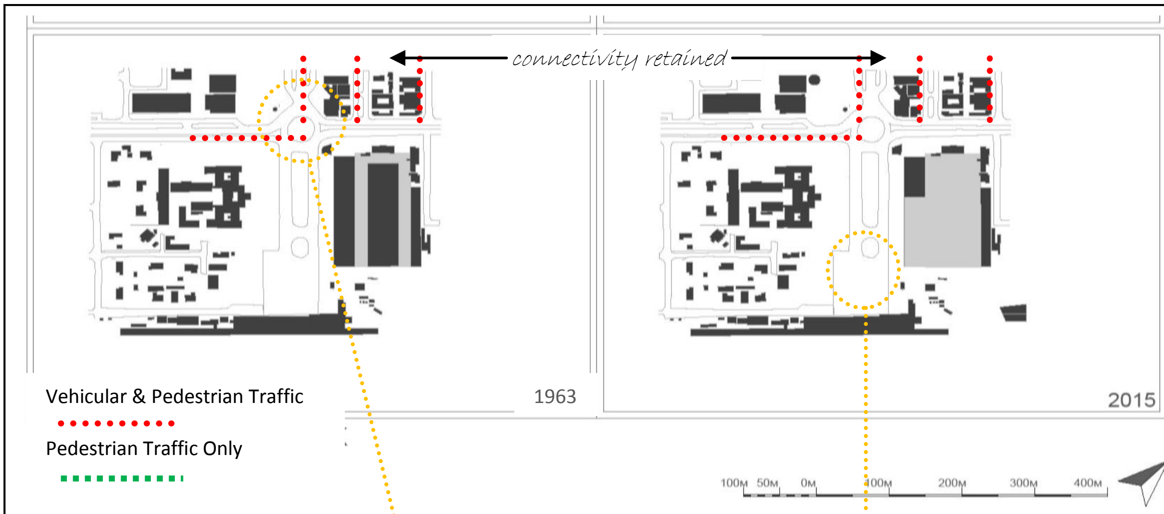


Figure 5.18: Railways Go-downs Parking Connectivity Maps (1963-2015) Source: Author

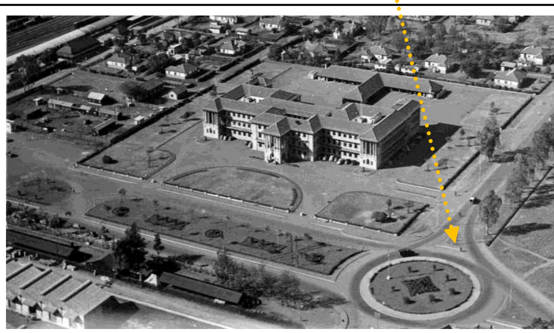


Plate 5.35: Haile Selassie Av and Moi Av. Connectors, 1960s Source: www.skyscrapercity.com

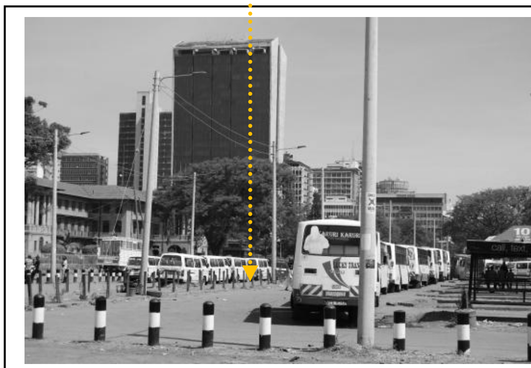


Plate 5.36: Moi Av Connector, 2015 Source: Author

KBS Terminus: as indicated in Table 5.3 the number of connectors declined from 1963-2015 by 25.7% from $3.49e^{-6}$ streets/m/sq.m. to $2.62e^{-6}$ streets/m/sq.m. (Figure 5.19). The terminus had three main access roads from 1963-2003, one of which is shown in Plate 5.37. By1998 vendors and small scale commercial stalls were introduced between the terminus and Khalsa Centre, an institutional building complex. This reduced pedestrian connectivity to the space. In 1998 construction of a building next to the Centre created an alley way that improved connectivity to the space (Plate 5.38). Construction of public toilets south of Khalsa Centre added to the number of connector lanes in 1998. By 2015 connectors decreased due to commercial structures that were built, blocking off connectors to the space along its east and west edges.

Figure 5.19: Kenya Bus Services Terminus Connectivity Maps (1963-2015) **Source: Author**

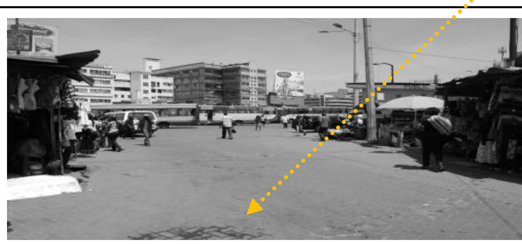


Plate 5.37: Bus Station Connector, 2015
Source: Author

Plate 5.38: Pedestrian Connector, 2015
Source: Author

Railways Bus Terminus: **1**963-2015 connectivity remained unchanged at $6.67e^{-7}$ streets/m/sq.m. as indicated in Table 5.3 and Figure 5.20. The space location at the terminal of Moi Avenue, the city's oldest formal road has contributed to connectivity consistency (Plate 5.39 and Plate 5.42). The railway station building and adjacent Rift Valley Railways Headquarters space have controlled densities and creation of new connectors to the space Plate 5.40 and Plate 5.41. The former Plate shows a fence on either side of the terminus has additionally limited the connectivity to the space from neighbouring properties.

Plate 5.39: Moi Ave., 1960s
Source: www.mccrow.org.uk

Plate 5.40: Railway Bus Terminus Fencing, 2015
Source: Author

Figure 5.20: Railways Bus Terminus Connectivity (1963-2015) Source: Author

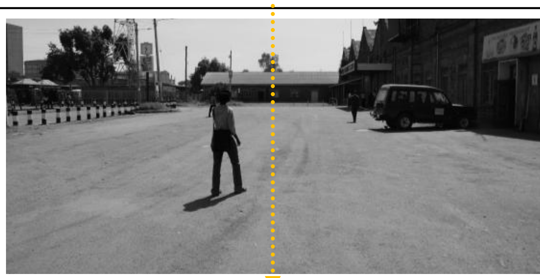


Plate 5.41: Connector to Railway Station, 2015

Plate 5.42: Haile Selassie Ave., 2015

Aga Khan Walk: Table 5.3 indicates that from 1963-2015 connectivity increased by 83.3% from 1.16e^{-6} streets/m/sq.m. to 2.15e^{-6} streets/m/sq.m. (Plate 5.43). Figure 5.21 further indicates that from 1963-1971 part of Aga Khan Walk was a paved pathway from Haile Selassie Avenue to NHC Walk and from ICDC Building to Harambee Avenue (Plate 5.44). Its western edge was bordered by car parks. Connectivity increased from 1963-1978 and remained constant at 2.15e^{-6} streets /m/sq.m. from 1998-2015. Increased connectivity typically means an increased carrying capacity of connections and greater number of users arriving at the promenade.

Plate 5.43: Aga Khan Walk 1960s.
Source: www.skyscrapercity.com

Plate 5.44: Harambee Ave., 2015
Source: Author

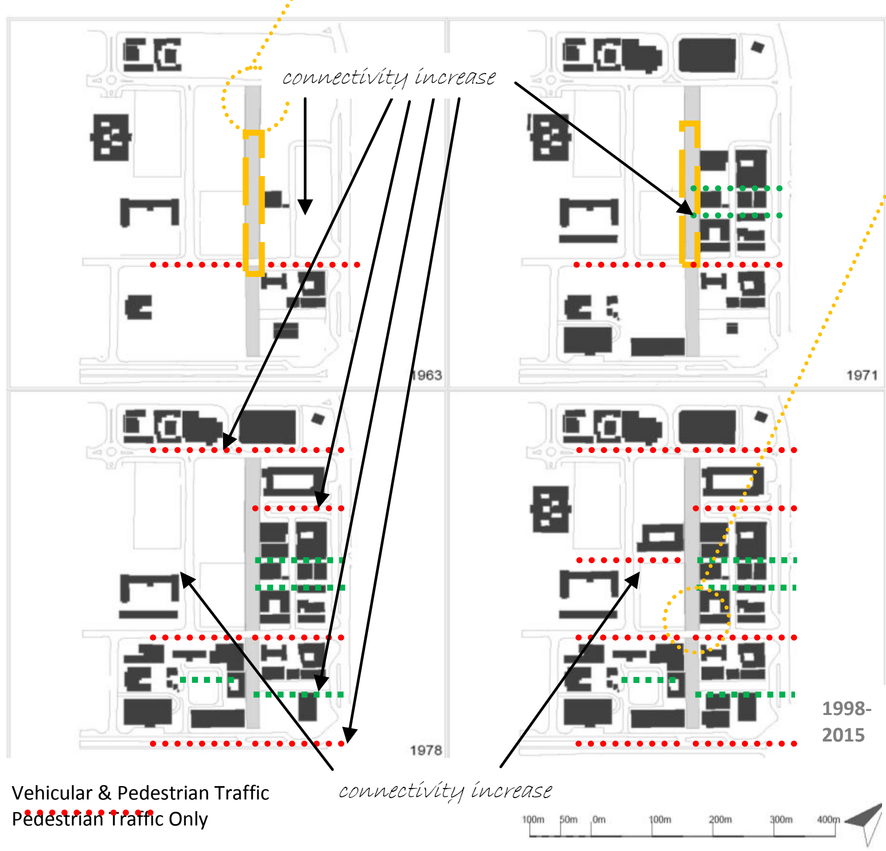


Figure 5.21: Aga Khan Walk Connectivity (1963-2015) Source: Author

National Housing Corporation Walk: Table 5.3 indicates that from 1963-2015 connectivity decreased by 21.6% from $8.8e^{-6}$ streets/m/sq.m. to $6.85e^{-6}$ streets/m/sq.m. as shown in Figure 5.22 and Plate 5.45. From 1971- 1978 connectivity to the NHC Walk decreased due to the blocking of a connector following construction of NHC building along the Walk. From 1978-2015 connectivity remained the same at $6.85e^{-6}$ streets/m/sq.m as street patterns and building footprints changed minimally over that period (Plate 5.46).

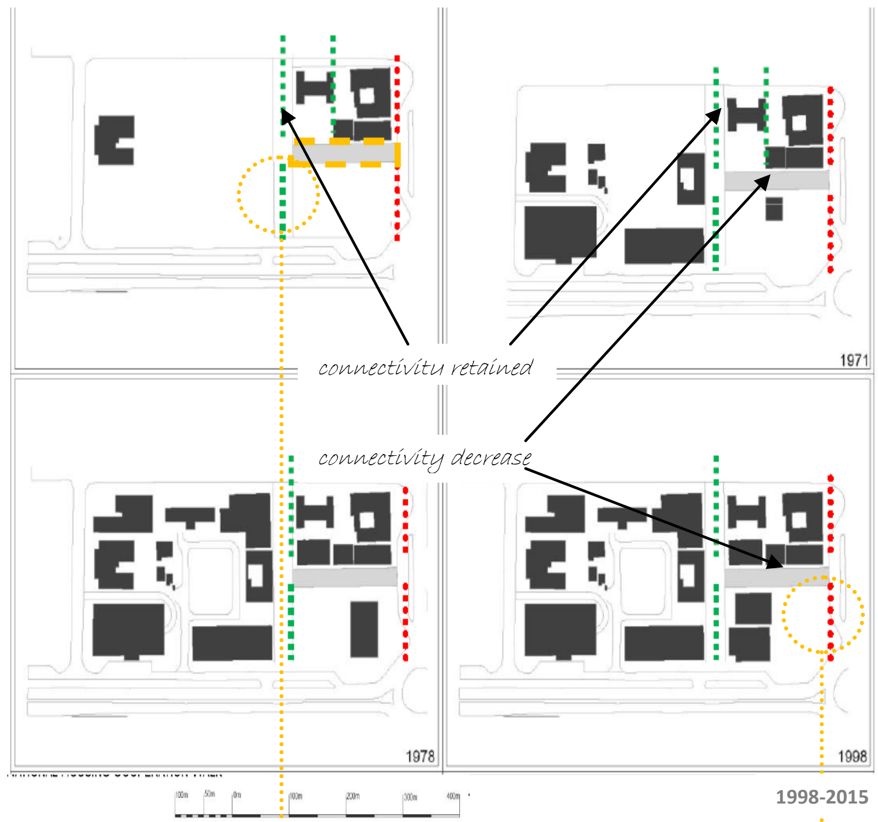


Figure 5.22: National Housing Corporation Walk Connectivity (1963-2015)
Source: Author

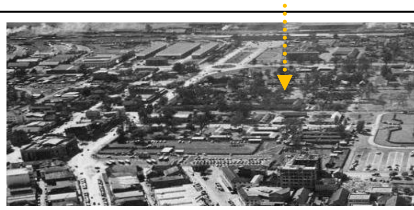


Plate 5.45: NHC Walk, 1960s Source: www.skyscrapercity.com

Plate 5.46: NHC Walk Connector, 2015
Source: Author

Wakulima Market: In 1963 the market did not exist. 1963-1971 connectors to the space had decreased due to construction of a building that blocked a footpath connector to the space (Figure 5.23). 1971-2015 connectors remained the same at $2.67e^{-6}$ streets/m/sq.m. due to street pattern and surrounding built up areas (Table 5.3). As shown in Plate 5.47 the main vehicular and pedestrian connector to the space is Haile Selassie Avenue, a key east-west CBD vehicular and pedestrian axis. The congested connection from Haile Selassie Avenue to the market access road in shown in Plate 5.48.

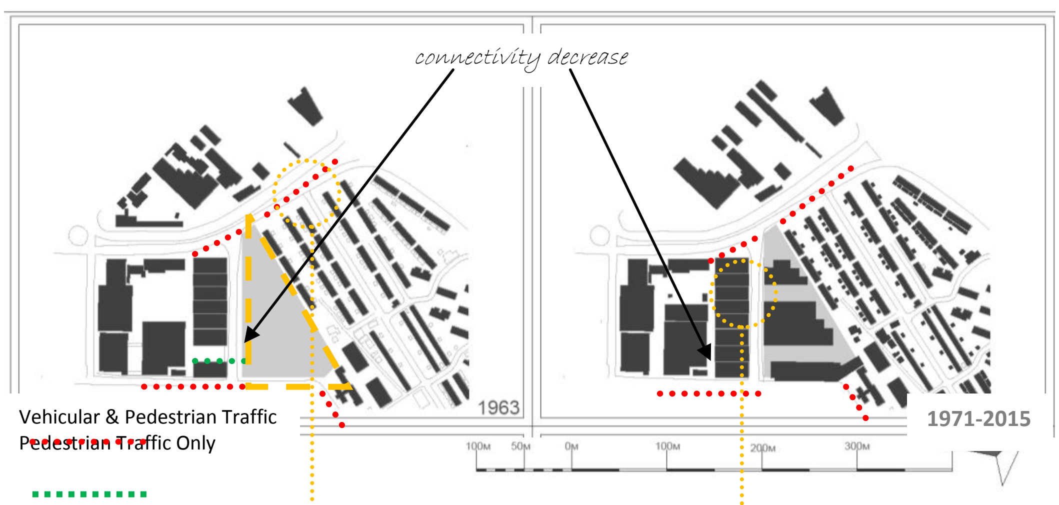


Figure 5.23: Wakulima Market Connectivity (1963-2015) Source: Author

Plate 5.47: Haile Selassie Ave., 2015 Source: Author

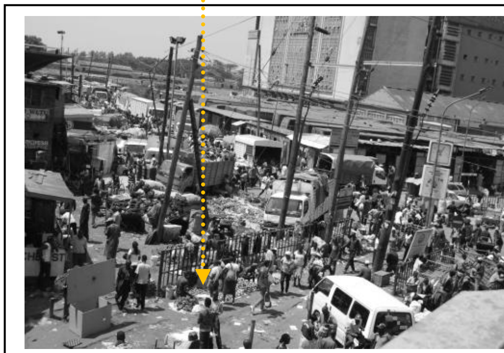


Plate 5.48: Haile Selassie Ave junction with market access road, 2015 Source: Author

5.2.3 Density

The third variable analysed was the building density in the space and its surroundings, measured in number of buildings per hectare. Table 5.5 indicates that all spaces and surroundings experienced increased densities from 1963-2015. Percentage increase ranged from 452.0% for KICC Parking to 15.2% for the Fire Station Roundabout. Changes in densities of neighbourhoods surrounding each space have been represented in Figure 5.24 for 1963-2015.

Table 5.5: Changes in Densities (1963-2015)

STUDY SPACE/VARIABLE	1963	1971	1978	1998	2003	2015	1963-2015 % change
DENSITY (no. bldgs/ha)							
Central Park	4.33	4.67	7.33	11	10	10.67	146.4
Jeevanjee Gardens	3.63	5.0	6.21	6.06	6.06	6.67	83.7
John Michuki Park	3.56	7.89	7.33	7.33	7.33	6.11	71.6
Hilton Hotel Circle	1.26	1.93	2.0	2.0	2.0	2.0	58.7
Globe Cinema Roundabout	1.8	1.8	2.7	3.2	3.2	2.8	55.6
Fire Station Roundabout	7.9	7.9	7.9	8.3	9.1	9.1	15.2
Supreme Courts Parking	0.94	1.31	1.44	1.50	1.56	1.56	64.0
NCC Sunken Parking	1	1.5	1.63	1.69	1.69	1.69	69.0
Railways Godowns Parking	1.70	1.77	2.15	2.37	2.37	2.30	35.3
KICC Parking	0.25	0.69	1.32	1.32	1.32	1.38	452.0
Railways Bus Terminus	1.70	1.77	2.15	2.37	2.37	2.30	35.3
KBS Bus Terminus	3.8	4.4	4.8	5.2	5.4	8.2	115.8
Aga Khan Walk	0.73	1.64	2.18	2.30	2.30	2.30	215.0
National Housing Corporation Walk	0.73	1.64	2.18	2.30	2.30	2.30	215.0
Wakulima Market	0.93	1.0	1.36	1.21	1.71	3.20	244.1

Source: Author

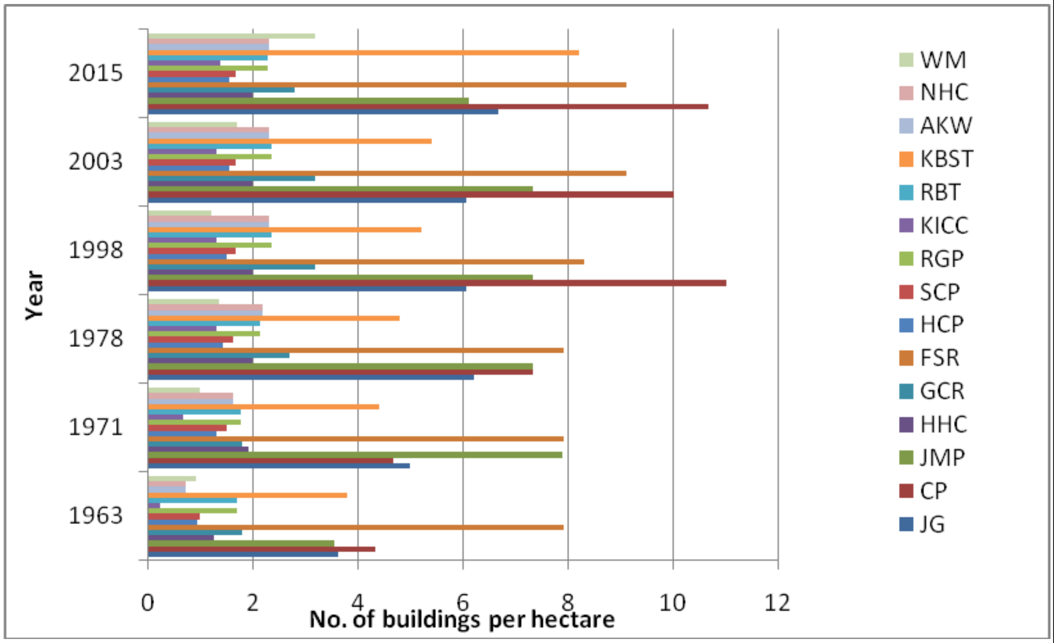


Figure 5.24: Graph of Density Changes (1963-2015) Source: Author

Table 5.6: Surrounding Space Density Averages (1963-2015)

YEAR	AVERAGE SIZE	AVERAGE CONNECTIVITY	AVERAGE ENCLOSURE	**AVERAGE DENSITY**	AV. TREE COVER	AV. COMM INDEX	AV. INSTIT INDEX	AV. RES INDEX	AV. INDST INDEX
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1978	11833.7333	9.42E-06	0.034766	**3.5122667**	0.22	20.3476	9.9348	0.135533	0.3088
1998	11833.7333	9.47286E-06	0.035054	**3.8637345**	0.24	24.99213	10.20187	0.111867	0.2492
2003	11567.0667	9.41486E-06	0.035054	**3.9144**	0.24	25.3528	11.01907	0.111867	0.250533
2015	11667.0667	9.41486E-06	0.035394	**4.1724**	0.32	25.43813	10.84907	0.108533	0.096867
DELTA	-421.2	1.8406E-06	0.0125	**1.88**	0.22	17.6	7.9	-0.007	-0.191
% DELTA	-3.5%	24.3%	54.50%	**82.1%**	220.0%	225.6%	272.4%	-6.03%	-66.6%

Source: Author

Table 5.6 and Figure 5.25 indicate changes in densities for all spaces, calculated as averages for each year 1963-2015. On average, densities of spaces increased by 82.1% from 1963-2015, due to increased number of buildings in Nairobi CBD.

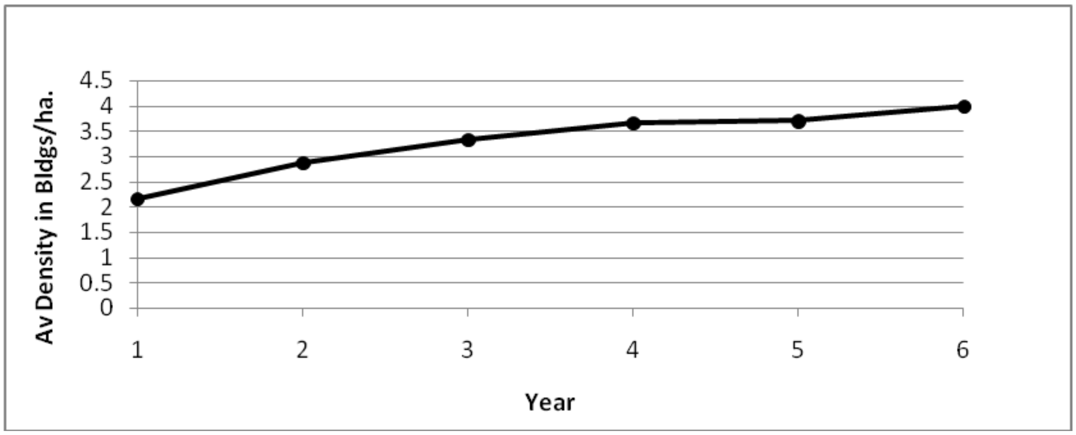


Figure 5.25: Average Densities All Spaces (1963-2015) Source: Author

Organized according to space type, density changes for 1963-2015 were recorded and analysed as follows.

Central Park: Table 5.5 indicates from 1963-2015 the density per hectare increased by 146.4% from 4.33 bldgs/ha. to 10.67 bldgs/ha as also captured in Figure 5.26. Increased density means an increased compactness and walkability both of which are characteristics of sustainable neighbourhoods as they reduce need for car use, increase convenience of walking, and thus create more opportunities for socio-economic activity and vitality. In terms of buildings per square distance, areas west and east of the park experienced greater densification from 1963-2015 (Plate 5.49 and Plate 5.50). Compact footprints concentrate functions and services, reduce vehicular movement, and increase the number of users of urban land per square area.

Jeevanjee Gardens: From 1963-2015 the density of the neighbourhood of Jeevanjee Gardens almost doubled from 3.63 bldgs/ha. to 6.67 bldgs/ha, an increase of 83.7% increase (Table 5.5 and Figure 5.27). As shown in Plate 5.51, densification has occurred to the south, east, and west of the park. Density remained low east of the park due to a government primary school whose function and footprint exhibit minimal change since 1971 (Plate 5.52). As shown in Plate 5.53, increased density means an increased compactness of urban form and walkability.

John Michuki Park: from 1963-1971 the density in the park area approximately doubled from 3.56 bldgs/ha to 7.89 bldgs/ha (Table 5.5 and Figure 5.28). Densities decreased from 1971-1978. From 1978-2003 densities remained consistent at 7.33 blgs/ha., declining again in 2015. Overall however, the neighbourhood building densities increased by 71.6% from 1963-2015. Densities increased due to development of buildings along Kijabe St , the main customer access road and Kipande Road (Plate 5.54). As shown in Plate 5.55 buildings included low-rise buildings at the park edge from the 1940s that served as warehouses and residences. The increase in the number of workshop sheds to the south and north of the river also contributed to the increased densities.

Hilton Hotel Circle: Table 5.5 and Figure 5.29 indicate that between 1963-1971 density of the neighbourhood increased by 58.7% from 1.26bldgs/ha. to 1.93 bldgs/ha. Plate 5.56 and Plate 5.57 show area density early as the 1950s. From 1978-2015 building densities remained unchanged at 2.0 bldgs/ha. Density increased to the north with construction of commercial office buildings, Hilton Hotel, and KCB Headquarter in the 1970s (Plate 5.58 and Plate 5.59). The number of buildings on Moi Avenue across from space did not change. As one of the oldest streets in Nairobi, it fronts buildings constructed prior to 1963 as government offices and public institutions such as Kenya National Archives.

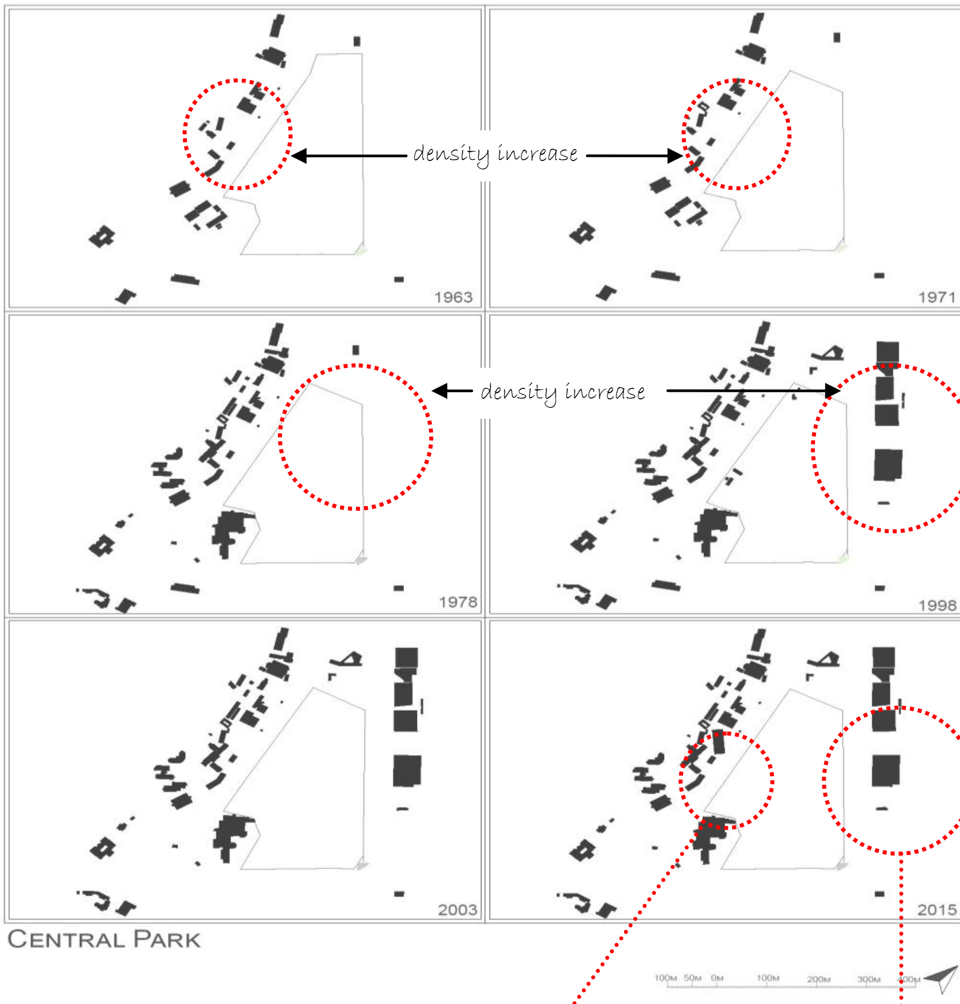


Figure 5.26: Central Park Area Density (1963-2015)   Source: Author

Plate 5.49 Densification along Nyerere Rd, 2015   Source: Author

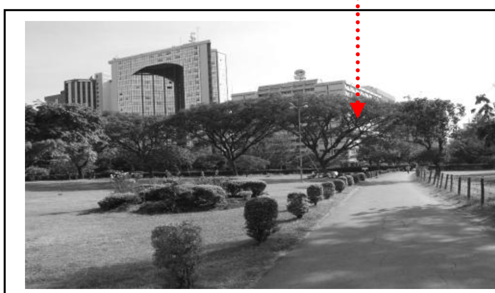


Plate 5.50: Densification on Uhuru Highway, 2 015 Source: Author

Plate 5.51: Jeevanjee Gardens Area Density, 1989
Source: Nevanlinna, 1996

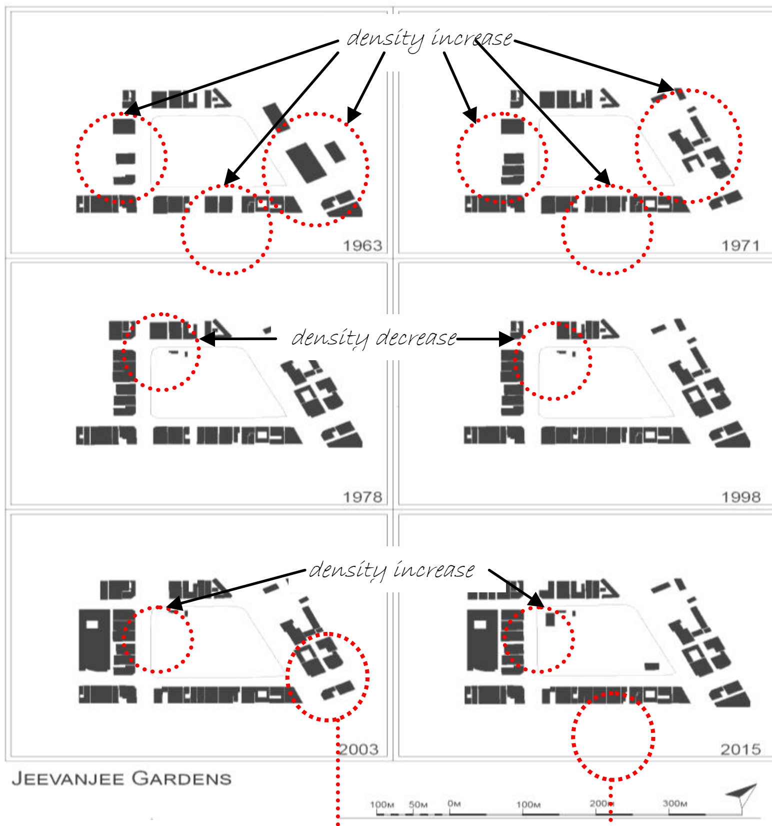


Figure 5.27: Jeevanjee Gardens Area Density (1963-2015)
Source:Author

Plate 5.52: Moi Av., 2003 Source: Author

Plate 5.53: Moktar Daddah St, 2015 Source: Author

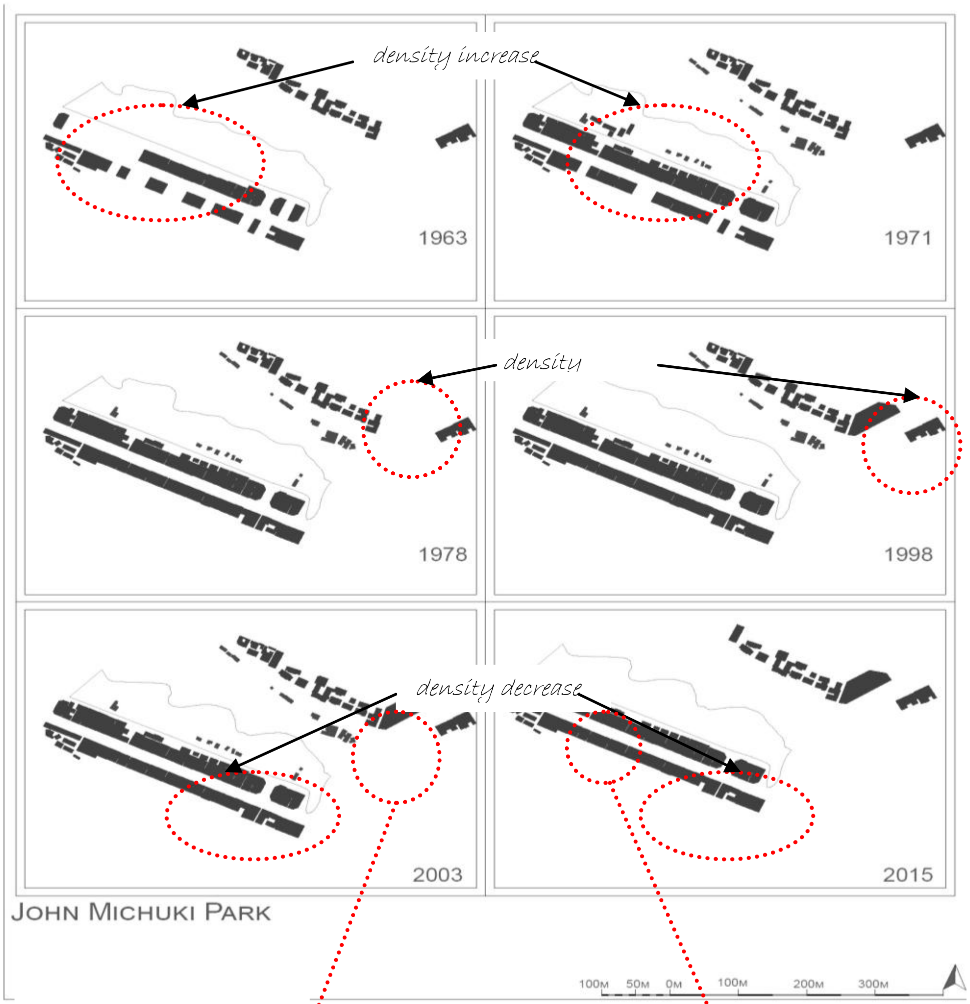


Figure 5.28: John Michuki Park Area Density (1963-2015) Source: Author

Plate 5.54: Kipande Road Buildings, 2015 Source: Author

Plate 5.55: Warehouses and residential buildings adjacent Michuki Park, 2015 Source: Author

Plate 5.56: Buildings on Moi Ave., 1950s Source: www.sikh-heritage.co.uk

Plate 5.57: Kenya National Archives Moi Ave, 1950s Source: www.sikh-heritage.co.uk

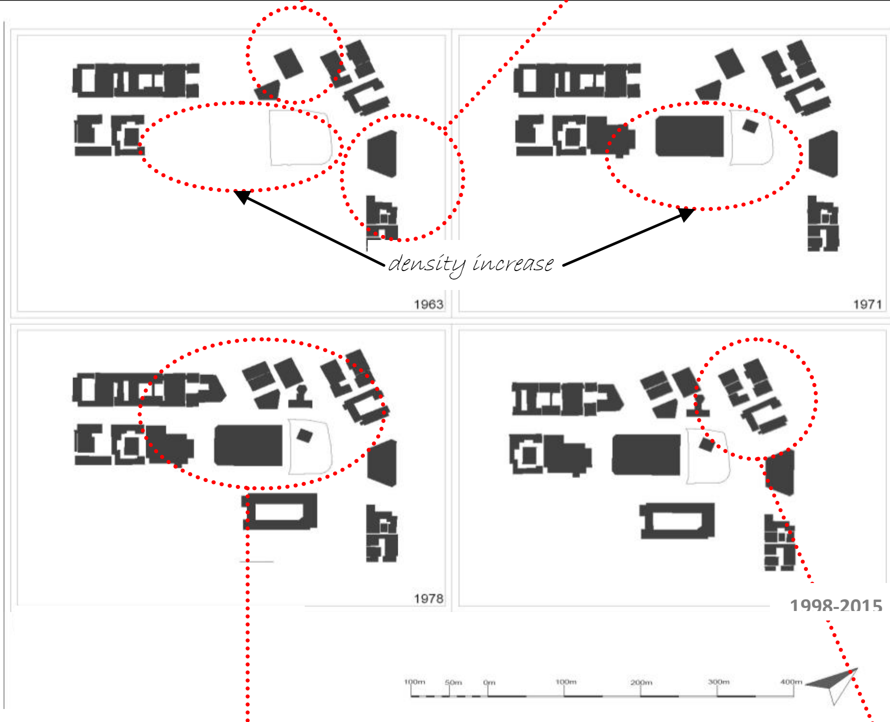


Figure 5.29: Hilton Hotel Circle Area Density (1963-2015) : Source: Author

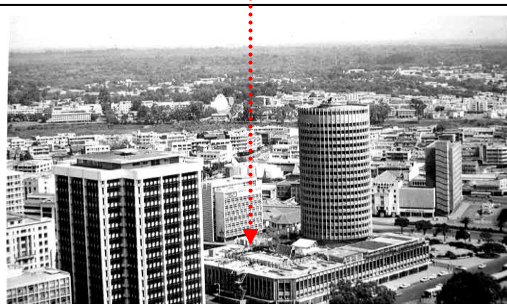


Plate 5.58: Hilton Hotel, 1970s Source: www.pinterest.com

Plate 5.59: Buildings along Moi Avenue, 2015 Source: Author

Globe Cinema Roundabout: from 1963-2015 densities around Globe Cinema Roundabout increased by 55.6% From 1971-1998 the density of buildings in the neighbourhood increased from 1.8 bldgs/ha.-3.2 bldgs/ha. (Table 5.5). Figure 5.30 indicates that densities remained consistent 1998-2003 then declined from 2003-2015. As number of buildings includes permanent and temporary construction, this reduction reflects the removal of the work sheds between these years. Increase in number of buildings that raised densities occurred primarily along Kijabe Street and Kipande Road (Plate 5.60 and Plate 5.61). Nairobi River that runs across the roundabout has influenced construction and densities. This is due to planning and development regulations that protect the river and restrict encroachment along its banks.

Fire Station Roundabout: The neighbourhood surrounding the roundabout experienced an increase in densities of 15.2% from 1963-2015 (Table 5.5). From 1963-1978 and 2003-2015 densities remained consistent at 7.9 bldgs/ha and 9.1 bldgs/ha respectively. Buildings constructed to the north and west of the space contributed to increased densities in those periods (Figure 5.31 and Plate 5.63). Due to plot patterns and building footprints before 1963, changes in densities as measured in buildings per hectare have experienced limited changes. Notable buildings along Tom Mboya Street include the Fire Station (Plate 5.62 and Plate 5.64) and the Old Nation Newspapers offices (Plate 5.65) built in 1906 and 1960s respectively.

Sunken Car-park: as shown in Plate 5.66, before 1963 the sunken car-park area was covered in natural vegetation, identifiable by the High Court Building. Figure 5.32 indicates that 1963-2015 there was an increase in density of 69% in NCC Sunken Parking neighbourhood (Table 5.5). From 1963-1998 there was an increase in densities from 1blg/ha to 1.69bldgs/ha. (Plate 5.67). From 1998-2015 the number of buildings per hectare remained the same. Most construction over the period occurred along Aga Khan Walk and Taifa Rd and was of commercial (retail and offices) and institutional buildings as shown in Plate 5.68 and Plate 5.69. Aga Khan Walk is a key pedestrian path of movement while the latter serves as an important east-west connector. Increased number of buildings per hectare enhanced the compactness and walkability that in turn influence social and economic vitality of surrounding neighbourhoods.

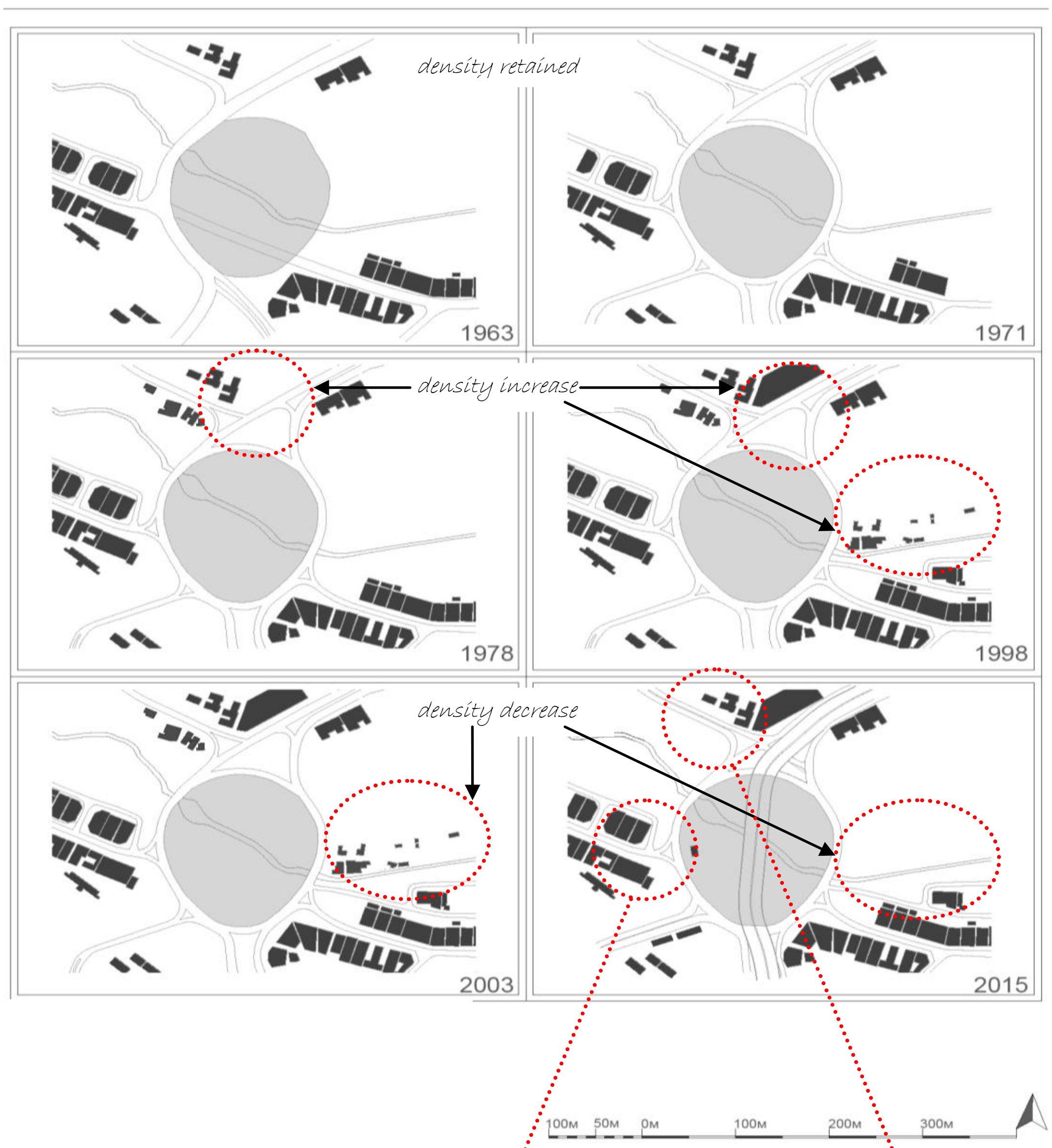


Figure 5.30: Globe Cinema Roundabout Area Density (1963-2015)

Plate 5.60: Kijabe Street Buildings, 2015
Source: Author

Plate 5.61: Kipande Road Buildings, 2015
Source: Author

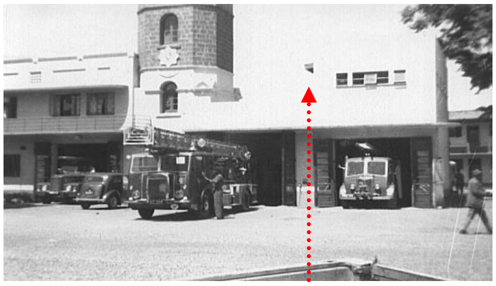


Plate 5.62: Fire Station, 1954 Source: www.mccrow.org.uk

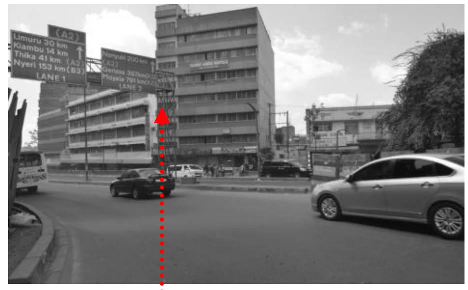


Plate 5.63: Muranga Rd Buildings, 2015 Source: Author

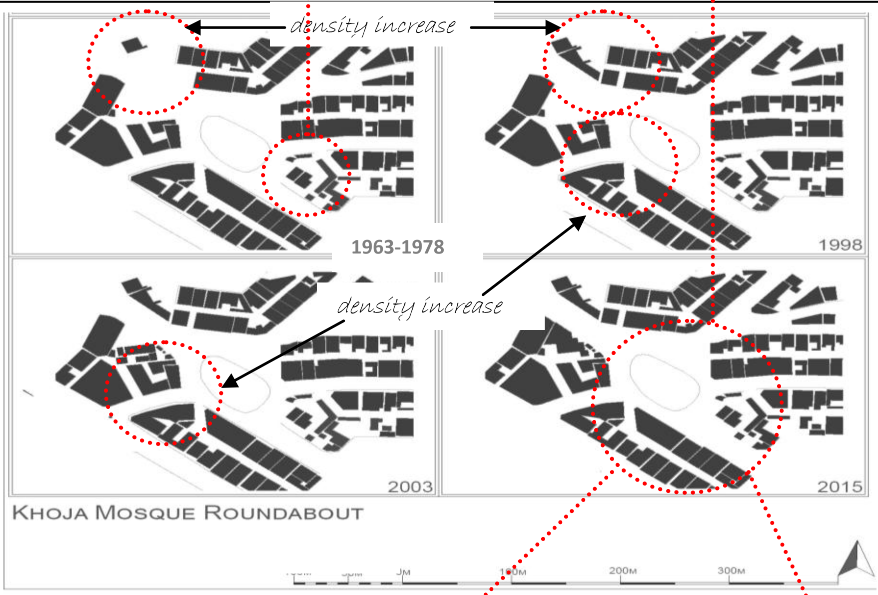


Figure 5.31: Fire Station Roundabout Area Density (1963-2015)

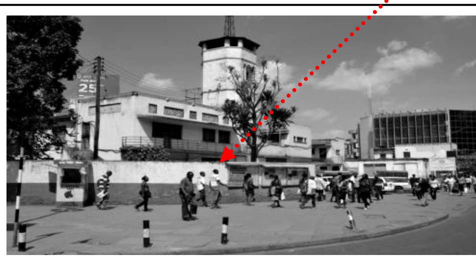


Plate 5.64: Fire Station Building, 2015 Source: Author

Plate 5.65: Old Nation House Building, 2015 Source: Author

Plate 5.66: High Court Building Area 1960s
Sourcewww.skyscrapercity.com

Plate 5.67: Harambee Ave, 1970
Source: www.sikh-heritage.co.uk

Figure 5.32: Sunken Car-park Area Density (1963-2015) Source: Author

Plate 5.68: Aga Khan Walk Density, 2015
Source: Author

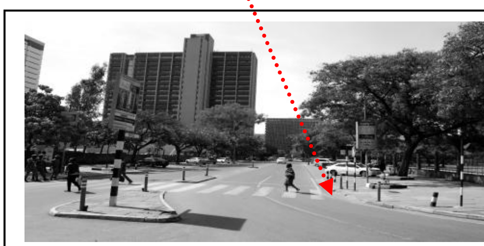


Plate 5.69: Buildings along Taifa Road, 2015 Source: Author

Supreme Courts Parking: density increased by 64.0% from 1963-2015 (Table 5.5 and Figure 5.33). Most building construction during this period was along Aga Khan Walk, a key pedestrian axis of movement. As shown in Plate 5.70, the space became a car-park from an open tree-covered area. From 1963-1971 densities increased from 0.94 bldgs/ha. to 1.31 bldgs/ha., which included construction of buildings namely International Life House and Hilton Hotel (Plate 5.71). From 1998-2003 densities increased from 1.50 bldgs/ha. to 1.56 bldgs/ha., remaining consistent until 2015. Higher density contributes to compactness ourban form when developing sustainable neighbourhoods.

KICC Parking: in the 1950s the law courts grounds were covered with natural vegetation as shown in Plate5.72. From 1963-2015 the density in the neighbourhood increased by 452.0% (Table 5.5). From 1963-1978 there was more than a six-fold increase in density from 0.25 bldgs/ha. to 1.32 bldgs/ha. that occurred along Parliament Road and City Hall Way (Plate 5.73). Density thereafter remained consistent from 1978-2003 at 1.32 bldgs/ha. rising to 1.38 bldgs/ha in 2015 (Figure 5.34). As of 2015 the car-park was mainly surrounded by public and private institutional buildings. These include Parliament Buildings, Holy Family Basilica, KICC Building, and the Supreme Courts Buildings, which have influenced the amount of construction allowable in the area due to their functions, and thus its density (Plate 5.74 and Plate 5.75).

KBS Bus Terminus experienced an increase in densities from 3.8 buildings/ha to 8.2 buildings/ha (115.8%) from 1963-2015 (Table 5.5). As shown in Plate 5.76 and Plate 5.77 this increase contributed to the compactness and walkability of the area around the terminus for which density is calculated. Figure 5.35 indicates that over this period there was a densification of buildings to the west and south of the space, especially along the main road.

Railways Bus Terminus: From 1963-2015 in the neighbourhood of the Railways Bus Terminus and adjacent Railways Godowns Parking densities increased (Table 5.5 and Plate 5.78). From 1963-1998 densities increased from 1.70 bldgs/ha to 2.37 bldgs/ha. Thereafter density declined to 2.30 blidgs/ha in 2015 (Figure 5.36). Increase in construction of buildings occurred along the north side of Haile Selassie Ave where majority of the buildings commercial retail and offices (Plate 5.79 and Plate 5.80). Increased densities mean greater compactness. As much as compactness of urban form indicates sustainability, the spaces and buildings to which pedestrians walk need to be conveniently located accessible to have more sustainable neighbourhoods.

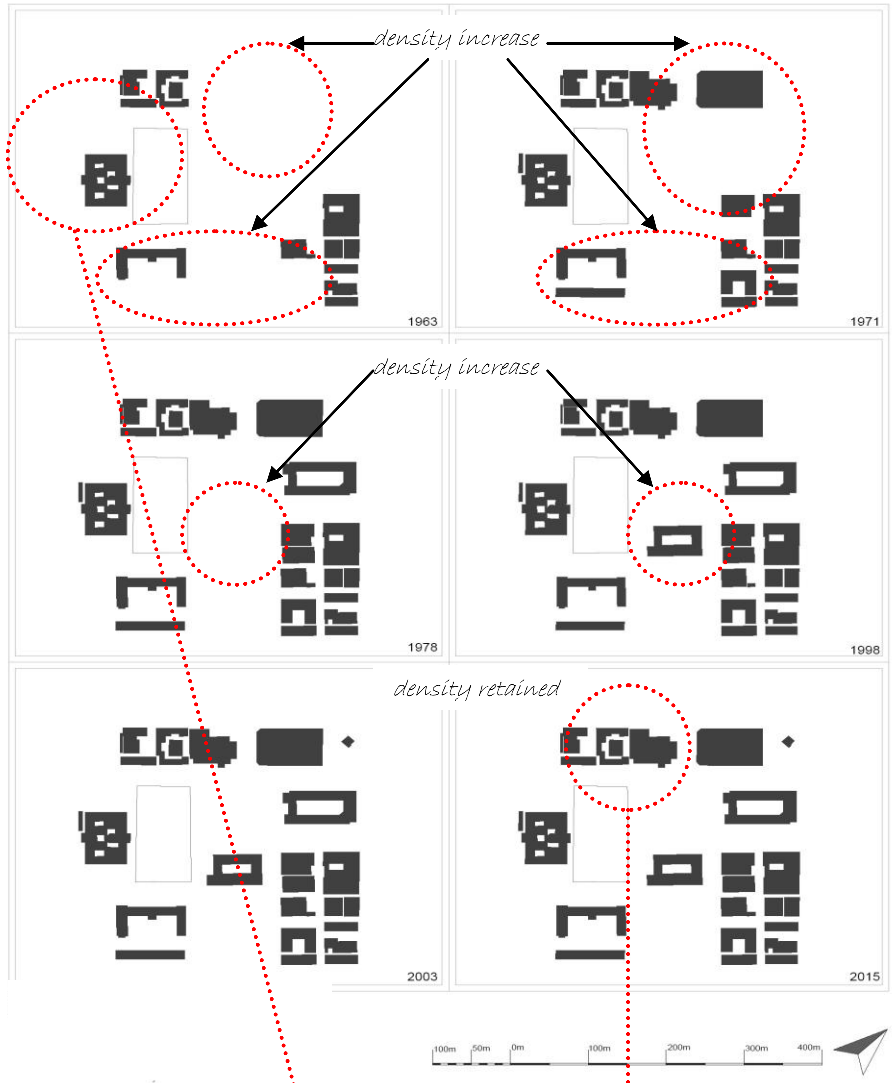


Figure 5.33 Supreme Court Parking Area Density (1963-2015) Source: Author

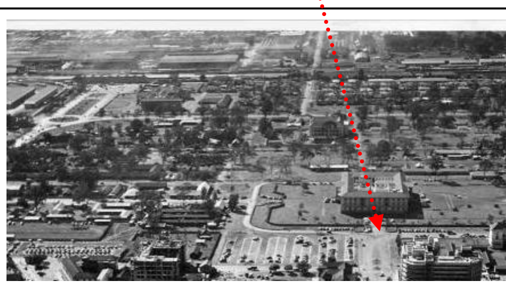


Plate 5.70: Supreme Court Building Area, 1960s Source: www.skyscrapercity.com

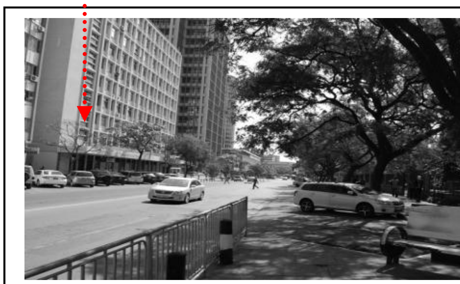


Plate 5.71: Buildings on City Hall Way, 2015 Source: Author

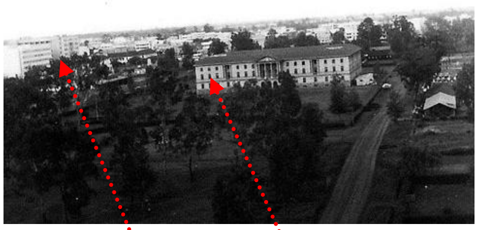


Plate 5.72: Low densities at Law Courts, 1950s Source: www.sikh-heritage.co.uk

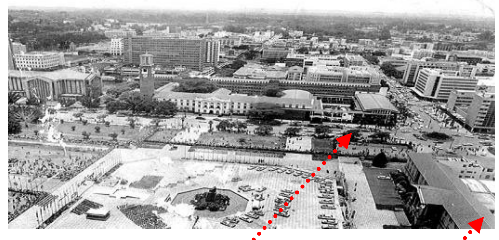


Plate 5.73: Density around KICC Plaza, 1970s Source: www.sikh-heritage.co.uk

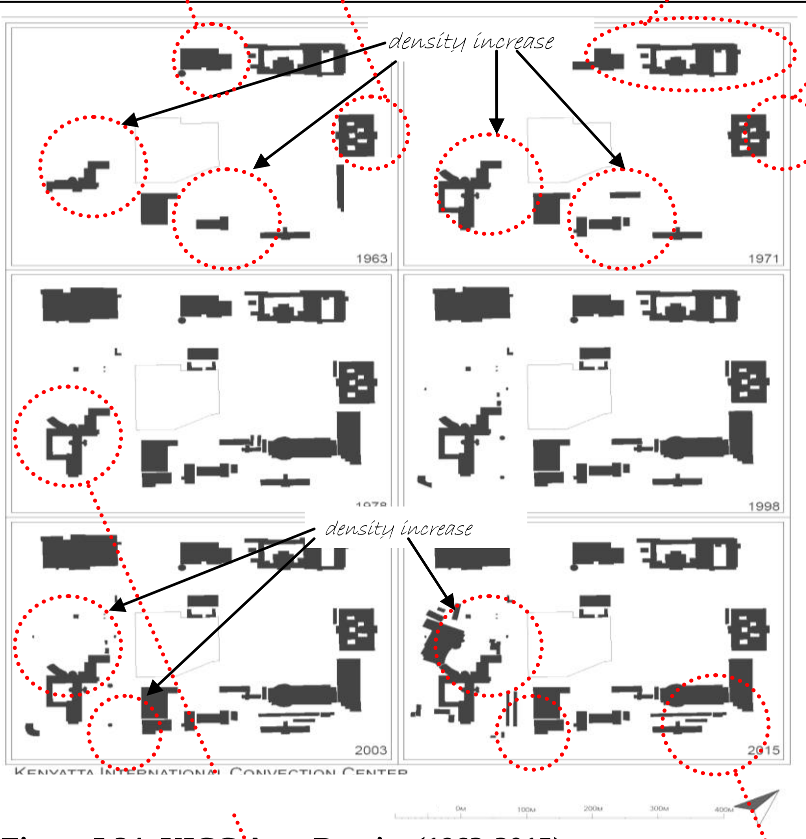


Figure 5.34: KICC Area Density (1963-2015)

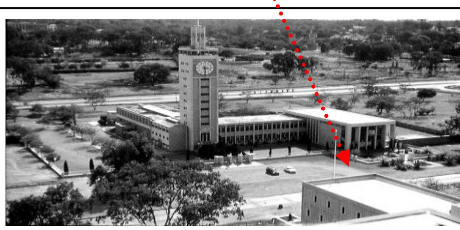


Plate 5.74: Low densities at Parliament Buildings, 1970s
Source: www.sikh-heritage.co.uk

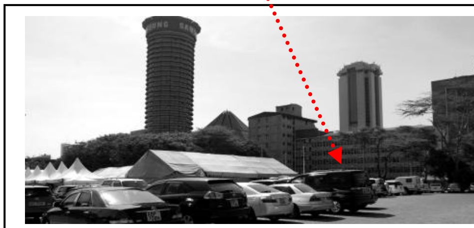


Plate 5.75: Densities around KICC, 2015
Source: Author

Figure 5.35: Kenya Bus Services Terminus Area Density (1963-2015) Source: Author

Plate 5.76: Densities around KBS Terminus (South), 2015
Source: Author

Plate 5.77: Densities around KBS Terminus (West), 2015
Source: Author

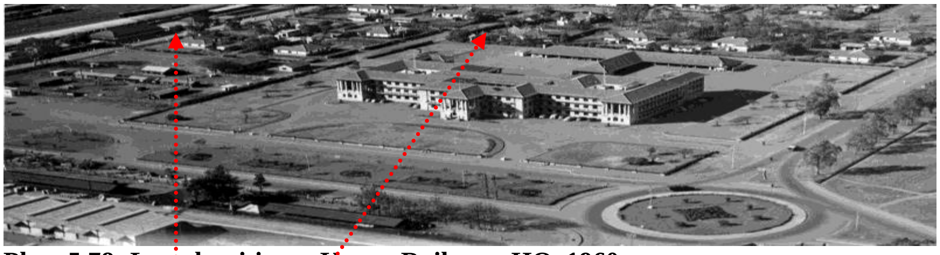


Plate 5.78: Low densities at Kenya Railways HQ, 1960s
Source: www.skyscrapercity.com

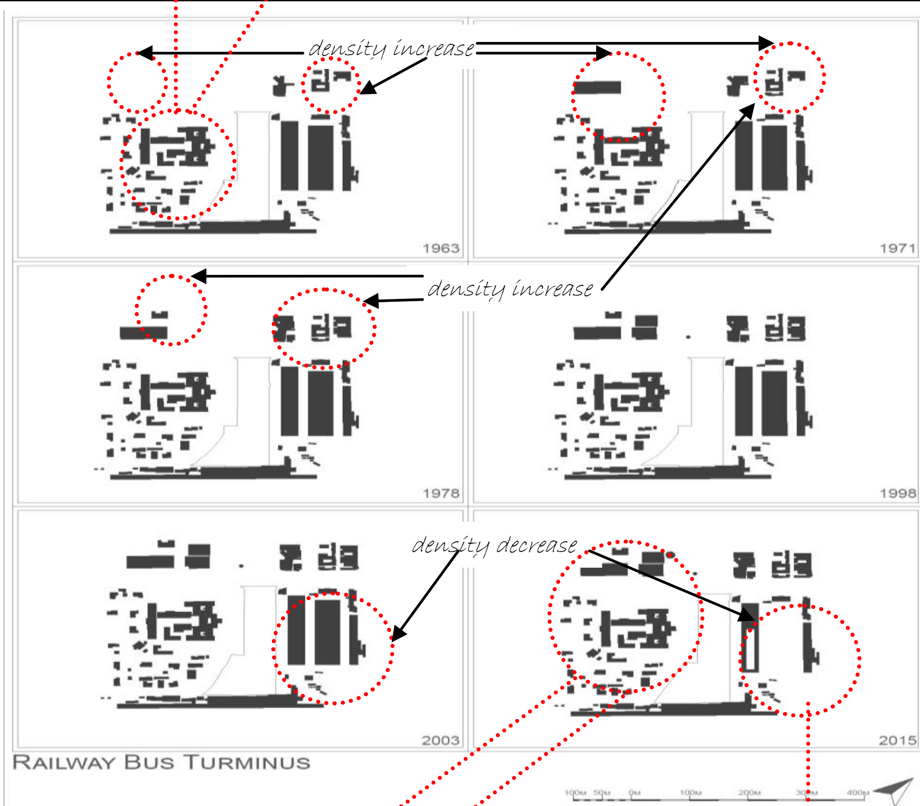


Figure 5.36: Railway Bus Terminus & Godowns Parking Area Density (1963-2015)
Source: Author

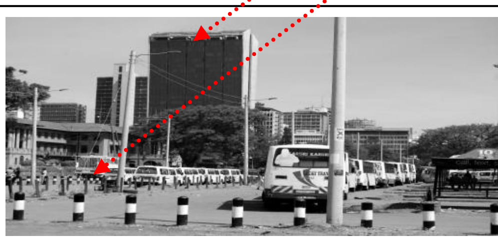


Plate 5.79: Density around Terminus, 2015
Source: Author

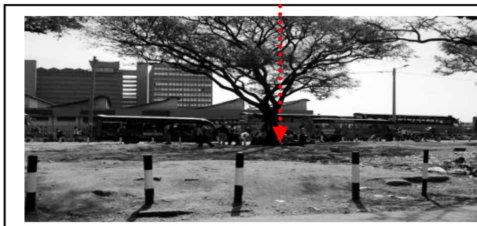


Plate 5.80: Railway Go-downs Buildings, 2015 Source: Author

Aga Khan Walk and National Housing Corporation Walk: these spaces are perpendicular to each other thus recording the same densities for 1963-2015 of an increase of 215.0% (Table 5.5). As shown by Plate 5.81, in the 1960s, the area on which the spaces are located was covered with natural vegetation. Figure 5.37 indicates that from 1963-1998 densities increased from 0.73 bldgs/ha. to 2.30 bldgs/ha., remaining consistent thereafter until 2015. Increased number of buildings per hectare meant an increased compactness of form around the space (Plate 5.82). For Aga Khan Walk (AKW), densification took place towards the east side as spaces to its west have been retained as public and private parking lots (Plate 5.83). As shown in Plate 5.84, for National Housing Corporation (NHCW) most construction over this period occurred west of the space across from AKW. This is due to the spatial layout of the neighbourhood that allowed for construction around the Central Bank of Kenya rear courtyard area. South of NHCW also experienced densification due to construction of commercial buildings between the Walk and Haile Selassie Slip Road. In addition the east side of the space is bordered by Moi Avenue that limits construction. Increased densities have resulted in greater compactness of urban form that is deemed a characteristic of sustainable settlements.

Wakulima Market: from 1963-2015 density increased by 244.1% from 0.93 bldgs/ha. to 3.20 bldgs/ha. (Table 5.5). As shown in Plate 5.85, densification occurred on both sides of the market and across Haile Selassie Avenue primarily due to construction of buildings for commercial retail and office use. From 1963-2005 density grew from 0.93 bldgs/ha. to 1.71 bldgs/ha., thereafter density almost doubled to 3.20bldgs/ha. This was mainly due to erection of structures in Muthurwa Market to the east as shown in Plate 5.86. As indicate in Figure 5.38, pre-1963 buildings to the west of the market indicate shifting building footprints and density. These buildings are mainly public institution offices, commercial offices, and retailers.

Plate 5.81: Densities Aga Khan Walk and NHC Walk, 1960s. Sourcewww.skyscraprecity.com

Plate 5.82: Aga Khan Walk Density, 2015 Source: Author

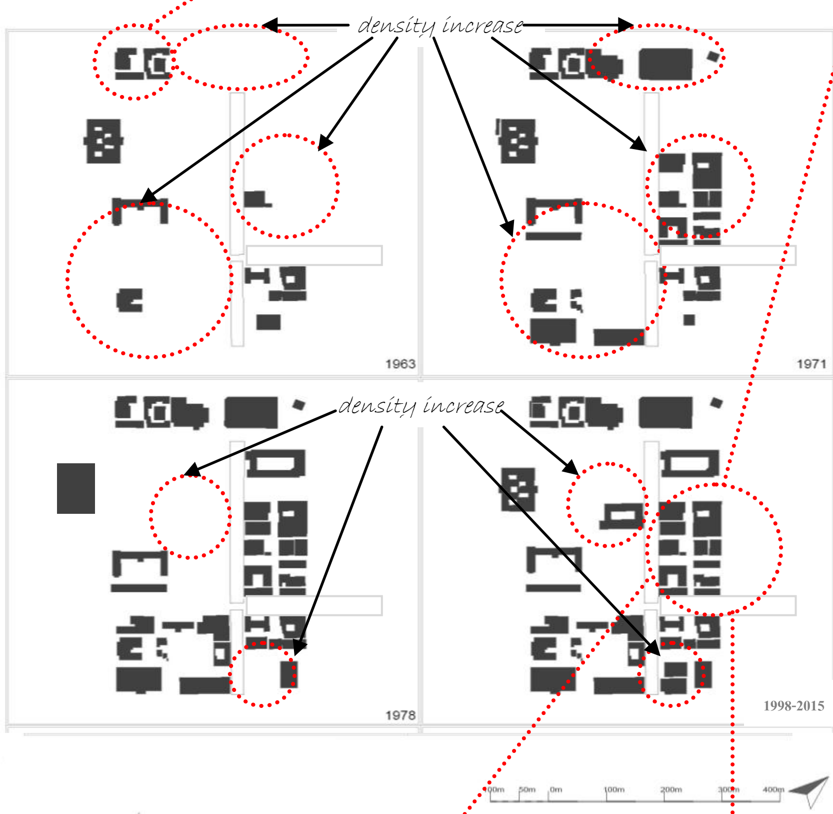


Figure 5.37: Aga Khan Walk & National Housing Corporation Walk Areas Density (1963-2015) Source: Author

Plate 5.83: Densification on Aga Khan Walk, 2015 Source: Author

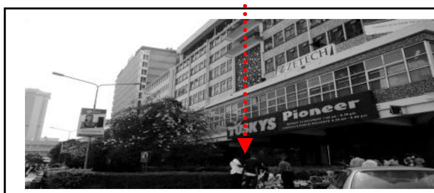


Plate 5.84: National Housing Corporation Walk Density, 2015 Source: Author

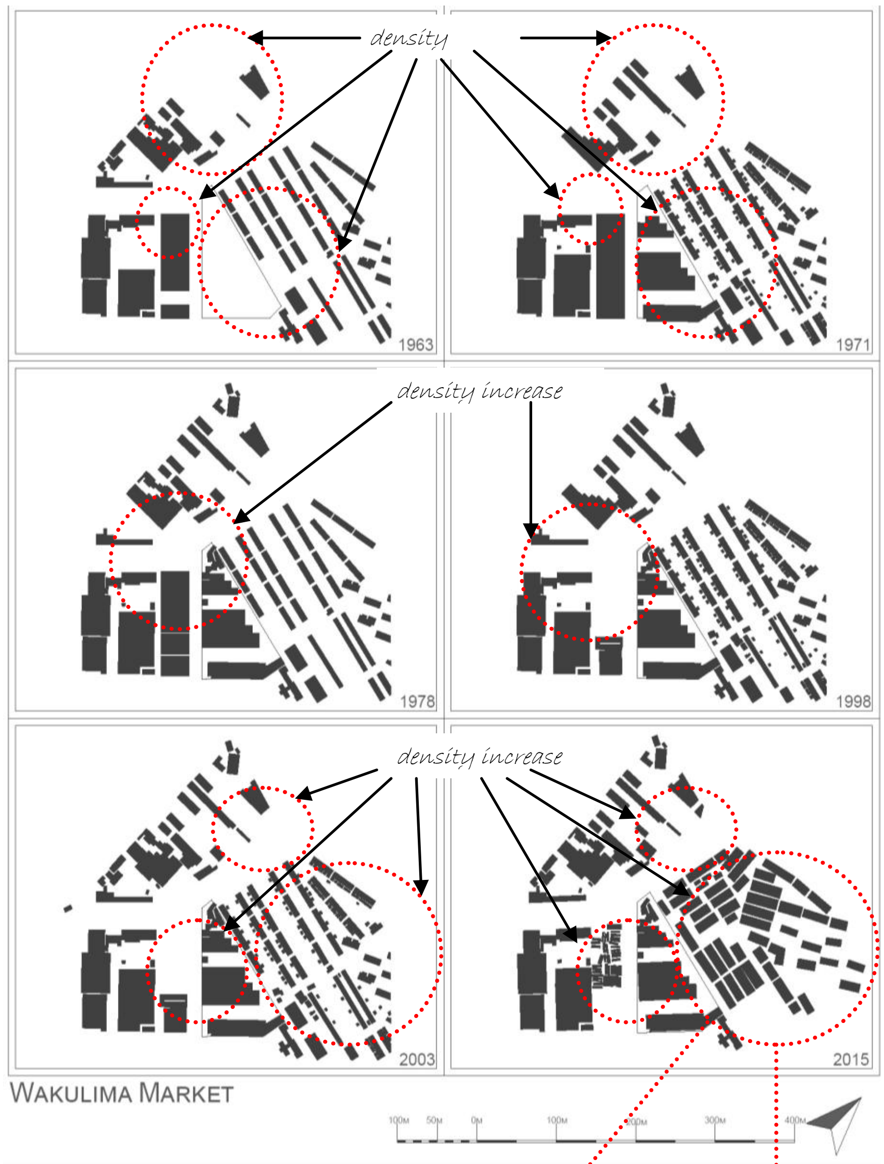


Figure 5.38: Wakulima Market Area Density (1963-2015) Source: Author

Plate 5.85: Muthurwa Market, 2015
Source: Author

Plate 5.86: Aerial View Wakulima Market, 2015 Source: Author

5.2.4 Enclosure

The enclosure of the space variable was measured by the number of buildings per linear metre. As enclosure entails frequency of buildings and building height and proximity to space, Height-to-Width Ratio was also used to measure enclosure. Table 5.7 indicates that 86.7% of the spaces increased regarding enclosure from 1963-2015, ranging from 402.7% for KBS Bus Terminus to 24.7% for Globe Cinema Roundabout. Of the remaining 13.3% of the spaces, the Fire Station Roundabout and Railways Bus Terminus did not experience change over the period. Changes in enclosure for each space have additionally been represented in Figure 5.39 for 1963-2015.

Table 5.7: Changes in Enclosure of All Spaces (1963-2015)

STUDY SPACE/VARIABLE	1963	1971	1978	1998	2003	2015	1963-2015 % change
ENCLOSURE (no. bldgs/m)							
Central Park	0.00789	0.00789	0.00789	0.0114	0.0114	0.0123	55.7
Jeevanjee Gardens	0.0448	0.0554	0.0618	0.0640	0.0640	0.0640	42.9
John Michuki Park	0.0389	0.0583	0.0583	0.0583	0.0583	0.0583	49.1
Hilton Hotel Circle	0.0138	0.0365	0.0487	0.0487	0.0487	0.0487	252.9
Globe Cinema Roundabout	N/A	0.0093	0.0116	0.0163	0.0163	0.0116	24.7
Fire Station Roundabout	0.0957	0.0957	0.0957	0.0957	0.0957	0.0957	-
Supreme Courts Parking	0.0064	0.0159	0.0159	0.0192	0.0192	0.0192	200.0
NCC Sunken Parking	0.0059	0.0147	0.0176	0.0235	0.0235	0.0235	298.3
Railways Godowns Parking	0.010	0.012	0.016	0.016	0.016	0.016	60.0
KICC Parking	0.0053	0.011	0.013	0.013	0.013	0.016	201.8
Railways Bus Terminus	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	-
KBS Bus Terminus	0.0370	0.0444	0.0481	0.0481	0.0481	0.0519	402.7
Aga Khan Walk	0.0046	0.0091	0.0134	0.0175	0.0175	0.0175	280.4
National Housing Corporation Walk	0.007	0.014	0.018	0.018	0.018	0.021	350.0
Wakulima Market	0.048	0.059	0.078	0.063	0.063	0.063	31.3

Source: Author

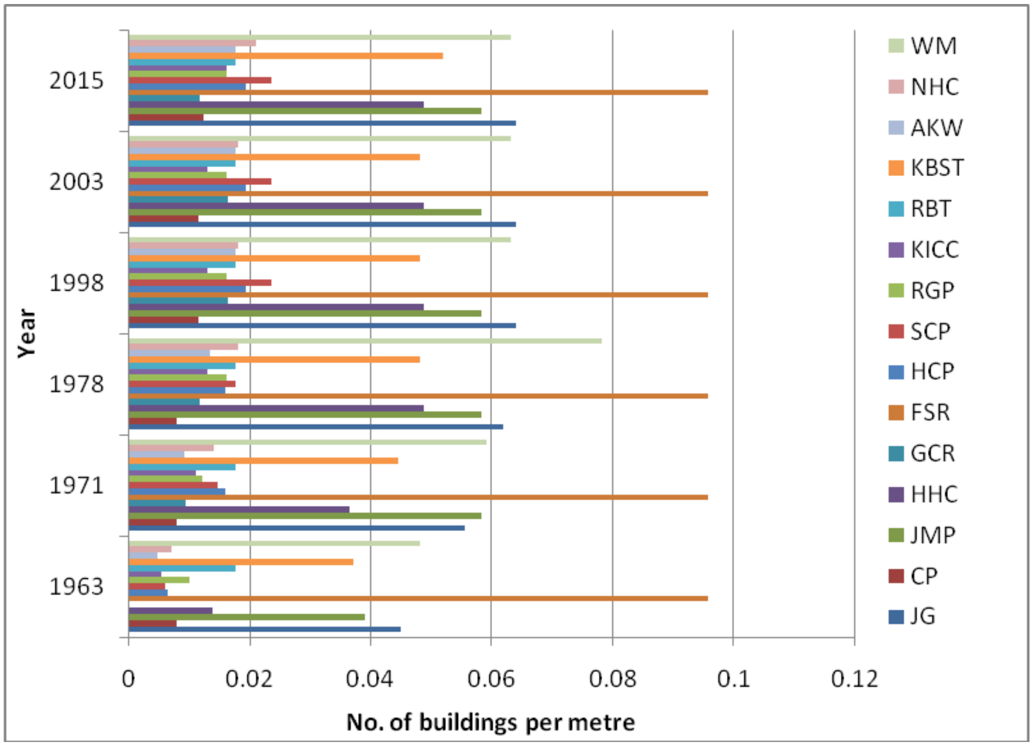


Figure 5.39: Graph of Enclosure Changes (1963-2015) Source: Author

Table 5.8: Space Enclosure Averages (1963-2015)

YEAR	AVERAGE SIZE	AVERAGE CONNECTIVITY	**AVERAGE ENCLOSURE**	AVERAGE DENSITY	AV. TREE COVER	AV. COMM INDEX	AV. INSTIT INDEX	AV. RES INDEX	AV. INDST INDEX
1963	12088.2667	7.57E-06	**0.022853**	2.28836	0.1	7.805867	2.918867	0.115533	0.286733
1971	11632.8	9.53E-06	**0.030713**	2.9934667	0.15	15.93193	6.132	0.135533	0.301467
1978	11833.7333	9.42E-06	**0.034766**	3.5122667	0.22	20.3476	9.9348	0.135533	0.3088
1998	11833.7333	9.47286E-06	**0.035054**	3.8637345	0.24	24.99213	10.20187	0.111867	0.2492
2003	11567.0667	9.41486E-06	**0.035054**	3.9144	0.24	25.3528	11.01907	0.111867	0.250533
2015	11667.0667	9.41486E-06	**0.035394**	4.1724	0.32	25.43813	10.84907	0.108533	0.096867
DELTA	-421.2	1.8406E-06	**0.0125**	1.88	0.22	17.6	7.9	-0.007	-0.191
% DELTA	-3.5%	24.3%	**54.50%**	82.1%	220.0%	225.6%	272.4%	-6.03%	-66.6%

Source: Author

Table 5.8 previous and Figure 5.40 following indicate changes in enclosure for all spaces, calculated as averages for each year 1963-2015. Based on the average enclosure of all spaces per year the enclosure of the spaces studied increased by 56.4% from 1963-2015.

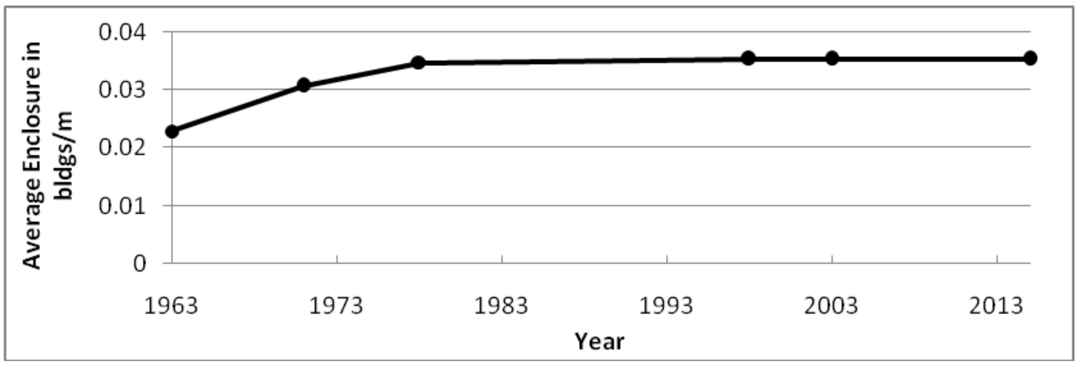


Figure 5.40: Average Enclosure All Spaces (1963-2015) Source: Author

Increased enclosure is attributed to construction of buildings and resultant higher building densities. The graphs for densities and enclosure both rise until 1978 after which densities continue on a steady upward trend while enclosure reflects minimal incremental change. Notable is that densities are calculated for the neighbourhoods surrounding the space within an area of one hectare. Buildings continued therefore to be constructed within that hectare, many of them away from the perimeter of the spaces, resulting in these findings from 1978-2015.

Organized according to space type, changes in enclosure from 1963-2015 were recorded and analysed as follows.

Central Park: Table 5.7 indicates that from1963-2015, enclosure of space increased by 55.7%. It remained consistent at 0.00789 bldgs/m. from 1963-1978. It increased to 0.0114 bldgs/m in 1998 and remained consistent until 2003. From 2003-2015 enclosure increased to 0.0123 bldgs/m (Figure 5.41). In 2015 the Height-to-Width Ratio (HWR) was calculated as 1:1.1 which is outside the acceptable HWR of at least 1:2 (Jacobs, 1993). This ratio indicates that enclosure experienced at the perimeter of the park is inadequate (Plate 5.87 and Plate 5.88). A low level of enclosure can reduce the attractiveness of the space. The eight-lane dual carriageways of Kenyatta Avenue and Uhuru Highway contribute to the reduced sense of enclosure of the park.

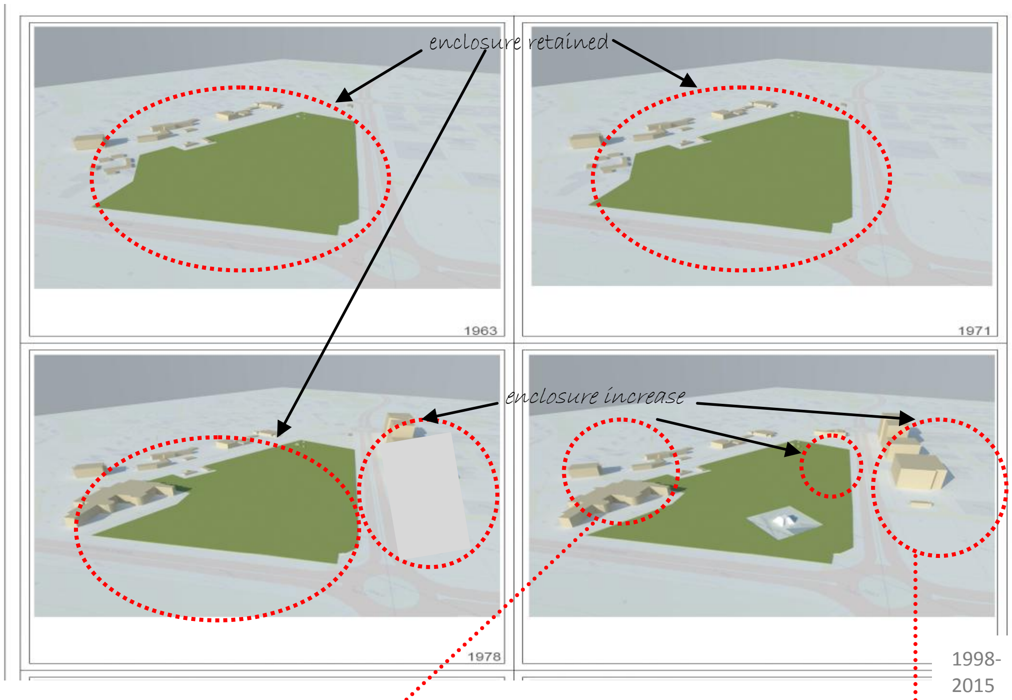


Figure 5.41: Central Park Enclosure (1963-2015) Source: Author

Plate 5.87: Enclosing Buildings on Nyerere Rd., 2015 Source: Author

Plate 5.88: Enclosing Buildings on Uhuru Highway, 2015 Source: Author

Jeevanjee Gardens: The sense of enclosure for Jeevanjee Gardens increased from 1963-2015 by 42.9% (Table 5.7). Figure 5.42 indicates that from 1963-1998 enclosure increased from 0.0448 bldgs/m. to 0.0640 bldgs/m. thereafter remaining consistent until 2015. In 2015 the HWR was calculated as 1:1.1 which is outside the acceptable HWR. This ratio indicates that enclosure experienced at the perimeter of the park is inadequate. Plate 5.89 and Plate 5.90 show the type of enclosing buildings along Moktar Daddah and Moi Avenue. The low building heights such as the single-storeyed and double-storeyed Moi Avenue Primary School and the multi-lane Moi Avenue have contributed to the low HWR. Notably, users experience different levels of enclosure dependent on the characteristics of buildings facing the space for individual streets.

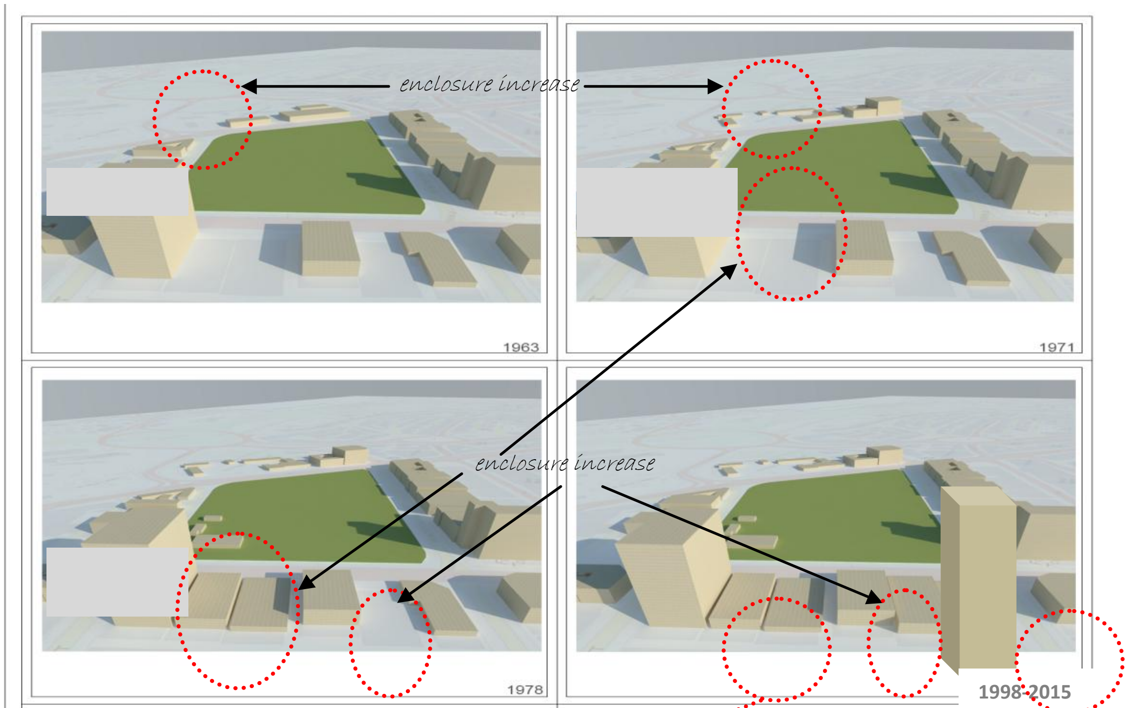


Figure 5.42: Jeevanjee Gardens Enclosure (1963-2015) **Source: Author**

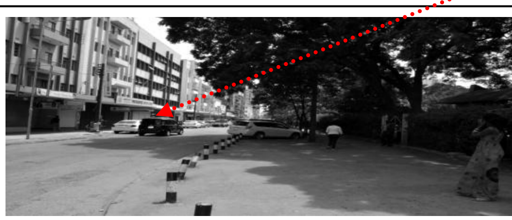


Plate 5.89: Enclosing Buildings on Moktar Daddah St **Source: Author**

Plate 5.90: Enclosing Buildings on Moi Avenue **Source: Author**

John Michuki Park: From 1963-2015 John Michuki Park experienced increased enclosure of 49.1% from 0.0389 bldgs/m to 0.0583 bldgs/m (Table 5.7 and Figure 5.43). The level of enclosure of the space has remained consistent from 1971-2015. In 2015 the HWR was calculated at 1:1.3 which is outside the acceptable HWR. This ratio indicates that low enclosure is experienced by users at the perimeter fence of the park. Average height of buildings facing the park is two floors adjacent to a single lane service street as shown in Plate 5.91 and Plate 5.92.

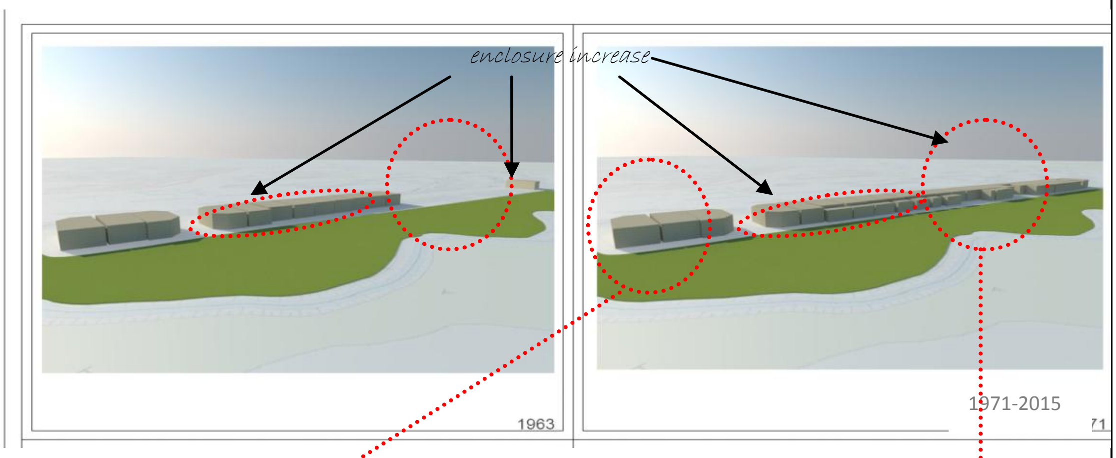


Figure 5.43: John Michuki Park Enclosure (1963-2015) Source: Author

Plate 5.91: Enclosing Buildings at John Michuki Park, 2015 Source: Author

Plate 5.92: Enclosing Buildings at John Michuki Park, 2015 Source: Author

Hilton Hotel Circle: Table 5.7 indicates that enclosure of Hilton Hotel Circle increased by 252.9% from 0.0138 bldgs/m to 0.0487 bldgs/m from 1963-2015. Plate 5.93 shows enclosing buildings in the 1960s. Enclosure rose from 1963-1978 and remained consistent at 0.0487 bldgs/m. until 2015 (Figure 5.44). In 2015 the HWR has been established as 1:0.7. This ratio indicates that enclosure experienced by users at the perimeter of the park can cause a sense of claustrophobia to park users. The heightened HWR is the result of the park being surrounded by multi-storeyed commercial buildings with retail and offices. The average number of floors for surrounding buildings is ten floors including KCB Headquarters, Hilton Hotel, and Standard Chartered Bank buildings (Plate 5.94). The park is enclosed by one and two lane streets, which affects the average street width used in calculation of HWR, resulting in a lower ratio.

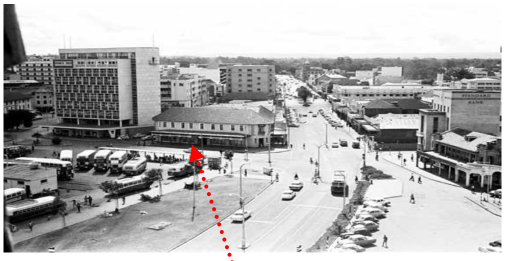


Plate 5.93: Hilton Hotel Area 1960s
Source: www.sikh-heritage.co.uk

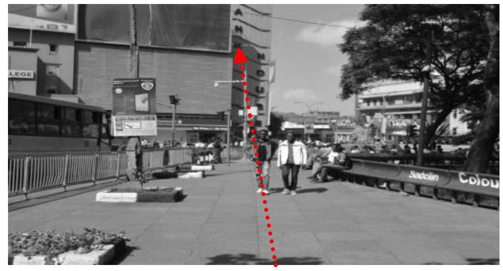


Plate 5.94: Enclosing Buildings Moi Ave. 2015 Source: Author

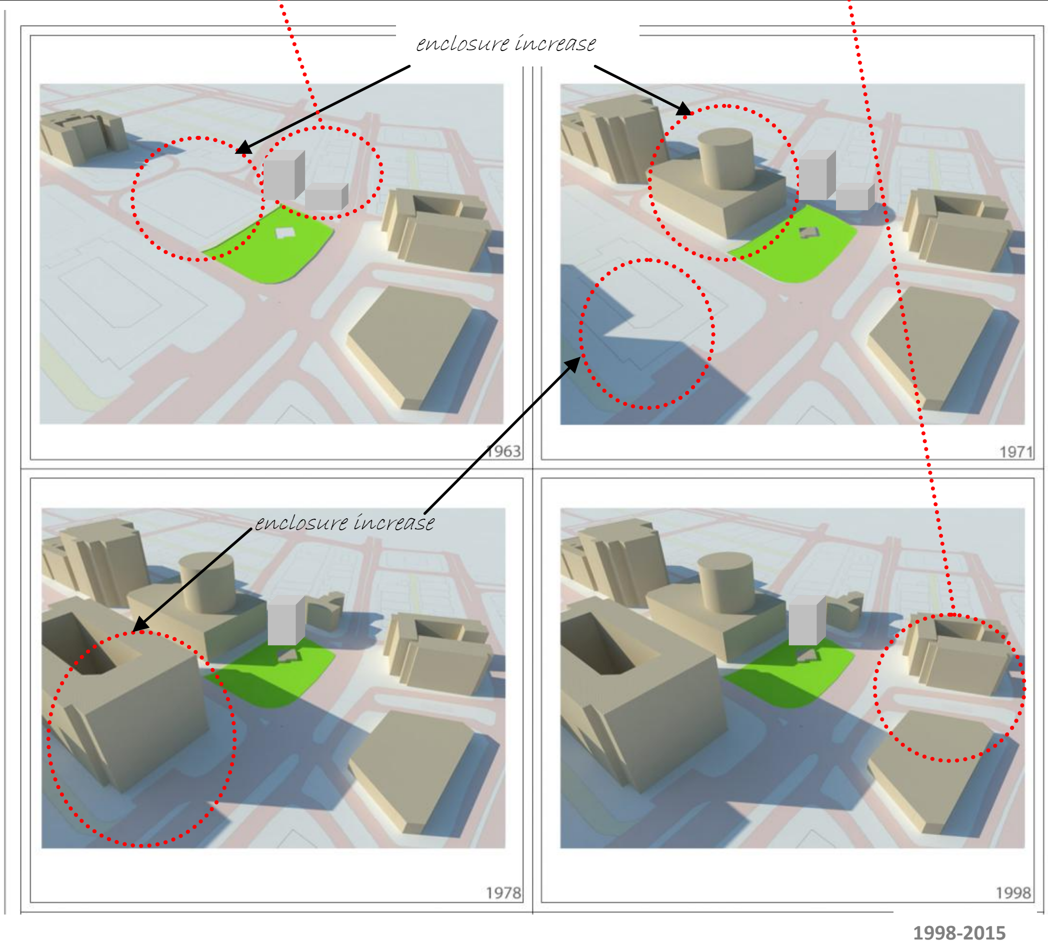


Figure 5.44: Hilton Hotel Circle Enclosure (1963-2015   Source: Author

Globe Cinema Roundabout: In 1963 the roundabout did not exist, so from 1971-2015 enclosure increased by 24.7% from 0.0093 blgs/m. - 0.0116 bldgs/m. (Table 5.7). Enclosure increased from 1971-1998 to 0.0163 bldgs/m. and thereafter decreased to 0.0116 bldgs/m. until 2015 (Figure 5.45). The building setbacks from Murang'a Rd and low numbers per distance of buildings both influence of buildings on space as enclosing elements as shown in Plate 5.95 and Plate 5.96.

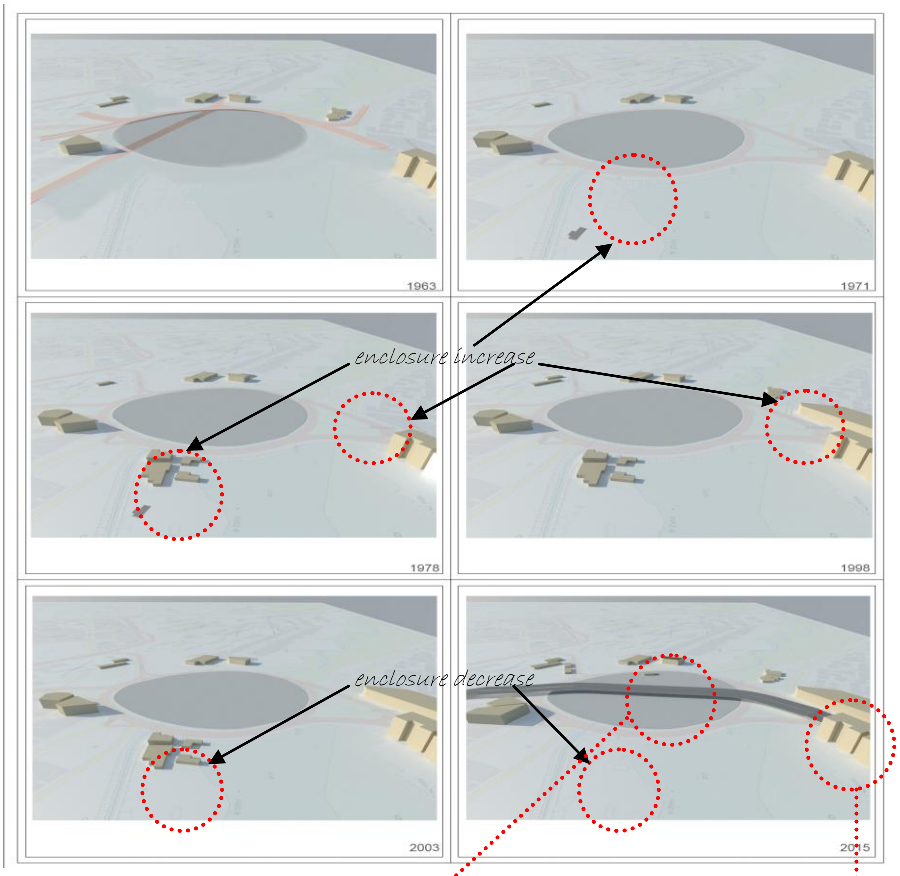


Figure 5.45: Globe Cinema Roundabout Enclosure (1963-2015) Source: Author

Plate 5.95: Kijabe Street Enclosing Buildings, 2015. Source: Author

Plate 5.96: Kipande Road Enclosing Buildings, 2015 Source: Author

Fire Station Roundabout: Table 5.7 and Figure 5.46 indicate that from 1963-2015 the enclosure remained consistent at 0.0957 blgs/m. As shown in Plate 5.97 and Plate 5.100 majority of enclosing buildings were built side by side before 1963. These buildings have undergone minimal change in terms of number of buildings per linear metre. They include Nairobi Fire Station and Old Nation House Head offices (Plate 5.98 and Plate 5.99).

Plate 5.97: Enclosing Buildings Tom Mboya Rd Source: Author

Plate 5.98: Enclosing Building Old Nation House Source: Author

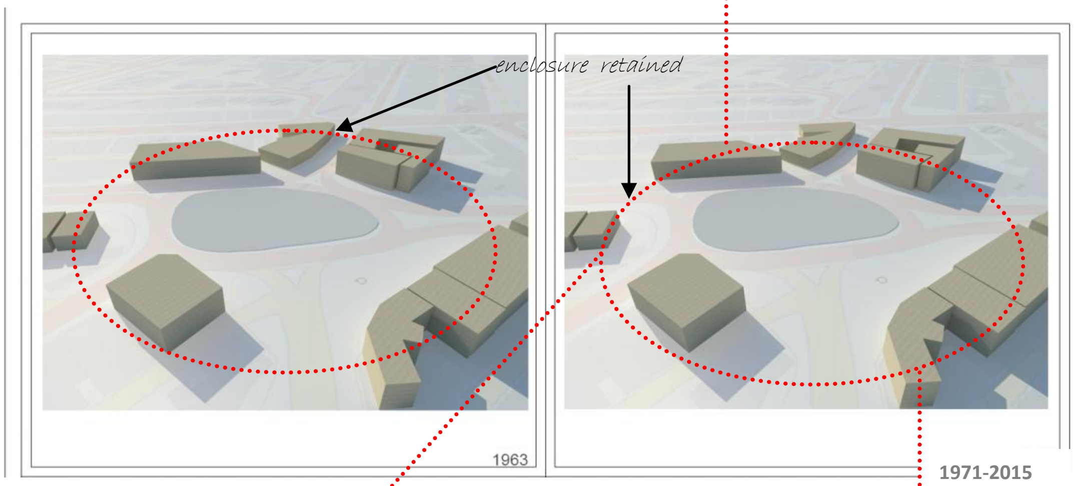


Figure 5.46: Fire Station Roundabout Enclosure (1963-2015) Source: Author

Plate 5.99: Enclosing Building Fire Station Source: Author

Plate 5.100: Enclosing Buildings Tom Mboya Rd Source: Author

Supreme Courts Parking: From 1963-2015 the space experienced a rise in enclosure by 200% from 0.0064 bldgs/m to 0.0192 bldgs/m. (Table 5.7). The influence of buildings constructed and increased density that also occurred within this period with regards to enclosure. This has been limited due in part to the location of another car park directly opposite the High Court Car park (Figure 5.47). Plate 5.101 shows the car park area in the 1960s. Since the early 1970s the construction of the 21-floor Uchumi House on Aga Khan Walk, 17-floor International Life House, 10-floor Transnational Plaza and 8-floor Cotts House on City Hall Way have been contributors to the sense of enclosure of the space (Plate 5.102). In 2015 the HWR was calculated at 1:1. This indicates that the level of enclosure to users of the space is outside the recommended ratio, so users would not experience a good sense of enclosure when within the car park. A good level of enclosure contributes to the appeal of the space for users. This increases the probability of users utilizing the space that in turn increases its vitality, both of which would reflect a more sustainable space.

Sunken Car-Park: Table 5.7 indicates that from 1963-2015 enclosure of NCC Sunken Car park increased by 298.3% over the period from 0.0059 bldgs/m to 0.0235 bldgs/m. This is illustrated in Figure 5.48. Higher buildings surrounding the space such as the 20-floor Reinsurance Plaza on Aga Khan Walk, the 16-floor Electricity House and the 21-floor National Bank building on Taifa Rd have contributed to the sense of enclosure of the space as shown in Plate 5.103 and Plate 5.104. In 2015 the HWR has been established as 1: 0.7. This indicates that the level of enclosure to users of the space is outside the preferred ratio, so users would not experience a good sense of enclosure when within the car park. Trees the space reduce a sense of claustrophobia that may be experienced by users in the car park. The multi-storey buildings do not enclose the space fully, which also reduces the sense of surrounding buildings towering over the space.

Railways Go-downs Parking: From 1963-2015 enclosure the Railways Godowns Parking increased by 60.0% from 0.010 bldgs/m to 0.016 bldgs/m (Table 5.7 and Figure 5.49). In 2015 the HWR has been established as 1:2. This indicates that the level of enclosure to users of the space is within the preferred ratio, so users would experience a good sense of enclosure when within the car park. As shown in Plate 5.105 and Plate 5.106 enclosing buildings included the Railway Administration Office and Uchumi Super Market, previously railway warehousing. As captured in Plate 5.107 the go-down warehouses bordered the space prior to 1963.

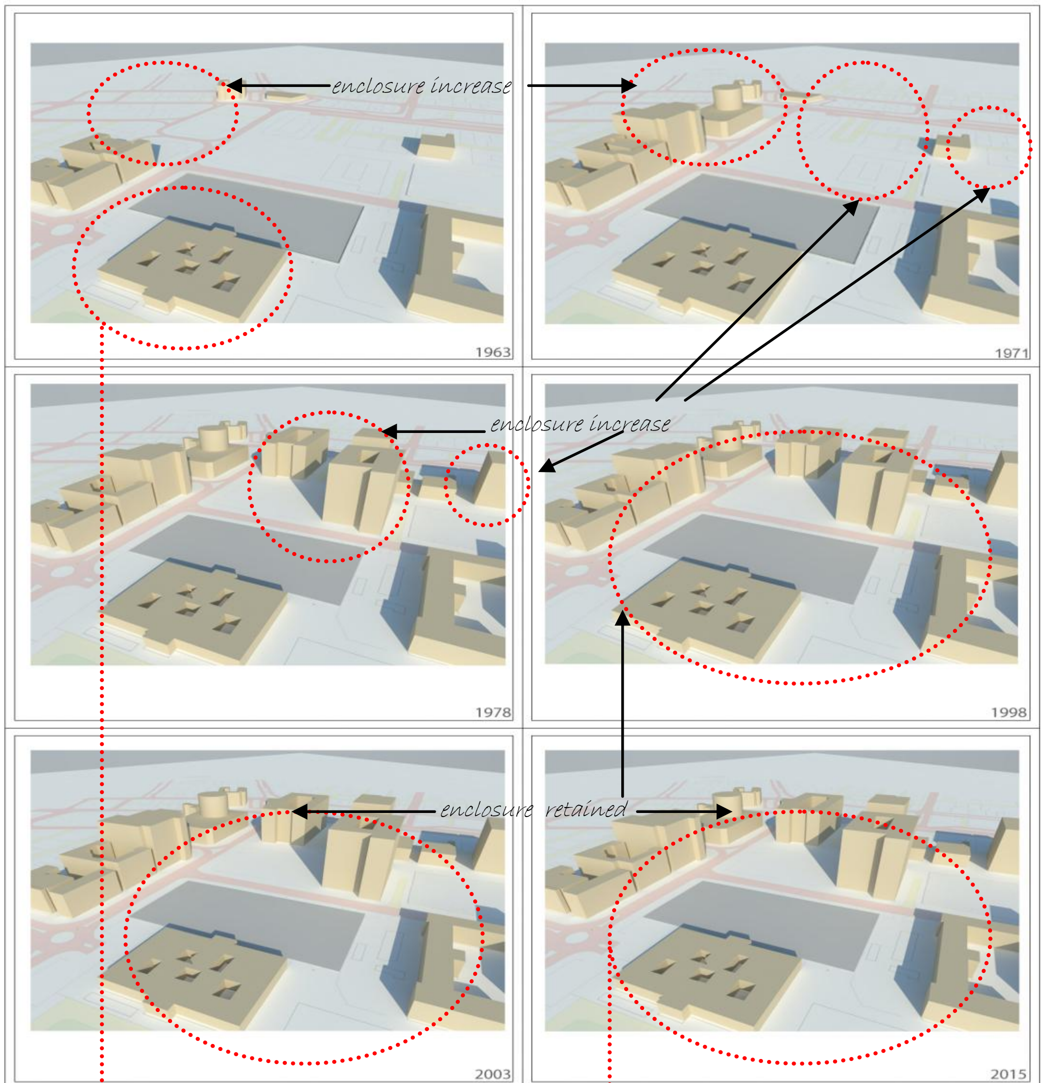


Figure 5.47: Supreme Court Parking Enclosure (1963-2015) Source: Author

Plate 5.101: High Court Building, 1960s
Source: www.skyscrapercity.com

Plate 5.102: Buildings on City Hall Way
Source: Author

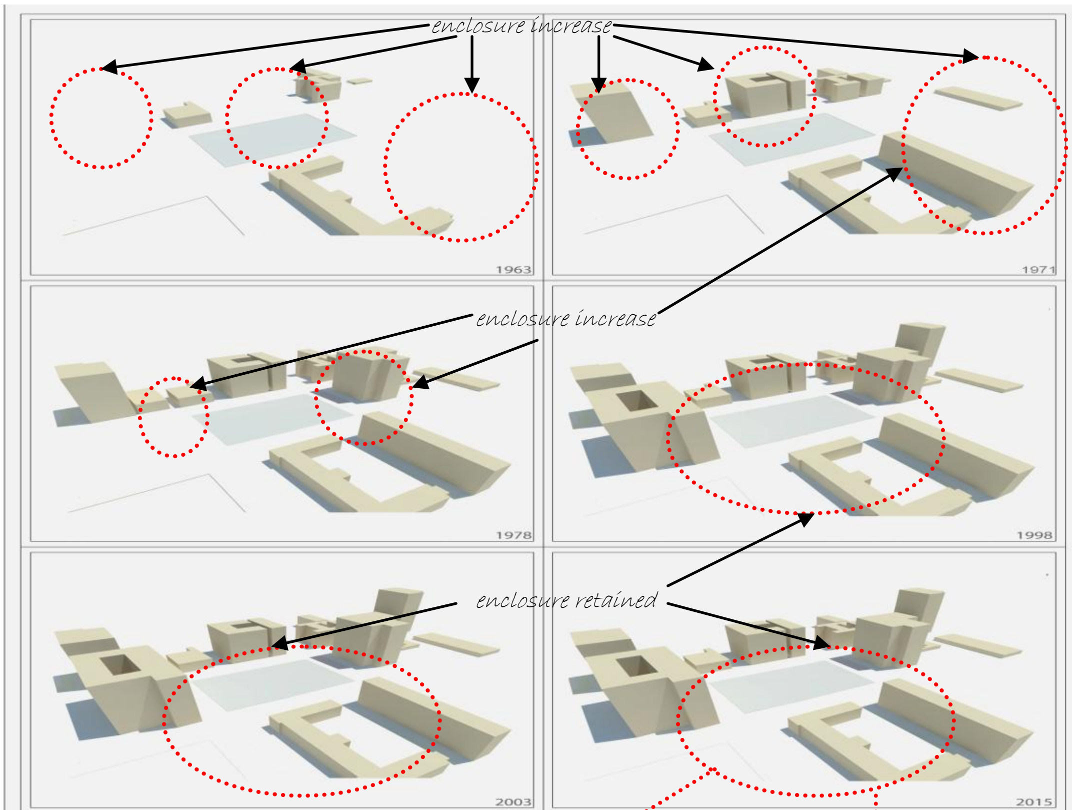


Figure 5.48: Sunken Car Park Enclosure (1963-2015) **Source: Author**

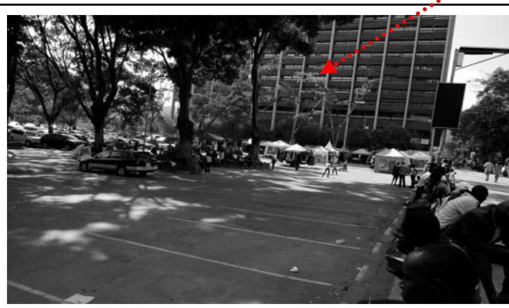


Plate 5.103: Reinsurance Plaza at Sunken Carpark, 2015 **Source: Author**

Plate 5.104: National Bank Building, 2015
Source: Author

Plate 5.105: Enclosing buildings on Haile Selassie Ave., 2015 Source: Author

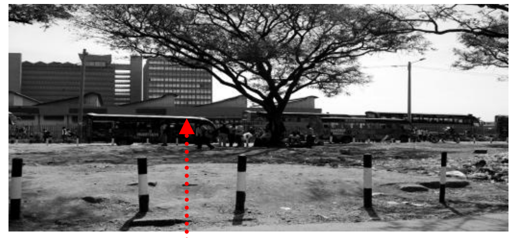


Plate 5.106: Uchumi Supermarket enclosing buildings, 2015 Source: Author

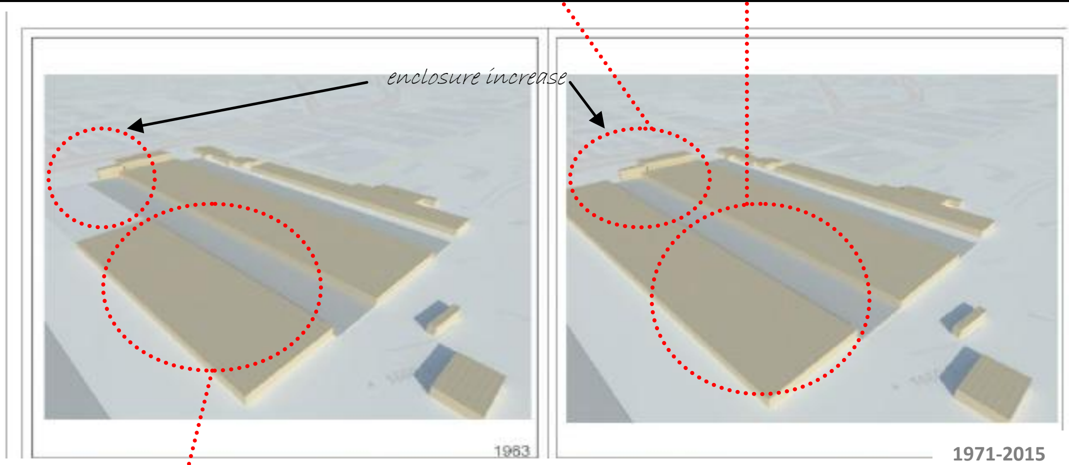


Figure 5.49: Railways Go-downs Parking Enclosure (1963-2015) Source: Author

Plate 5.107: Kenya Railways Headquarters, 1960s Source: www.skyscrapercity.com

KICC Parking: From 1963-2015 there has been an increase in the enclosure of KICC Parking of 201.8% from 0.0053 bldgs/m to 0.016 bldgs/m. (Table 5.7 and Figure 5.50). As shown in Plate 5.108, sense of enclosure is influenced by the distance which the Parliament buildings are set back from Parliament Road. Catholic Parochial Primary School across City Wall Way is separated from the road by a private car park, which also reduces its influence as an enclosing element of the KICC car-park. This increases distance between KICC parking area and the school buildings, further reducing enclosure in the space. In 2015 the HWR was calculated at 1:2.4. Enclosure is thus outside the recommended ratio, so users would experience a low sense of enclosure at the space perimeter. The sidewalk and street width of the Houses of Parliament and the setback of the Parliament Buildings from the perimeter fence lessen the sense of enclosure experienced from the perimeter of the car park (Plate 5.109 and Plate 5.110).

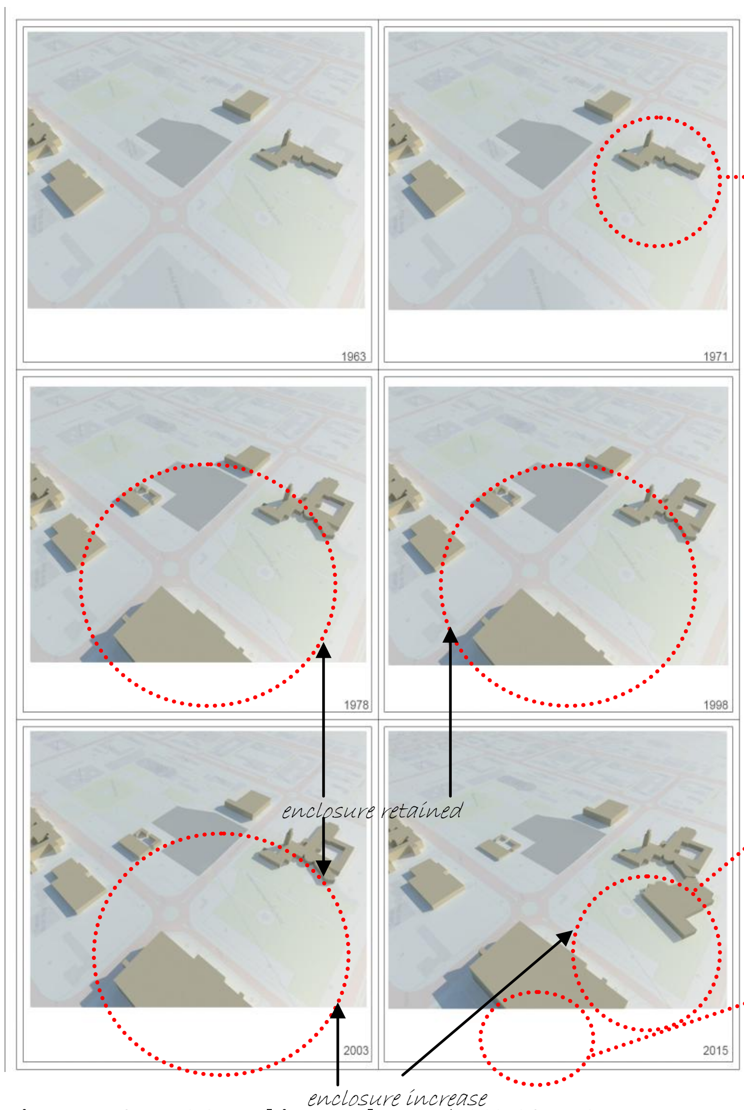


Figure 5.50: KICC Parking Enclosure (1963-2015 Source: Author

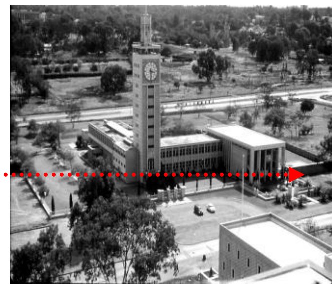


Plate 5.108: Parliament Building, 1970s

Plate 5.109: Parliament Building, 2015 Source: Author

Plate 5.110: Parliament Road and Car-park Edge, 2015 Source: Author

Railways Bus Terminus: Table 5.7 indicates that from 1963-2015 the enclosure remained consistent at 0.0175 bldgs/m. This is also consistent with the enclosure at Aga Khan Walk at 0.0175 bldgs/m for 1998-2015 (Figure 5.51). As with the Fire Station Roundabout, this consistency is attributable to the age, function, and ownership of surrounding buildings, some of which were built in the 1920s and 1930s. These include the Railway Station (1922), the Kenya Railways Headquarters (1935), and the Railway Go-down warehouses (Plate 5.111 and Plate 5.112) Ownership of the land by Kenya Railways Corporation, a state-owned organization, no permanent construction has occurred on the premises or its immediate surrounding land. This has resulted in minimal change in terms of number of buildings per linear metre of the terminus perimeter, and thus its enclosure.

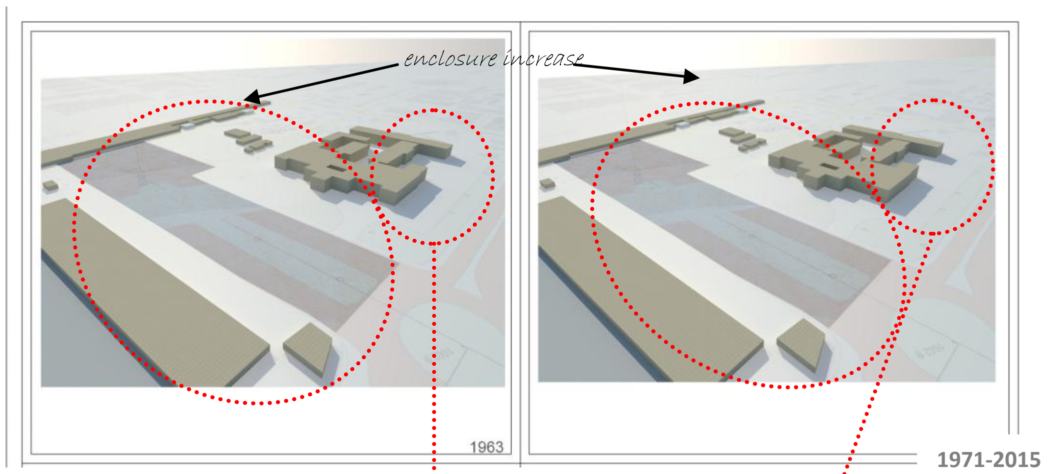


Figure 5.51: Railways Bus Terminus Enclosure (1963-2015) Source: Author

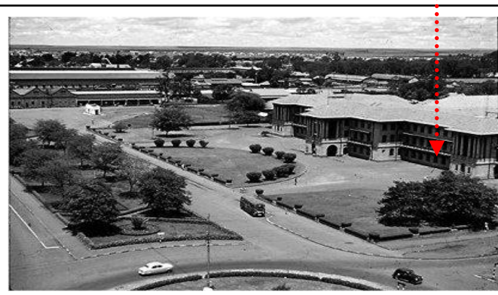


Plate 5.111: Railways Bus Terminus enclosing building, 1960s
Source: www.mccrow.org.uk

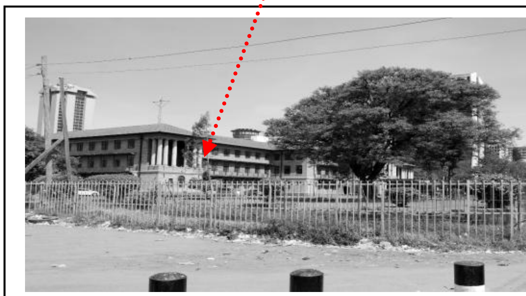


Plate 5.112: Minimal change in Railways Bus Terminus, enclosing building, 2015
Source: Author

KBS Bus Terminus: Enclosure of KBS Bus Terminus increased by 402.7% from 0.0370 to 0.0519 bldgs/m. from 1963-2015 (Table 5.7). Enclosure rose from 1963-1978 and remained consistent at 0.0481 bldgs/m. until 2003. It thereafter increased to 0.0519 bldgs/m. in 2015 (Figure 5.52). In 2015 the HWR has been calculated at 1: 0.9 which is outside the acceptable HWR of at least 1:2 (Jacobs, 1993). This ratio indicates that enclosure experienced at the perimeter of the park is higher than recommended and can result in a claustrophobic feeling for users at the perimeter of the space. This can make the space less attractive for users. The height of enclosing buildings ranged from 7 floor buildings (Plate 5.113) to 4m-high commercial stalls (Plate 5.114). Both structure types contribute to to sense of enclosure at the at the space boundary.

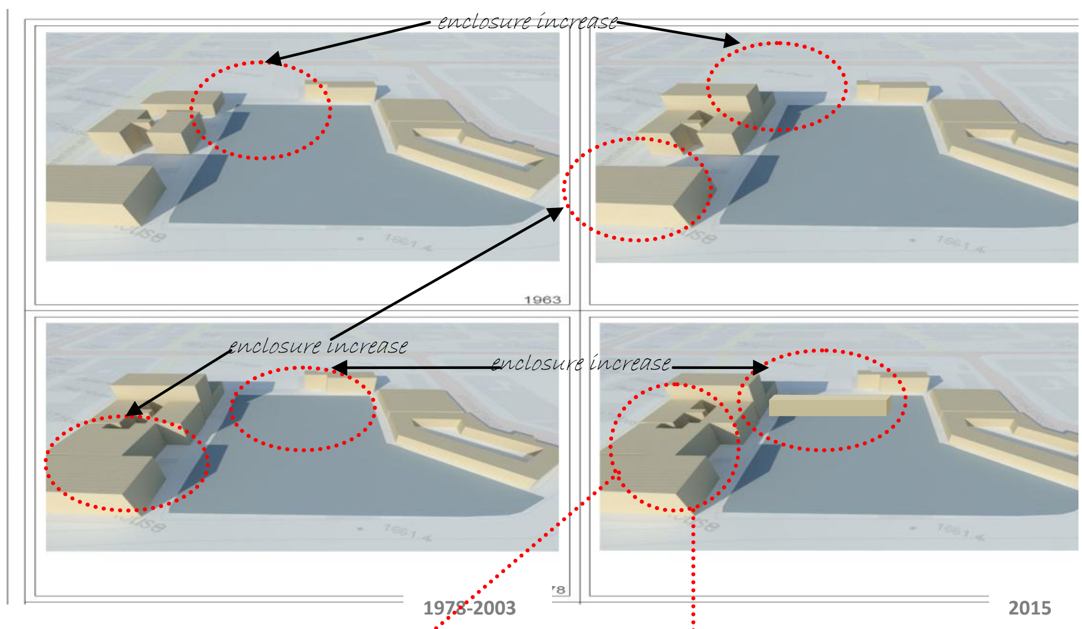


Figure 5.52 KBS Terminus Enclosure (1963-2015) Source: Author

Plate 5.113: Enclosing Buildings KBS Terminus Source: Author

Plate 5.114: Stalls at KBS Terminus Perimetre Source: Author

Aga Khan Walk: From 1963-2015 the number of buildings facing Aga Khan Walk (AKW) per linear distance increased by 280.4% (Table 5.7 and Figure 5.53). Pre-1963 the land on which AKW emerged was primarily covered in natural vegetation (Plate 5.115). The 20-floor Reinsurance Plaza Building, the 15-floor Kencom House, and the 21-floor Uchumi House significantly contribute to the sense of enclosure of the promenade (Plate 5.116 and Plate 5.118) In 2015 the HWR was calculated at 1: 0.4. This indicates that the level of enclosure to users of the space is outside the recommended ratio, so users would not experience a good sense of enclosure on AKW. This heightened ratio can contribute to a sense of claustrophobia within the space. Tall buildings on AKW are interspersed by open spaces such as the NCC sunken car park (Plate 5.117). These open spaces create a solid-void relationship that breaks up the continuity of tall buildings, reducing the sense of claustrophobia that may arise.

National Housing Corporation Walk: From 1963-2015 the enclosure of National Housing Corporation (NHC) Walk increased by 350% from 0.007 bldgs/m. to 0.021 bldgs/m. (Table 5.7). Enclosure rose from 0.007 bldgs/m. to 0.018 bldgs/m. in 1978 and remained consistent at that level of enclosure until 2003. Thereafter it rose to 0.021 bldgs/m (Figure 5.54). Plate 5.119 shows the location of NHC Walk covered in vegetation in the 1960s. As shown in Plate 5.120 and Plate 5.121, 7-floor Solar House, 7-floor Pioneer House and the 5-floor Co-operative Bank building contribute to the enclosure of the space. In 2015 the HWR was calculated at 1:1.1. This indicates that the level of enclosure to users is outside the recommended ratio, so users would not experience a good sense of enclosure on NHC Walk. A good level of enclosure contributes to the appeal of the space for users. This increases the probability of users utilizing the space that in turn increases its vitality, both of which would reflect a more sustainable space.

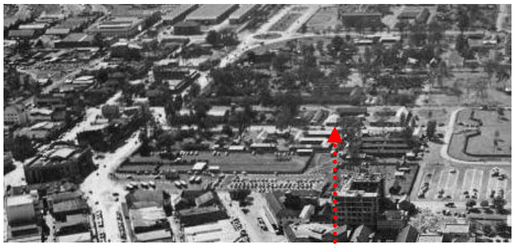


Plate 5.115: Aga Khan Walk Area, 1960s
Source: www.skyscrapercity.com

Plate 5.116: Kencom House enclosing building on Aga Khan Walk, 2015
Source: Author

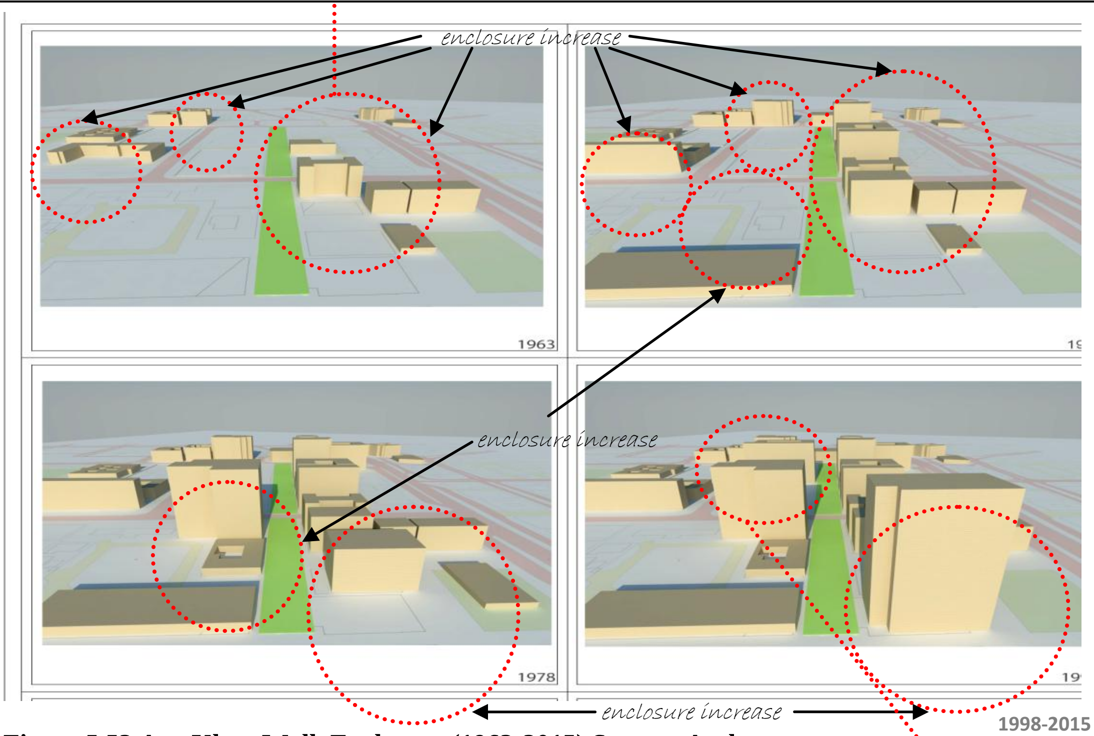


Figure 5.53 Aga Khan Walk Enclosure (1963-2015) Source: Author

Plate 5.117: Sunken car-park and Reinsurance Plaza solid-void relationship, 2015 Source: Author

Plate 5.118: Reinsurance Plaza building enclosing Aga Khan Walk, 2015
Source: Author

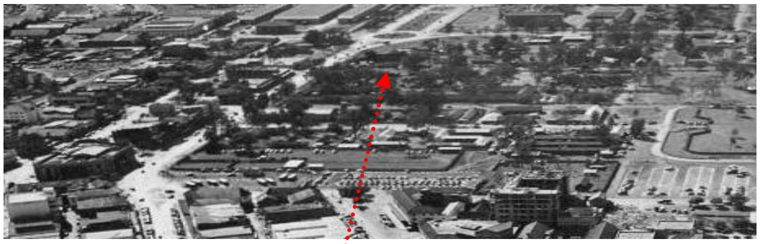


Plate 5.119: Aga Khan Walk Area, 1960s
Source: www.skyscrapercity.com

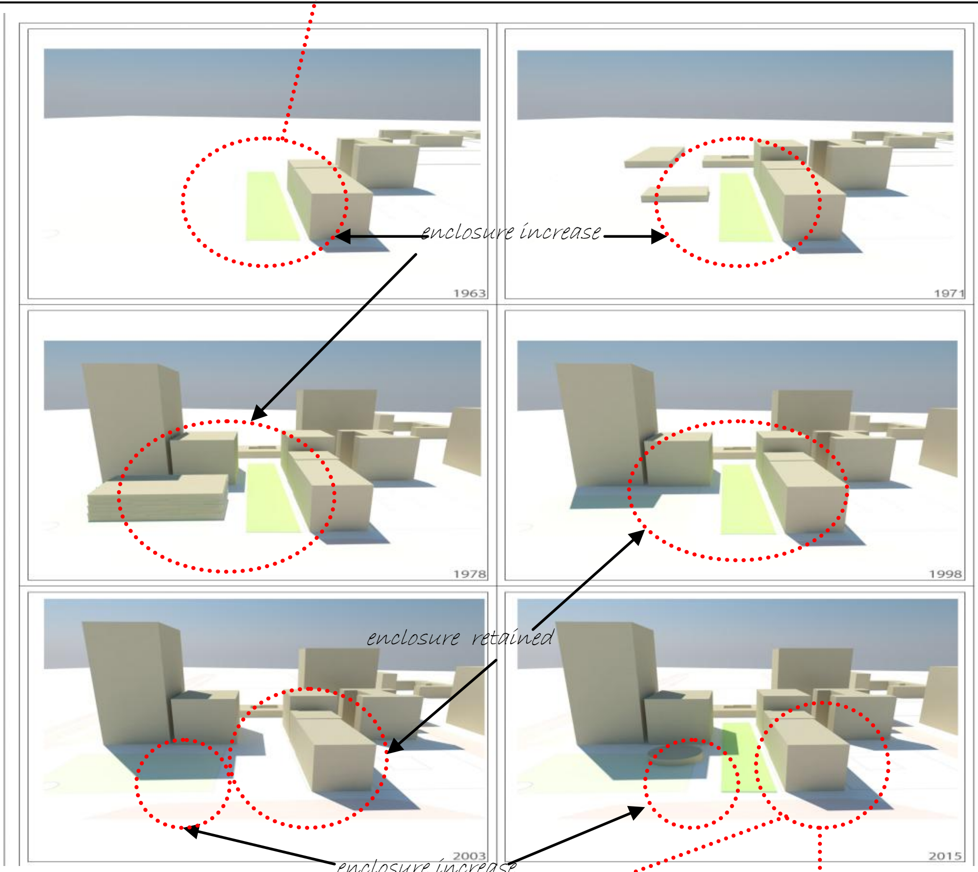


Figure 5.54: National Housing Corporation Enclosure (1963-2015) Source: Author

Plate 5.120: National Housing Corporation Walk enclosing buildings
Source: Author

Plate 5.121: Pioneer House and Solar House as enclosing buildings, 2015
Source: Author

Wakulima Market: Enclosure of KBS Bus Terminus increased by 31.3% from 0.0480 bldgs/m. to 0.063 bldgs/m. from 1963-2015 (Table 5.7). A rise was experienced from 1963-1978, after which enclosure remained consistent at 0.063 bldgs/m. from 1998-2015 (Figure 5.55). As shown in Plate 5.122, multi-storey buildings border the west side of the space. The market is enclosed by a stone wall adjacent to a commercial area with eateries, small scale retailing, and ablution facilities. The wall and concrete canopies sheltering the space heighten the sense of containment and reduce the sense of spatial openess as compared to the other open spaces (Plate 5.123).

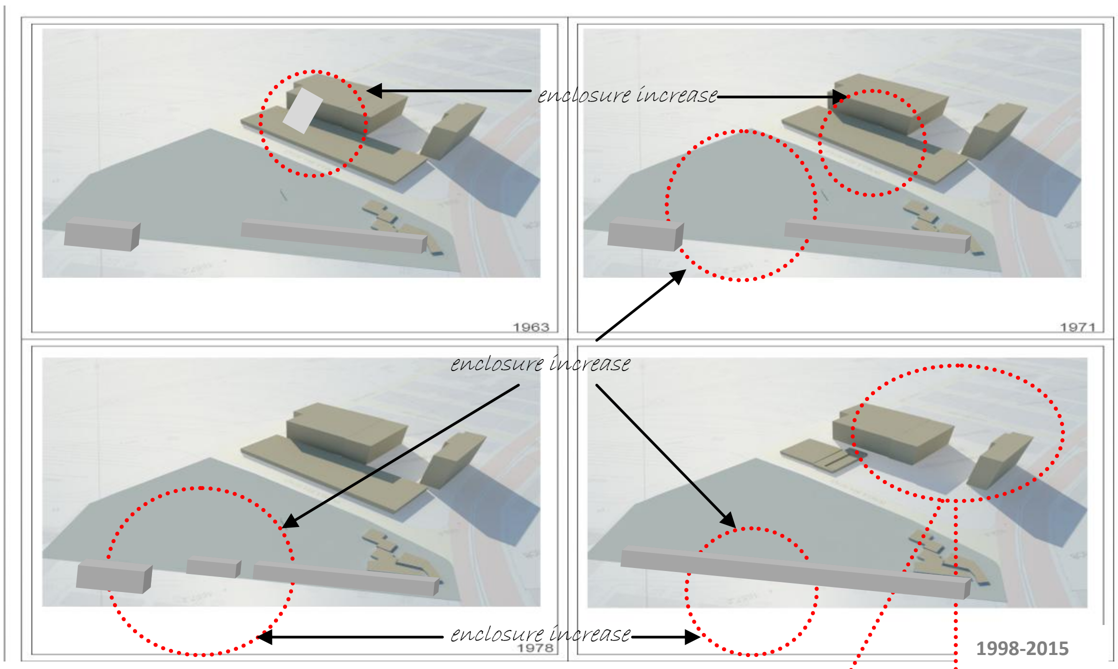


Figure 5.55: Wakulima Market Enclosure (1963-2015) Source: Author

Plate 5.122: Wakulima Market Canopies, 2015 Source: Author

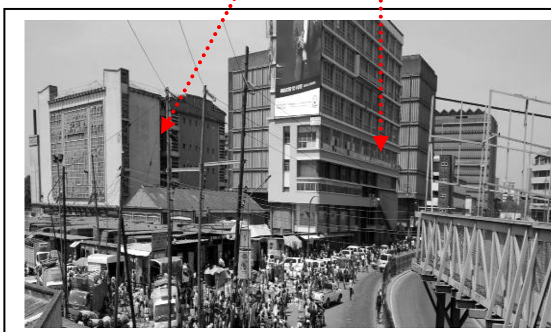


Plate 5.123: Haile Selassie Ave at Wakulima Market, 2015 Source: Author

5.2.5 Land Use

The fifth variable analysed was land use measured as the total number of square metres of building use per area of public open space, for buildings within and adjacent to space perimeter. These indexes were calculated for each use category namely commercial, institutional, residential, and industrial/workshops/ warehouses. Commercial use comprises retail and office spaces. Institutional use comprises educational, cultural, financial, public, and religious institutions. Where information on individual building use was unavailable, land uses designated in 1962-2011 land use maps were used. The assumption was that land use reflects space and building use.

Using commercial use indexes, Table 5.9 indicates that 86.7% of the spaces experienced increased commercial use in surrounding buildings from 1963-2015 while 66.7% of the spaces experienced increased institutional use in surrounding buildings over the same period. 20% and 26.7% of surrounding buildings displayed change in residential and industrial/ workshop/ warehouse use respectively from 1963-2015.Changes in land use for commercial purposes are also represented in Figure 5.56.

Table 5.9: Changes in Commercial Use Indexes for All Spaces (1963-2015)

STUDY SPACE/VARIABLE	1963	1971	1978	1998	2003	2015	1963-2015 % change
COMMERCIAL USE INDEX (sq.m./sq.m.)							
Central Park (CP)	0.022	0.023	0.428	1.096	1.096	1.096	4881.8
Jeevanjee Gardens (JG)	2.48	2.62	3.53	3.67	4.14	4.14	66.9
John Michuki Park (JMP)	0.126	0.126	0.126	0.126	0.126	0.126	0
Hilton Hotel Circle (HHC)	36.92	73.84	109.79	109.79	109.79	109.8	197.4
Globe Cinema Roundabout (GCR)	0.80	1.45	1.56	3.63	3.52	3.52	340.0
Fire Station Roundabout (FSR)	34.30	34.30	34.30	34.30	34.30	34.30	0
Supreme Courts Parking (SCP)	18.02	32.72	32.72	47.14	47.14	47.14	161.6
NCC Sunken Parking (NSCP)	3.15	21.1	45.21	60.66	60.66	60.66	1825.7
Railways Godowns Parking (RGP)	1.25	1.25	1.57	1.70	1.70	1.64	31.2
KICC Parking (KP)	0	2.76	9.34	9.34	14.39	11.97	333.7
Railways Bus Terminus (RBT)	1.86	2.5	2.5	11.83	11.83	11.7	529.0
KBS Bus Terminus (KBT)	1.34	3.71	4.24	4.58	4.58	4.80	258.2
Aga Khan Walk (AKW)	6.26	52.02	47.58	72.25	72.25	72.25	1054.1.
National Housing Corporation Walk (NHCW)	10.56	10.56	12.32	14.77	14.77	14.87	40.8
Wakulima Market (WM)	0	0	0	0	0	3.57	357.0

Source: Author

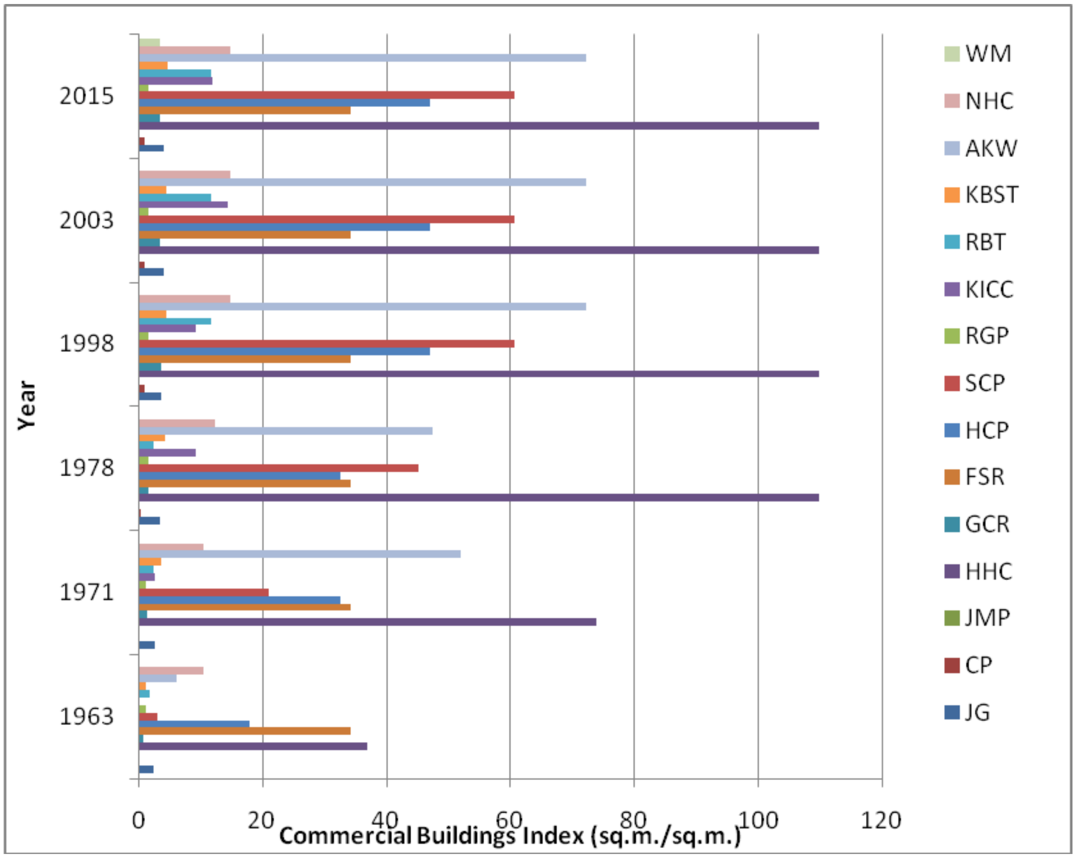


Figure 5.56: Graph of Commercial Use Index Changes (1963-2015) Source: Author

Figure 5.57 following indicates changes in commercial use indexes for all spaces, calculated as averages for each year 1963-2015. Based on the averages of all spaces per year the commercial use indexes increased by 225.6% from 1963-2015.

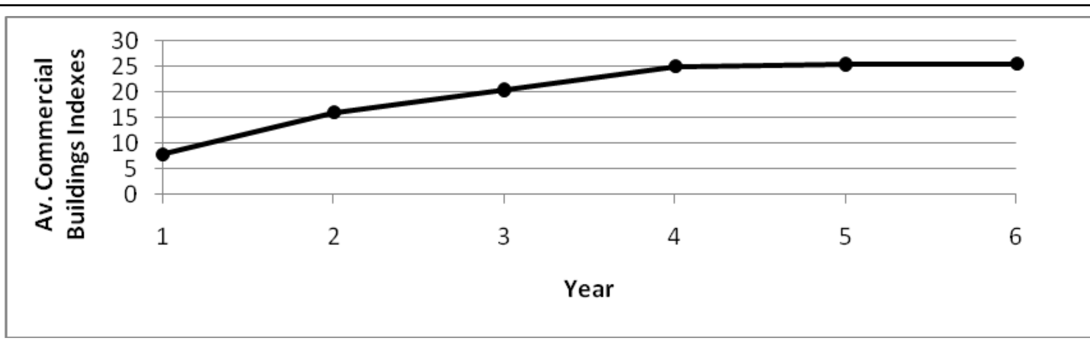


Figure 5.57: Graph of Commercial Use Indexes Average Change (1963-2015) Source: Author

Table 5.10 and Figure 5.58 following indicate changes for institutional land use (1963-2015) using an institutional use index.

Table 5.10: Changes in Institutional Use Indexes for All Spaces (1963-2015)

STUDY SPACE/VARIABLE	1963	1971	1978	1998	2003	2015	1963-2015 % change
INSTITUTIONAL USE INDEX (sq.m./sq.m.)							
Central Park (CP)	0.081	0.088	0.070	0.116	0.116	0.116	43.2
Jeevanjee Gardens (JG)	0.36	0.60	0.62	0.76	1.23	1.24	244.4
John Michuki Park (JMP)	0	0	0	0	0	0	0
Hilton Hotel Circle (HHC)	1.62	19.52	48.52	48.52	48.52	48.52	2895.1
Globe Cinema Roundabout (GCR)	0.082	0.082	0.082	0.082	0.18	0.20	143.9
Fire Station Roundabout (FSR)	2.26	2.26	2.26	2.26	2.26	2.26	0
Supreme Courts Parking (SCP)	6.32	6.32	6.32	6.32	6.32	6.32	0
NCC Sunken Parking (NSCP)	4.56	9.47	21.39	21.39	21.39	21.39	369.1
Railways Godowns Parking (RGP)	2.98	2.98	2.98	2.98	2.98	2.98	0
KICC Parking (KP)	6.21	21.61	21.61	21.61	33.30	30.72	394.7
Railways Bus Terminus (RBT)	5.97	5.97	5.97	6.63	6.63	6.63	11.05
KBS Bus Terminus (KBT)	2.40	2.40	2.40	2.40	2.40	2.40	0
Aga Khan Walk (AKW)	0	6.89	17.14	17.86	17.86	17.86	159.2
National Housing Corporation Walk (NHCW)	3.08	3.08	8.95	11.39	11.39	11.39	269.8
Wakulima Market (WM)	7.86	10.71	10.71	10.71	10.71	10.71	36.3

Source: Author

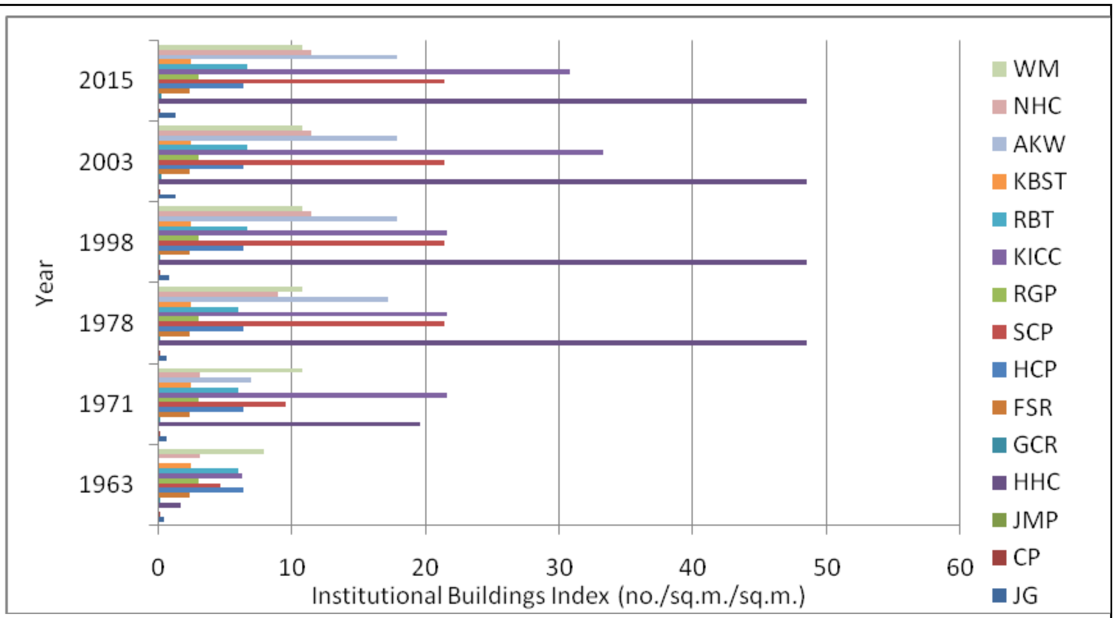


Figure 5.58: Graph of Institutional Use Index Changes (1963-2015) Source: Author

Figure 5.59 following indicates changes in institutional use indexes for all spaces, calculated as averages for each year 1963-2015. Based on the averages of all spaces per year the institutional use indexes increased by 272.4% from 1963-2015.

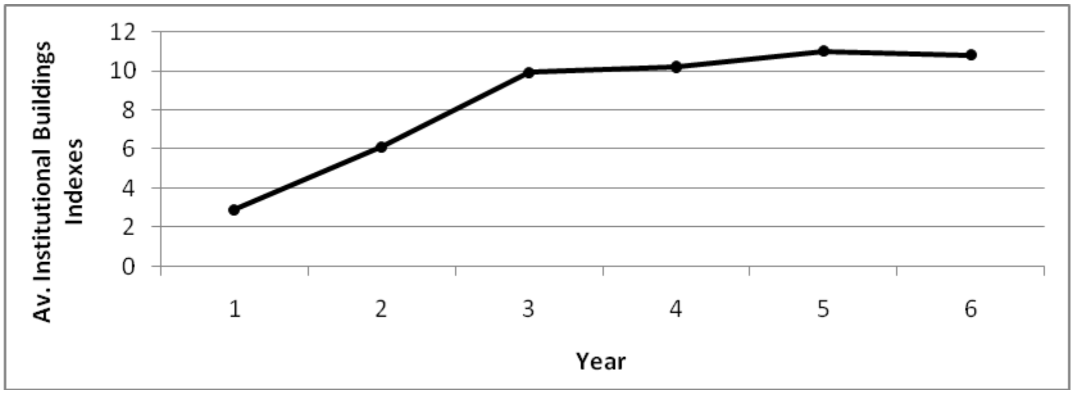


Figure 5.59: Graph of Institutional Use Indexes Average Change (1963-2015) Source: Author

Table 5.11 and Figure 5.60 following capture changes for residential land use (1963-2015) using a residential use index.

Table 5.11: Changes of Residential Use Indexes for All Spaces (1963-2015)

STUDY SPACE/VARIABLE	1963	1971	1978	1998	2003	2015	1963-2015 % change
RESIDENTIAL USE INDEX (sq.m./sq.m.)							
Central Park (CP)	0	0	0	0	0	0	0
Jeevanjee Gardens (JG)	0.14	0.14	0.14	0.10	0.10	0.05	-64.3
John Michuki Park (JMP)	1.263	1.893	1.893	1.578	1.578	1.578	24.9
Hilton Hotel Circle (HHC)	0	0	0	0	0	0	0
Globe Cinema Roundabout (GCR)	0.33	0	0	0	0	0	-100.0
Fire Station Roundabout (FSR)	0	0	0	0	0	0	0
Supreme Courts Parking (SCP)	0	0	0	0	0	0	0
NCC Sunken Parking (NSCP)	0	0	0	0	0	0	0
Railways Godowns Parking (RGP)	0	0	0	0	0	0	0
KICC Parking (KP)	0	0	0	0	0	0	0
Railways Bus Terminus (RBT)	0	0	0	0	0	0	0
KBS Bus Terminus (KBT)	0	0	0	0	0	0	0
Aga Khan Walk (AKW)	0	0	0	0	0	0	0
National Housing Corporation Walk (NHCW)	0	0	0	0	0	0	0
Wakulima Market (WM)	0	0	0	0	0	0	0

Source: Author

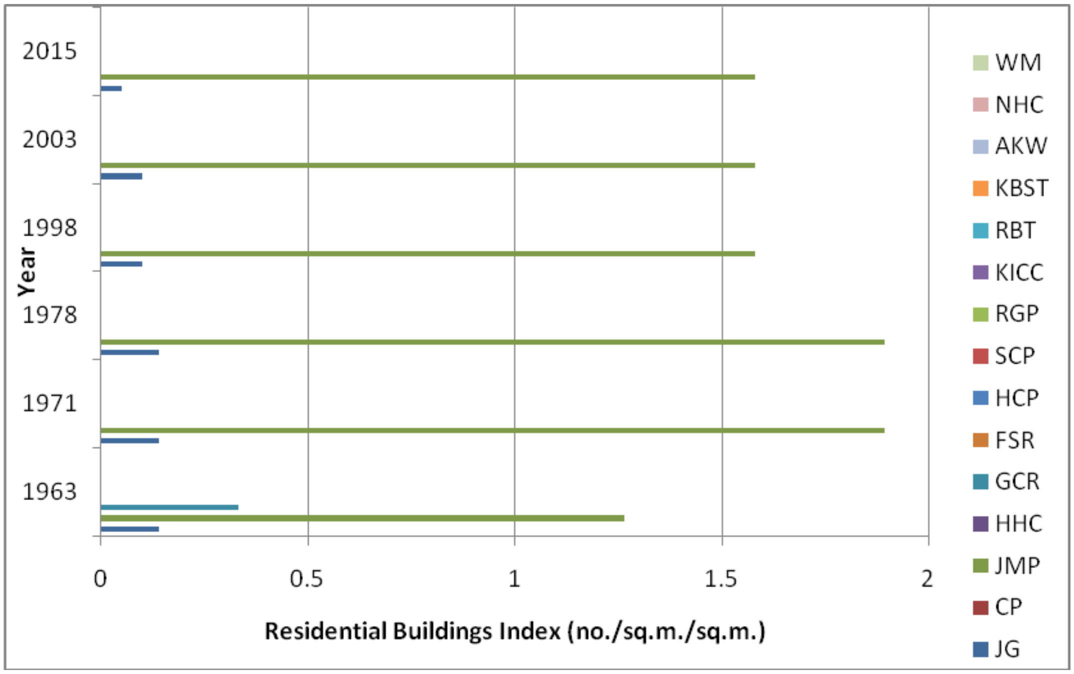


Figure 5.60: Graph of Residential Use Index Changes (1963-2015) Source: Author

Figure 5.61 following indicates changes in residential use indexes for all spaces, calculated as averages for each year 1963-2015. Based on the averages of all spaces per year the residential use indexes decreased by 66.6% from 1963-2015.

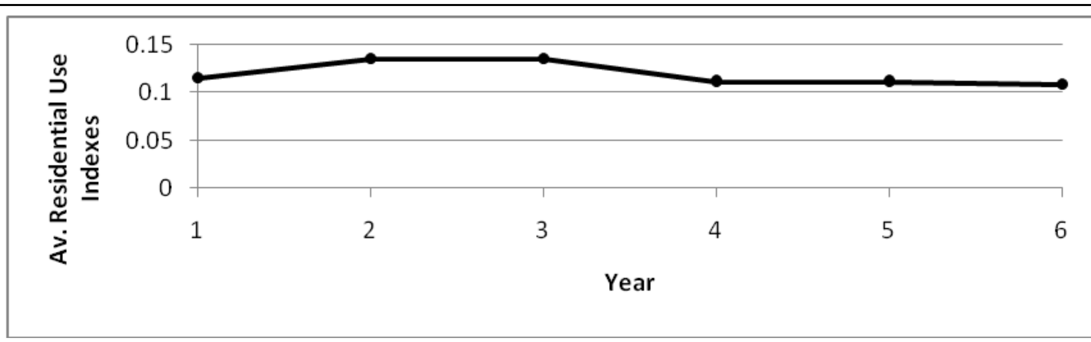


Figure 5.61: Graph of Residential Use Indexes Average Change (1963-2015) Source: Author

Table 5.12 and Figure 5.62 following captures changes for residential land use (1963-2015) using a residential use index.

Table 5.12: Changes in Industrial, Warehouse, & Workshop Use Indexes for All Spaces (1963-2015)

STUDY SPACE/VARIABLE	1963	1971	1978	1998	2003	2015	1963-2015 % change
INDUSTRIAL/WAREHOUSE & WORKSHOP USE INDEX (sq.m./sq.m.)							
Central Park (CP)	0	0	0	0	0	0	0
Jeevanjee Gardens (JG)	0	0	0	0	0	0	0
John Michuki Park (JMP)	0.631	1.042	1.152	1.168	1.168	1.073	20.0
Hilton Hotel Circle (HHC)	0	0	0	0	0	0	0
Globe Cinema Roundabout (GCR)	0.33	0.14	0.14	0.14	0.16	0	-100.0
Fire Station Roundabout (FSR)	0	0	0	0	0	0	0
Supreme Courts Parking (SCP)	0	0	0	0	0	0	0
NCC Sunken Parking (NSCP)	0	0	0	0	0	0	0
Railways Godowns Parking (RGP)	1.09	1.09	1.09	0.95	0.95	0.13	-88.1
KICC Parking (KP)	0	0	0	0	0	0	0
Railways Bus Terminus (RBT)	1.32	1.32	1.32	1.05	1.05	0.25	-81.1
KBS Bus Terminus (KBT)	0	0	0	0	0	0	0
Aga Khan Walk (AKW)	0	0	0	0	0	0	0
National Housing Corporation Walk (NHCW)	0	0	0	0	0	0	0
Wakulima Market (WM)	0.93	0.93	0.93	0.43	0.43	0	-100.0

Source: Author

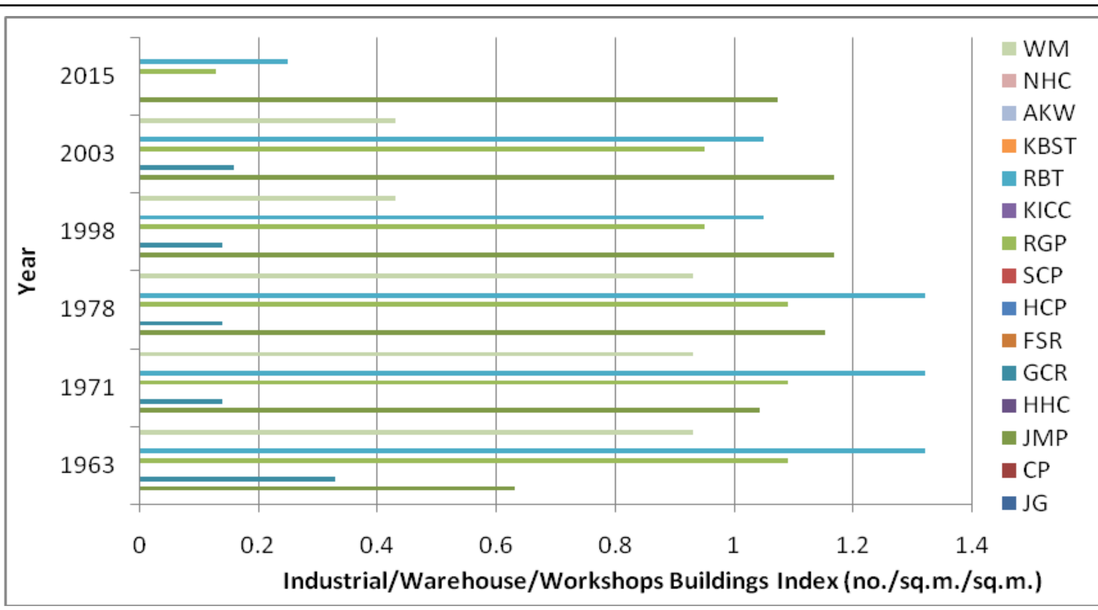


Figure 5.62: Graph of Industrial/Warehouse/Workshops Use Index Changes (1963-2015)
Source: Author

Figure 5.63 following indicates changes in industrial/warehouse/workshop use indexes for all spaces, calculated as averages for each year 1963-2015. Based on the averages of all spaces per year the use indexes decreased by 69.0% from 1963-2015. Table 5.13 following compiles and details the changes in land use from 1963-2015 for all spaces.

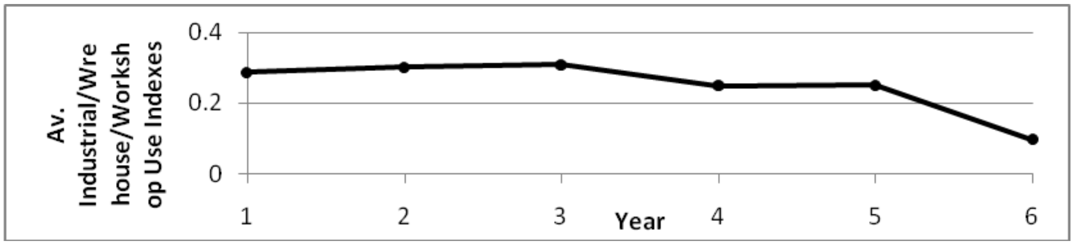


Figure 5.63: Graph of Industrial/Workshop Use Indexes Average Change (1963-2015)
Source: Author

Table 5.13: Detailed Table of Use Changes for All Spaces (1963-2015)

STUDY SPACE/VARIABLE	1963	1971	1978	1998	2003	2015
LAND USE						
Central Park	POS;C;R;GO;PI; NPI	POS;C;R;GO;PI; NPI;	POS;C;R;GO;PI; NPI;	POS;C;R; GO;PI; NPI; RC; C; CO	POS;C;R;GO;PI; NPI; C; CO	POS;C;R;GO;PI; NPI; C; CO
Jeevanjee Gardens	POS; S	POS; CR	POS; CR	POS; CR	POS; CR	POS; CR
John Michuki Park	POS; W;R	POS;W	POS;W	POS;W	POS;W	POS
Hilton Hotel Circle	CO;CR;C; BT	CO; CR;POS	CO; CR;POS	CO; CR;POS	CO; CR;POS	CO; CR;POS
Globe Cinema Roundabout	GO;PI;W; R	GO;PI;W; R; POS	GO;PI;W; POS	NPI;W; POS; CR	NPI;W; POS; CR	NPI;W; POS; CR
Fire Station Roundabout	C; CR; W;R	C; CR; W;R	C; CR; W;R	BT; CR	BT; CR	BT; CR
Supreme Courts Parking	GO;PI; CR	GO;PI; CR	GO;PI; CR	GO;PI; CR	GO;PI; CR	GO;PI; CR
NCC Sunken Parking	GO;PI; CR	GO;PI; CR	GO;PI; CR	GO;PI; CR	GO;PI; CR	GO;PI; CR
Railways Godowns Parking	I;W	I;W	I;W	I;W; CR	I;W; CR	C
KICC Parking	POS; GO; PI; NPI	POS; GO; PI; NPI	POS; GO; PI; NPI	POS; GO; PI; NPI	C; GO; PI; NPI	C; GO; PI; NPI
Railways Bus Terminus	I; GO;PI;CR	I; GO;PI;CR	I; GO;PI;CR	I; GO;PI;CR	I; GO;PI;CR; BT	I; GO;PI;CR; BT
KBS Bus Terminus	NPI; CR; C	NPI; CR; C; BT	NPI; CR; C; BT	NPI; CR; C; BT	NPI; CR; C; BT	NPI; CR; C; BT
Aga Khan Walk	CO;CR;GO; PI; P	CO;CR;GO; PI; P	CO;CR;GO; PI; P	CO;CR;GO;PI; P	CO;CR;GO; PI; P	CO;CR;GO;PI; P
National Housing Corporation Walk	CO;CR;GO; P	CO;CR;GO; P	CO;CR;GO; P	CO;CR;GO;NPI; P	CO;CR;GO; NPI; P	CO;CR;GO;NPI; P
Wakulima Market	I; POS; NPI	I; POS; NPI; M	I; POS; NPI; M	I; POS; NPI; M	I; POS; NPI; M	I; POS; NPI; M

POS=public open space; CR=Commercial Retail; C=carpark; R=residential; CO= Commercial Office; GO=government offices; PI=public institutions; NPI=non-public institutions; W=workshops & warehouses; BT= Bus Terminus; I=light & heavy industry; P=pedestrian pathway; M=market

Source: Author

Figure 5.64 indicates land designated as 24 hour public parking in 1962 and referenced in Table 5.13 previous. Also referenced in the table is Figure 5.65 that follows. It captures changes in 1964 of land use from public parking space to institutional and other uses. Changes in land use are also captured in Figure 5.66 that indicate a decline in public institution use between 1964 and 2011. In addition, comparison of 1964 and 2011 land use maps indicate a decline in residential use in the CBD. The south part of the CBD however retained its use for government and public institution offices over that period. Further comparison indicates that the area to the east of the city core continued to be predominantly for retail and office use from 1964-2011.

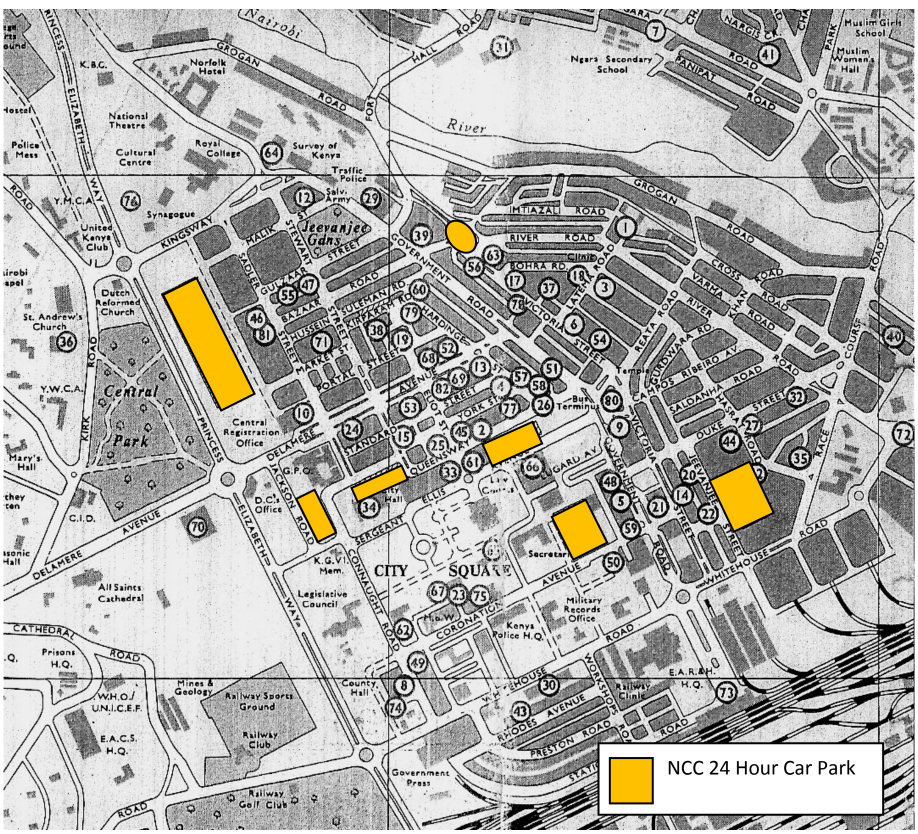


Figure 5.64: Nairobi CBD Parking Areas Map 1962
Source: Adapted from Nairobi City County, 1962

Figure 5.65: Nairobi CBD Land Use Map 1964 Morgan, 1967 Adapted by Author

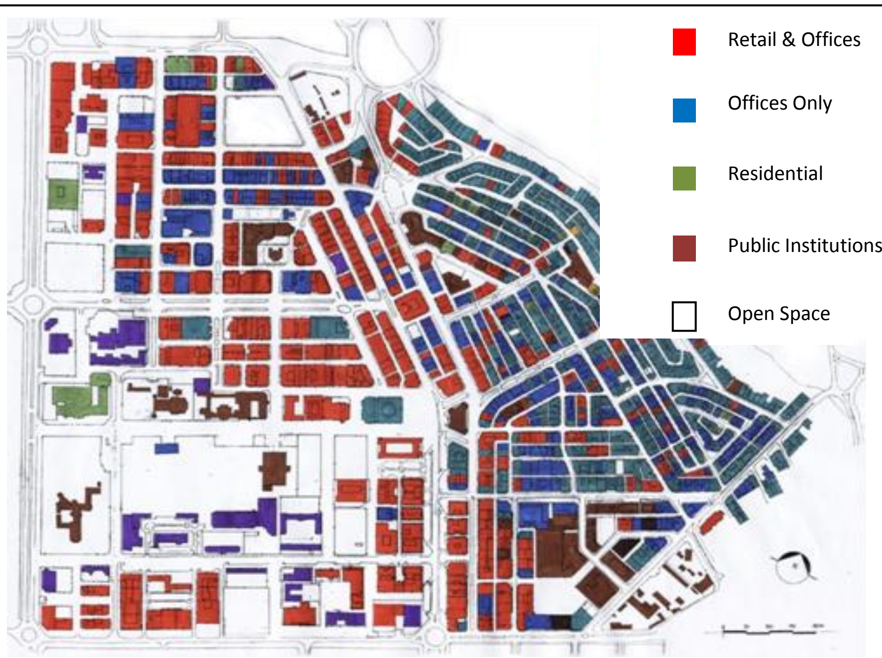


Figure 5.66: Nairobi CBD Land Use Map 2011 Source: Moirongo, 2011

Organized according to space type, land use changes for 1963-2015 were recorded and analysed for each space as follows.

Central Park: Table 5.9 indicates that from 1963-2015 the commercial use index surrounding the park increased from 0.02. to 1.1 while the institutional use index increased from 0.08 to 0.12 (Table 5.10). Table 5.11 and Table 5.12 indicate absence of residential and industrial use in the park environs over that period.

From 1963-2015 predominantly commercial and institutional buildings surrounded Central Park. In 1963 the Dutch Reformed Church existed but was replaced by the Lutheran Church and a commercial office block (Figure 5.67). By 1963 there was an almost equal distribution of commercial and institutional use buildings around the park. In 2015 however majority of the buildings surrounding the park were commercial offices (Plate 5.124 and Plate 5.125). Designated as an upper income residential area in 1964 the YWCA on Nyerere Road catered to mid-income renters in 2015. Also on Nyerere Road, by 1978 Serena Hotel had replaced government offices to the south of the park.

Diversity in building use as demonstrated around Central Park that is expected to enhance sustainability. However, mixed use alone is not enough to enhance social and economic sustainability. Compactness of form and spatial interaction between the buildings are additional key factors. Barriers such as fences and wide, high-speed, high-volume traffic also reduce the influence of mixed uses in creating neighbourhoods that are sustainable.

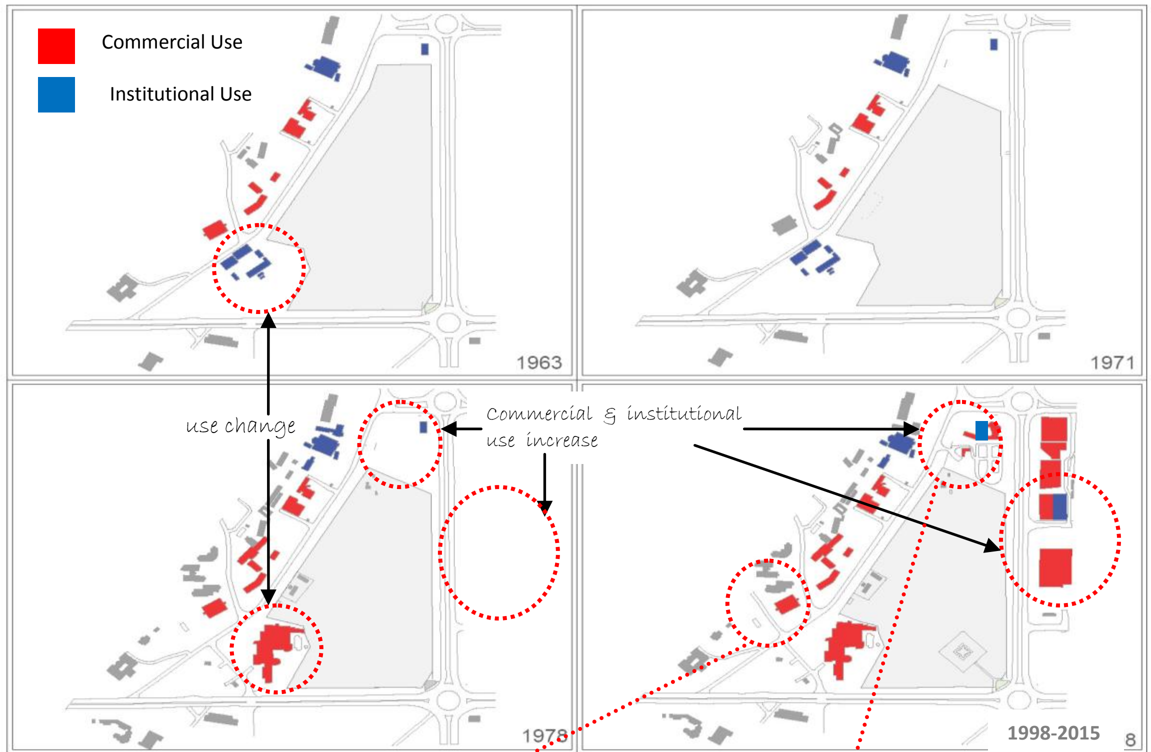


Figure 5.67: Central Park Land Use (1963-2015) **Source: Author**

Plate 5.124: Commercial Use Buildings on Nyerere Rd, 2015
Source: Author

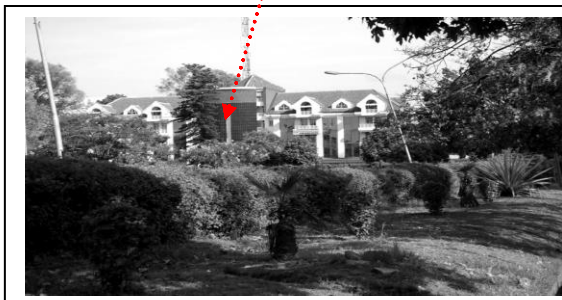


Plate 5.125: Commercial Use Building on University Way/Nyerere Rd, 2001
Source: Author

Jeevanjee Gardens: from 1963-2015 the commercial use index surrounding the park increased by 66.9% from 2.48 to 4.14 while the institutional use index increased by 244.4% from 0.36 to 1.24. Over the same period, residential use index decreased by 64.3% (Table 5.9 - Table 5.12).

Figure 5.65 indicates that in 1963 the area surrounding the park was designated as an upper income shopping area. Most of the buildings have had commercial retail and wholesale shops since 1963. Institutional surrounding buildings prior to 1963 include Moi Avenue Primary School on Moi Avenue and the Salvation Army Headquarters on Monrovia Street, built in 1928 (Plate 5.126). As shown in Plate 5.127 from 1978-2015 more commercial retail and office space emerged around the park. As at 2015, a mix of commercial activities takes place in buildings facing Jeevanjee Gardens such as eateries, hotels, service businesses and retailers. Buildings in the space are public toilets and small scale retail goods and services which increased from 1978-2015 (Figure 5.68).

John Michuki Park: from 1963-2015 the commercial use index surrounding the park remained consistent at 0.126 while the residential use index increased by 24.9% from 1.26 to 1.58. Over the same period, the industrial/warehouse/workshop use index increased by 20.0% from 0.63 to 1.07 (Table 5.9 - Table 5.12).

From 1963-2015 the buildings adjacent to the park have been warehouses, workshops and residences, many since the 1940s (Plate 5.128). As of 2015, upper floors of some buildings on Kijabe Street were still residential, being among the few residential areas in the CBD. From 1971-2003 workshop sheds developed on the river banks as spaces for open-air auto garages and charcoal dealers (Figure 5.69). Although sustainability advocates mixing of functions, the diversity of functions must be compatible. Auto-mechanic work is not compatible with a recreational park and influences its attractiveness park users. By 2015 the informal sheds had been removed and river banks reclaimed as public space by the national government Ministry of Environment and Natural Resources. In 1964 the area north of Kipande Rd was a high density, low income residential area, which has been retained until 2015 (Plate 5.129).

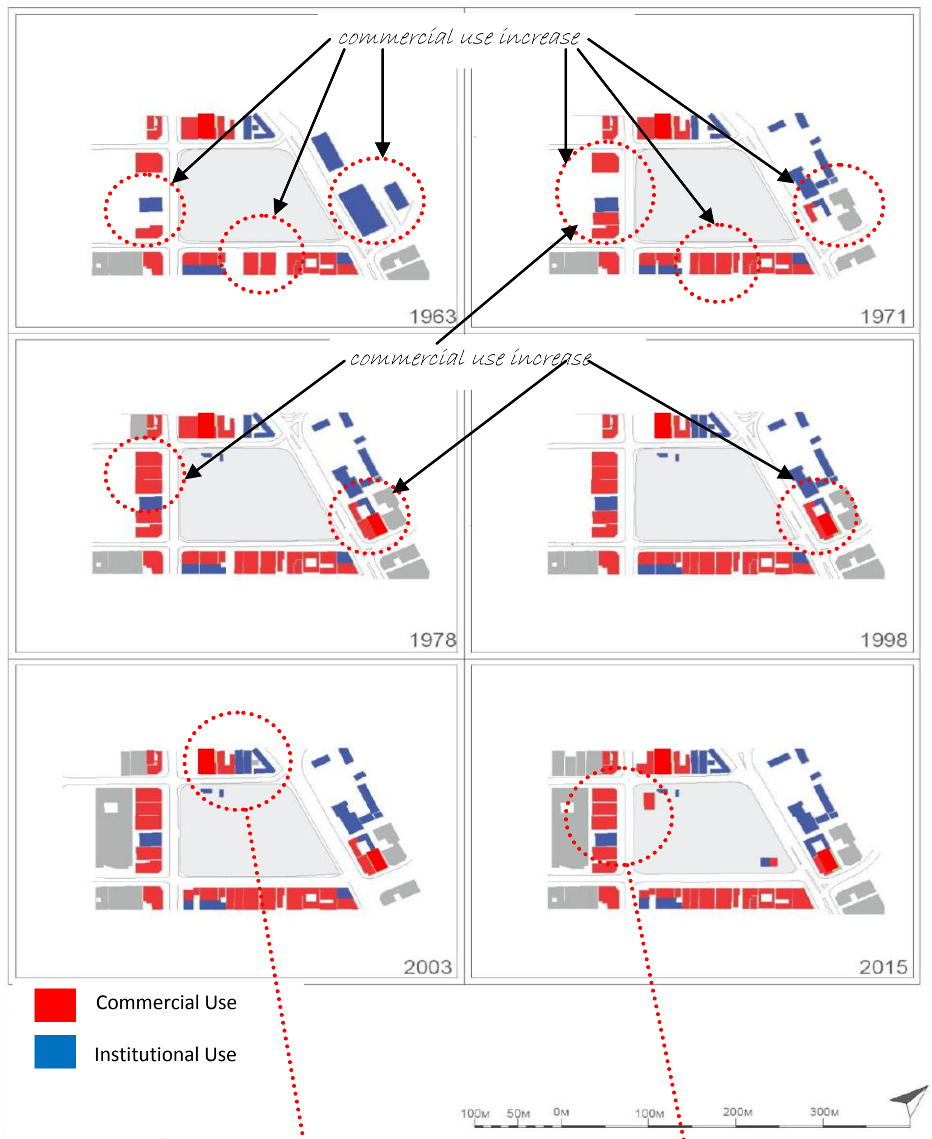


Figure 5.68: Jeevanjee Gardens Land Use (1963-2015). Source: Author

Plate 5.126: Salvation Army Office on Monrovia St., 2005 Source: Author

Plate 5.127: Commercial Use on Muindi Mbingu Rd., 2015 Source: Author

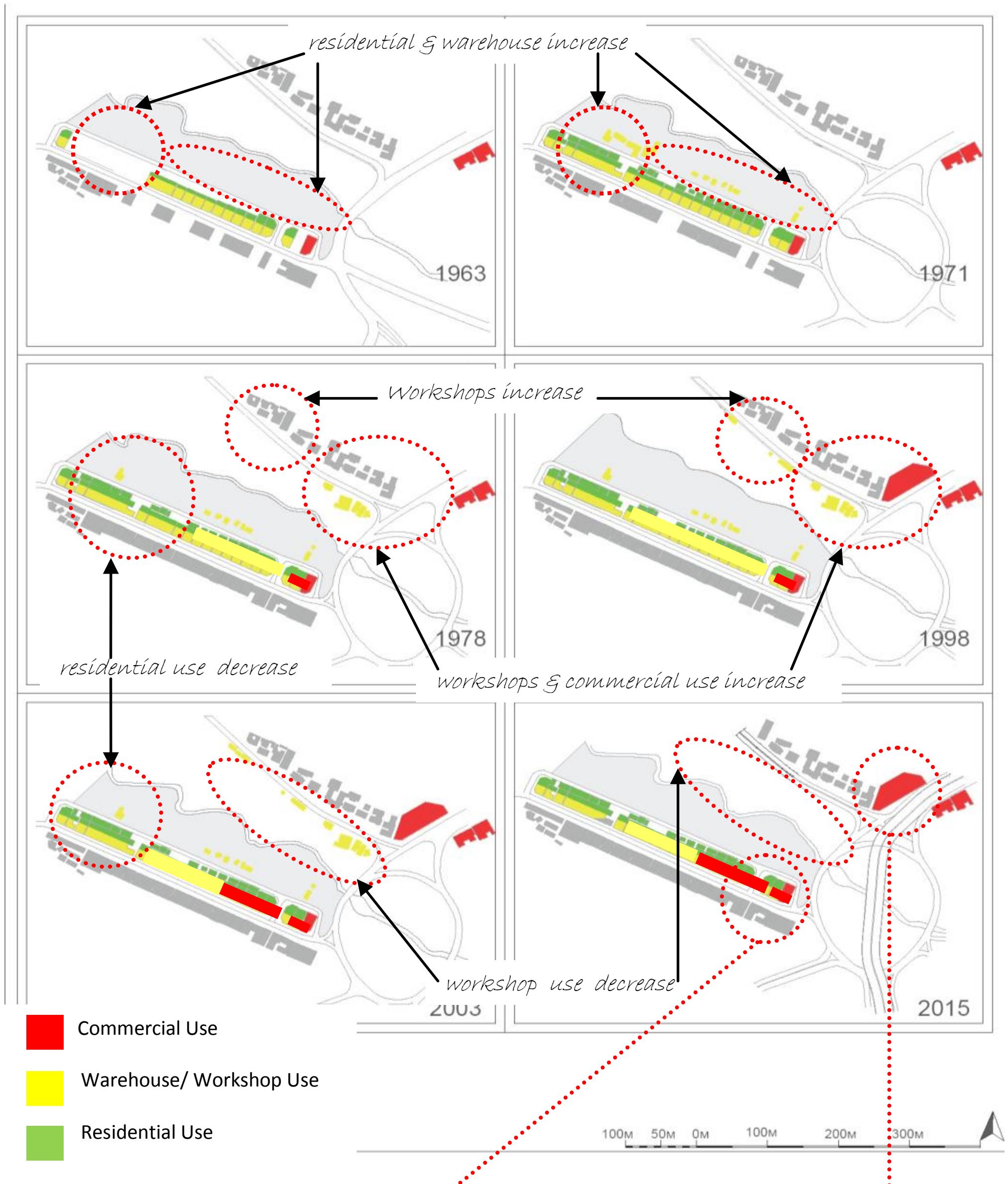


Figure 5.69: John Michuki Park Land Use (1963-2015) Source: Author

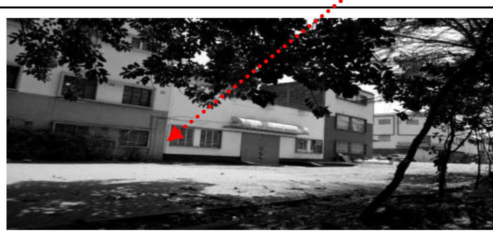


Plate 5.128: Warehouses adjacent J. Michuki Park, 2015 Source: Author

Plate 5.129: Commercial Use Buildings on Kipande Rd, 2015 Source: Author

Hilton Hotel Circle: Table 5.9 - Table 5.12 indicate that from 1963-2015 the commercial use index surrounding the park increased by 197.4% from 36.92 to 109.79 while the institutional use index increased from 1.62 to 48.52. Over the same period, the residential and industrial/warehouse/workshop use indexes remained at zero. As shown in Plate 5.130 office buildings bordered the space. From 1971 majority of the buildings surrounding the park have been for commercial retail and office use. 1971-2015 institutional buildings use has mainly comprised financial and educational institutions. From 1978-2015 land use around Hilton Hotel Circle has remained consistent (Figure 5.70). Increased commercial activities such as retail shops, service businesses, restaurants, hotels and eateries meant more activity, greater economic and social diversity, and enhanced vitality in the neighbourhood (Plate 5.131).

Plate 5.130: Commercial Use, Hilton Hotel, 1960s

Plate 5.131: Commercial Use Moi Ave, 2015
Source: Author

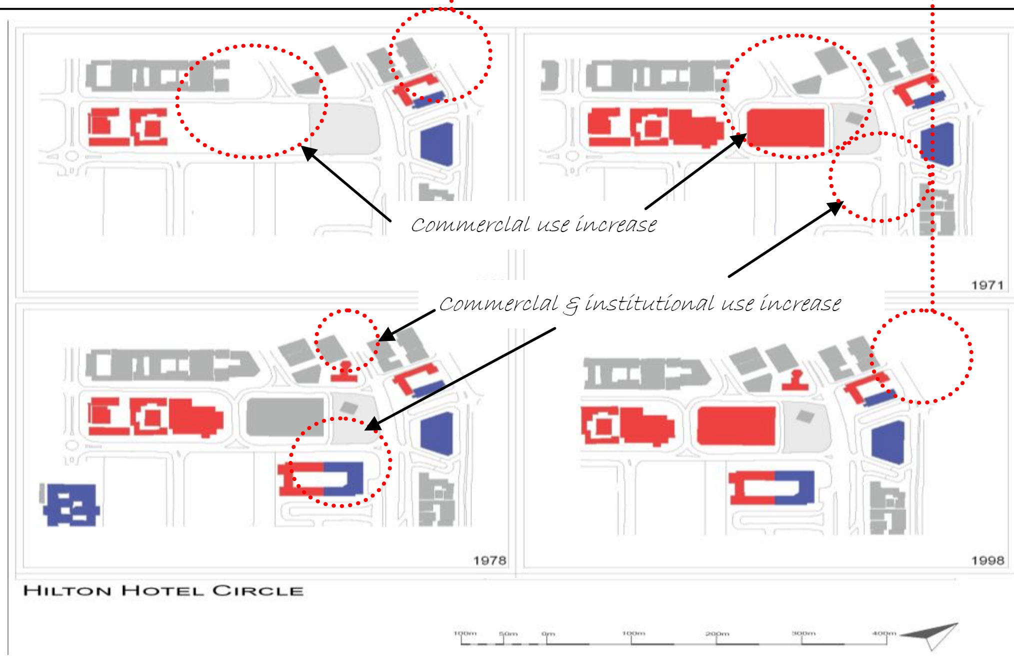


Figure 5.70: Hilton Hotel Circle Land Use (1963-2015) Source: Author

Globe Cinema Roundabout: Table 5.9 - Table 5.12 indicate that from 1963-2015 the commercial use index surrounding the park increased by 340.0% from 0.80 to 3.52 while the institutional use index increased by 143.9% 0.082 to 0.20. Over the same period, the residential and industrial/warehouse/workshop use indexes each decreased by 100.0%.

In 1963 the roundabout did not exist and was defined by Murang'a Road to its east edge. In the 1970s the space was recreational, used for football and cricket by residents of Ngara and other neighbourhoods. It also functioned as a transportation hub for local and sub-regional buses in the 1980s. This changed in the 1990s with relocation of the hub and by 2015 was still used for recreation and public transport vehicle parking. From 1964 south and west of the space was for government offices and public institutions, warehouses, workshops and residential use. The north side was a high density, low income residential area (Figure 5.65).

Figure 5.71 indicates that from the 1990s surrounding buildings changed to more commercial and residential use especially along Kipande Road. During the 1990s until the first decade of 2000, a weekend roadside cultural market lined Slip Road that connects onto the roundabout. This was removed and in 2015 small scale food and produce vendors lined the road (Plate 5.132 and 5.133). Institutional use also increased as indicated by building of Paramount Plaza for educational use and Globe Cinema Theatre for religious use Open-air auto mechanic workshops west and east of the roundabout were removed from1978-2003 as this land was reclaimed as a park. From 1963-2015, commercial and institutional use around the space has increased, but declined for residential, warehouse and workshop uses (Plate 5.134 and Plate 5.135). Warehouses along Kijabe St. service lane were still functional as of 2015. The mix of uses of buildings in 1963 reflected a neighbourhood that had social and economic vitality as a result of diversity of uses. The presence of workshops, warehouses, retail and office spaces, residential spaces and institutional buildings indicate that surrounding the space was an environment with the characteristics of a sustainable neighbourhood due to mixed use.

Plate 5.134: Commercial Use at Globe Roundabout, 2015 Source: Author

Plate 5.135: Commercial Use off Moi Ave., 2015 Source: Author

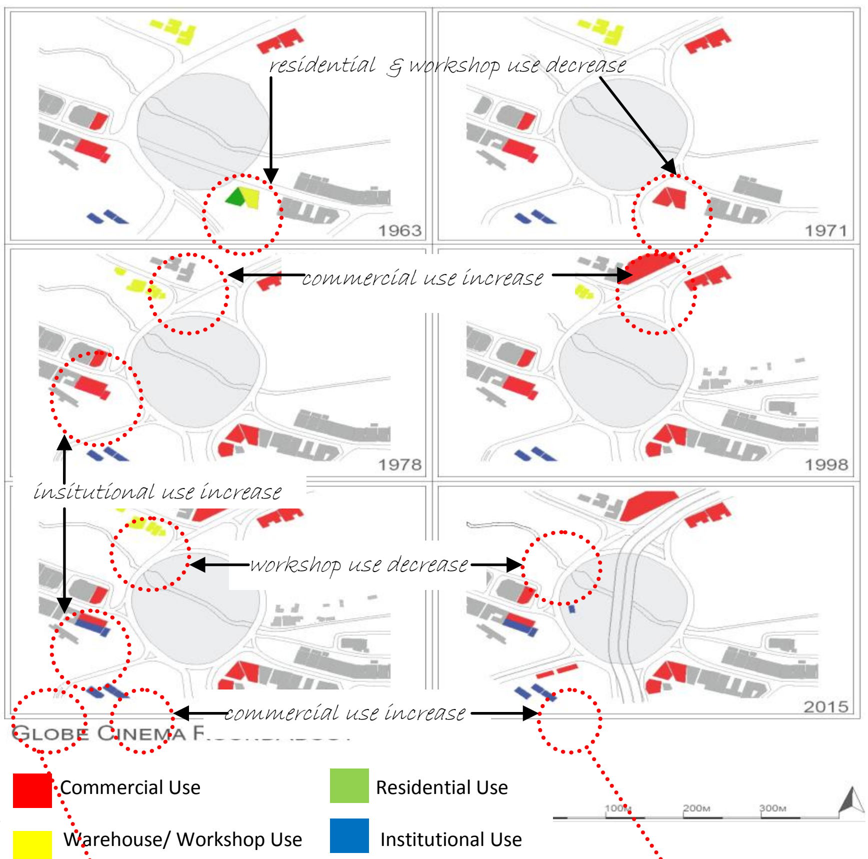


Figure 5.71: Globe Cinema Roundabout Land Use (1963-2015) Author

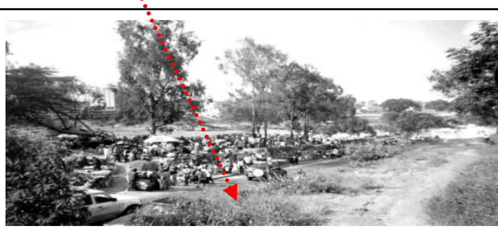


Plate 5.132: Slip Rd. Commercial Activity, 2003 Source: Author

Plate 5.133: Vendors on Slip Rd, 2015 Source: Author

Fire Station Roundabout: from 1963-2015 the commercial and institutional use index surrounding the park remained consistent at 34.30 and 2.26 respectively. Over the same period, the residential and industrial/warehouse/workshop use indexes remained at zero (Table 5.9 - Table 5.12).

In 1964 buildings surrounding the space were high and low income shopping areas, warehouses, workshops and for residential use (Figure 5.65). In 2015, the roundabout served as a public transportation hub as shown in Plate 5.136. Majority of buildings were retailer, service businesses and offices, and in 2015 still retained their commercial uses as designated in the 1960s (Figure 5.72 and Plate 5.137). The fire station, a public facility under management of NCC also retained its function from 1963-2015 (Figure 5.72).

Plate 5.136: Fire Station Roundabout Transport Hub, 2015 Source: Author

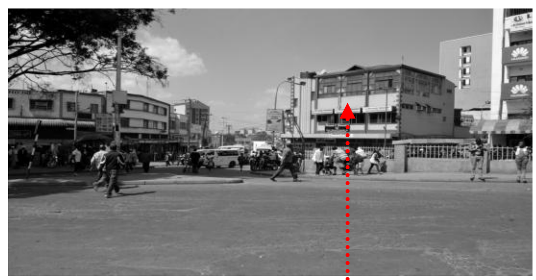


Plate 5.137: Commercial Use at Fire Station Roundabout, 2015 Source: Author

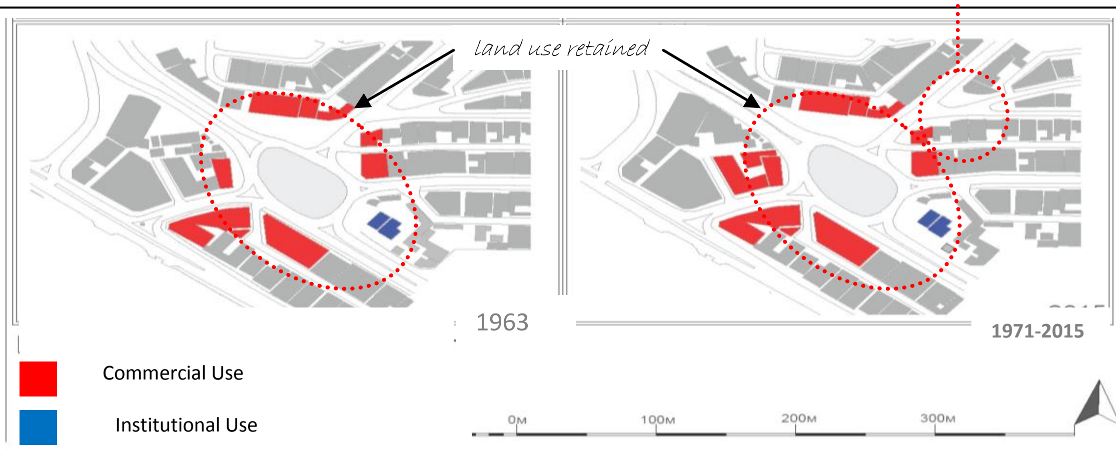


Figure 5.72: Fire Station Roundabout Land Use (1963-2015) Source: Author

Supreme Court Parking: from 1963-2015 the commercial use index increased by 161.6% from 18.02 to 47.14 while the institutional use, residential, and industrial/warehouse/workshop use indexes remained unchanged at 6.32 and zero respectively (Table 5.9 - Table 5.12).

As shown in Plate 5.18, in the 1940s the area surrounding the law courts was covered in natural vegetation. In 1964 the area designated land use was for government and public institutions (Figure 5.65). Thereafter, in 1971 the High Court car park had been created and was in service as a public parking facility. It has retained its use as public parking managed by NCC from 1971 – 2015 (Figure 5.73). In 2015 in addition to serving as parking, it served as a weekend cultural market fostering social and economic vitality in the CBD. Majority of surrounding buildings has been commercial office space from 1978-2015 (Plate 5.139).

Plate 5.138: Rear side of Law Courts, 1940s Source: www.pinterest.com

Plate 5.139: Office Buildings on City Hall Way, 2015 Source: Author

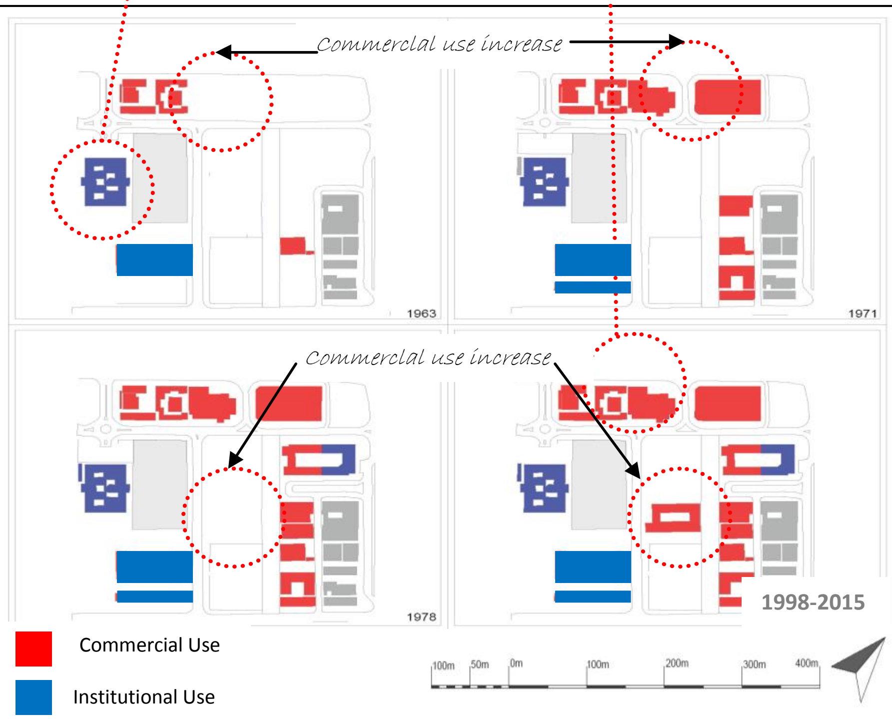


Figure 5.73: Supreme Court Parking Land Use (1963-2015) Source: Author

Sunken Car-park: Table 5.9 - Table 5.12 indicate that from 1963-2015 commercial use index increased from 3.15 to 60.66 while the institutional use index increased by 369.1% from 4.56 to 21.39. Residential and industrial/warehouse/workshop use indexes remained at zero over the period.

In 1964 for the area was designated for offices, multi-storey hotels and ground floor shops (Figure 5.65). From 1970s -2015 the space has functioned as a car park. In 2015 the car park also served as a roller-skating space for youth and clothes market on weekends (Plate 5.140). These weekend activities make the space more sustainable because they help to mix uses in the neighbourhood. They also enhance social and economic vitality and attractiveness of the space particularly to children and youth. This vitality and diversity of users are characteristics of sustainable urban spaces. From 1963-2015 most surrounding buildings have had commercial and institutional use, the latter comprising mainly government offices and public institutions. As of 2015, majority of surrounding commercial buildings were office and retail spaces used as service businesses, shops and supermarkets (Figure 5.74 and Plate 5.141).

Railways Godowns Parking: from 1963-2015 commercial use index increased by 31.2% from 1.25 to 1.64 while the institutional use index remained consistent at 2.98. Industrial/warehouse/workshop use indexes decreased by 88.1% from 1.09 to 0.13 while residential use and remained at zero over the period (Table 5.9 - Table 5.12).

In 1964 the space was allocated for light and heavy industry use and functioned as railways warehouses from 1963-2003 (Figure 5.65 and Plate 5.143). From 2003-2015 the function changed to commercial retail use and then to a parking area. In 2015 workshop sheds for auto-mechanics, services businesses, kiosks, and eateries had emerged the space edges (Figure 5.75). Kenya Railways, which is a national corporation has been headquartered on the corner of Haile Selassie Ave and Moi Avenue since 1935 (Plate 5.142). From the 1960s, majority of buildings across Haile Selassie Ave have had commercial offices and retail use.

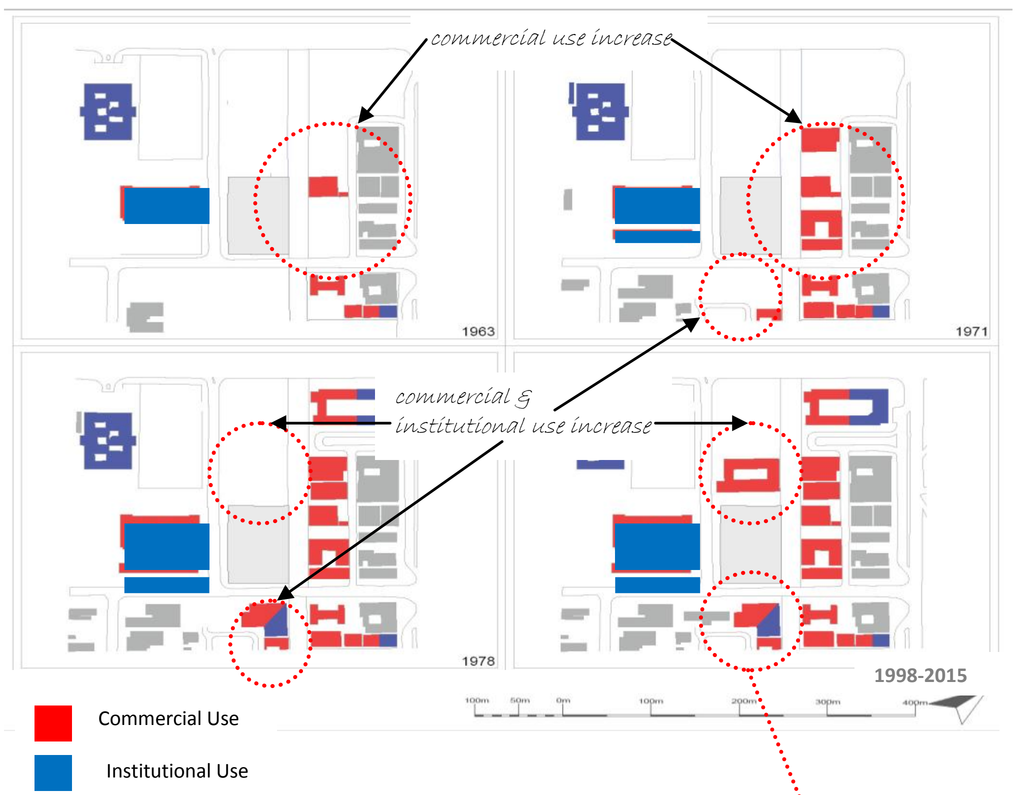


Figure 5.74: Sunken Car-park Land Use (1963-2015) Source: Author

Plate 5.140: Sunken Car-park Weekend Market, 2015 Source: Author

Plate 5.141: Offices blocks opposite Sunken Car-park, 2015 Source: Author

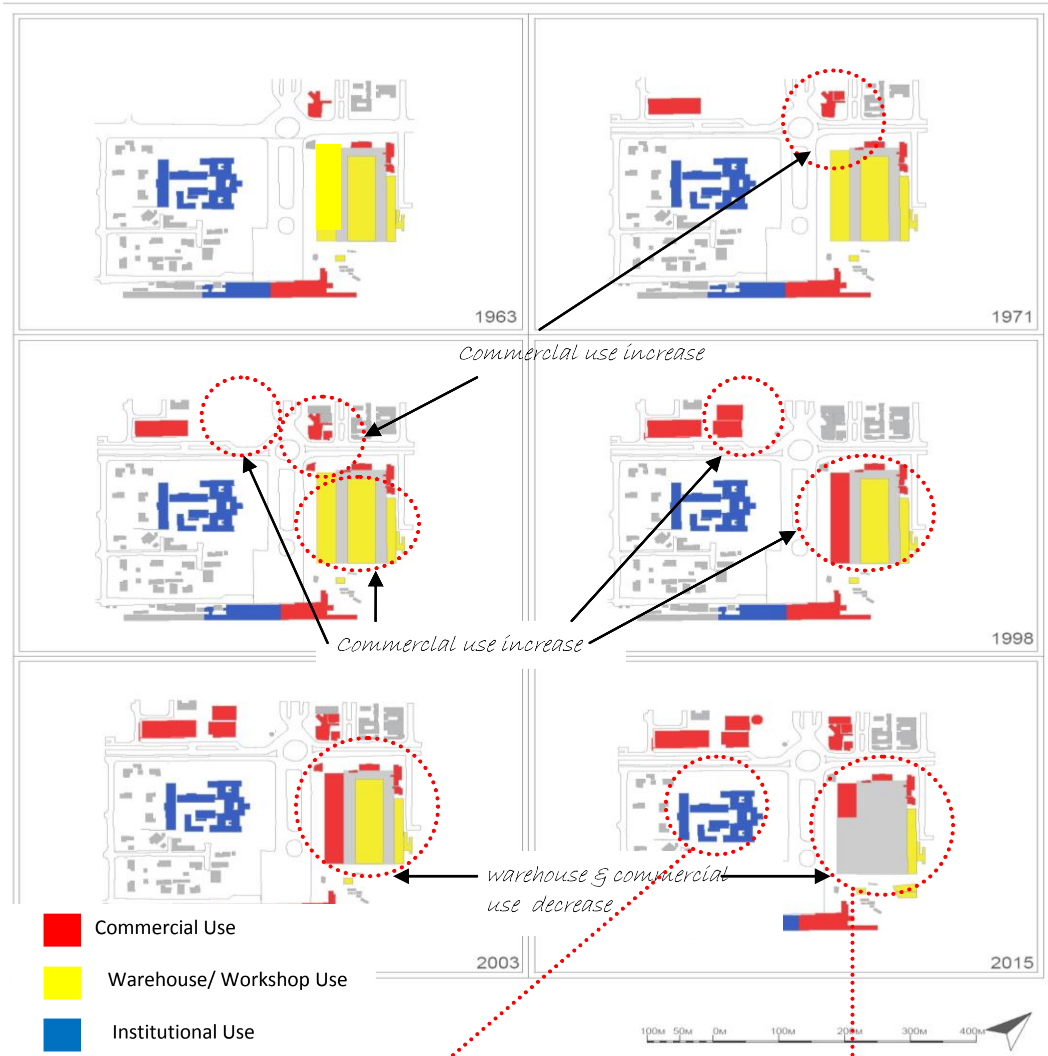


Figure 5.75: Railways Godowns Parking Land Use (1963-2015) **Source: Author**

Plate 5.142: Kenya Railways Headquarters, 2015 Source: Author

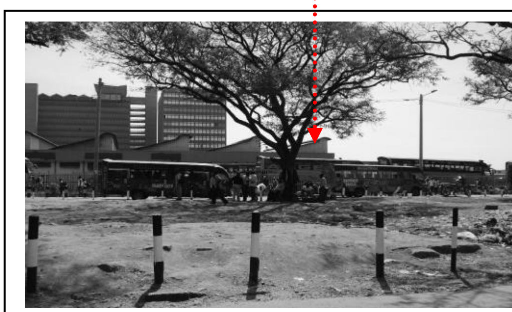


Plate 5.143: Railways Warehouses, 2015 Source: Author

KICC Parking: Table 5.9 - Table 5.12 indicate that from 1963-2015 the commercial use index surrounding the parking increased by 333.7% while the institutional use index increased by 394.7% from 6.21 to 30.72. Over the same period, the residential and industrial/warehouse/workshop use indexes remained at zero (Figure 5.76).

In 1963 the area surrounding the KICC was allocated for as government offices and public institutions (Figure 5.65). In 2003 the public open space had become a public parking facility. In 1963 the site was surrounded by institutional buildings namely public institutions, government offices, religious and educational facilities. From 1971-2015 commercial functions emerged in the area through construction of Hotel Intercontinental and KICC that had commercial and public institution functions. The increase in commercial use of buildings from 1963-1971 indicate increased diversity of uses which contribute to urban space sustainability due to increase socio-economic vitality. The functions of Parliament Buildings, the Jomo Kenyatta Mausoleum, the Supreme Court, and City Hall do not promote active use of the buildings by the public (Plate 5.144). As shown in Plate 5.145, from 1963-2015 surrounding buildings were mainly institutional namely of public, educational, and religious use. Public institutions and financial institutions increased in the area from 1963- 1978, remaining consistent in terms of use from 1978-2015.

Railways Bus Terminus: from 1963-2015 commercial use index increased by 529.0% from 1.86 to 11.7 while the institutional use index rose by 11.05% from 5.97 to 6.63 Industrial/warehouse/workshop use indexes decreased by 88.1% from 1.09 to 0.13 while residential use and remained at zero over the period (Table 5.9 - Table 5.12).In 1963, area land use as light and heavy industry because of railway operations, government and public institution offices (Figure 5.65). From 1963-2015 commercial use retail and offices on Haile Selassie Ave increased. Change in surrounding commercial use increased and declined from 1998-2015 with introduction of Uchumi Supermarket alongside the railway warehouses (Figure 5.77). The warehouses were converted from storage facilities to a supermarket to car-park (Plate 5.146 and Plate 5.147).

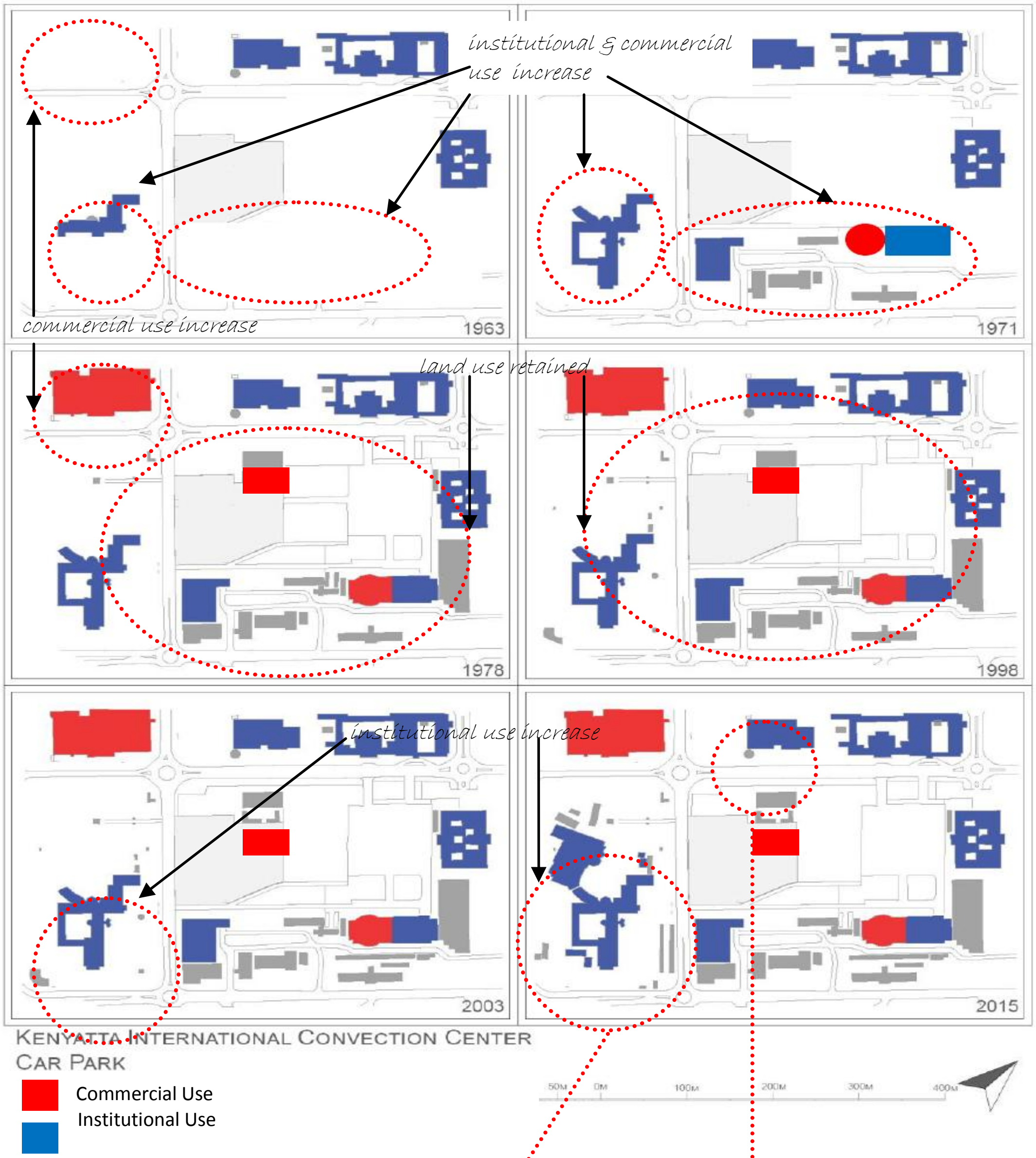


Figure 5.76: KICC Parking Land Use (1963-2015) **Source: Author**

Plate 5.144: Parliament Buildings, 2015
Source: Author

Plate 5.145: Holy Family Basilica, 2015
Source: Author

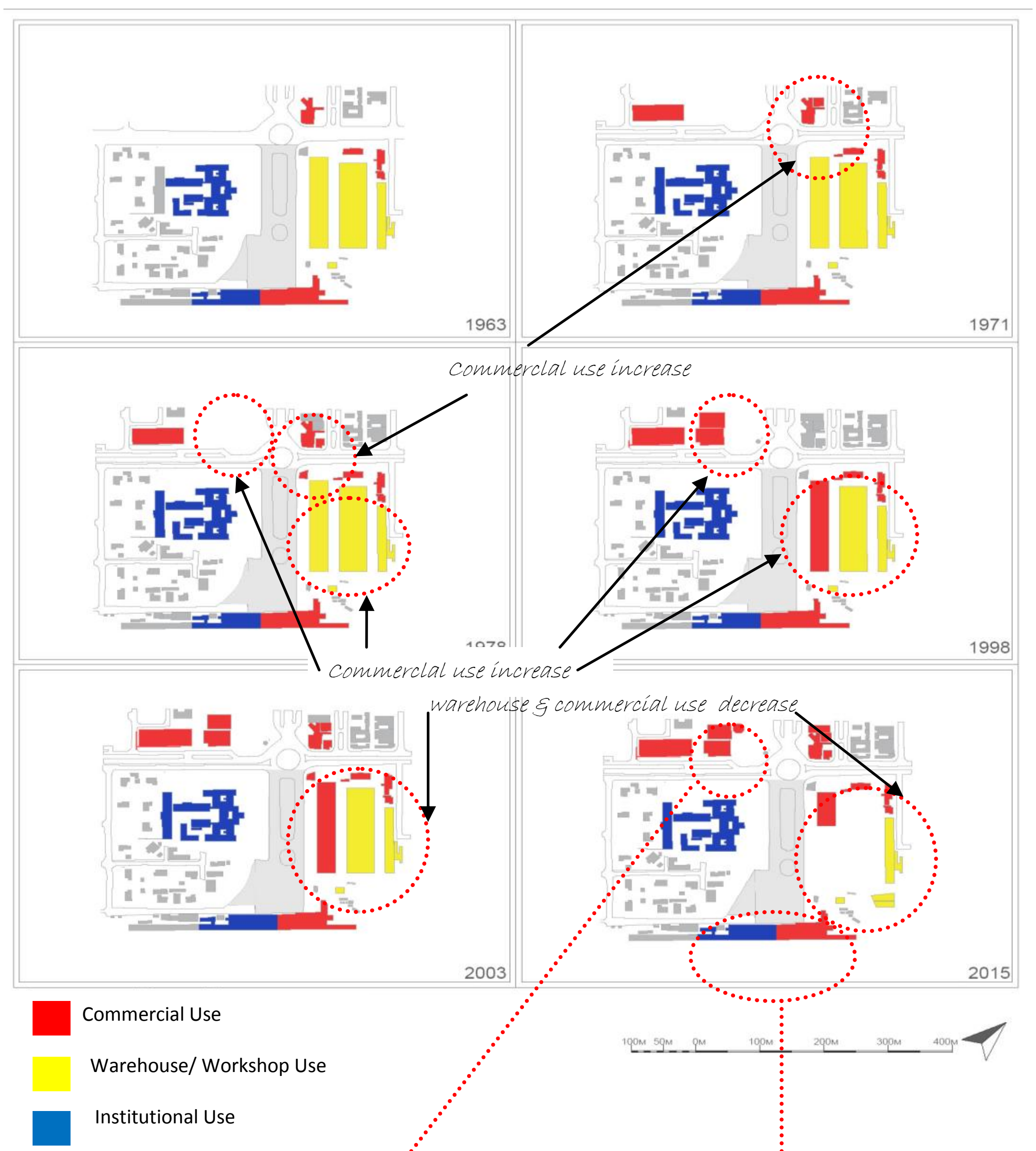


Figure 5.77: Railways Bus Terminus Land Use (1963-2015) Source: Author

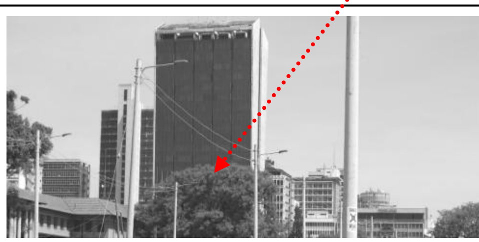


Plate 5.146: Commercial Use on Haile Selassie Av. Source: Author

Plate 5.147: Railway Station Buildings, 2015 Source: Author

KBS Terminus: from 1963-2015 commercial use index increased by 258.2% from 1.34 to 4.80 while the institutional use index remained consistent at 2.40. Industrial/warehouse/workshop and residential use indexes decreased remained at zero over the period (Table 5.9 - Table 5.12).

In 1963 the terminus area was designated for religious and cultural use and as a low-income shopping area (Figure 5.65). The east CBD including in the terminus area were African and Asian commercial areas comprising smaller plots and higher densities than other parts of the city core. From 1963-2015 the Khalsa Centre recognizable by the distinctive dome of the Sikh Sabha Temple housed Sikh religious, cultural, and educational activities. By 1998 a public toilet block next to Khalsa Centre.

Surrounding buildings such as Tusker House built in 1963, Rurwe Co-operative House built in 1978 and Mecca House built in 1977 still functioned as retail and office spaces in 2015 (Plate 5.149). Figure 5.78 indicates that from 1963-2015 commercial office and retail uses increased around the space. Small scale vendor structures along the space peripheries also increased from 1998-2015. Transportation hubs are typically associated with commuter-related commercial and social activities. In 2015 these peripheral structures comprise eateries, retail shops, fresh fruit sellers, shoe shiners, and mobile money services (Plate 5.148). Such activities improve function and convenience of the transport hub as a public space, contributing to its social and economic vitality, and thus its sustainability.

Aga Khan Walk: Table 5.9 - Table 5.12 previous indicates that from 1963-2015 commercial use index increased 6.26 to 72.25 while the institutional use index rose from zero to 17.86 Industrial/warehouse/workshop use and residential use indexes remained at zero over the period (Figure 5.79).

From 1963-2015 most buildings surrounding the space were for commercial retail and office use. Majority of surrounding institutional uses were learning and financial institutions. The adjacent public and private car-parks have retained their function since

1963. The space across from Hilton Hotel changed from a car-part to the KCB Headquarters in 1978. From 1978-2015, area government offices and public services buildings have increased. These include Kenya Power in Electricity House, Kenya Commercial Bank (KCB) in KCB Headquarters, Industrial and Commercial Development Corporation in Uchumi House, and Extelcoms House off Haile Selassie Avenue (Plate 5.150). The combination of commercial and institutional activities contributes to diversity of users on the streets and different times (Plate 5.151). This is further enhanced by the private and national government banks surrounding the promenade namely Standard Chartered, Cooperative Bank, KCB and National Bank of Kenya. This diversity of use and pedestrian traffic is a characteristic of sustainable neighbourhoods.

National Housing Corporation Walk: Table 5.9 - Table 5.12 previous indicates that from 1963-2015 commercial use index increased by 40.8% from 10.56 to 14.87 while the institutional use index increased by 269.8% from 3.08 to 11.39. Industrial/warehouse/workshop use and residential use indexes remained at zero over the period (Figure 5.80).

In 1963 the space was un-built and designated for offices, multi-storey hotels, ground floor shops and upper income shopping use (Figure 5.65). From 1971 -2015 the space has functioned as a major pedestrian path connecting Moi Avenue to AKW and to buildings further west of the Walk. From 1971-2015 the buildings surrounding the space have been used as retail and office space and for educational and public institutional use (Plate 5.152 and Plate 5.153). The mix in institutional and commercial functions provides diversity in space use that is favourable to the creation of neighbourhoods that are sustainable as it allows users to be present in the space at different times for different reasons.

Wakulima Market: from 1963-2015 commercial use index increased from zero to 3.57 while the institutional use index rose by 36.3% from 7.86 to 10.71. Industrial use index decreased by 100.0% . The residential use index remained at zero over the period (Table 5.9 - Table 5.12).

In 1963 the market area was designated for light industry, open space, religion and cultural use (Figure 5.65). Figure 5.81 indicates that from 1971-2015 the space has been a wholesale fresh produce market. Warehouses present in 1971-2003 had been replaced by smaller storage structures by 2015. From 1971-2003 buildings east of the space were primarily for industrial use. These changed to commercial use by 2015 by which time Muthurwa Market had been built adjacent to the space (Plate 5.155). From 1963-2015 buildings further west served as public institution offices (Plate 5.154). Institutional, warehousing, and industrial uses surrounding the space indicate a mix of uses that is a characteristic of sustainable neighbourhoods. This diversity was exhibited from 1963-2003 and thereafter changed with the removal of warehouses and introduction of commercial uses.

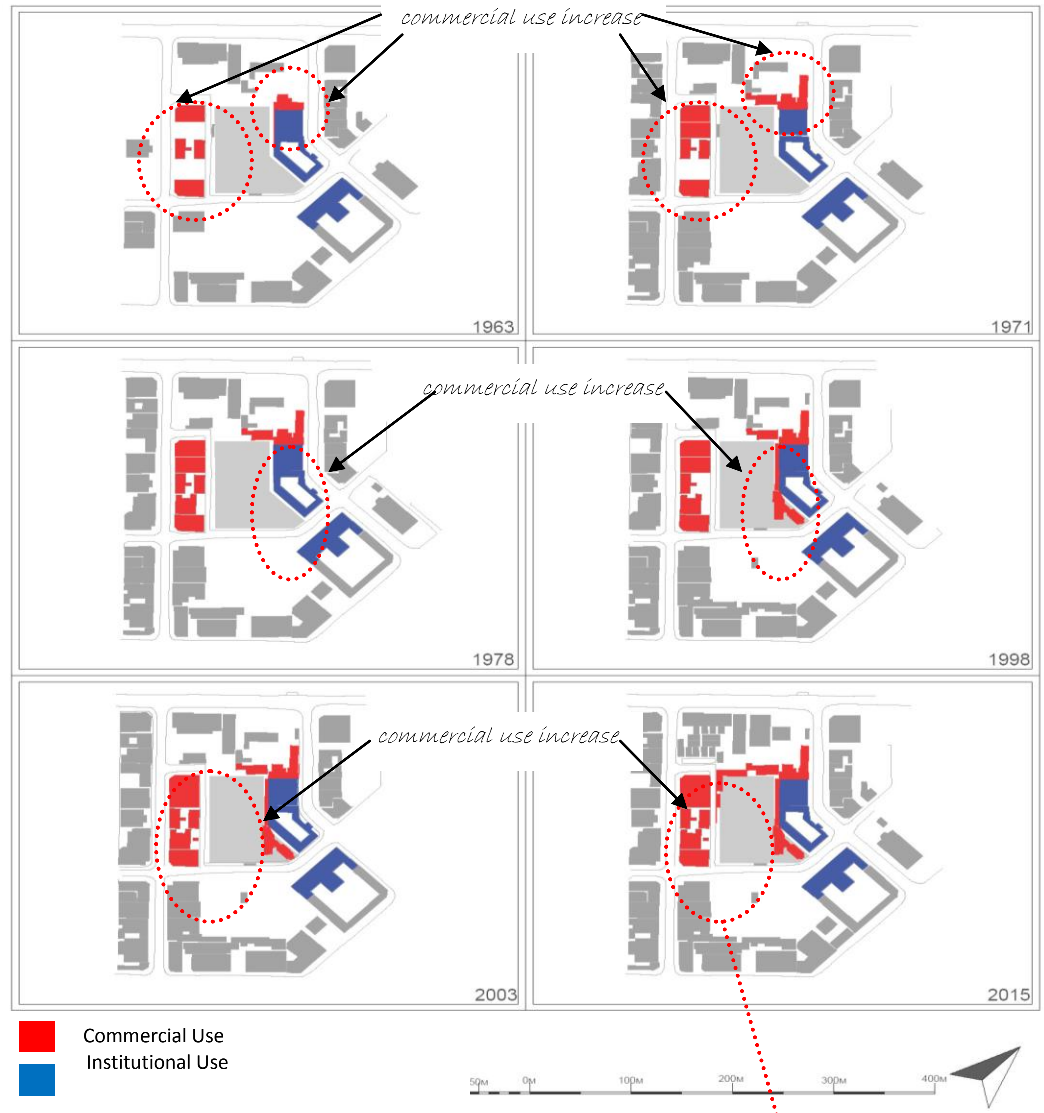


Figure 5.78: KBS Terminus Land Use (1963-2015) **Source: Author**

Plate 5.148: Periphery Stalls at Bus Terminus, 2015 Source: Author

Plate 5.149: Commercial Buildings, KBS Terminus, 2015 Source: Author

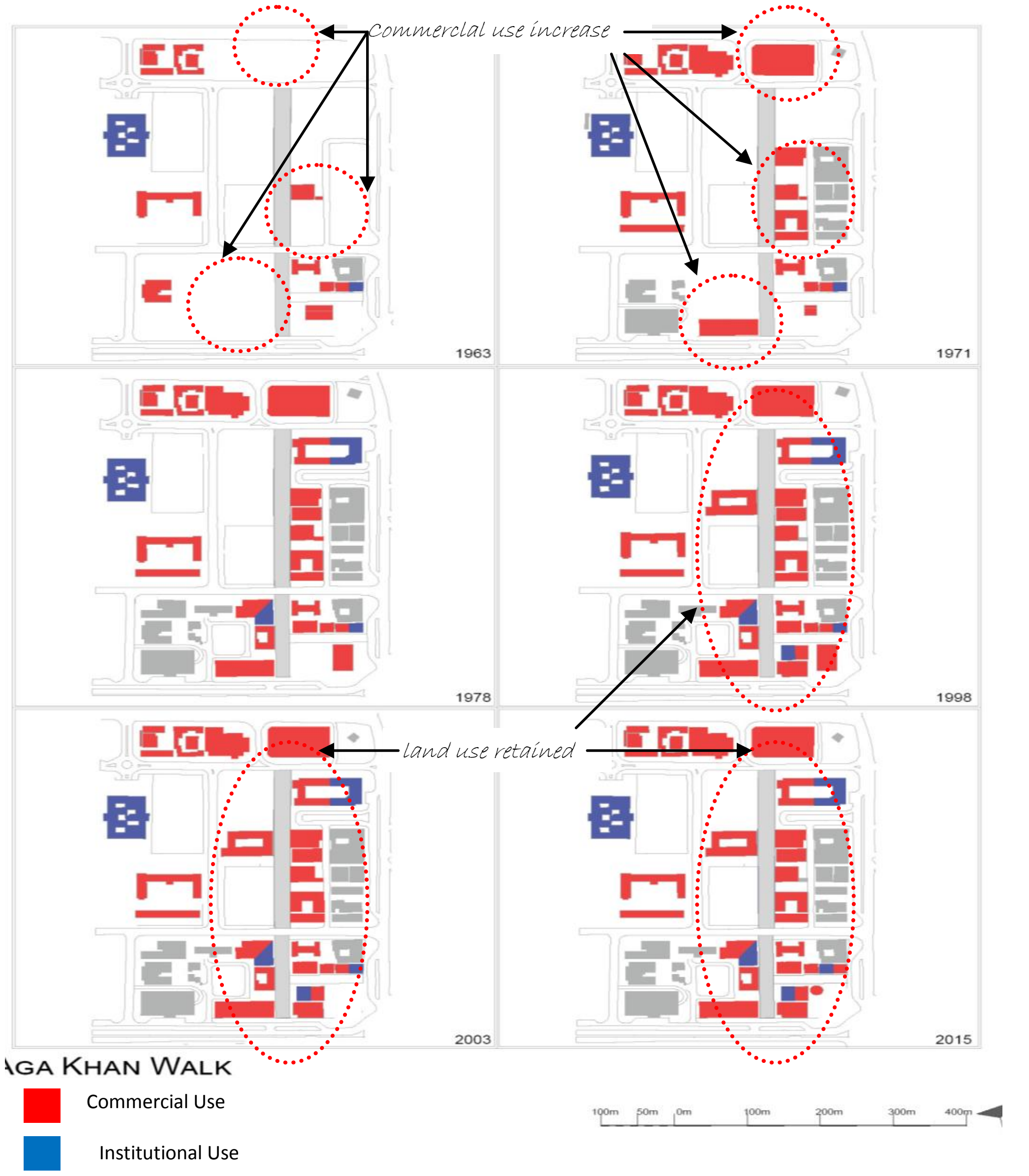


Figure 5.79: Aga Khan Walk Land Use (1963-2015) Source: Author

Plate 5.150: Electricity House at Aga Khan Walk, 2015 Source: Author

Plate 5.151: Supermarket and offices at Aga Khan Walk, 2015 Source Author

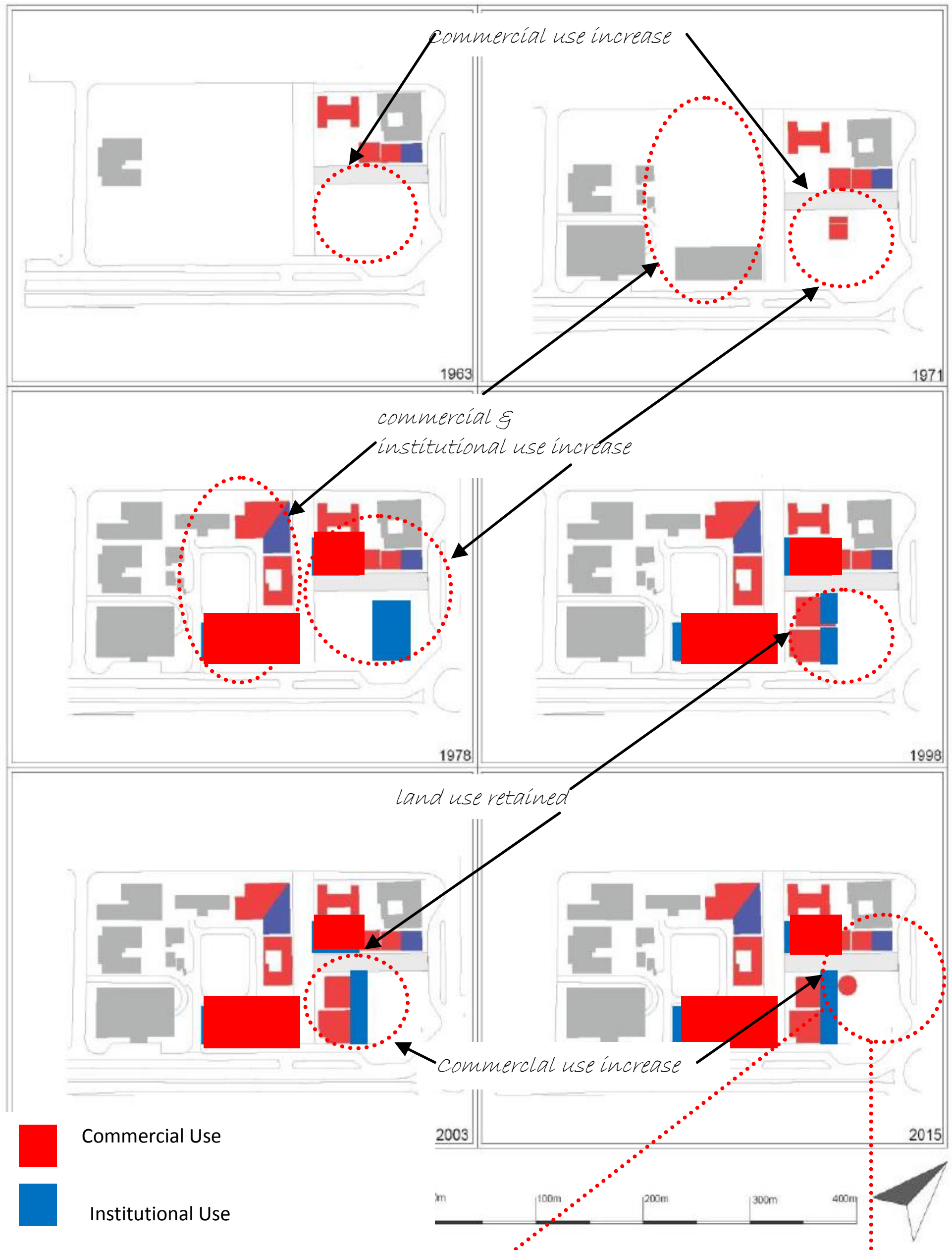
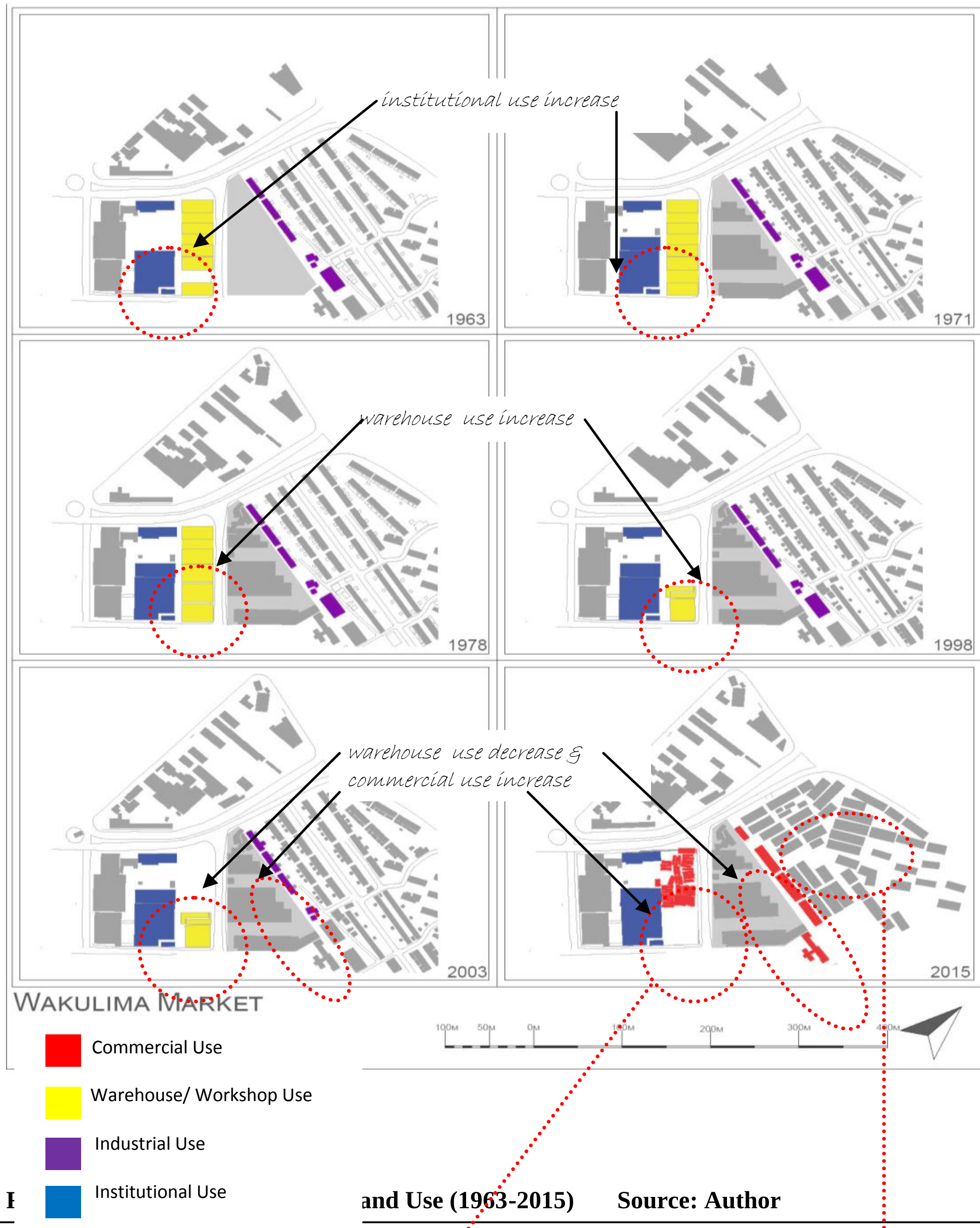


Figure 5.80 National Housing Corporation Walk Land Use (1963-2015)

Plate 5.152: Bank on NHC Walk, 2015
Source: Author

Plate 5.153: Commercial and Institutional Use at NHC Walk, 2015
Source: Author



F and Use (1963-2015) Source: Author

Plate 5.154:Institutional Buildings, 2015

Plate 5.155: Muthurwa Market, 2015

5.2.6 Tree Cover

The sixth variable analysed was the tree cover in the space measured as a percentage ratio estimate of tree canopy area to total space area. Table 5.14 following indicates that 66.7% of the spaces experienced increased tree cover from 1963-2015. Percentage increase ranged from 70.0% for John Michuki Park and Hilton Hotel Circle to 5.0% for Globe Cinema Roundabout and Fire Station Roundabout. 26.7% of the spaces namely Railways Godowns Parking, Railways Bus Terminus, and National Housing Corporation decreased in tree cover by 5.0% over the period, while KBS Terminus did not experience any tree cover change from 1963-2015. Changes in tree cover (1963-2015) for each space have additionally been represented in Figure 5.82 that follows.

Table 5.14: Changes in Tree Cover (1963-2015)

STUDY SPACE/VARIABLE	1963	1971	1978	1998	2003	2015	1963-2015 % change
TREE COVER (% ratio)							
Central Park (CP)	0	0.05	0.1	0.2	0.2	0.35	35.0
Jeevanjee Gardens (JG)	0.6	0.45	0.7	0.7	0.55	0.8	20.0
John Michuki Park (JMP)	0.1	0.1	0.4	0.35	0.2	0.8	70.0
Hilton Hotel Circle (HHC)	0	0.1	0.2	0.35	0.35	0.7	70.0
Globe Cinema Roundabout (GCR)	0	0.2	0.2	0.1	0.1	0.05	5.0
Fire Station Roundabout (FSR)	0	0.1	0.1	0.1	0.1	0.05	5.0
Supreme Courts Parking (SCP)	0	0.05	0.10	0.30	0.35	0.40	40.0
NCC Sunken Parking (NSCP)	0	0.2	0.4	0.5	0.55	0.5	50.0
Railways Godowns Parking (RGP)	0.05	0.1	0.1	0.05	0	0	-5.0
KICC Parking (KP)	0	0.1	0.3	0.2	0.3	0.25	25.0
Railways Bus Terminus (RBT)	0.25	0.45	0.45	0.3	0.1	0.2	-5.0
KBS Bus Terminus (KBT)	0	0	0	0	0	0	-
Aga Khan Walk (AKW)	0.1	0.2	0.2	0.25	0.3	0.4	30.0
National Housing Corporation Walk (NHCW)	0.3	0.1	0.1	0.2	0.25	0.25	-5.0
Wakulima Market (WM)	0.1	0	0	0	0	0	-10.0

Source: Author

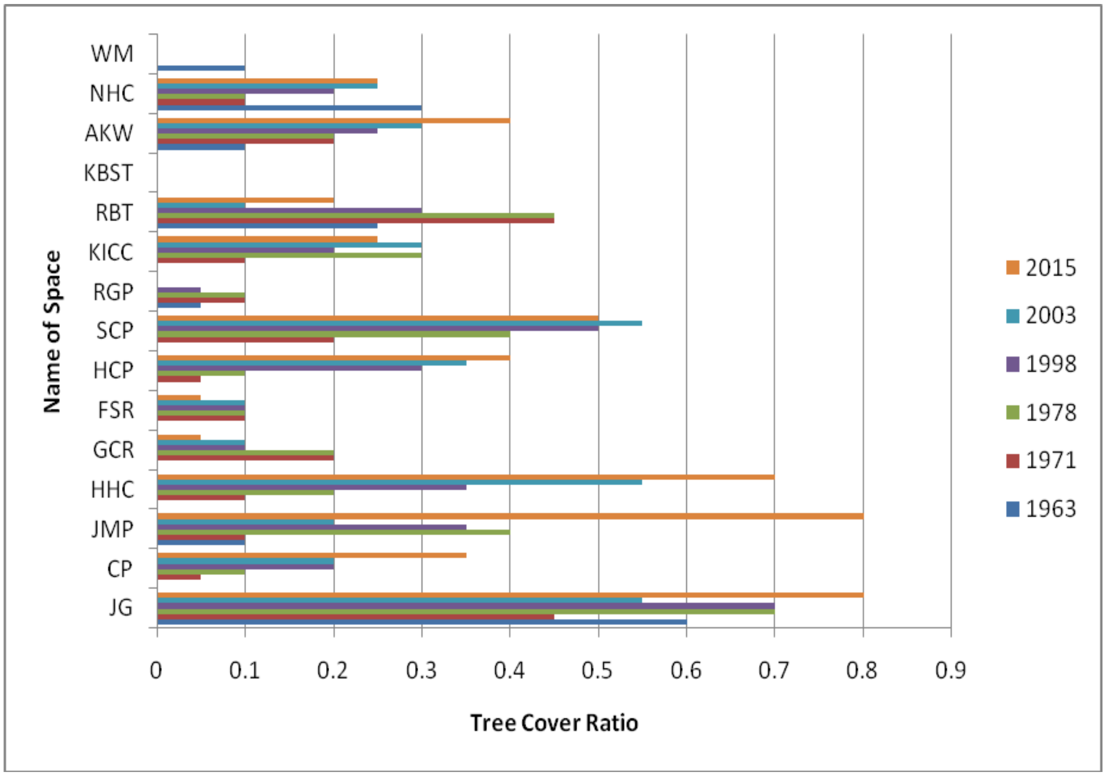


Figure 5.82: Graph of Tree Cover Changes (1963-2015) Source: Author

Table 5.15 following highlights tree cover change for all spaces calculated as averages for each year 1963-2015. Based on the average tree cover of all spaces per year tree coverage increased by 220.0% from 1963-2015. This average change is further captured in Figure 5.83 that follows.

Table 5.15: Table of Tree Cover Averages (1963-2015)

YEAR	AVERAGE SIZE	AVERAGE CONNECTIVITY	AVERAGE ENCLOSURE	AVERAGE DENSITY	**AV. TREE COVER**	AV. COMM INDEX	AV. INSTIT INDEX	AV. RES INDEX	AV. INDST INDEX
1963	12088.2667	7.57E-06	0.022853	2.28836	**0.1**	7.805867	2.918867	0.115533	0.286733
1971	11632.8	9.53E-06	0.030713	2.9934667	**0.15**	15.93193	6.132	0.135533	0.301467
1978	11833.7333	9.42E-06	0.034766	3.5122667	**0.22**	20.3476	9.9348	0.135533	0.3088
1998	11833.7333	9.47286E-06	0.035054	3.8637345	**0.24**	24.99213	10.20187	0.111867	0.2492
2003	11567.0667	9.41486E-06	0.035054	3.9144	**0.24**	25.3528	11.01907	0.111867	0.250533
2015	11667.0667	9.41486E-06	0.035394	4.1724	**0.32**	25.43813	10.84907	0.108533	0.096867
DELTA	-421.2	1.8406E-06	0.0125	1.88	**0.22**	17.6	7.9	-0.007	-0.191
% DELTA	-3.5%	24.3%	54.50%	82.1%	**220.0%**	225.6%	272.4%	-6.03%	-66.6%

Source: Author

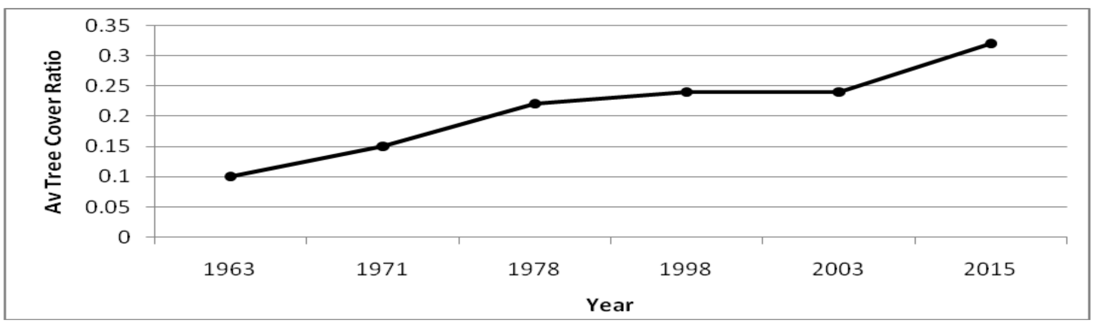


Figure 5.83: Average Tree Cover (1963-2015) Source: Author

Increased tree cover is attributed to maturing of trees enabled by protection of existing natural vegetation and promotion of tree planting by national and local government in public spaces. Key initiatives include the reclamation and greening of John Michuki Park by the Ministry of Water and Natural Resources. Tree canopies increased over the period as trees have matured.

Central Park: Table 5.14 and Plate 5.156 indicate that in 1963 tree cover was zero. From 1971-1998 it coverage increased to 0.2 meaning that the tree canopy covered 20% of the space. Most tree cover was along paths of circulation (Plate 5.157). From 2003-

2015 it further increased to 0.35 with increased canopy to the west of the park along Nyerere Road (Figure 5.84).

John Michuki Park: from 1963-2015 tree cover increased by 70% from 0.1 to 0.8 (Table 5.14). Figure 5.85 indicates that there was an increase from 1963 until 1978 after which coverage declined to 0.2 in 2003. The highest increase occurred from 2003-2015 from 0.2 to 0.8. This was due to the space reclamation project by national government focused on enhancing natural vegetation by cleaning Nairobi River and planting trees (Plate 5.158 and Plate 5.159).

Jeevanjee Gardens: from 1963-2015 tree cover increased by 20% from 0.6 to 0.8 (Table 5.14). As shown in Plate 5.160, in the 1950s the park already had tree cover. Figure 5.86 indicates that in 1963-1971 experienced decrease in tree cover that increased to 0.7 for 1978 and 1998 (Plate 5.161). Cover declined in 2003 then increased to 0.8 in 2015. Notably, from 1963-1978 most increase in canopy occurred along Moktar Daddah St. edge (Plate 5.162). From 2003-2015 foliage also increased along Muindi Mbingu St., Moktar Daddah St., and Moi Ave (Plate 5.163).

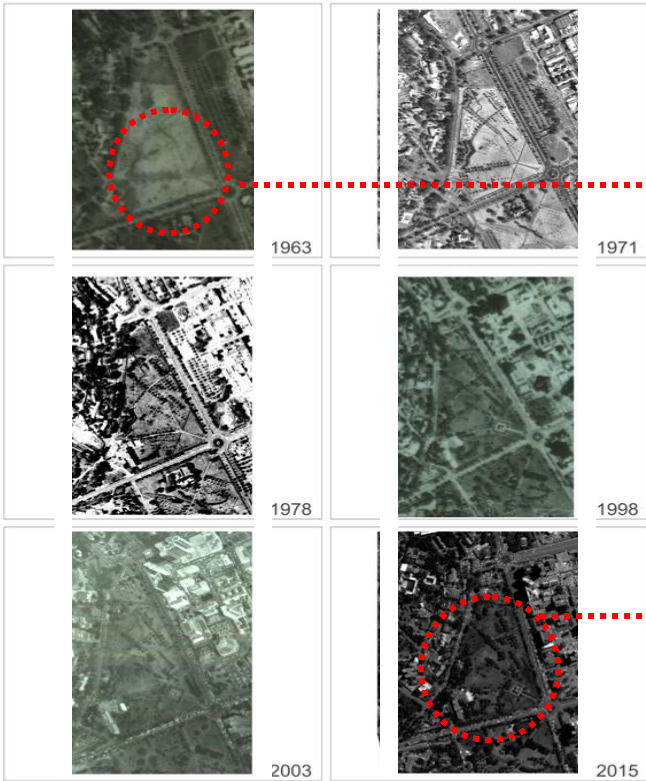


Figure 5.84: Central Park Tree Cover (1963-2015) Author

Plate 5.156: Aerial View of Central Park. 1950s

Plate 5.157: Trees along Paths in Central Park, 2015

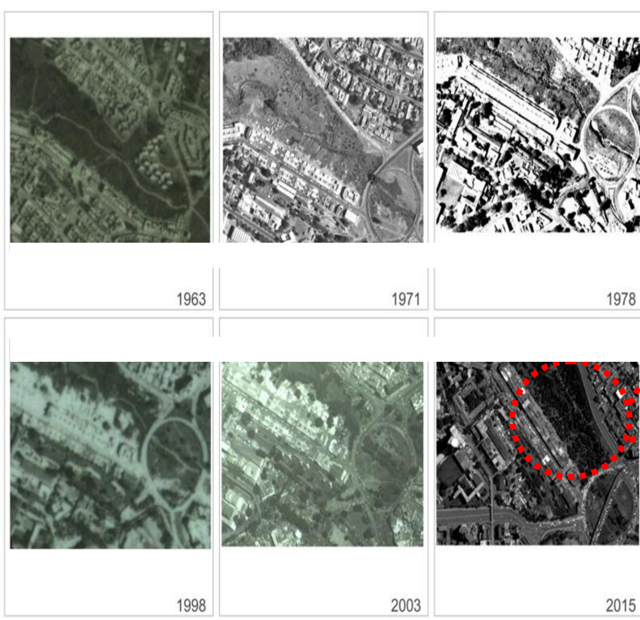


Figure 5.85: John Michuki Park Tree Cover (1963-2015)

Plate 5.158: Trees at John Michuki Park edge, 2015 Source: Author

Plate 5.159: Rehabilitated John Michuki Park, 2015 Source: Author

Plate 5.160: Jeevanjee Gardens Interior, 1956 Source: www.sikhheritage.co.uk

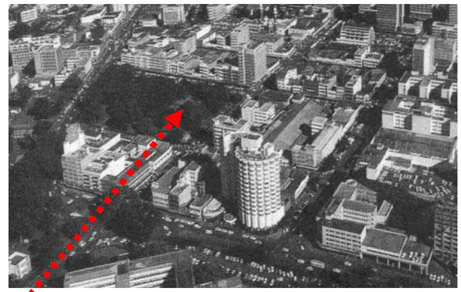


Plate 5.161: Jeevanjee Gardens Aerial, 1989 Source: Nevanlinna, 1996

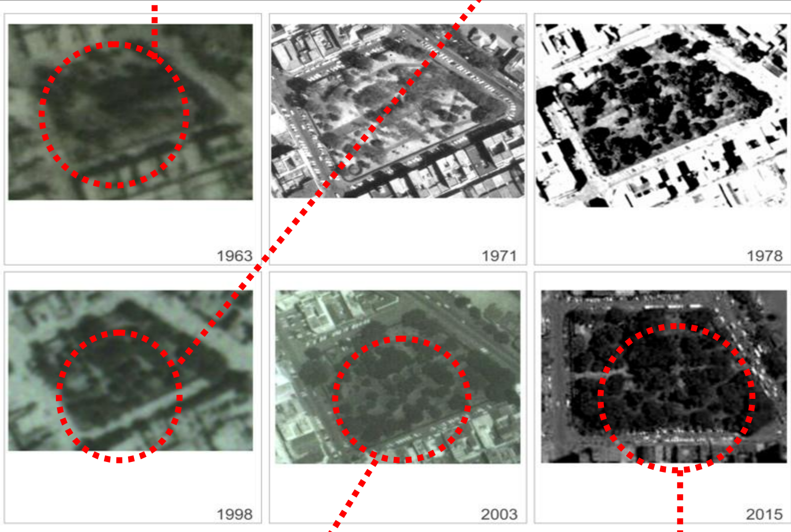


Figure 5.86: Jeevanjee Gardens Tree Cover (1963-2015) Author

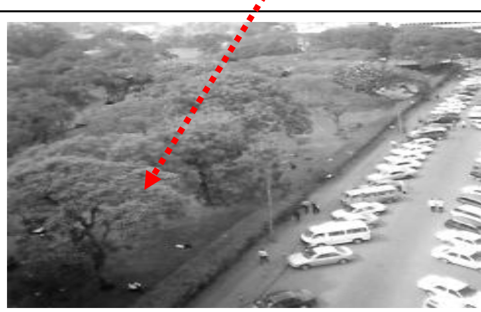


Plate 5.162: Tree Cover along Moktar Daddah St., 2003 Source: Author

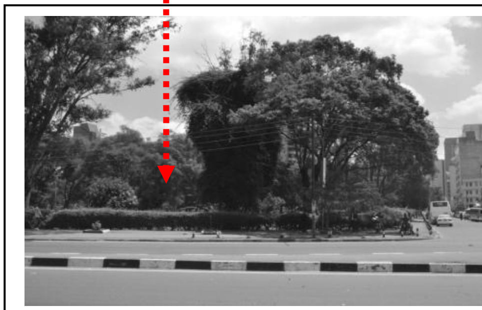


Plate 5.163: Trees in Park at Monrovia Rd., 2015 Source: Author

Hilton Hotel Circle: Table 5.14 and Figure 5.87 indicate tree cover increase of 70% from no tree cover in 1963 to a ratio of 0.7 in 2015 (Plate 5.167). As shown in Plate 5.164 and Plate 5.165 tree cover was limited due to the function of the space as a bus terminus. Tree coverage located on edges of space of Moi Avenue, City Hall Way and Mama Ngina St. doubled from 35% to 70% from 1998 to 2015 (Plate 5.166).

Plate 5.164: Moi Avenue, 1950s Source: www.sikhheritage.co.uk

Plate 5.165: Harding St. Bus Stage, 1967 Source:www.sikhheritage.co.uk

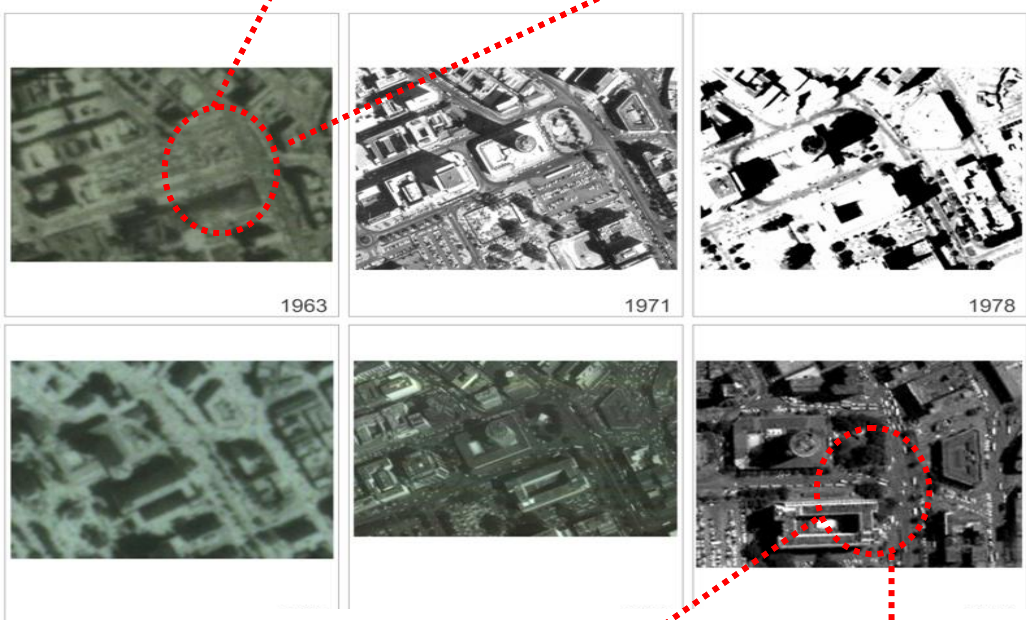


Figure 5.87: Hilton Hotel Circle Tree Cover (1963-2015) Source: Author

Plate 5.166: Trees along Moi Ave, 2015 Source: Author

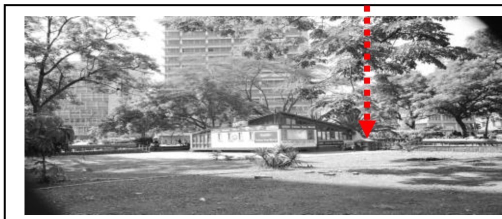


Plate 5.167: Trees in Hilton Hotel Circle, 2015 Source: Author

Globe Cinema Roundabout: Table 5.14 indicates that from 1963-2015 tree cover increased by 5% from 0 to 0.05 mostly along eastern river banks (Figure 5.88 and Plate 5.169). Greenery is in stark contrast to foliage of neighbouring John Michuki Park whose a ratio increased from 0.1 in 1963 to 0.8 in 2015. In the early 1960s and 1970s, part of the roundabout was used as a playground for soccer and cricket while in 2015 the space was used for recreation and as parking for buses (Plate 5.168).

Fire Station Roundabout: from 1963-2015 tree cover increased by 5% from 0 to 0.05 (Table 5.14 and Figure 5.89). As shown in Plate 5.170 and Plate 5.171 sparse tree cover occurs on the west edge of the space near Murang's Rd and Tom Mboya Street. Due to its function as a PSV transport hub with parking bays, sitting areas, and movement of vehicles, tree cover has been necessarily low over the period.

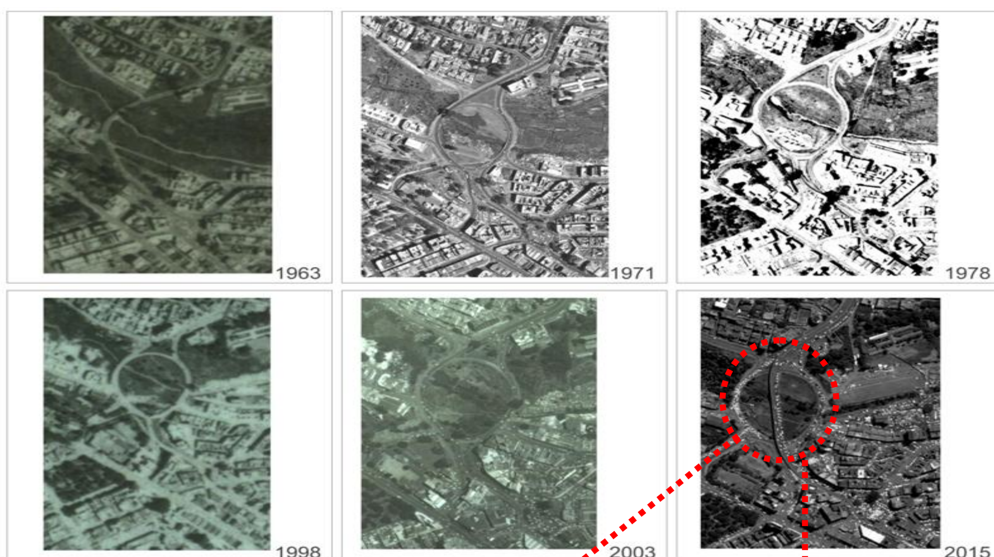


Figure 5.88: Globe Cinema Roundabout Tree Cover (1963-2015Source: Author

Plate 5.168: Bus parking in Globe Cinema Roundabout, 2015
Source: Author

Plate 5.169: Trees along riverbank at Globe Cinema Roundabout, 2015
Source: Author

Plate 5.170: Trees at Fire Station Roundabout, 2015 Source: Author

Plate 5.171: Trees along Tom Mboya St., 2015 Source: Author

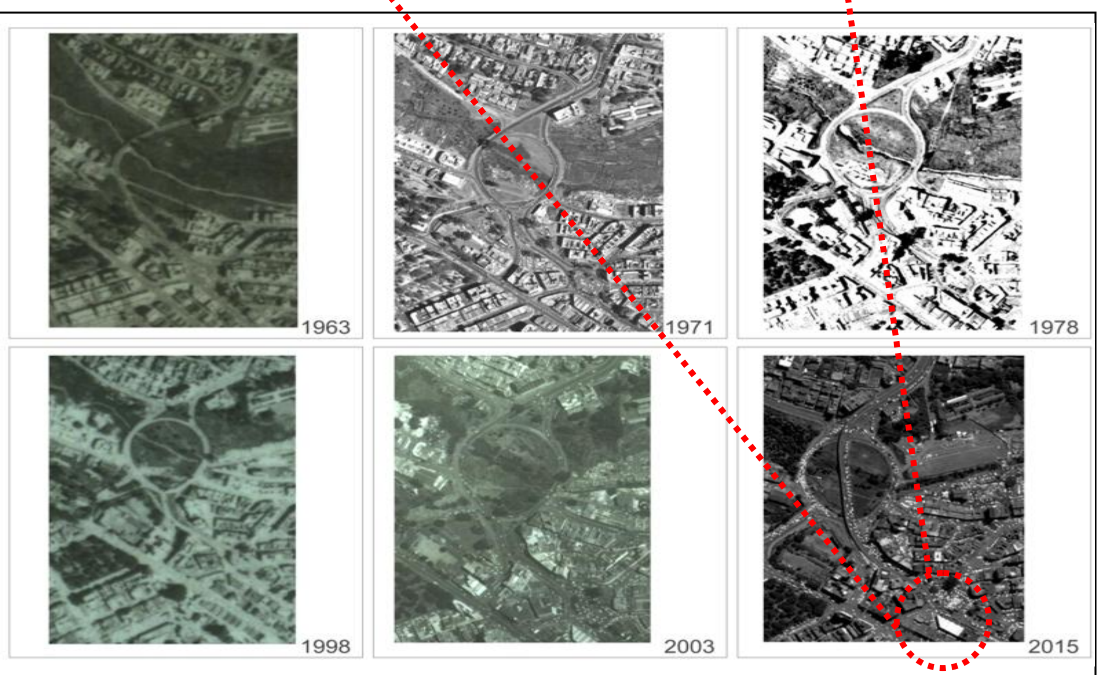


Figure 5.89 Fire Station Roundabout Tree Cover (1963-2015) Source: Author

Supreme Courts Car-park: Table 5.14 and Figure 5.90 indicate tree cover increase of 40% from no tree cover in 1963 to 0.40 in 2015. Tree planting occurred in rows along parking bays in the centre of the space and at the edges on City Hall Way and Taifa Rd (Plate 5.172 and Plate 5.173).

Sunken Car-park: tree cover increased from zero in 1963 to 0.55 in 2003 after which it decreased to 0.5 in 2015 (Table 5.14 and Figure 5.90). Most trees are located and lined in the mid section of the space with less vegetation on Harambee Rd edge (Plate

5.174). As shown in Plate 5.175, tree canopies provide shade for people sitting on car-park low walls, along Aga Khan Walk, and vendors during the weekend market.

KICC Parking: Table 5.14 and Figure 5.91 indicate 25% increase in tree cover from 0 to 0.25 (1963-2015). As shown in Plate 5.176, in the 1950s the area at KICC Plaza was covered in natural vegetation. In 1971 rows of trees had been planted along City Hall Way edge (Plate 5.177 and Plate 5.178). By 2003 tree canopy had matured and additional trees were planted at the south edge and space centre. In 2015 tree cover reduced from 0.3 in 2003 to 0.25 due to increased parking area, most of which was along Parliament Rd (Plate 5.179).

Plate 5.172: Trees along Taifa Rd., 2015 Source: Author

Plate 5.173: Trees in Supreme Courts Parking, 2015 Source: Author

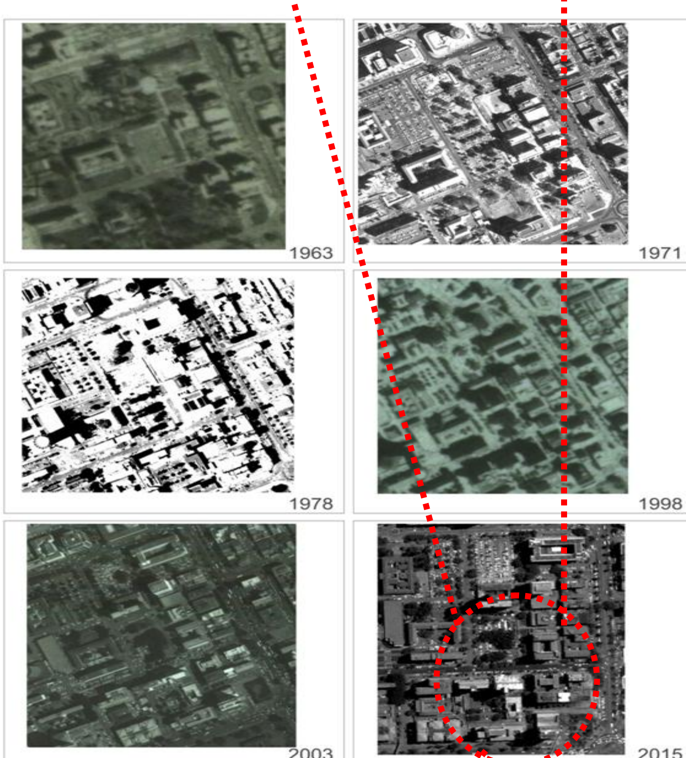


Figure 5.90: Supreme Courts & Sunken Car-park Tree Cover (1963-2015) Source: Author

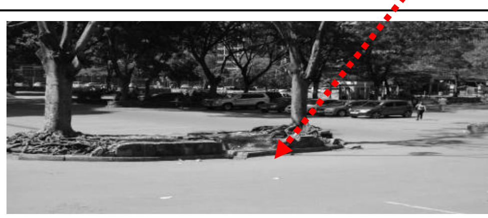


Plate 5.174: Trees in Sunken Car-park mid section, 2015 Source: Author

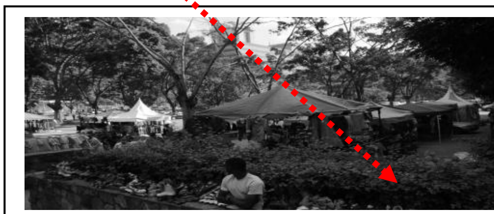


Plate 5.175: Tree Cover, weekend market at Sunken Car-park, 2015 Source: Author

Plate 5.176: Law Courts, 1955 Source: www.pinterest.com

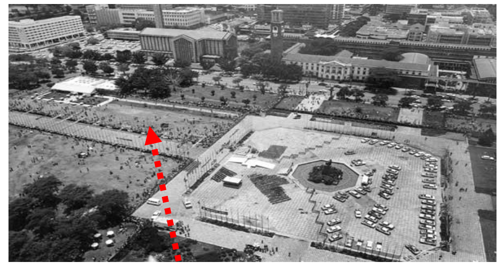


Plate 5.177: Trees at KICC Grounds and Plaza, 1970s www.sikhheritage.co.uk

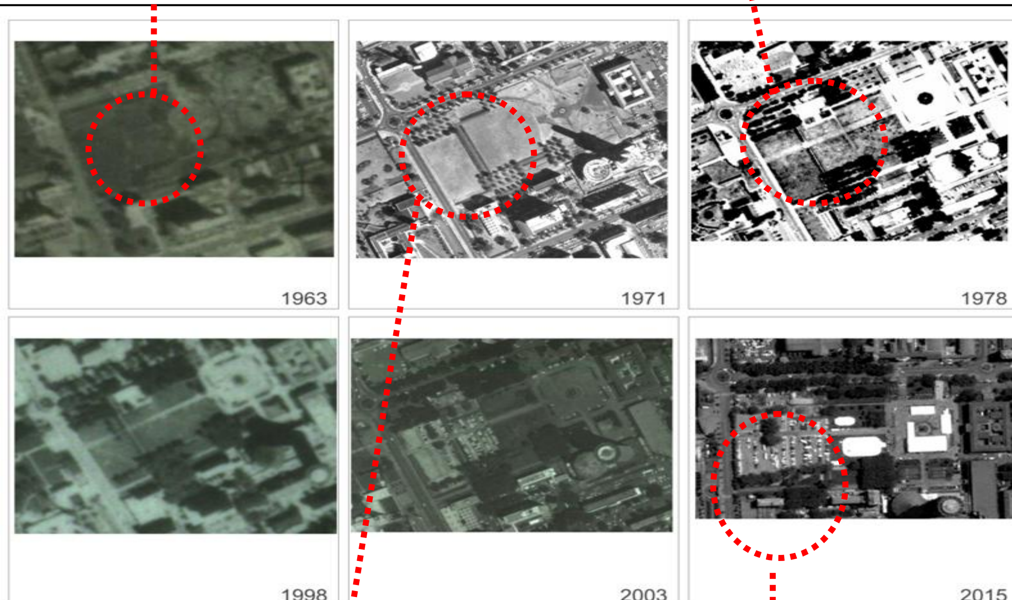


Figure 5.91: KICC Parking Tree Cover (1964-2015) Source: Author

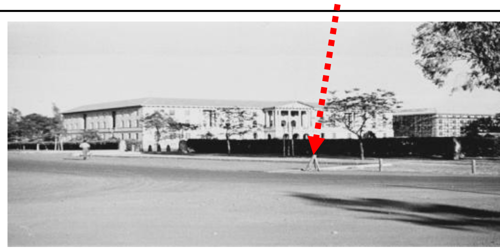


Plate 5.178: Law Courts
Source: www.sikhheritag.co.uk

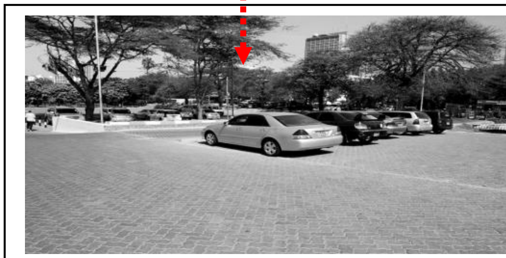


Plate 5.179 Trees in KICC Car-park, 2015
Source: Author

Railways Bus Terminus: adjacent to the Railways Godowns Parking, the terminus also decreased in tree cover decreased by 5% from 0.25 to 0.2 (Table 5.14 and Figure 5.92). Pre-1963 the green island in the bus terminus area had maintained gardens (Plate 5.180 and Plate 5.181). As shown in Plate 5.182, the area outside the Railway Station entrance had no tree cover. Tree coverage rose to a high of 0.45 in 1971 and 1978, declining to a low of 0.1 in 2003. Thereafter there was increased tree canopy from 2003-2015 (Plate 5.183).

Railways Godowns Parking: from 1963-2015 tree cover decreased by 5% from 0.05 to 0 (Table 5.14). Figure 5.92 indicates that from 1963-2003 majority of the space was occupied by the railway warehouse with trees on the west edge between the space and the Railways Bus Terminus. Haile Selassie Ave also displayed some tree cover. This greening increased from 1963-1978 and declined thereafter until 2015 to zero.

KBS Terminus: Table 5.14 and Figure 5.93 indicate that from 1963-2015 tree cover was unchanged and recorded at zero, influenced by the space function as a transportation hub. Bus parking is located in the centre and east of the space alongside commuter shelters and public toilets (Plate 5.184 and Plate 5.185).

Aga Khan Walk: Table 5.14 and Figure 5.94 indicate a rise in tree cover of 30% from 0.1 in 1963 to 0.4 in 2015. As shown in Plate 5.186, the Aga Khan Walk area was covered in natural vegetation prior to 1963. As shown in Plate 5.187, the section of the Walk near City Hall Way has had majority of the tree cover over the period, with additional coverage on both sides of the Harambee Avenue junction.

National Housing Corporation Walk: from 1963-2015 tree cover decreased by 5% from 0.3 to 0.25 (Table 5.14 and Figure 5.94). Coverage declined from 1963-1978 and increased thereafter until 2015. All trees are planted in a green island and majority of coverage has been to the east of the space towards its intersection with Aga Khan Walk (Plate 5.188).

Plate 5.180: Tree Cover at Railways HQ Area, 1950s
Source: www.skyscrapercity.com

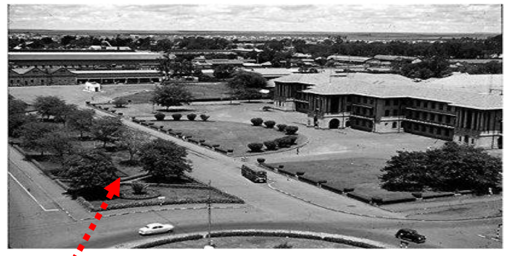


Plate 5.181: Gardens outside Railway Headquarters
Source: www.mcgrow.org.uk

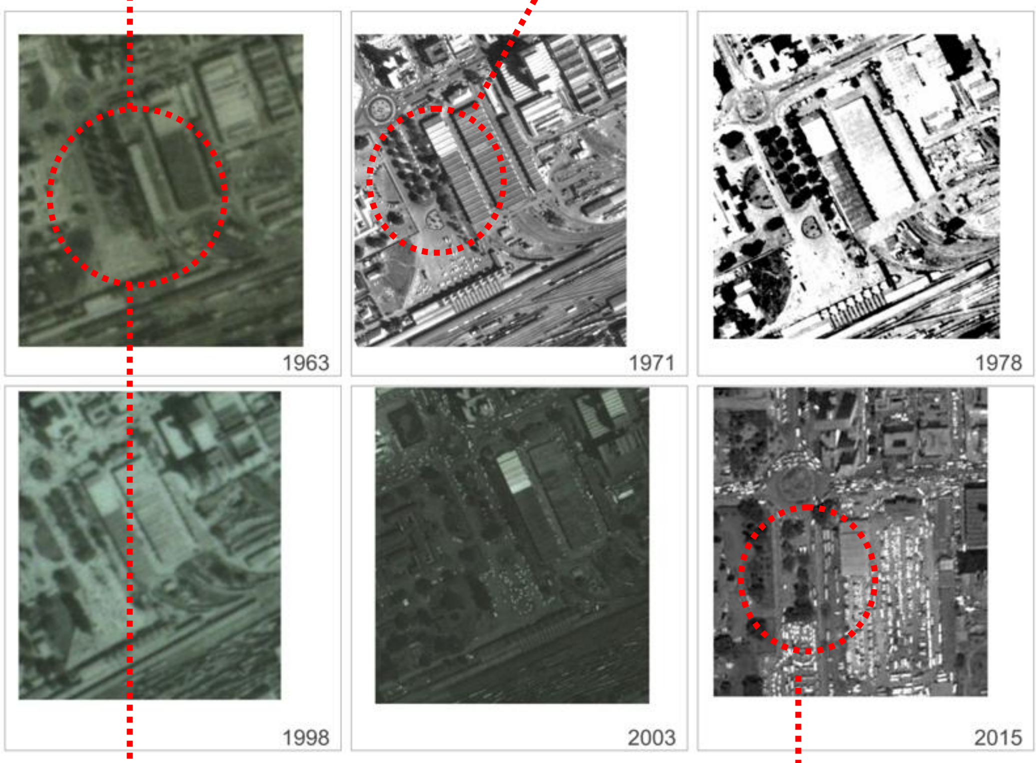


Figure 5.92: Railways Godowns Parking & Bus Terminus Tree Cover (1963-2015) Author

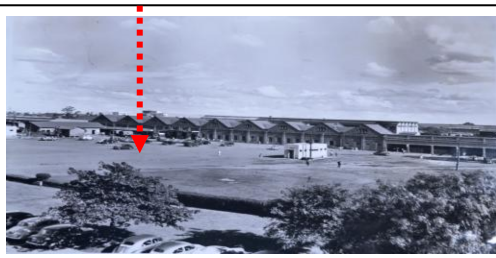


Plate 5.182: Railway Station tree cover, pre-1963 Source: www.mcgrow.org.uk

Plate 5.183: Trees at Railways Bus Terminus, 2015 Source: Author

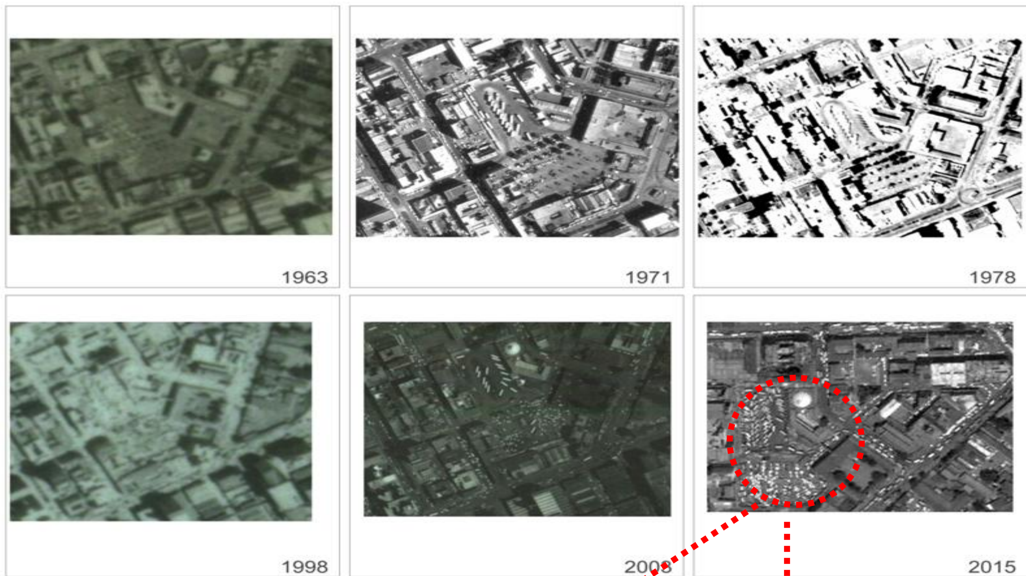


Figure 5.93: KBS Terminus Tree Cover (1963-2015) **Source: Author**

Plate 5.184: No Tree Cover KBS Terminus, 2015 Source: Author

Plate 5.185: Commuter Shelters at KBS Terminus, 2015 Source: Author

Plate 5.186: Tree Cover in Aga Khan and National Housing Corporation Walk Area, 1950s
Source: www.skyscrapercity.com

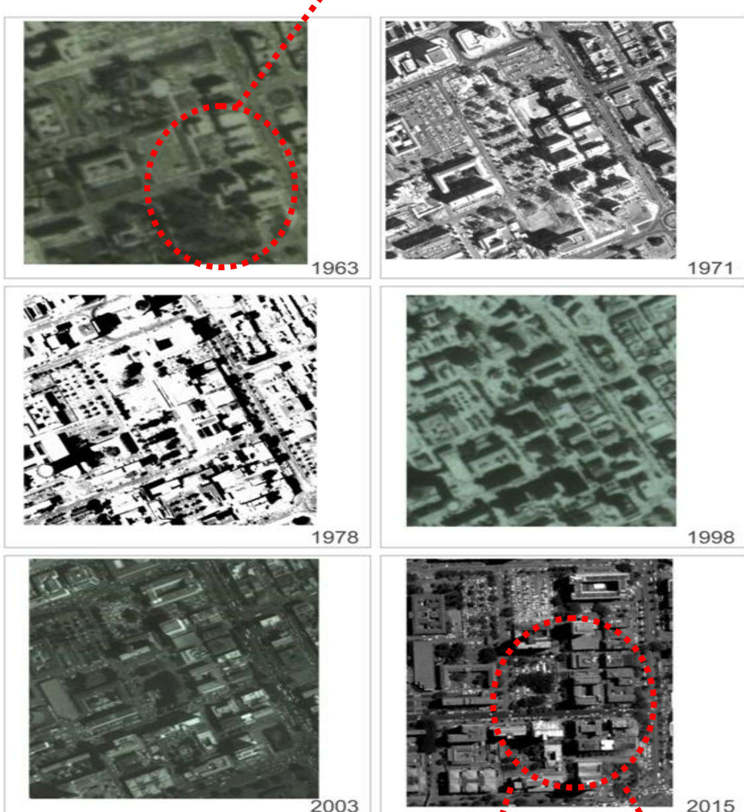


Figure 5.94: Aga Khan & National Housing Corporation Walks (1963-2015) **Source: Author**

Plate 5.187: Trees in Aga Khan Walk, 2015
Source: Author

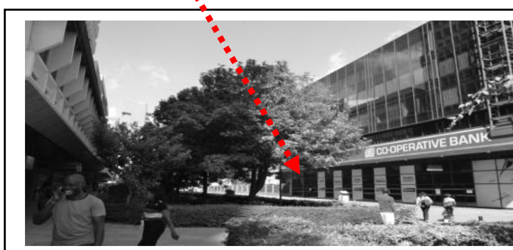


Plate 5.188: Trees in National Housing Corporation Walk, 2015 **Source: Author**

Wakulima Market: Table 5.14 and Figure 5.95 indicate that from 1963-2015 tree cover in the space was unchanged and recorded at zero (Plate 5.190). This is because the market has had hard surface floors and has been sheltered by concrete canopies since 1963 (Plate 5.189).

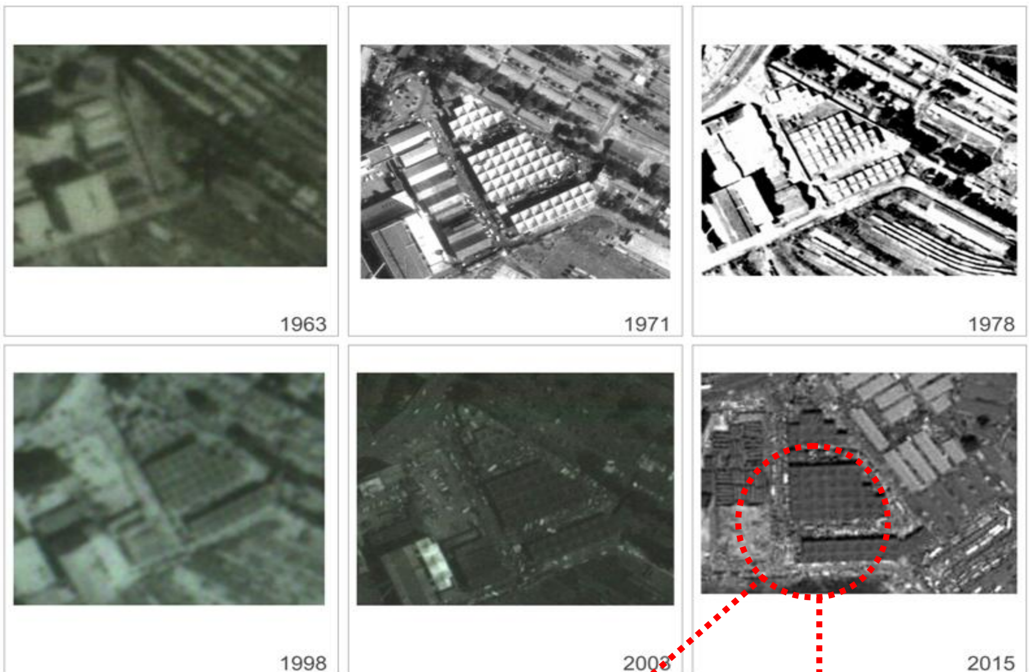


Figure 5.95: Wakulima Market Tree Cover (1963-2015) Source: Author

Plate 5.189: Wakulima Market Canopies, 2015 Source: Author

Plate 5.190: Wakulima Market Access Road, 2015 Source: Author

5.3 Determinants of Sustainability

This section is focused on analysis of the four models of sustainability. Its structure and content target the second research objective that deals with the establishment of the social, economic, environmental, and governance factors that have contributed to the sustainability of public open spaces in the CBD. As indicated in the models that follow, the dependent variables were determined as the number of users of space (social sustainability), number of retail shops in space (economic sustainability), area covered by grass (environmental sustainability) and level of cleanliness of space (governance sustainability).

SPSS was used to generate the models of sustainability. Before performing any parametric test, the data in the four models was subjected to tests to prove that the assumptions made by parametric tests are not violated. The tests included observation that the data is continuous, that is, dependent variable is measured on a continuous scale. Also conducted were normality tests (using the Shapiro Wilk's Test), which was performed to test whether the dependent variables of the four models followed a normal distribution. Testing for multi-collinearity (high correlation of the independent variables) was also carried out. In all the four models, a correlation test was conducted on the independent variables to check for multi-collinearity. No multi-collinearity was found, thus the independence assumption was not violated.

From the comprehensive literature review conducted, the four measures of sustainability were identified (dependent variables). These were number of users (social), area of grass in space (environmental), number of retail shops in space (economic), and cleanliness of space (governance).

Using all variables, a Pearson Correlation Coefficients table (two-tailed significance) was generated. Acting as independent variables, variables with strong and significant correlations with the identified dependent variable were used to generate each regression model. This was done for each dependent variable using the enter method. In the Enter Method all variables are entered at once for which a model summary, ANOVA table, and coefficient of determinants table are produced. Data in these three outputs then informed the models for each aspect of sustainability.

5.3.1 Social Sustainability

Under Social Sustainability, a multiple linear regression was performed with Number of services in Facing Ground floors, Number of Connector to Space and the Number of Users of Sidewalks as the predictors and Number of User Space as the dependent variable. Using the enter method, the first output was the model summary (Table 5.16), which informed regarding fitness of the model. Therein R=multiple regression coefficient; R-Square (R^2)=coefficient of determination; Adjusted R-Square (R^2)=adjusted coefficient of determination. The findings in table below indicated that the predictor variables (Number of services in Facing Ground floors, Number of Connector to Space and the Number of Users of Sidewalks) significantly predicted the dependent variable (Number of User Space). Adjusted R^2= 85.7% which implied that 85.7% of variation of Number of User of Space was explained by the predictor variables.

Table 5.16: Social Sustainability Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.942	.888	.857	.2077299

Source: Author from SPSS

Following the model summary, the second output called the Analysis of Variance (ANOVA) was used to determine whether the model was significant in predicting the number of users of space. Table 5.17 following indicated that at 0.05 level of significance, the model significantly predicted Number of Users of Space, where F (3,11) =28.996; and p=0.0001 (which is less than 0.05).

Table 5.17: ANOVA for Social Sustainability

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	3.754	3	1.251	28.996	.0001
1	Residual	.475	11	.043		
	Total	4.228	14			

Source: Author from SPSS

The third output was the Coefficients of Multiple Determinations of the Variables table (Table 5.18). This showed which independent variables were individually significant predictors of the dependent variable. From the following table, the Number of Services in Facing Ground Floors and Number of Connector to Space were found to be significant predictors of the Number of Users of Space as indicated by the p-values 0.005 ($p=0.005<0.05$) and 0.007 ($p=0.007<0.05$) respectively. However, the Number of Users of Sidewalks was found to be a non-significant predictor of the Number of Users of Space as indicated by the p-value 0.064 ($p=0.064>0.05$).

The predicted regression model was given as follows:

$$Y_1= -0.017+11.942X_1+0.\ 228X_2+0.\ 059X_3 +€$$

Equation 5.1: Social Sustainability Regression Model   Source: Author

Where Y_1 was the dependent variable (Number of Users of Space), $X_1$was the Number of Services in Facing Ground Floors, X_2 was the Number of Connectors to Space, and X_3 was the Number of Users of Sidewalks (the independent variables).

Table 5.18: Coefficients of Multiple Determinations of Variables for Social Sustainability

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-.017	.079		-.216	.833
No of Services in Facing Ground Floors	11.942	3.462	.498	3.449	.005
No of Connectors to Space	.228	.068	.429	3.340	.007
No of Users of Sidewalks	.059	.029	.242	2.063	.064

Source: Author from SPSS

A similar process of analysis was used to determine the predictors for environmental, economic, and governance sustainability. The respective model summaries, coefficients of multiple determinations of variables, and regression models have been recorded hereafter.

It is noteworthy that in multiple linear regressions the actual regression model is of the form: $Y=B_0+B_1X_1+B_2X_2+.....B_nX_n+€$, while the predicted model which is also called the expected model (of the actual model) is of the form: Ypredicted = $\beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3$

The error in the regression model (€) is the deviation of the predicted score from the raw score of a quantity of interest. This can be illustrated as follows: taking an original model to be $Y=B_0+B_1X+€$ and a predicted (expected) model to be $\hat{Y}=b_0+b_1X$, then the error term is given as $€=Y-\hat{Y}$. Note that the € is normally distributed with mean 0 and variance σ^2 ($€ \sim N(0, \sigma^2)$), therefore, the error term becomes zero in the predicted model (Kutner, Nachtsheim, Neter, & Li, 2005). Standard Error of the Estimate as indicated in the model summary tables is the standard deviation of the error term and thus not the error for the regression model.

5.3.2 Economic Sustainability

Under Economic Sustainability, a multiple linear regression was performed with the Number of Retail Shops in Space as the dependent variable, and the Number of Users of Space, the Number of Service Businesses in Space, and the Number of Retail Shops in Facing Ground Floors as the predictor variables. According to Table 5.19 following, the value of Adjusted R-Square was found to be 0.994 implying that 99.4% of variation of the dependent variable (Number of Retail Shops in Space) was explained by the predictor variables.

Table 5.19: Economic Sustainability Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.999	.998	.994	.10680

Source: Author from SPSS

Following the model summary, an ANOVA was used to determine whether the model was significant in predicting the Number of Retail Shops in Space. Table 5.20 following showed that at 0.05 level of significance the model significantly predicted Number of Retail Shops in Space, where F (3,1) =211.480; and p=0.049 (which is less than 0.05).

Table 5.20: ANOVA for Economic Sustainability

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	7.236	3	2.412	211.480	.049
1	Residual	.011	1	.011		
	Total	7.247	4			

Source: Author from SPSS

From Table 5.21, the Coefficients of Determinations of the Variables table again showed which independent variables were individually significant predictors of the dependent variable. The Number of User of Space was found to be a significant predictor of the Number of Retail Shops in Space as indicated by the p-value 0.036 ($p=0.036<0.05$). The Number of Service Businesses in Space was not a significant predictor as indicated by the p-value of 0.056 ($p=0.056>0.05$). Finally, the Number of Shops in Facing Ground Floors was also found to be a non-significant predictor as indicated by a p-value of 0. 099 ($p=0.099>0.05$).

The predicted model was given as follows:

Y_2 predicted= $-12.286+2.314X_1+-1.317X_2+0.454X_3+€$

Equation 5.2: Economic Sustainability Regression Model Source: Author

Where Y_2 was the dependent variable (Number of Retail Shops in Space), $X_1$was the Number of Users in Space, X_2 was the Number of Service Businesses in Space and X_3 was the Number of Shops in Facing Ground Floors.

Table 5.21: Coefficients of Multiple Determinations of Variables for Economic Sustainability

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-12.286	.413		-29.724	.021
No. of Users of Space	2.314	.132	2.467	17.497	.036
No. of Business in Space	-1.317	.116	-1.993	-11.312	.056
No. of Ret Shops in Facing Ground Floors	.454	.071	.527	6.384	.099

Source: Author from SPSS

5.3.3 Environmental Sustainability

Under Environmental Sustainability, a multiple linear regression was performed with Area of Grass in Space as the dependent variable, and Area of Space and the Longest

Distance of Space as the independent or predictor variables. According to 5.22 following, 94.4% of variation in the dependent variable (Area of Grass in Space) was explained by the predictor variables (Area of Space and the longest distance of space).

Table 5.22: Environmental Sustainability Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.983	.966	.944	.10633

Source: Author from SPSS

An ANOVA was used to determine whether the model was significant in predicting the Area of Grass in Space (Table 5.23). The table indicated that at 0.05 level of significance, the model significantly predicted the Area of Grass in Space, where F (2,13) =43.212; and p=0.006 (which is less than 0.05).

Table 5.23: ANOVA for Environmental Sustainability

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.977	2	.489	43.212	.006
	Residual	.034	3	.011		
	Total	1.011	5			

Source: Author from SPSS

From Table 5.24 the coefficients of the predictor variables were deduced and the model given as follows:

Y_3 predicted= $-3.035+0.463X_1-0.381X_2+€$

Equation 5.3: Environmental Sustainability Regression Model Source: Author

Where, Y_3 was the dependent variable (Area of Grass in Space), X_1 was the Area of Space and X_2 was the Longest Distance of Space (the independent variables).

From the coefficients of determinations of the variables at 95% level of confidence, both independent variables were found to be significant in predicting Area of Grass in Space as indicated by p-values (0.003<0.05 and 0.042<0.05) for Area of Space and Longest Distance in Space respectively.

Table 5.24: Coefficients of Multiple Determinations of Variables for Environmental Sustainability

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-3.035	.445		-6.827	.006
Area of Space	.463	.053	1.239	8.709	.003
Longest distance of Space	-.381	.112	-.485	-3.408	.042

Source: Author from SPSS

5.3.4 Governance Sustainability

Under Governance Sustainability, a multiple linear regression was performed with Cleanliness of as the dependent variable, and Proximity of Space to PSV Stage, Number of Parking Spaces in Space, and the Area of Paved Pathways in Space as the independent variables. According to Table 5.25 that follows, the value of Adjusted R-Square was 0.413 implying that 41.3% of variation of the dependent variable was explained by the predictor variables.

Table 5.25: Governance Sustainability Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.734	.539	.413	.69740

Source: Author from SPSS

The second output (ANOVA), was used to determine whether the model was significant in predicting Cleanliness of Space. Table 5.26 showed that at 0.05level of significance, the model significantly predicted Cleanliness of Space, where $F(3,11) = 4.283$; and $p=0.031$ (which is less than 0.05).

Table 5.26: ANOVA for Governance Sustainability

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.250	3	2.083	4.283	.031
	Residual	5.350	11	.486		
	Total	11.600	14			

Source: Author from SPSS

From the Coefficients of Determinations of the Variables table (Table 5.27) the Proximity of Space to PSV Stage was found to be a significant predictor of the dependent variable Y_4 (Cleanliness of Space) as indicated by the p-value 0.024 ($p=0.024<0.05$). The Number of Parking Spaces in Space was not a significant predictor as indicated by the p-value of 0.068 ($p=0.068>0.05$). Also, the Area of Pathways in Space was found to be a non-significant predictor as indicated by a p-value of 0. 977 ($p=0.977>0.05$).

The predicted model was given as follows:

$$Y_4 \text{ predicted} = 2.690 - 0.016X_1 + 4.020X_2 + 0.003X_3 + €$$

Equation 5.4: Governance Sustainability Regression Model   Source: Author

Where Y_4 was the dependent variable (Cleanliness of Space), and $X_1$was the Area of Paved Pathways in Space, X_2 was the Number of Parking Spaces in Space and X_3 was the Proximity of Space to PSV stage (independent variables).

Table 5.27: Coefficients of Multiple Determinations of Variables for Governance Sustainability

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2.690	.283		9.519	.000
Area of Paved Pathways in Space	-.016	.534	-.008	-.029	.977
No of Parking Spaces in Surrounding Space	4.020	1.985	.453	2.025	.068
Proximity of Space to PSV Stage	.003	.001	.663	2.627	.024

Source: Author from SPSS

5.4 Relationship between Spatial Evolution and Sustainability

In order to establish the relationship between spatial evolution and sustainability of public open spaces in the CBD (research objective 3), another set of dependent and independent variables were identified based on data for the period (1963-2015). The dependent variables served as indicators for sustainability as follows:

$Y_{1\ (1963\text{-}2015)}$ = density (social sustainability);

$Y_{2\ (1963\text{-}2015)}$ = index of commercial buildings (economic sustainability);

$Y_{3\ (1963\text{-}2015)}$ = tree cover in space (environmental & governance sustainability).

Correlations deal with linear relationships between variables. Using SPSS, correlations were determined and used to explain the relationships between the dependent and independent variables for each space thus showing the connection between evolution and sustainability.

Table 5.28 following shows averages of aforementioned dependent variables from 1963-2015. Over the period there was an increase in density, index of commercial buildings, and tree cover. Density, index of commercial buildings, and tree cover are indictors for social sustainability, economic sustainability, and environmental/governance sustainability respectively. These variables that are determinants of spatial evolution have displayed an overall increase from 1963-2015. This increase indicates an increase in sustainability because of the link between evolution and sustainability that is articulated following.

Table 5.28: Averages and Percentage Change of Dependent Variables (1963-2015)

YEAR	AVE RAGE DENSITY	AVERAGE TREE COVER	AVERAGE COMMERCIAL USE INDEX
1963	2.29	0.1	7.81
1971	3.00	0.15	15.93
1978	3.51	0.22	20.35
1998	3.86	0.24	24.99
2003	3.91	0.24	25.35
2015	4.17	0.32	25.44
DELTA	1.88	0.22	17.60
% DELTA	82.1%	220.0%	225.6%

Source: Author

5.4.1 Relationships between Dependent and Independent Variables

Values of the dependent and independent variables for each space were tabulated according to year to indicate the changes that occurred over the period 1963-2015 (Annex 1). Correlations between dependent and independent variables were identified for all spaces for each year using correlation tables from SPSS. Using Pearson's Correlation the relationship between the dependent variables (density, commercial use, and tree cover) and each individual independent variable was determined and tabulated for each year (Annex 2). Strong, positive, significant correlations and strong, negative, significant correlations between variables were highlighted in Table 5.9 following. Therein, a strong positive or strong negative correlation is one that has a coefficient correlation value greater than 0.5 (>0.5). Correlations have a 0.05 level of significance whereby values less than 0.05 (<0.05) indicate that the relationship between the two variables is significant. In this section only strong and significant correlations are considered for analysis. As correlation measures existence and strength of linear relationships having at least one of the variables being constant indicates no linear relationship and thus yields no values.

All positive correlations mean that from 1963-2015 as the relevant independent variables (X_n) increased individually, the density, commercial use, or tree cover in the space also increased. For all negative correlations it means that as the relevant independent variable (X_n) increased, the density, commercial use, or tree cover decreased. Table 5.9 indicated that there was an increase in average density by 82.1% for all spaces from 1963-2015. Commercial use indexes and tree cover also increased on average by 225.6% and 222.0% respectively. In order to articulate the connection between changes of variables over time, data in the correlation table following has been organized according to years. In analysis of the correlation coefficients (r-values) that follows in Table 5.9:

Dependent Variables are Y_1=Density; Y_2=Commercial Use; Y_3=Tree Cover.

Independent Variables are X_1=Density; X_2=Commercial Use; X_3=Tree Cover; X_4= Institutional Use; X_5=Residential Use; X_6=Connectors; X_7=Enclosure; X_8=Warehouse/Workshop Use.

Table 5.29: Table of Correlation Coefficients for All Spaces (1963-2015)

Dependant Variables		Independent Variables							
1963		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
Y_1	Correlation	1.00	-.374	-.008	**-.533****	.180	.366	.439	.113
	Significance	.000	.169	.978	**.041**	.521	.179	.102	.689
Y_2	Correlation	-.374	1.000**	.373	**.759****	-.218	.275	.086	-.261
	Significance	.169	.000	.171	**.001**	.435	.322	.761	.347
Y_3	Correlation	-.008	.373	1.000**	.289	.487	-.153	.137	.404
	Significance	.978	.171	.000	.297	.066	.585	.626	.135
1971									
Y_1	Correlation	1.00	-.321	-.015	**-.552***	**.584***	-.277	**.666****	.008
	Significance	.000	.243	.957	**.033**	**.022**	.317	**.007**	.978
Y_2	Correlation	-.321	1.000**	-.056	.503	-.180	-.200	-.031	-.365
	Significance	.243	.000	.843	.056	.521	.475	.913	.181
Y_3	Correlation	-.015	-.056	1.000**	-.151	-.049	.460	-.099	.177
	Significance	.957	.843	.000	.591	.863	.084	.726	.528
1978									
Y_1	Correlation	1.000**	-.249	.151	-.510	.453	.211	.315	-.056
	Significance	.000	.371	.592	.052	.090	.449	.252	.842
Y_2	Correlation	-.249	1.000**	-.046	**.856****	-.198	.451	.295	-.410
	Significance	.371	.000	.872	**.000**	.480	.091	.286	.129
Y_3	Correlation	.151	-.046	1.000**	.002	.304	-.173	-.036	.113
	Significance	.592	.872	.000	.993	.271	.536	.898	.689
1998									
Y_1	Correlation	1.000**	-.329	.041	-.513	.332	.337	.317	-.012
	Significance	.000	.231	.886	.050	.227	.220	.250	.966
Y_2	Correlation	-.329	1.000**	.295	**.812****	-.219	.275	.085	-.389
	Significance	.231	.000	.287	**.000**	.434	.321	.763	.152
Y_3	Correlation	.041	.295	1.000**	.197	.203	-.163	.055	-.097
	Significance	.886	.287	.000	.482	.468	.561	.847	.732
2003									
Y_1	Correlation	1.000**	-.339	-.174	**-.539***	.338	.418	.412	-.009
	Significance	.000	.217	.536	**.038**	.217	.121	.127	.974
Y_2	Correlation	-.339	1.000**	**.630***	**.744****	-.223	.274	.077	-.400
	Significance	.217	.000	**.012**	**.001**	.425	.324	.784	.139
Y_3	Correlation	-.174	**.630***	1.000**	**.551***	-.024	-.062	-.002	-.447
	Significance	.536	**.012**	.000	**.033**	.933	.825	.995	.095
2015									
Y_1	Correlation	1.000**	-.374	-.008	**-.533***	.180	.366	.439	.113
	Significance	.000	.169	.978	**.041**	.521	.179	.102	.689
Y_2	Correlation	-.374	1.000**	.373	**.759****	-.218	.275	.086	-.261
	Significance	.169	.000	.171	**.001**	.435	.322	.761	.347
Y_3	Correlation	-.008	.373	1.000**	.289	.487	-.153	.137	.404
	Significance	.978	.171	.000	.297	.066	.585	.626	.135

Source: Author from SPSS

* Correlation is significant at the 0.05 level. **Correlation is significant at the 0.01 level. Coefficient Correlation value >0.5 indicates a strong relationship between variables, 0.3-0.49 indicates a moderate relationship, and <0.29 indicates a weak relationship.

Independent Variables: $X_{1=}$Density; $X_{2=}$Commercial Use; $X_{3=}$Tree Cover; $X_{4=}$ Institutional Use; $X_{5=}$Residential Use; $X_{6=}$Connectors; $X_{7=}$Enclosure; X_8=Warehouse & Workshop Use. Dependent Variables: $Y_{1=}$Density; $Y_{2=}$Commercial Use; $Y_{3=}$Tree Cover. Dependent Variables: $Y_{1=}$Density; $Y_{2=}$Commercial Use; $Y_{3=}$Tree Cover and Independent Variables: $X_{1=}$Density; $X_{2=}$Commercial Use; $X_{3=}$Tree Cover are mutually exclusive variables

Table 5.29 indicates for all spaces in 1963 there was a strong positive correlation between institutional use (independent variable) and commercial use (dependent variable). As correlations refer to simple linear relationships, this means that as the index of institutional use increased, the index of commercial use also increased. Commercial use is serving as a surrogate indicator for economic sustainability. Therefore, wherever area of institutional use in buildings surrounding the space increased in 1963, area of commercial use in buildings surrounding the space also increased. Spaces therefore improved in terms of presence and vitality of commercial activities including service businesses, retailers, eateries, and offices. The table also indicates a strong negative correlation between institutional use (independent variable) and density (dependent variable). This means that as the index of institutional use increased, the density surrounding the space decreased. With regards to social sustainability for which density serves as an indicator, it shows that wherever institutional buildings around the space increased, social sustainability of the space declined.

According to the table, in 1971 there was a strong positive correlation between residential use (independent variable) and density (dependent variable). In this year, where residential use increased, density surrounding the spaces studied also increased. In addition, spaces exhibited a strong positive correlation between enclosure and density, which meant that as enclosure increased density also increased. From the table, there was a strong negative correlation between institutional use (independent variable) and density (dependent variable). In 1971therefore, as institutional buildings around the space increased, social sustainability decreased. Density is a surrogate indicator for social sustainability as measured by number of users of space. This means that as related to the institutional use of buildings, the public open spaces declined in density and in number of users of the spaces.

In 1978 and 1998 there was a strong positive correlation between institutional use (independent variable) and commercial use (dependent variable) as shown in the table. During these periods therefore, as the institutional buildings around the spaces increased, buildings used for office and retailing around the spaces also increased. This correlation indicates that wherever learning, religious, cultural, and public institutions increased, they influenced economic vitality of the public open spaces. These spaces increased in terms of activities of retailers, service businesses, and provision of goods. Mixed use in buildings and within public open space is a characteristic of sustainable neighbourhoods wherein environmental, economic, and social activities are compatible. In 1978 and 1998 therefore, wherever institutional use increased, commercial use and resultant mixture of buildings use also increased.

The table indicates that in 2003 there was a strong negative correlation between institutional use (independent variable) and density (dependent variable). During this year therefore, as the index of institutional use increased, the density surrounding the space decreased. With regards to social sustainability for which density serves as an indicator, it shows that wherever institutional buildings around the space increased, social sustainability declined. Also indicated is a strong positive correlation between commercial use (independent variable) and tree cover (dependent variable). During this year therefore, as the buildings used for office and retailing around the spaces increased, tree cover within the spaces also increased. In addition, there was a strong positive correlation between institutional use (independent variable) and tree cover (dependent variable). In that year therefore, as institutional use of buildings increased, tree cover in the space also increased. The same year exhibited a strong positive correlation between institutional use (independent variable) and commercial use (dependent variable). So, as the institutional buildings around the spaces increased, buildings used for office and retailing around the spaces also increased.

In 2015, the table indicates a strong negative correlation between institutional use (independent variable) and density (dependent variable). During this year therefore, as the index of institutional use increased, the density surrounding the space decreased. With regards to social sustainability for which density serves as an indicator, it shows that wherever institutional buildings around the space increased, social sustainability declined. The Table shows a strong positive correlation between institutional use (independent variable) and commercial use (dependent variable), so as the institutional buildings around the spaces increased, buildings used for office and retailing around the spaces also increased.

CHAPTER SIX

DISCUSSION

6.1 Introduction

This chapter is divided into three main sections. The first section relates to the first research objective. Focusing on the six physical characteristics of size, connectivity, density, enclosure, land use, and tree cover, it discusses the changes undergone by the study spaces from 1963-2015. The second section relates to the second research objective. It discussed the social, economic, environmental and governance factors that contribute to sustainability of public open spaces in Nairobi CBD. The third section of discussion relates to the third research objective. Its discussion focuses on the relationship between spatial evolution and sustainability.

6.2 Elements of Spatial Evolution

From 1963-2015 the area of public open space and grass and tree cover decreased, influenced by an increase in construction of buildings and infrastructure in the CBD. The sizes of designated public open spaces in the CBD however have not changed significantly during this time. Over this period land use in the CBD changed to be predominantly used for commerce only, offices only or a combination of use for commerce and offices. CBD as a residential area decreased from the 1960s - 2015.

<u>Evolution of Spaces: A Summary from 1963-2015</u>

According to Darwinian theory (1859) those species that displayed the most traits that were most useful had the greatest capacity for survival through inheritance. When considering all spaces studies in Table 6.1 that follows, the spatial characteristics that have endured and increased (1963-2015) are connectivity (24.3%), density (82.1%), enclosure (54.5%), tree cover (220.0%), commercial use in buildings surrounding the space (225.6%) and institutional use in buildings surrounding the space (272.4%). This implies that on average, public open spaces in Nairobi CBD have possessed advantageous characteristics or favourable traits with regards to connectivity, density, enclosure, commercial and institutional land use, and tree cover. These advantageous characteristics have been passed on through the years, thus enabling the spaces to display a 'survival of the fittest'. Evolution entails the gradual passing on of beneficial or advantageous traits over time. Persistence of connectivity to spaces, tree cover in spaces, density, enclosure, commercial and institutional use in surrounding buildings therefore indicate that these characteristics are advantageous to the function, life, and appeal of the space.

The spatial characteristics that have not endured and declined (1963-2015) are size of public open spaces (-3.5%), residential use in buildings surrounding the space (-6.03%) and industrial use in buildings surrounding the space (-66.6%). According to Darwin's theory, the evolutionary passing on of advantageous characteristics has therefore not occurred with regards to size, residential and industrial use. These characteristics have gradually fallen away or diminished as they have become non-advantageous or non-beneficial to the public open spaces and their environs over the period of time.

Table 6.1: Table Showing Averages of Variables (1963-2015)

YEAR	AVERAGE SIZE	AVERAGE CONNECTIVITY	AVERAGE ENCLOSURE	AVERAGE DENSITY	AV. TREE COVER	AV. COMM INDEX	AV. INSTIT INDEX	AV. RES INDEX	AV. INDST INDEX
1963	12088.2667	7.57E-06	0.022853	2.28836	0.1	7.805867	2.918867	0.115533	0.286733
1971	11632.8	9.53E-06	0.030713	2.9934667	0.15	15.93193	6.132	0.135533	0.301467
1978	11833.7333	9.42E-06	0.034766	3.5122667	0.22	20.3476	9.9348	0.135533	0.3088
1998	11833.7333	9.47286E-06	0.035054	3.8637345	0.24	24.99213	10.20187	0.111867	0.2492
2003	11567.0667	9.41486E-06	0.035054	3.9144	0.24	25.3528	11.01907	0.111867	0.250533
2015	11667.0667	9.41486E-06	0.035394	4.1724	0.32	25.43813	10.84907	0.108533	0.096867
DELTA	-421.2	1.8406E-06	0.0125	1.88	0.22	17.6	7.9	-0.007	-0.191
% DELTA	-3.5%	24.3%	54.50%	82.1%	220.0%	225.6%	272.4%	-6.03%	-66.6%

Source: Author

The following are more detailed discussions on the six spatial characteristics of size of space, connectivity, density, enclosure, land use and tree cover based on Table 6.1.

6.2.1 Space Size

Average space size of studied public open spaces decreased by 3.5% from 1963-2015. 73.3% of the public open spaces studied did not exhibit any change in space size from 1963-2015. There was a decrease in space size in 20.0% of the spaces. The spaces that decreased were green parks or green open spaces whose use had been converted into parking space. Majority of the spaces that exhibited no change in size of space were paved surface spaces comprising bus termini, markets, or car parks. Increased paved surface areas lower the function and appeal of public open spaces because natural tree and grass ground cover is reduced. More paved surfaces also attract and reflect heat, thus contributing to the Urban Heat Island (UHI) effect in the CBD. UHI occurs when cities replace natural land cover with dense concentrations of pavement, buildings, and other surfaces that absorb and retain heat. Concrete and asphalt commonly used in urban areas for pavement and roofs contribute to UHI (Oke, 1982). From 1963-2015 the size of green open space declined. In line with Darwin's theory, this means that larger green open spaces were not advantageous in the CBD over the period. It thus highlights that solutions to public open space challenges are not necessarily about increasing total green CBD footprint but can be about better, smarter, more innovative use of smaller green space.

6.2.2 Connectivity

46.7% of the public open spaces studied indicated an overall increase in connectivity from 1963-2015 while 20.0% of the spaces indicated an overall decrease over the same period. Average connectivity of studied public open spaces increased by 24.3 % from 1963-2015. Increased connectivity in turn results in an increase in number of users in the space, which is a measure of social sustainability. The more people arriving at the space, the more socially sustainable it becomes because more users enhance the vitality, function and attractiveness/appeal of the space. In 33.3% there was no change in connectivity from 1963-2015.

Connectivity influences the number of people that have access to the public open space through designated linear spatial connectors that link to the public open space itself or a perimeter road enclosing the space. Good connectivity provides easy access to public open spaces for pedestrians and vehicles thereby increasing the potential number of users of the space. From an evolutionary perspective, the new pedestrian and vehicular connectors can be considered to be variations on the preceding connectivity. Their emergence can be argued to have occurred so as to enhance the performance of the space. Where there have not been changes in connectivity, it is attributable to their usefulness and advantage which has thus caused them to be preserved.

Small block sizes, and thus greater connectivity, promote urban vitality, connectivity, and legibility (Jacobs, 1961). The presence of people in a space contributes to the vitality of the space. According to Jacobs (1960) people confer use on parks and make them successes or else withhold use and doom parks to rejection and failure. Shaftoe (2008) observes that people are the ones that play the most important role in animating public open spaces. He further notes that the idea that public spaces must be functional and used, which underscores the relationship between the vitality of a space and its sustainability.

Increased connectivity from 1963-2015 would be an indicator that more people had opportunity to arrive at the public open spaces. This would mean an increase in number of users in the space, which is a measure of social sustainability. The more people arriving at the space, the more it tends towards social sustainability because more users enhance the vitality, function, and attractiveness of the space.

The layout and type of streets or roads also influence how sustainable a public open space is. If streets connect directly to the public open space or connect to a pedestrian-friendly street that does not make access to the space difficult, then the number of users arriving at the space will increase. From 1963-2015 Nairobi has experienced growth and public significant infrastructure development. This emergence of major highways and bridges that constitute the street/road pattern of the CBD has reduced the access and appeal/ attractiveness of the space for pedestrians that have to cross six-eight lane highways, with their high-speed traffic, in order to get to their destination space. This is particularly the case where roadways/highways encircle the public open space or act as a boundary on one or more sides of the space.

6.2.3 Land Use

Land use for spaces and their surroundings was categorized and measured using indexes namely commercial use, institutional use, residential use, and warehouse/workshop/industrial use. Average commercial use and institutional use indexes increased by 225.6% and 272.4% respectively, while average residential and warehouse/workshop/industrial use indexes decreased by 6.03% and 66.6% respectively. 87% and 67% of the spaces exhibited changes in commercial use and institutional use indexes respectively. 80% of spaces demonstrated no change in surrounding residential use, while 27% of spaces experienced a decrease in surrounding warehouse/workshop/industrial use from 1963-2015.

There was no notable change in land use for 60% of public open spaces from 1963-2015. Clear change of use occurred for 40% of the spaces studied. These include change of use from car park to bus terminus as in the case of KBS Terminus and car park and bus terminus to park, as in the case of Hilton Hotel Circle.

More mixed use within a neighbourhood provides for a better and more sustainable model of urbanism. Diversity of uses within buildings and spaces is advantageous because it encourages different people to use the city for different purposes and at different times. This contributes to the social and economic sustainability of the urban space as the mixture and diversity of use enhances the vitality, function, and/or appeal of the spaces by providing multiple opportunities through which the citizen can engage and interact with the city.

Cities in developing countries, as opposed to those in developed countries, are already characterized by high levels of mixed use, ease of access to a wide range of goods and services and by high levels of vitality and vibrancy (Jenks, and Burgess, 2004). In this regard therefore, developing country cities are therefore exhibiting characteristics of sustainability that developing country cities are striving towards. In the case of Nairobi as such a city, adherence to by-laws and other regulations must accompany the mixed use of buildings and spaces to maximize on the vitality, convenience, and attractiveness that such mixed use offers.

Settlements can be categorized in terms of the key elements of land uses, building structures, plot pattern and street patterns. Of these, buildings and the land uses they accommodate are usually the least resilient elements (Conzen as cited in Tisdell, Carmona, Oc, & Heath, 2003). The fact that the latter is the most prone to change means that there is opportunity in cities where zoning persists, and therefore sustainability low, to introduce mixing of uses as an element of strategic spatial planning. In line with the thinking of Jacobs (1961), ensuring that people go outdoors at different times for different reasons contributes to sustainable neighbourhoods that are characterized by function, vitality and appeal.

6.2.4 Enclosure

80.0% of the spaces experienced an increase in enclosure over the period. In 13% of spaces studied no change in enclosure occurred from 1963-2015. Too little enclosure of the space and there is tendency for users to feel overly exposed and sense that the space is poorly defined, influencing its attractiveness for users. Correct levels of spatial enclosure contribute to the appeal and attraction of users and potential users, encouraging them to linger, return, or enjoy their experience of the space. Together with other characteristics, this draws more people into the space, thus making it more sustainable from social and economic perspectives.

Public spaces in their relation with the constituting buildings should be of the right scale. In this regard, the height of enclosing walls should not be more than twice the width of the constituted public space (Makworo, 2012). This is commonly accepted, but continuity of height of buildings and the levels of permeability of surroundings influence sense of enclosure by pedestrians. The way in which tall buildings are designed at pedestrian level (the human scale at street level) also has an effect on whether the space has a good sense of enclosure or not.

Correct levels of spatial enclosure contribute to the appeal and attraction of users and potential users, encouraging them to linger, return, or enjoy their experience of the space. Together with other characteristics, this draws more people into the space thus making it more sustainable from social and economic perspectives. From 1963-2015 therefore decreased enclosure of spaces means decreased sustainability while increased enclosure would mean that the space had become more sustainable.

6.2.5 Density

All the public open spaces studied indicated an overall increase in density of the surrounding neighbourhood from 1963-2015. Average density of studied public open spaces increased by 82.1 % from 1963-2015. The greater the number of buildings in an area per hectare means the higher the density of that area or neighbourhood. Land use mix, fine grain, high user density, and diversity are necessary for sustainable urban settlements (Moirongo, 2011). All the neighbourhoods within which the spaces are located experienced an increase in densities of buildings per unit area from 1963-2015. Increased number of buildings per hectare means an increased compactness and walkability both of which are characteristics of sustainable neighbourhoods as they reduce car use, attract more people onto streets and spaces (social sustainability), and thus create more opportunities for economic activity and vitality (economic sustainability).

The higher the density of an area or neighbourhood, the more walkable it becomes. Walkability is among the principles of New Urbanism and supports being able to walk in a short period of time between key function locations such as work and home, pedestrian friendly street design and less vehicular traffic on streets. Walkability is thus an indicator of sustainability. From 1963-2015 there was increased density in neighbourhoods surrounding public open spaces in Nairobi CBD. Increased density means more compact neighbourhoods which make it more possible to walk from place to place. More walking means less driving and therefore less pollution of the environment; this promotes sustainability within the city. In addition, higher pedestrian traffic increases the vitality of users on the streets and in spaces which in turn makes streets and spaces more attractive. People are attracted to where other people are. It can be deduced therefore that because of heightened densities, there was an increased numbers of people in Nairobi's streets and other spaces. These people in turn improved social interactions and economic vitality. The spaces become more economically sustainable because the more people in a space, the greater the chances of them meeting one another and using restaurants, retail shops, and service business.

6.2.6 Tree Cover

67% of the spaces displayed increased tree cover from 1963-2015. Presence of natural grass, trees, shrubs, bushes can contribute to a space keeping up its vitality, function and attractiveness. Van der Ryn and Cowan (cited in Jabareen, 2006) note that greening of the city makes urban and suburban places appealing, pleasant, and sustainable. The more natural vegetation and tree cover, the more sustainable the settlement is from an environmental perspective.

6.3 Factors Contributing to Sustainability

This section of discussion is related to the second research objective. The research has established the social, economic, environmental and governance factors that contribute to sustainability of public open spaces in Nairobi CBD. The number of users in the space, the grass coverage in the space, the number of retail shops in the space, and the level of cleanliness of the space are the measures of sustainability. Their spatial and non-spatial drivers (or predictors) have also been established. These diverse combination of the driver variables for each outcome variable indicate the interconnectedness of the four aspects of sustainability. This knowledge of drivers of sustainability can be used to enhance the vitality, function, and attractiveness of existing public open spaces in city centres. In addition, it can inform urban planners, urban designers, and other built environment practitioners in their creation of new public open spaces that are intended to be sustainable.

6.3.1 Social Sustainability

The social sustainability model indicates that it is influenced by a combination of spatial and social factors. With number of users of the space as the outcome variable, the drivers of social sustainability in public open spaces in Nairobi CBD have been established as the number of services in ground floors of buildings facing the space, the number of connectors to the space, and the number of users of the sidewalks surrounding the space.

From the coefficients of determinations of the variables, only the number of services in ground floors of buildings facing the space and number of connectors to space were found to be significant predictors of the number of users of the space. Service businesses include barbers, photo studios, photocopying services, and mobile money services.

The number of services businesses in ground floors of buildings facing the space, influences pedestrian traffic on surrounding sidewalks. This pedestrian presence in turn increases the vitality of the environment around the space. The more people using the space, the more vitality it has and the more attractive it becomes for other users. The importance of people in spaces has been captured by Jacobs's (1961) argument that when people use public open spaces they make them successful. The importance of this measure of social sustainability is underscored by Shaftoe (2008) who states that in order for public space to be real they must be functional and used. Connectors enable the arrival of users to the space. Increased number of connectors means that greater volumes of people can access the space, and thus increases the probability of entry/use of the space. Since the number of users is a measure of social sustainability, introduction of more services in ground floors of buildings facing the space and increased connectivity to the space will enhance its social sustainability.

When designing interventions on how to make public open spaces more sustainable therefore, introduction of more services businesses should be prioritized. It is important that such businesses should be located in buildings whose entrances face the public open space and located on the ground floor of the buildings. This creates a functional and visual connection between the building, its services, and the space. The service businesses typically support short-term interaction with customers, meaning that they experience high volumes of pedestrian traffic. It is critical that entrances to the business be easily accessible, and not separated from the public open space by fencing or other spatial obstacles. To take it a step further, an increase in the number of service businesses should be accompanied by an improvement in the quality of environment such as installation of garbage bins. Encouragement of greater diversity in the types of services should accompany the increase in numbers as both will enhance the attractiveness and vitality of the adjacent public open space.

6.3.2 Economic Sustainability

The economic sustainability model indicates that it is influenced by a combination of economic use and social factors. With the number of retail shops in the space as the outcome variable, the drivers of economic sustainability are the number of users of the space, the number of service businesses in space and the number of retail shops in ground floors of buildings facing the space.

From the coefficients of determinations of the variables, the number of users of the space was found to be a significant predictor of the number of retail shops in the space. This is because users are the consumers of retail goods and services, and the more consumers, the greater the number of retailers. Since retailing is available in shops surrounding the space, consumers are less likely to enter the space for the same goods and products that they can purchase outside the public open space. As in the case of service businesses, it is important that interventions encourage that the surrounding retail shops be located on the ground floors of buildings facing the space. This is because orientation of shop entrances to the public space is important and the ease of access to and from the ground floors of these buildings.

Although less significantly, other economic activities around the space also influence the economic vitality and attractiveness of the space. Economic activities attract people. This in turn attracts more economic activities. This leads to more pedestrian traffic that uses the surrounding spaces for multiple reasons at different times of the day, which is good for retail and service businesses. The number of retail shops in ground floors of buildings facing the space, influences pedestrian traffic on surrounding sidewalks. This pedestrian presence in turn increases the vitality of the environment around the space and also increases the number of users that can potentially arrive within the space. The more people using the space, the more vitality it has and the more attractive it becomes for other users.

As retailing in the space are improved, increased, or introduced, the number of retail shops in the space will increase. Since the number of retail shops in the space is a measure of economic sustainability, its increase, together with that of service businesses in the space and number of retail shops on the ground floor of buildings surrounding the space will enhance the sustainability of the space.

6.3.3 Environmental Sustainability

The environmental sustainability model indicates that it is influenced by spatial factors. With the area of grass in space as the outcome variable, the drivers of environmental sustainability in the spaces have been established as the area of space and the longest distance of space. Both were found to be significant in predicting the area of grass in the space. Along with tree cover and shrubbery, grass cover is a key aspect of the natural landscape. Jabareen (2006) has posited that greening of the city makes places more attractive and pleasant. There tends to be an esteem attached to natural green space (Lefebre, 1991). The more appealing the space is, the more users it attracts, and this attractiveness increases because people like going to where other people are (Alexander, 1977). When designing interventions on how to make public open spaces more environmentally sustainable in Nairobi CBD, increasing the overall area of the space will improve its grass cover.

6.3.4 Governance Sustainability

Governance is concerned with the way in which institutions, cities, situations are controlled, ruled, or conducted. At city level, governance contributes to delivery of services such as adequately maintained open spaces for use by the public. The governance sustainability model indicates that it is influenced by spatial factors. With the cleanliness of space as the outcome variable, proximity of space to PSV stage, the number of parking spaces in space, and the area of paved path ways in space have been established as factors that influence the cleanliness of the CBD public open spaces. Cleanliness and maintenance of the space is the responsibility of the public authority.

Clean and well kept spaces are therefore an indicator of efficiency in service and appropriate financial and human resources allocation to the upkeep of the space. The condition of the natural physical environment therefore contributes to the attractiveness to potential users particularly in recreation spaces. From the coefficients of determinations of the variables, proximity to PSV stage was found to be a significant predictor of cleanliness of space.

When designing interventions on how to make public open spaces more sustainable from a governance perspective therefore, is would be important to increase the number of garbage bins and NCC workers assigned to cleanliness and maintenance of spaces. Areas near public transportation hubs mean that more members of the public can easily access the spaces for recreation and other functions. In order to increase the function of public open spaces as open spaces that are enjoyed and used by as many members of the public as possible, locating PSV hubs, stops, or stages at convenient distances from the spaces would be strategic.

Close proximity to PSV stage means that more users can arrive within the space and thus potentially generate greater quantities of litter and garbage. Cleanliness and maintenance of the space would be therefore enhanced with increased numbers of garbage bins en route to and within the space. In addition, increased assignment of the number of NCC workers to clean and maintain the spaces would assist in making them more sustainable in terms of governance.

The following Figure 6.1 summarizes variables that have influenced the social, economic, environmental, and governance aspects of sustainability in Nairobi CBD. Predictor variables that influence the respective aspects of sustainability are in colour, while significant predictors of the respective outcome variables are presented in bold boxes.

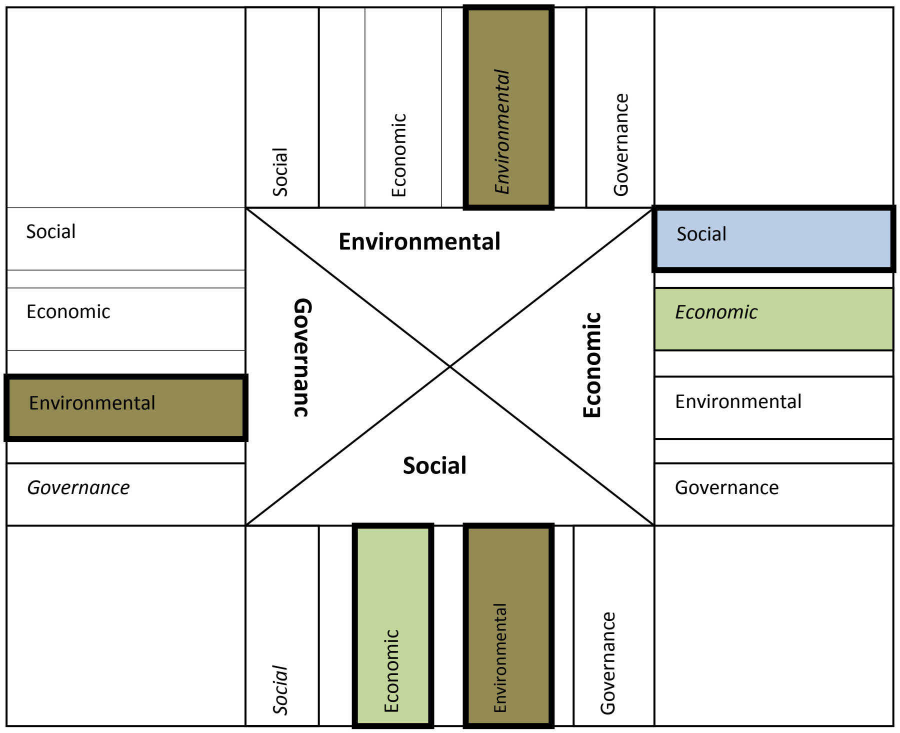


Figure 6.1: Summary of Factors Influencing Sustainability Source: Author

6.4 Relationship between Spatial Evolution and Sustainability

This section of discussion is related to the third research objective. In establishing relationship between spatial evolution and sustainability, commercial use was identified as a measure for economic sustainability. As indicated in the data analysis section, there was a strong positive correlation between institutional use (independent variable) and commercial use (dependent variable). Between 1963 and 2015 therefore, as the institutional buildings around the spaces increased, surrounding buildings used for office and retailing also increased. This correlation indicates that wherever buildings of learning, religious, cultural, and public institutions increased, there was also a rise in retailers, eateries, vendors, service businesses, and economic vitality of the public open spaces. Increased commercial use from 1963-2015 therefore indicates that due to use of surrounding buildings, the public open spaces became more economically sustainable over the period.

Mixed use in buildings and within public open space is a characteristic of sustainable neighbourhoods wherein environmental, economic, and social activities are compatible. Wherever surrounding institutional use increased, commercial use and resultant mixture of buildings use also increased. From 1963-2015 the average of surrounding institutional use indexes increased by 272.2% while commercial use indexes increased by 225.6%. The increased commercial and institutional use has resulted in a wider range of services and uses. These include mixing of uses as offices, retail spaces, commercial services, cultural spaces, educational, financial and public institutions, whose variety contribute to upholding vitality, attractiveness, and convenience of the public open space.

Density was identified as a measure for social sustainability. Table 6.1 shows that from 1963-2015 there was an average increase of 82.1% in density in the study areas. Increased density enhances compactness of urban form and walkability of city neighbourhoods. More conducive walking distances enabled by rising density and resultant compactness of form means more pedestrians use the streets and sidewalks. This increased presence of people in urban space is an indicator that the neighbourhood has become more sustainable from a social perspective. From an environmental perspective, more walking and less use of vehicles mean less pollution from vehicular noise and emissions. This therefore also contributes to making the neighbourhood more sustainable in terms of the natural environment.

Increased densities also means an increased popular concentration within the urban space, whether inside offices, retail spaces or inside buildings used for educational, cultural, or religious use. More buildings within the neighbourhood indicates that more people use the buildings for commercial, institutional and other purposes. Density therefore acts as a surrogate variable for social sustainability, showing that from 1963-2015 as density increased, spaces demonstrated sustainability from a social perspective over the period.

As indicated in the data analysis, tree cover was identified as a measure for environmental and governance sustainability. Table 6.1 shows that from 1963-2015 average tree cover ratio increased by 220.0%. This means that the public open spaces have increased in foliage and canopy over the period. This increase of vegetation is an indicator of improved greenness and increased natural environment in the city. Spaces have thus demonstrated sustainability from an environment perspective over the period. Tree cover is a surrogate for governance because the county government is mandated to protect, maintain, and manage the natural vegetation within city public open spaces. As tree coverage has increased over the period, it indicates that from the governance perspective, sustainability has been demonstrated from 1963-2015 as local government has delivered on its responsibilities with regards to planting and protection of trees.

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This chapter is focused on conclusions and recommendations based on information presented in chapters one to six. It outlines general conclusions, tests the research hypothesis, and reiterates key elements emergent from the preceding chapters. It also presents theoretical and practical implications of the research and identifies areas of further research.

7.2 Testing of Hypothesis

Hypotheses: H_o and H_a

Research Hypothesis (H_a): Social, economic, environmental, and governance factors contribute to the sustainability of public open spaces in Nairobi CBD.

Null Hypothesis (H_o): Social, economic, environmental, and governance factors do not contribute to the sustainability of public open spaces in Nairobi CBD.

Hypotheses have been tested by establishing the p-values for each of the four aspects of sustainability. Small p-values suggest that the coefficient is important to that aspect of sustainability. A coefficient with a p-value of 0.01 is statistically significant at 99% confidence level; the associated variable is an effective predictor. In social research the probability or significance level is set at less or equal to 0.05. For this research, the p-value of 0.05 has been used, which indicates significance at 95% confidence level. From the p-values extracted from the ANOVA tables for each aspect of sustainability, it has been determined whether the hypotheses should be accepted or rejected. P-values of less than 0.05 mean that the null hypothesis (H_o) is rejected and the research hypothesis (H_a) is accepted.

From Table 7.1 the p-values for sustainability related to the social, environmental, economic, and governance are all less than 0.05. The research therefore has rejected the null hypothesis and accepted the research hypothesis that states that social, economic, environmental, and governance factors contribute to the sustainability of public open spaces in Nairobi CBD.

Table 7.1: Table of p-values for Sustainability from SPSS ANOVA Tables

	R Square	F	Sig (p-value)	df	Research Hypothesis
Social Sustainability	.942	28.996	.0001	3	Accepted
Economic Sustainability	.998	211.480	.049	3	Accepted
Environmental Sustainability	.966	43.212	.006	2	Accepted
Governance Sustainability	.539	4.283	.031	3	Accepted

Source: Author

7.3 Theoretical Implications

This research has highlighted several elements of sustainability. Notably, sustainability is concerned with the ability of the space to keep up and uphold its function, appeal, and vitality. Also notable is that sustainability can be enhanced so that spaces not only keep up certain abilities, but can improve them thus enabling them to become more sustainable. Enhancing sustainability of a space refers to it becoming more able or better equipped in terms of its vitality, attractiveness, and function.

Sustainability is not just about maintaining a blanket status-quo, nor is it merely about going back to the way things were, thus reverting to and maintaining conditions from eras past. Rather sustainability is about creating distinction which entails identification of valuable and beneficial characteristics of spaces. It is about deliberately enabling their reproduction in other spaces and their reproduction over time. It is indeed therefore necessary to develop a body-knowledge of the critical and valuable characteristics that make African and developing country cities (more) sustainable.

These may be very different from those of developed countries. In developing cities for instance informal trading is a vital and valuable characteristic of social and economic life, and a likely contributor to economic and social sustainability. Detecting distinctions and peculiarities with regards to elements of sustainability of different world regions would improve accuracy of recommendations on ways in which to enhance vitality, attractiveness, and function of public open spaces.

According to Darwin (1859) natural selection cannot modify the structure of one species without giving it any advantage. In the practical context of cities however, the modification and passing on of characteristics generationally in urban form involves passing on of both beneficial and non-beneficial characteristics. Variation in the strict sense of Darwinian evolution in reality does not happen in urban settings, including public open spaces. There is always a passing on of the good and beneficial along with the bad and disadvantageous characteristics in terms of spatial features in urban space. This research highlights this conclusion as a useful consideration for any future studies on spaces from an evolution perspective.

From the findings of the research in order to make a public open space in Nairobi CBD socially sustainable, it involves social, spatial, and economic spheres. Compared to the other aspects of sustainability, social sustainability is influenced by a combination of different clusters of variables. This research therefore contributes to understanding sustainability by indicating the need for multi-sector interventions to enhance social sustainability.

From data analyses, it has emerged that older spaces such as Jeevanjee Gardens and the Railways Bus Terminus, and Railways Godowns Parking area do not display much change in connectivity. This confirms the thinking that street patterns are the elements that change the least in urban contexts. This has emerged for key public institutions as well, where functions are highly controlled such as areas near Houses of Parliament and City Hall. The persistence of street patterns could thus also be influenced more significantly by the function of adjacent buildings. This would be contrary to the

Conzenian perspective that the building use endures the least as compared to street pattern, which is least likely to change in the urban context.

On the building height and street-width ratio (HWR) streets and spaces may violate the recommended HWR but are functional, attractive, and have vitality. Old towns and cities such as Lamu in Kenya, Shambles in England, and Bangkok in Thailand display HWR above the 1:2 HWR recommended by Jacobs (1993) but are vibrant and popular. From a theoretical perspective therefore, measurement of enclosure can be improved through consideration of historical, cultural, and climatic contexts in defining these spatial ratios.

In addition, recommended HWR must take into account other factors of the built and natural environment such as human scale at ground level of buildings and presence of mature trees can that enhance sense of enclosure. Design of buildings with a human scale at ground level as emphasized by Gehl (1996) can be a factor to countering any claustrophic effect that users may feel. Aga Khan Walk (AKW) is lined with tall buildings such as Reinsurance Plaza and Uchumi House but these are interspersed by opens spaces such as the NCC sunken car park and the private car park at the corner of Taifa Rd and City Hall Way. Solid-void relationships of buildings and open spaces that spatially define AKW thus of enclosure can be increased or reduced by features other than the relationship between the building height and street width.

Walkability is described as a characteristic of sustainable neighbourhoods. During data collection and analysis however it was recognized that walkability by definition must include an actual ability to access the public spaces. Due to fences at the Railways Bus Terminus and KICC car park for instance the benefits of urban compactness were lost because pedestrian access to the space was hindered. Conceptual definitions of it in literature should therefore emphasize the importance of access to buildings and spaces if walkability is to be a meaningful characteristic of sustainable settlements.

7.4 Practical Implications

As a practical contribution to the body-knowledge and available data on spatial change for Nairobi public open space, this research provides solid baseline data focused on connectivity, enclosure, densities, land use, tree cover, and space size. Such information, in conjunction with theoretical and methodological inputs, provides a credible basis for conducting future scholarship in the area.

During the data collection stage, the researcher designed an 'Observation Form Tally Table' that served as an intermediary tool to record and organize field data. This tool that comprised data that needed collection on several days at different times of day improved the efficiency of the data entry and management process. The researcher therefore contributed to tools that can better manage field data, which can be employed by other researchers.

7.5 Conclusions

From the model for social sustainability the number of users in the space is the outcome variable. For economic sustainability however, the same variable acts as a predictor variable. These two models have thus helped to demonstrate that there is a relationship and interconnectedness between economic and social sustainability.

The typical interlinked rings or pillars often used to describe the relationship between social, economic, and environmental sustainability can prove misleading. This is because firstly, the interconnected nature of sustainability has been captured by the diverse variables contributing to each measure of sustainability as per the regression models. This implies that the social, economic, and environmental sustainability do not of necessity have to happen all at the same time. The researcher proposes that these sustainabilities can be sequential.

Second, a mix of variables from the other sustainabilities is consistently evident when generating regression models for social, economic, environmental, and governance sustainability. For instance, social sustainability whose outcome variable is measured by number of users is predicted by economic, built environment, and social variables. For environmental sustainability whose outcome variable is measured by the area of the space that is covered with grass, predictor variables are built environmental variables. For economic sustainability whose outcome variable is measured by the number of retail shops in the public space, its predictor variables are social and economic. For governance sustainability whose outcome variable is measured by the cleanliness of the space, its predictor variables are governance and built physical environmental variables. One aspect of sustainability can therefore be dominant at any given period in time and because of the interconnectedness of the variables, for public open spaces in Nairobi CBD, when social sustainability is improving, it means that there will also be improvement in the economic, built environment, and social spheres.

All cities can be described as having a degree or measure of sustainability because they all possess the ability to enhance their vitality, appeal, and function. Cities experiencing extreme conditions such as war and natural disasters can be described as unsustainable at that particular period of time, being able to recover and be restored in terms of their function, appeal, and vitality. Cities and their spaces can also be more sustainable in one aspect (e.g. environmental) and less sustainable in another aspect, such as economic. In reality of cities, spaces as captured by public open spaces exhibit movement in two directions. In some ways they are becoming more sustainable while in others they are becoming less so.

As shown from Table 6.1, from 1963-2015 Nairobi's CBD public open spaces have become more sustainable (able to uphold their function, vitality, and appeal) in terms of connectivity, density, enclosure, tree cover and land use. The first four characteristics increased as indicated in the table while the last characteristic of land use became more interspersed but interestingly, less diversified over time. In particular on the latter, commercial and institutional use in surrounding buildings increased over the period, but residential and industrial use declined.

In as much as the spaces have become more sustainable as per the four characteristics, they have also become less sustainable in terms space size and land use (residential and industrial) (Table 7.2). The former has decreased in terms of total area of public open space, while the latter declined in terms of diversity of use over the period.

Table 7.2: Sustainability of Environmental Variables (1963-2015)

Environmental Variables	More Sustainable	Less Sustainable	No Change
Size		√	-
Connectivity	√		-
Density	√		-
Enclosure	√		-
Land Use (Intersperse)	√		-
Land Use (Diversity)		√	-
Tree Cover	√		-

Source: Author

From 1963-2015, there has been spatial evolution with regards to connectivity, density, enclosure, tree cover, and land use. The term evolutionary applies to the aforementioned because their good spatial characteristics have persisted and indeed increased over time. The more connectivity to a space, the greater probability of users arriving at the space, and in turn, the better the space fulfils its function as a socio-economic amenity with greater vitality and appeal. Spatial evolution can also be described as having taken place because changes have occurred over a 52-year period of time, indicating that the process has been gradual.

Urban spaces are ultimately made by human beings for human beings. Achieving spaces that are able to uphold their vitality, function, and attractiveness from the social perspective has proved to be the most complex and comprehensive of the four aspects of sustainability. This conclusion is informed by the comparative analysis of dependant and independent variables for each aspect of sustainability. Additionally, spatial factors proved to be significant predictors of three of the four aspects of sustainability namely for environmental, social, and governance. These spatial factors refer to the six variables used for measurement of the built and natural environments.

7.5 Recommendations

More mixture of uses should be encouraged in the buildings surrounding CBD public open spaces. The research shows for instance that over the years there has been a direct relationship between institutional and commercial use in buildings that front the spaces. As institutional use of surrounding buildings has increased, commercial uses have increased too. Opening up of more institutions in buildings surrounding spaces should therefore be promoted. This would encourage more people to be in buildings, on streets, and in the public open spaces at different times of day, for varied purposes thus enhancing area vitality, function, and safety. Importantly however there must be compatibility of uses in the mixture, and control of the same by the rule of law.

Models in the research have also demonstrated that there is a relationship and interconnectedness between economic and social sustainability. Efforts by county governments therefore can be designed to make public open spaces more socially sustainable by providing conducive environments for economic activities to flourish. Due to the interconnectedness of the variables, when social sustainability is improving, improvement in the economic, built environment and social spheres will also occur.

Since social, economic, and environmental sustainability do not happen all at the same time and can be sequential, efforts to enhance sustainability of spaces by public agencies can be done in phases. Engaging a phased strategy to make spaces more sustainable in terms of the social, economic, or natural environment can mean better use of government human and financial resources. This would be because such an approach would allow for periodic allocation of resources and also allow for evaluation and adjustment of efforts and interventions towards making spaces more sustainable.

As spatial factors are significant predictors of three of the four aspects of sustainability, in determining ways of improving sustainability of public open spaces, public agencies and relevant actors should prioritize spatial interventions. In so doing, interventions related to the built and natural environments would have greater scope of impact, increasing sustainability in the three spheres of the social, environmental, and governance.

7.6 Further Research Areas

- A similar study can be conducted on the evolution and sustainability factors for public open spaces in residential areas of Nairobi;
- Comparative studies can be conducted for public open spaces in other cities in Kenya to establish factors that influence spatial evolution and sustainability on a national level;
- Comparative studies can be conducted for public open spaces in other cities in East Africa to establish factors that influence spatial evolution and sustainability on a sub-regional level.

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APPENDICES

Appendix 1: Tables of Dependent and Independent Variables for All Spaces (1963-2015)

SPACE	INDEPENDENT VARIABLES								DEPENDENT VARIABLES		
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	Y_1	Y_2	Y_3
S_1 (CP)	4.33	0.022	0.0	0.081	0.0	$6.29e^{-8}$	0.00789	0.0	4.33	0.022	0.0
S_2 (JG)	3.63	2.48	0.60	0.36	0.14	$1.69e^{-6}$	0.0448	0.0	3.63	2.48	0.60
S_3 (JMP)	3.56	0.126	0.1	0.0	1.263	$1.75e^{-6}$	0.0389	0.631	3.56	0.126	0.1
S_4 (HHC)	1.26	1.76	0.0	1.62	0.0	$7.36e^{-7}$	0.0389	0.0	1.26	1.76	0.0
S_5 (GCR)	1.8	0.80	0.0	0.082	0.33	$4.75e^{-7}$	0.0093	0.33	1.8	0.80	0.0
S_6 (FSR)	7.9	34.30	0.0	2.26	0.0	$9.02e^{-5}$	0.0957	0.0	7.9	34.30	0.0
S_7 (SCP)	0.94	18.02	0.0	6.32	0.0	$6.59e^{-7}$	0.0064	0.0	0.94	18.02	0.0
S_8 (NSCP)	1.0	3.15	0.0	4.56	0.0	$8.77e^{-7}$	0.0059	0.0	1.0	3.15	0.0
S_9 (RGP)	1.70	1.25	0.05	2.98	0.0	$4.0e^{-7}$	0.010	1.09	1.70	1.25	0.05
S_{10} (KP)	0.25	0.0	0	6.21	0.0	$4.65e^{-7}$	0.0053	0.0	0.25	0.0	0
S_{11}(RBT)	1.70	1.86	0.25	5.97	0.0	$6.67e^{-7}$	0.0175	1.32	1.70	1.86	0.25
S_{12}(KBT)	3.8	1.34	0.0	2.40	2.40	2.40	0.0370	0.0	3.8	1.34	0.0
S_{13}(AKW)	0.73	6.26	0.1	0.0	0.0	$1.16e^{-6}$	0.0046	0.0	0.73	6.26	0.1
S_{14}(NHCW)	0.73	10.56	0.3	3.08	0.0	$8.8e^{-6}$	0.007	0.0	0.73	10.56	0.3
S_{15}(WM)	0.93	0.0	0.1	7.86	0.0	$2.67e^{-6}$	0.048	0.93	0.93	0.0	0.1

Independent Variables: $X_{1=}$Density; $X_{2=}$Commercial Use; $X_{3=}$Tree Cover; $X_{4=}$ Institutional Use; $X_{5=}$Residential Use; $X_{6=}$Connectors; $X_{7=}$Enclosure; X_8=Warehouse & Workshop Use. Dependent Variables: $Y_{1=}$Density; $Y_{2=}$Commercial Use; $Y_{3=}$Tree Cover.Dependent Variables: $Y_{1=}$Density; $Y_{2=}$Commercial Use; $Y_{3=}$Tree Cover and Independent Variables: $X_{1=}$Density; $X_{2=}$Commercial Use; $X_{3=}$Tree Cover are mutually exclusive variables.

Table 1: Variables for All Spaces 1963 Source: Author

SPACE	INDEPENDENT VARIABLES								DEPENDENT VARIABLES		
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	Y_1	Y_2	Y_3
S_1 (CP)	4.67	0.023	0.05	0.088	0.0	$6.8e^{-8}$	0.00789	0.0	4.67	0.023	0.05
S_2 (JG)	5.0	2.62	0.45	0.60	0.14	$1.69e^{-6}$	0.0554	0.0	5.0	2.62	0.45
S_3 (JMP)	7.89	0.126	0.1	0.0	1.893	$1.31e^{-6}$	0.0583	1.042	7.89	0.126	0.1
S_4 (HHC)	1.93	73.84	0.1	19.52	0.0	$2.74e^{-5}$	0.0583	0.0	1.93	73.84	0.1
S_5 (GCR)	1.8	1.45	0.2	0.082	0.0	$1.58e^{-6}$	0.0093	0.14	1.8	1.45	0.2
S_6 (FSR)	7.9	2.26	0.1	2.26	0.0	$9.02e^{-5}$	0.0957	0.0	7.9	2.26	0.1
S_7 (SCP)	1.31	32.72	0.05	6.32	0.0	$6.59e^{-7}$	0.0159	0.0	1.31	32.72	0.05
S_8 (NSCP)	1.5	21.1	0.2	9.47	0.0	$1.31e^{-6}$	0.0147	0.0	1.5	21.1	0.2
S_9 (RGP)	1.77	1.25	0.1	2.98	0.0	$4.0e^{-7}$	0.012	1.09	1.77	1.25	0.1
S_{10} (KP)	0.69	2.76	0.1	21.61	0.0	$4.65e^{7}$	0.011	0.0	0.69	2.76	0.1
S_{11}(RBT)	1.77	2.5	0.45	5.97	0.0	$6.67e^{7}$	0.0175	1.32	1.77	2.5	0.45
S_{12}(KBT)	4.4	3.71	0.0	2.40	0.0	$3.49e^{-6}$	0.0444	0.0	4.4	3.71	0.0
S_{13}(AKW)	1.64	52.02	0.2	6.89	0.0	$2.30e^{-6}$	0.0091	0.0	1.64	52.02	0.2
S_{14}(NHCW)	1.64	10.56	0.1	3.08	0.0	$8.8e^{-6}$	0.014	0.0	1.64	10.56	0.1
S_{15}(WM)	1.0	0.0	0.0	10.71	0.0	$2.67e^{-6}$	0.059	0.93	1.0	0.0	0.0

Independent Variables: $X_{1=}$Density; $X_{2=}$Commercial Use; $X_{3=}$Tree Cover; $X_{4=}$ Institutional Use; $X_{5=}$Residential Use; $X_{6=}$Connectors; $X_{7=}$Enclosure; X_8=Warehouse & Workshop Use. Dependent Variables: $Y_{1=}$Density; $Y_{2=}$Commercial Use; $Y_{3=}$Tree Cover.Dependent Variables: $Y_{1=}$Density; $Y_{2=}$Commercial Use; $Y_{3=}$Tree Cover and Independent Variables: $X_{1=}$Density; $X_{2=}$Commercial Use; $X_{3=}$Tree Cover are mutually exclusive variables.

Table 2: Variables for All Spaces 1971 Source: Author

SPACE	INDEPENDENT VARIABLES								DEPENDENT VARIABLES		
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	Y_1	Y_2	Y_3
S_1 (CP)	7.33	0.428	0.10	0.070	0.0	$6.8e^{-8}$	0.00789	0.0	7.33	0.428	0.10
S_2 (JG)	6.21	3.53	0.70	0.62	0.14	$2.03e^{-6}$	0.0618	0.0	6.21	3.53	0.70
S_3 (JMP)	7.33	0.126	0.40	0.0	1.893	$1.31e^{-6}$	0.0583	1.152	7.33	0.126	0.40
S_4 (HHC)	2.0	109.79	0.2	48.52	0.0	$2.74e^{-5}$	0.0583	0.0	2.0	109.79	0.2
S_5 (GCR)	2.7	1.56	0.2	0.082	0.0	$1.58e^{-6}$	0.0116	0.14	2.7	1.56	0.2
S_6 (FSR)	7.9	34.30	0.1	2.26	0.0	$9.02e^{-5}$	0.0957	0.0	7.9	34.30	0.1
S_7 (SCP)	1.44	32.72	0.10	6.32	0.0	$6.59e^{-7}$	0.0159	0.0	1.44	32.72	0.10
S_8 (NSCP)	1.63	45.21	0.4	21.39	0.0	$1.31e^{-6}$	0.0176	0.0	1.63	45.21	0.4
S_9 (RGP)	2.15	1.57	0.1	2.98	0.0	$4.0e^{-7}$	0.016	1.09	2.15	1.57	0.1
S_{10} (KP)	1.32	9.34	0.3	21.61	0.0	$4.65e^{-7}$	0.013	0.0	1.32	9.34	0.3
S_{11}(RBT)	2.15	2.5	0.45	5.97	0.0	$6.67e^{-7}$	0.0175	1.32	2.15	2.5	0.45
S_{12}(KBT)	4.8	4.24	0.0	2.40	0.0	$3.49e^{-6}$	0.0481	0.0	4.8	4.24	0.0
S_{13}(AKW)	2.18	47.58	0.2	17.14	0.0	$9.02e^{-5}$	0.0957	0.0	2.18	47.58	0.2
S_{14}(NHCW)	2.18	12.32	0.1	8.95	0.0	$6.85e^{-6}$	0.018	0.0	2.18	12.32	0.1
S_{15}(WM)	1.36	0.0	0.0	10.71	0.0	$2.67e^{-6}$	0.078	0.93	1.36	0.0	0.0

Independent Variables: X_1=Density; X_2=Commercial Use; X_3=Tree Cover; X_4= Institutional Use; X_5=Residential Use; X_6=Connectors; X_7=Enclosure; X_8=Warehouse & Workshop Use. Dependent Variables: Y_1=Density; Y_2=Commercial Use; Y_3=Tree Cover.Dependent Variables: Y_1=Density; Y_2=Commercial Use; Y_3=Tree Cover and Independent Variables: X_1=Density; X_2=Commercial Use; X_3=Tree Cover are mutually exclusive variables.

Table 3: Variables for All Spaces 1978

Source: Author

SPACE	INDEPENDENT VARIABLES								DEPENDENT VARIABLES		
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	Y_1	Y_2	Y_3
S_1 (CP)	11.0	1.096	0.20	0.116	0.0	$9.09e^{-8}$	0.00701	0.0	11.0	1.096	0.20
S_2 (JG)	6.06	3.67	0.70	0.76	0.10	$2.03e^{-6}$	0.0640	0.0	6.06	3.67	0.70
S_3 (JMP)	7.33	0.126	0.35	0.0	1.578	$1.31e^{-6}$	0.0583	1.168	7.33	0.126	0.35
S_4 (HHC)	2.0	109.79	0.35	48.52	0.0	$2.74e^{-5}$	0.0583	0.0	2.0	109.79	0.35
S_5 (GCR)	3.2	3.63	0.1	0.082	0.0	$1.74e^{-6}$	0.0163	0.14	3.2	3.63	0.1
S_6 (FSR)	8.3	34.30	0.1	2.26	0.0	$9.02e^{-5}$	0.0957	0.0	8.3	34.30	0.1
S_7 (SCP)	1.50	47.14	0.30	6.32	0.0	$1.32e^{-6}$	0.0192	0.0	1.50	47.14	0.30
S_8 (NSCP)	1.69	60.66	0.5	21.39	0.0	$1.31e^{-6}$	0.0235	0.0	1.69	60.66	0.5
S_9 (RGP)	2.37	1.70	0.05	2.98	0.0	$4.0e^{-7}$	0.016	0.95	2.37	1.70	0.05
S_{10} (KP)	1.32	9.34	0.2	21.61	0.0	$4.65e^{-7}$	0.013	0.0	1.32	9.34	0.2
S_{11}(RBT)	2.37	11.83	0.3	6.63	0.0	$6.67e^{-7}$	0.0175	1.05	2.37	11.83	0.3
S_{12}(KBT)	5.2	4.58	0.0	2.40	0.0	$3.49e^{-6}$	0.0481	0.0	5.2	4.58	0.0
S_{13}(AKW)	2.30	72.25	0.25	17.86	0.0	$2.13e^{-6}$	0.0175	0.0	2.30	72.25	0.25
S_{14}(NHCW)	2.30	14.77	0.2	11.39	0.0	$6.85e^{-6}$	0.018	0.0	2.30	14.77	0.2
S_{15}(WM)	1.21	0.0	0.0	10.71	0.0	$2.67e^{-6}$	0.063	0.43	1.21	0.0	0.0

Independent Variables: X_1=Density; X_2=Commercial Use; X_3=Tree Cover; X_4= Institutional Use; X_5=Residential Use; X_6=Connectors; X_7=Enclosure; X_8=Warehouse & Workshop Use. Dependent Variables: Y_1=Density; Y_2=Commercial Use; Y_3=Tree Cover.Dependent Variables: Y_1=Density; Y_2=Commercial Use; Y_3=Tree Cover and Independent Variables: X_1=Density; X_2=Commercial Use; X_3=Tree Cover are mutually exclusive variables.

Table 4: Variables for All Spaces 1998

Source: Author

SPACE	INDEPENDENT VARIABLES								DEPENDENT VARIABLES		
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	Y_1	Y_2	Y_3
S_1 (CP)	10	1.096	0.20	0.116	0.0	$9.09e^{-8}$	0.00701	0.0	10	1.096	0.20
S_2 (JG)	6.06	4.14	0.55	1.23	0.10	$2.03e^{-6}$	0.0640	0.0	6.06	4.14	0.55
S_3 (JMP)	7.33	0.126	0.20	0.0	1.578	$1.31e^{-6}$	0.0583	1.168	7.33	0.126	0.20
S_4 (HHC)	2.0	109.79	0.55	48.52	0.0	$2.74e^{-5}$	0.0583	0.0	2.0	109.79	0.55
S_5 (GCR)	3.2	3.52	0.1	0.18	0.0	$1.74e^{-6}$	0.0163	0.16	3.2	3.52	0.1
S_6 (FSR)	9.1	34.30	0.1	2.26	0.0	$9.02e^{-5}$	0.0957	0.0	9.1	34.30	0.1
S_7 (SCP)	1.56	47.14	0.35	6.32	0.0	$1.32e^{-6}$	0.0192	0.0	1.56	47.14	0.35
S_8 (NSCP)	1.69	60.66	0.55	21.39	0.0	$1.31e^{-6}$	0.0235	0.0	1.69	60.66	0.55
S_9 (RGP)	2.37	1.70	0	2.98	0.0	$4.0e^{-7}$	0.016	0.95	2.37	1.70	0
S_{10} (KP)	1.32	14.39	0.3	33.30	0.0	$4.65e^{-7}$	0.013	0.0	1.32	14.39	0.3
S_{11}(RBT)	2.37	11.83	0.1	6.63	0.0	$6.67e^{-7}$	0.0175	1.05	2.37	11.83	0.1
S_{12}(KBT)	5.4	4.58	0.0	2.40	0.0	$2.62e^{-6}$	0.0481	0.0	5.4	4.58	0.0
S_{13}(AKW)	2.30	72.25	0.3	17.86	0.0	$2.13e^{-6}$	0.0175	0.0	2.30	72.25	0.3
S_{14}(NHCW)	2.30	14.77	0.25	11.39	0.0	$6.85e^{-6}$	0.018	0.0	2.30	14.77	0.25
S_{15}(WM)	1.71	0.0	0.0	10.71	0.0	$2.67e^{-6}$	0.063	0.43	1.71	0.0	0.0

Independent Variables: X_1=Density; X_2=Commercial Use; X_3=Tree Cover; X_4= Institutional Use; X_5=Residential Use; X_6=Connectors; X_7=Enclosure; X_8=Warehouse & Workshop Use. Dependent Variables: Y_1=Density; Y_2=Commercial Use; Y_3=Tree Cover.Dependent Variables: Y_1=Density; Y_2=Commercial Use; Y_3=Tree Cover and Independent Variables: X_1=Density; X_2=Commercial Use; X_3=Tree Cover are mutually exclusive variables.

Table 5: Variables for All Spaces 2003

Source: Author

SPACE	INDEPENDENT VARIABLES								DEPENDENT VARIABLES		
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	Y_1	Y_2	Y_3
S_1 (CP)	10.67	1.096	0.35	0.116	0.0	$9.09e^{-8}$	0.00701	0.0	10.67	1.096	0.35
S_2 (JG)	6.67	4.14	0.8	1.24	0.05	$2.03e^{-6}$	0.0640	0.0	6.67	4.14	0.8
S_3 (JMP)	6.11	0.126	0.80	0.0	1.578	$1.31e^{-6}$	0.0583	1.073	6.11	0.126	0.80
S_4 (HHC)	2.0	109.79	0.7	48.52	0.0	$2.74e^{-5}$	0.0583	0.0	2.0	109.79	0.7
S_5 (GCR)	2.8	3.52	0.05	0.20	0.0	$1.74e^{-6}$	0.0116	0.0	2.8	3.52	0.05
S_6 (FSR)	9.1	34.30	0.05	2.26	0.0	$9.02e^{-5}$	0.0957	0.0	9.1	34.30	0.05
S_7 (SCP)	1.56	47.14	0.40	6.32	0.0	$1.32e^{-6}$	0.0192	0.0	1.56	47.14	0.40
S_8 (NSCP)	1.69	60.66	0.5	21.39	0.0	$1.31e^{-6}$	0.0235	0.0	1.69	60.66	0.5
S_9 (RGP)	2.30	1.64	0	2.98	0.0	$4.0e^{-7}$	0.016	0.13	2.30	1.64	0
S_{10} (KP)	1.38	11.97	0.25	30.72	0.0	$4.65e^{-7}$	0.016	0.0	1.38	11.97	0.25
S_{11}(RBT)	2.30	11.7	0.2	6.63	0.0	$6.67e^{-7}$	0.0175	0.25	2.30	11.7	0.2
S_{12}(KBT)	8.2	4.58	0.0	2.40	0.0	$2.62e^{-6}$	0.0519	0.0	8.2	4.58	0.0
S_{13}(AKW)	2.30	72.25	0.4	17.86	0.0	$2.13e^{-6}$	0.0175	0.0	2.30	72.25	0.4
S_{14}(NHCW)	2.30	14.87	0.25	11.39	0.0	$6.85e^{-6}$	0.021	0.0	2.30	14.87	0.25
S_{15}(WM)	3.20	3.57	0.0	10.71	0.0	$2.67e^{-6}$	0.063	0.0	3.20	3.57	0.0

Independent Variables: X_1=Density; X_2=Commercial Use; X_3=Tree Cover; X_4= Institutional Use; X_5=Residential Use; X_6=Connectors; X_7=Enclosure; X_8=Warehouse & Workshop Use. Dependent Variables: Y_1=Density; Y_2=Commercial Use; Y_3=Tree Cover.Dependent Variables: Y_1=Density; Y_2=Commercial Use; Y_3=Tree Cover and Independent Variables: X_1=Density; X_2=Commercial Use; X_3=Tree Cover are mutually exclusive variables.

Table 6: Variables for All Spaces 2015

Source: Author

Appendix 2: Pearson Correlation Coefficients Table for All Spaces (1963-2015)

Note for all Correlations: *. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).
Independent Variables: $X_{1=}$Density; $X_{2=}$Commercial Use; $X_{3=}$Tree Cover; $X_{4=}$ Institutional Use; $X_{5=}$Residential Use; $X_{6=}$Connectors; $X_{7=}$Enclosure; X_8=Warehouse & Workshop Use
Dependent Variables: $Y_{1=}$Density; $Y_{2=}$Commercial Use; $Y_{3=}$Tree Cover.
Dependent Variables: $Y_{1=}$Density; $Y_{2=}$Commercial Use; $Y_{3=}$Tree Cover and Independent Variables: $X_{1=}$Density; $X_{2=}$Commercial Use; $X_{3=}$Tree Cover are mutually exclusive variables.

1963 Correlations

		X1	X2	X3	X4	X5	X6	X7	X8	Y1	Y2	Y3
X1	Pearson Correlation	1	-.374	-.008	-.533*	.180	.366	.439	.113	1.000**	-.374	-.008
	Sig. (2-tailed)		.169	.978	.041	.521	.179	.102	.689	.000	.169	.978
	N	15	15	15	15	15	15	15	15	15	15	15
X2	Pearson Correlation	-.374	1	.373	.759**	-.218	.275	.086	-.261	-.374	1.000**	.373
	Sig. (2-tailed)	.169		.171	.001	.435	.322	.761	.347	.169	.000	.171
	N	15	15	15	15	15	15	15	15	15	15	15
X3	Pearson Correlation	-.008	.373	1	.289	.487	-.153	.137	.404	-.008	.373	1.000**
	Sig. (2-tailed)	.978	.171		.297	.066	.585	.626	.135	.978	.171	.000
	N	15	15	15	15	15	15	15	15	15	15	15
X4	Pearson Correlation	-.533*	.759**	.289	1	-.224	.047	-.021	-.255	-.533*	.759**	.289
	Sig. (2-tailed)	.041	.001	.297		.422	.868	.942	.359	.041	.001	.297
	N	15	15	15	15	15	15	15	15	15	15	15
X5	Pearson Correlation	.180	-.218	.487	-.224	1	-.099	.241	.966**	.180	-.218	.487
	Sig. (2-tailed)	.521	.435	.066	.422		.726	.387	.000	.521	.435	.066
	N	15	15	15	15	15	15	15	15	15	15	15
X6	Pearson Correlation	.366	.275	-.153	.047	-.099	1	.682**	-.132	.366	.275	-.153
	Sig. (2-tailed)	.179	.322	.585	.868	.726		.005	.639	.179	.322	.585
	N	15	15	15	15	15	15	15	15	15	15	15
X7	Pearson Correlation	.439	.086	.137	-.021	.241	.682**	1	.160	.439	.086	.137
	Sig. (2-tailed)	.102	.761	.626	.942	.387	.005		.568	.102	.761	.626
	N	15	15	15	15	15	15	15	15	15	15	15
X8	Pearson Correlation	.113	-.261	.404	-.255	.966**	-.132	.160	1	.113	-.261	.404
	Sig. (2-tailed)	.689	.347	.135	.359	.000	.639	.568		.689	.347	.135
	N	15	15	15	15	15	15	15	15	15	15	15
Y1	Pearson Correlation	1.000**	-.374	-.008	-.533*	.180	.366	.439	.113	1	-.374	-.008
	Sig. (2-tailed)	.000	.169	.978	.041	.521	.179	.102	.689		.169	.978
	N	15	15	15	15	15	15	15	15	15	15	15
Y2	Pearson Correlation	-.374	1.000**	.373	.759**	-.218	.275	.086	-.261	-.374	1	.373
	Sig. (2-tailed)	.169	.000	.171	.001	.435	.322	.761	.347	.169		.171
	N	15	15	15	15	15	15	15	15	15	15	15
Y3	Pearson Correlation	-.008	.373	1.000**	.289	.487	-.153	.137	.404	-.008	.373	1
	Sig. (2-tailed)	.978	.171	.000	.297	.066	.585	.626	.135	.978	.171	
	N	15	15	15	15	15	15	15	15	15	15	15

1971 Correlations

		X1	X2	X3	X4	X5	X6	X7	X8	Y1	Y2	Y3
X1	Pearson Correlation	1	-.321	-.015	-.552*	.584*	-.277	.666**	.008	1.000**	-.321	-.015
	Sig. (2-tailed)		.243	.957	.033	.022	.317	.007	.978	.000	.243	.957
	N	15	15	15	15	15	15	15	15	15	15	15
X2	Pearson Correlation	-.321	1	-.056	.503	-.180	-.200	-.031	-.365	-.321	1.000**	-.056
	Sig. (2-tailed)	.243		.843	.056	.521	.475	.913	.181	.243	.000	.843
	N	15	15	15	15	15	15	15	15	15	15	15
X3	Pearson Correlation	-.015	-.056	1	-.151	-.049	.460	-.099	.177	-.015	-.056	1.000**
	Sig. (2-tailed)	.957	.843		.591	.863	.084	.726	.528	.957	.843	.000
	N	15	15	15	15	15	15	15	15	15	15	15
X4	Pearson Correlation	-.552*	.503	-.151	1	-.268	.369	-.042	-.139	-.552*	.503	-.151
	Sig. (2-tailed)	.033	.056	.591		.334	.176	.883	.621	.033	.056	.591
	N	15	15	15	15	15	15	15	15	15	15	15
X5	Pearson Correlation	.584*	-.180	-.049	-.268	1	-.111	.283	.396	.584*	-.180	-.049
	Sig. (2-tailed)	.022	.521	.863	.334		.694	.307	.144	.022	.521	.863
	N	15	15	15	15	15	15	15	15	15	15	15
X6	Pearson Correlation	-.277	-.200	.460	.369	-.111	1	-.253	.378	-.277	-.200	.460
	Sig. (2-tailed)	.317	.475	.084	.176	.694		.362	.165	.317	.475	.084
	N	15	15	15	15	15	15	15	15	15	15	15
X7	Pearson Correlation	.666**	-.031	-.099	-.042	.283	-.253	1	.040	.666**	-.031	-.099
	Sig. (2-tailed)	.007	.913	.726	.883	.307	.362		.888	.007	.913	.726
	N	15	15	15	15	15	15	15	15	15	15	15
X8	Pearson Correlation	.008	-.365	.177	-.139	.396	.378	.040	1	.008	-.365	.177
	Sig. (2-tailed)	.978	.181	.528	.621	.144	.165	.888		.978	.181	.528
	N	15	15	15	15	15	15	15	15	15	15	15
Y1	Pearson Correlation	1.000**	-.321	-.015	-.552*	.584*	-.277	.666**	.008	1	-.321	-.015
	Sig. (2-tailed)	.000	.243	.957	.033	.022	.317	.007	.978		.243	.957
	N	15	15	15	15	15	15	15	15	15	15	15
Y2	Pearson Correlation	-.321	1.000**	-.056	.503	-.180	-.200	-.031	-.365	-.321	1	-.056
	Sig. (2-tailed)	.243	.000	.843	.056	.521	.475	.913	.181	.243		.843
	N	15	15	15	15	15	15	15	15	15	15	15
Y3	Pearson Correlation	-.015	-.056	1.000**	-.151	-.049	.460	-.099	.177	-.015	-.056	1
	Sig. (2-tailed)	.957	.843	.000	.591	.863	.084	.726	.528	.957	.843	
	N	15	15	15	15	15	15	15	15	15	15	15

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

1978 Correlations

		X1	X2	X3	X4	X5	X6	X7	X8	Y1	Y2	Y3
X1	Pearson Correlation	1	-.249	.151	-.510	.453	.211	.315	-.056	1.000**	-.249	.151
	Sig. (2-tailed)		.371	.592	.052	.090	.449	.252	.842	.000	.371	.592
	N	15	15	15	15	15	15	15	15	15	15	15
X2	Pearson Correlation	-.249	1	-.046	.856**	-.198	.451	.295	-.410	-.249	1.000**	-.046
	Sig. (2-tailed)	.371		.872	.000	.480	.091	.286	.129	.371	.000	.872
	N	15	15	15	15	15	15	15	15	15	15	15
X3	Pearson Correlation	.151	-.046	1	.002	.304	-.173	-.036	.113	.151	-.046	1.000**
	Sig. (2-tailed)	.592	.872		.993	.271	.536	.898	.689	.592	.872	.000
	N	15	15	15	15	15	15	15	15	15	15	15
X4	Pearson Correlation	-.510	.856**	.002	1	-.226	.167	.113	-.265	-.510	.856**	.002
	Sig. (2-tailed)	.052	.000	.993		.418	.553	.689	.340	.052	.000	.993
	N	15	15	15	15	15	15	15	15	15	15	15
X5	Pearson Correlation	.453	-.198	.304	-.226	1	-.133	.166	.442	.453	-.198	.304
	Sig. (2-tailed)	.090	.480	.271	.418		.636	.555	.099	.090	.480	.271
	N	15	15	15	15	15	15	15	15	15	15	15
X6	Pearson Correlation	.211	.451	-.173	.167	-.133	1	.742**	-.291	.211	.451	-.173
	Sig. (2-tailed)	.449	.091	.536	.553	.636		.002	.293	.449	.091	.536
	N	15	15	15	15	15	15	15	15	15	15	15
X7	Pearson Correlation	.315	.295	-.036	.113	.166	.742**	1	-.033	.315	.295	-.036
	Sig. (2-tailed)	.252	.286	.898	.689	.555	.002		.907	.252	.286	.898
	N	15	15	15	15	15	15	15	15	15	15	15
X8	Pearson Correlation	-.056	-.410	.113	-.265	.442	-.291	-.033	1	-.056	-.410	.113
	Sig. (2-tailed)	.842	.129	.689	.340	.099	.293	.907		.842	.129	.689
	N	15	15	15	15	15	15	15	15	15	15	15
Y1	Pearson Correlation	1.000**	-.249	.151	-.510	.453	.211	.315	-.056	1	-.249	.151
	Sig. (2-tailed)	.000	.371	.592	.052	.090	.449	.252	.842		.371	.592
	N	15	15	15	15	15	15	15	15	15	15	15
Y2	Pearson Correlation	-.249	1.000**	-.046	.856**	-.198	.451	.295	-.410	-.249	1	-.046
	Sig. (2-tailed)	.371	.000	.872	.000	.480	.091	.286	.129	.371		.872
	N	15	15	15	15	15	15	15	15	15	15	15
Y3	Pearson Correlation	.151	-.046	1.000**	.002	.304	-.173	-.036	.113	.151	-.046	1
	Sig. (2-tailed)	.592	.872	.000	.993	.271	.536	.898	.689	.592	.872	
	N	15	15	15	15	15	15	15	15	15	15	15

1998 Correlations

		X1	X2	X3	X4	X5	X6	X7	X8	Y1	Y2	Y3
X1	Pearson Correlation	1	-.329	.041	-.513	.332	.337	.317	-.012	1.000**	-.329	.041
	Sig. (2-tailed)		.231	.886	.050	.227	.220	.250	.966	.000	.231	.886
	N	15	15	15	15	15	15	15	15	15	15	15
X2	Pearson Correlation	-.329	1	.295	.812**	-.219	.275	.085	-.389	-.329	1.000**	.295
	Sig. (2-tailed)	.231		.287	.000	.434	.321	.763	.152	.231	.000	.287
	N	15	15	15	15	15	15	15	15	15	15	15
X3	Pearson Correlation	.041	.295	1	.197	.203	-.163	.055	-.097	.041	.295	1.000**
	Sig. (2-tailed)	.886	.287		.482	.468	.561	.847	.732	.886	.287	.000
	N	15	15	15	15	15	15	15	15	15	15	15
X4	Pearson Correlation	-.513	.812**	.197	1	-.229	.068	.002	-.299	-.513	.812**	.197
	Sig. (2-tailed)	.050	.000	.482		.411	.809	.994	.279	.050	.000	.482
	N	15	15	15	15	15	15	15	15	15	15	15
X5	Pearson Correlation	.332	-.219	.203	-.229	1	-.103	.255	.576*	.332	-.219	.203
	Sig. (2-tailed)	.227	.434	.468	.411		.716	.358	.024	.227	.434	.468
	N	15	15	15	15	15	15	15	15	15	15	15
X6	Pearson Correlation	.337	.275	-.163	.068	-.103	1	.690**	-.221	.337	.275	-.163
	Sig. (2-tailed)	.220	.321	.561	.809	.716		.004	.428	.220	.321	.561
	N	15	15	15	15	15	15	15	15	15	15	15
X7	Pearson Correlation	.317	.085	.055	.002	.255	.690**	1	-.015	.317	.085	.055
	Sig. (2-tailed)	.250	.763	.847	.994	.358	.004		.958	.250	.763	.847
	N	15	15	15	15	15	15	15	15	15	15	15
X8	Pearson Correlation	-.012	-.389	-.097	-.299	.576*	-.221	-.015	1	-.012	-.389	-.097
	Sig. (2-tailed)	.966	.152	.732	.279	.024	.428	.958		.966	.152	.732
	N	15	15	15	15	15	15	15	15	15	15	15
Y1	Pearson Correlation	1.000**	-.329	.041	-.513	.332	.337	.317	-.012	1	-.329	.041
	Sig. (2-tailed)	.000	.231	.886	.050	.227	.220	.250	.966		.231	.886
	N	15	15	15	15	15	15	15	15	15	15	15
Y2	Pearson Correlation	-.329	1.000**	.295	.812**	-.219	.275	.085	-.389	-.329	1	.295
	Sig. (2-tailed)	.231	.000	.287	.000	.434	.321	.763	.152	.231		.287
	N	15	15	15	15	15	15	15	15	15	15	15
Y3	Pearson Correlation	.041	.295	1.000**	.197	.203	-.163	.055	-.097	.041	.295	1
	Sig. (2-tailed)	.886	.287	.000	.482	.468	.561	.847	.732	.886	.287	
	N	15	15	15	15	15	15	15	15	15	15	15

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

2003 Correlations

		X1	X2	X3	X4	X5	X6	X7	X8	Y1	Y2	Y3
X1	Pearson Correlation	1	-.339	-.174	-.539*	.338	.418	.412	-.009	1.000**	-.339	-.174
	Sig. (2-tailed)		.217	.536	.038	.217	.121	.127	.974	.000	.217	.536
	N	15	15	15	15	15	15	15	15	15	15	15
X2	Pearson Correlation	-.339	1	.630*	.744**	-.223	.274	.077	-.400	-.339	1.000**	.630*
	Sig. (2-tailed)	.217		.012	.001	.425	.324	.784	.139	.217	.000	.012
	N	15	15	15	15	15	15	15	15	15	15	15
X3	Pearson Correlation	-.174	.630*	1	.551*	-.024	-.062	-.002	-.447	-.174	.630*	1.000**
	Sig. (2-tailed)	.536	.012		.033	.933	.825	.995	.095	.536	.012	.000
	N	15	15	15	15	15	15	15	15	15	15	15
X4	Pearson Correlation	-.539*	.744**	.551*	1	-.230	.041	-.047	-.316	-.539*	.744**	.551*
	Sig. (2-tailed)	.038	.001	.033		.410	.885	.869	.252	.038	.001	.033
	N	15	15	15	15	15	15	15	15	15	15	15
X5	Pearson Correlation	.338	-.223	-.024	-.230	1	-.102	.255	.576*	.338	-.223	-.024
	Sig. (2-tailed)	.217	.425	.933	.410		.718	.358	.025	.217	.425	.933
	N	15	15	15	15	15	15	15	15	15	15	15
X6	Pearson Correlation	.418	.274	-.062	.041	-.102	1	.688**	-.221	.418	.274	-.062
	Sig. (2-tailed)	.121	.324	.825	.885	.718		.005	.429	.121	.324	.825
	N	15	15	15	15	15	15	15	15	15	15	15
X7	Pearson Correlation	.412	.077	-.002	-.047	.255	.688**	1	-.017	.412	.077	-.002
	Sig. (2-tailed)	.127	.784	.995	.869	.358	.005		.951	.127	.784	.995
	N	15	15	15	15	15	15	15	15	15	15	15

X8	Pearson Correlation	-.009	-.400	-.447	-.316	.576*	-.221	-.017	1	-.009	-.400	-.447
	Sig. (2-tailed)	.974	.139	.095	.252	.025	.429	.951		.974	.139	.095
	N	15	15	15	15	15	15	15	15	15	15	15
Y1	Pearson Correlation	1.000**	-.339	-.174	-.539*	.338	.418	.412	-.009	1	-.339	-.174
	Sig. (2-tailed)	.000	.217	.536	.038	.217	.121	.127	.974		.217	.536
	N	15	15	15	15	15	15	15	15	15	15	15
Y2	Pearson Correlation	-.339	1.000**	.630*	.744**	-.223	.274	.077	-.400	-.339	1	.630*
	Sig. (2-tailed)	.217	.000	.012	.001	.425	.324	.784	.139	.217		.012
	N	15	15	15	15	15	15	15	15	15	15	15
Y3	Pearson Correlation	-.174	.630*	1.000**	.551*	-.024	-.062	-.002	-.447	-.174	.630*	1
	Sig. (2-tailed)	.536	.012	.000	.033	.933	.825	.995	.095	.536	.012	
	N	15	15	15	15	15	15	15	15	15	15	15

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

2015 Correlations

		X1	X2	X3	X4	X5	X6	X7	X8	Y1	Y2	Y3
X1	Pearson Correlation	1	-.374	-.008	-.533*	.180	.366	.439	.113	1.000**	-.374	-.008
	Sig. (2-tailed)		.169	.978	.041	.521	.179	.102	.689	.000	.169	.978
	N	15	15	15	15	15	15	15	15	15	15	15
X2	Pearson Correlation	-.374	1	.373	.759**	-.218	.275	.086	-.261	-.374	1.000**	.373
	Sig. (2-tailed)	.169		.171	.001	.435	.322	.761	.347	.169	.000	.171
	N	15	15	15	15	15	15	15	15	15	15	15
X3	Pearson Correlation	-.008	.373	1	.289	.487	-.153	.137	.404	-.008	.373	1.000**

	Sig. (2-tailed)	.978	.171		.297	.066	.585	.626	.135	.978	.171	.000
	N	15	15	15	15	15	15	15	15	15	15	15
X4	Pearson Correlation	-.533*	.759**	.289	1	-.224	.047	-.021	-.255	-.533*	.759**	.289
	Sig. (2-tailed)	.041	.001	.297		.422	.868	.942	.359	.041	.001	.297
	N	15	15	15	15	15	15	15	15	15	15	15
X5	Pearson Correlation	.180	-.218	.487	-.224	1	-.099	.241	.966**	.180	-.218	.487
	Sig. (2-tailed)	.521	.435	.066	.422		.726	.387	.000	.521	.435	.066
	N	15	15	15	15	15	15	15	15	15	15	15
X6	Pearson Correlation	.366	.275	-.153	.047	-.099	1	.682**	-.132	.366	.275	-.153
	Sig. (2-tailed)	.179	.322	.585	.868	.726		.005	.639	.179	.322	.585
	N	15	15	15	15	15	15	15	15	15	15	15
X7	Pearson Correlation	.439	.086	.137	-.021	.241	.682**	1	.160	.439	.086	.137
	Sig. (2-tailed)	.102	.761	.626	.942	.387	.005		.568	.102	.761	.626
	N	15	15	15	15	15	15	15	15	15	15	15
X8	Pearson Correlation	.113	-.261	.404	-.255	.966**	-.132	.160	1	.113	-.261	.404
	Sig. (2-tailed)	.689	.347	.135	.359	.000	.639	.568		.689	.347	.135
	N	15	15	15	15	15	15	15	15	15	15	15
Y1	Pearson Correlation	1.000**	-.374	-.008	-.533*	.180	.366	.439	.113	1	-.374	-.008
	Sig. (2-tailed)	.000	.169	.978	.041	.521	.179	.102	.689		.169	.978
	N	15	15	15	15	15	15	15	15	15	15	15
Y2	Pearson Correlation	-.374	1.000**	.373	.759**	-.218	.275	.086	-.261	-.374	1	.373
	Sig. (2-tailed)	.169	.000	.171	.001	.435	.322	.761	.347	.169		.171
	N	15	15	15	15	15	15	15	15	15	15	15

Y3	Pearson Correlation	-.008	.373	1.000**	.289	.487	-.153	.137	.404	-.008	.373	1
	Sig. (2-tailed)	.978	.171	.000	.297	.066	.585	.626	.135	.978	.171	
	N	15	15	15	15	15	15	15	15	15	15	15

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix 3: Data Collection Observation Form

STRICTLY CONFIDENTIAL
JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
CENTRE FOR URBAN STUDIES

Research: "Establishing Factors that Contribute to Sustainability of Public Open Space in Nairobi CBD".

OBSERVATION FORM

Research Assistant: ____________________________Name of Space: ______________________________

Date: ____________Day of Week: ________________ Time of Day: ________________________________

Note:

- Where applicable observation form items will be observed on Monday, Wednesday and Saturday.
- Where applicable observation form items data will be collected at 8.30am; 11.00am; 1.30pm; 3.00pm; and 5.30pm.
- Confidentiality Clause: In the event that questions are asked by the researcher, respondents should note that their responses are voluntary and will be kept confidential. All responses will be compiled together and analyzed as a group.

I) GENERAL INFORMATION

Type of space; tick as appropriate:

Code No.	Space
1	Park/Garden
2	Pedestrian Accessible Roundabout
3	Car Park
4	Bus/PSV Terminus
5	Promenade

II) VARIABLES RELATED TO BUILT PHYSICAL ENVIRONMENT

Within the Space

1. Size of Space

BPE1A: Length of space in metres___________

(For irregular shaped spaces indicate perimetre lengths on sketch or map)

BPE1B: Width of space in metres___________

BPE1C: Diametre of space in metres___________

(PI to calculate Area of space in sq. metres)

2. Legibility

Code: Yes: 1; No: 0

BPE2A: Presence of boundary wall, edge, or fence defining perimeter of the space___________

BPE2B: Presence of good sight line from centre of space to main entries/exits of space________
BPE2C: Presence of clearly visible entries/exits to the space__________

3. Entry Control
BPE3A: No. of lockable gate/s into the space per sq.m.__________
BPE3B: No. of security barriers into the space per sq.m.____________
BPE3C: No. of entries and exits per linear distance of space_______________
BPE3D: No of wheelchair accessible ramps into space per unit area_______________

4. Circulation
BPE4A: Length of pathways in space in metres__________
BPE4B: Width of pathways in space in metres__________
(PI to calculate Area covered by paved pathways calculated as % of area of space)
(PI to calculate Total area of paved ground surface (including pathways) as % of area of space)

5. Permeability
BPE5A: No. of connector spaces perpendicular to space boundary per linear perimeter distance___________
BPE5B: Width(s) of connector spaces perpendicular to space boundary___________
(PI to calculate Average width of connector spaces perpendicular to space boundary)

6. Shape of Space
BPE6A: Shortest (narrowest) distance of space in metres_____________
BPE6B: Longest most direct distance of space in metres_____________

7. Boundary of Space
BPE7A: Height of wall or fence enclosing the space______________
BPE7B: No. of roads/streets enclosing the space ________________

8. Focal Point within Space
Code: Yes: 1; No: 0.
BPE8A: Presence of monuments/statues within space_____________
BPE8B: Presence of natural or man-made water feature within space______

9. Diversity of Space Use within Space
Code: Yes: 1; No: 0.
Public Services:
BPE9A: No. of parking spaces for cars in space per unit area____________
BPE9B: No. of parking spaces for PSVs in space per unit area _______________
BPE9C: No. of public toilets in space per unit area __________________
BPE9D: No. of drinking fountains in space per unit area_______________
(PI to calculate Area of parking space within space as % of total area)
Offices:
BPE9E: No. of offices in space per unit area_______________
Industrial:
BPE 9F: No. of mechanical workshops in space per unit area ___________
Other:
BPE9G: Presence of swings in space_____________
BPE9H: Presence of dais/space for performances in space ____________

10. Density of Buildings and Structures within Space
Structures refer to permanent, temporary, or movable constructions that are not buildings e.g. bus shelters, bandas & police booths.
BPE10A: No. of buildings and structures in space per unit area ________________

11. Condition of Buildings/Structures within Space
BPE11A: No. of abandoned buildings/structures in space per unit area_________________

12. Cross-section of Space
Code: Yes: 1; No: 0.
BPE12A: Ground level in space lower than surrounding street level_____________
BPE12B: Ground level in space higher than surrounding street level ________________

13. Provision of Seats within Space
BPE13A: No. of benches in the space per unit area________________
BPE13B: Length of hard, man-made surface used as seating in space in metres________________
BPE13C: Width of hard, man-made surface used as seating in space in metres________________
(PI to calculate Area of hard, man-made surface used as seating in space per unit area)

14. Cleanliness within Space
(Data to be collected M/W/Sat at 4.00pm)
BPE14A: Length of rubbish heap(s) in space in metres________________
BPE14B: Width of rubbish heap(s) in space in metres________________
BPE14C: Height of rubbish heaps(s)in space in metres________________
BPE14D: No. of garbage bins in space per unit area________________
(PI to calculate Volume of rubbish in space per unit area)

15. Maintenance/ Upkeep within Space
Code: Yes: 1; No: 0.
BPE15A: Presence of broken or missing paving in space________________
BPE15B: Presence of clogged open drains in space________________
BPE15C: Presence of trimmed hedges, bushes, and flower beds________________
BPE15D: No. of broken benches in space as % of total no. of benches________________

16. Comfort within Space
BPE16A: Length(s) of built shading canopies in space per unit area________________
BPE16B: Width(s) of built shading canopies in space per unit area________________
(PI to calculate Area of built shading canopies in space per unit area)

Surrounding the Space
17. Diversity of Space Use on Surrounding Streets & Sidewalks
Public Services:
BPE17A: No. of parking spaces for cars per linear distance on surrounding streets___________________
BPE17B: No. of parking spaces for PSVs (buses, matatus, boda-bodas) per linear distance on surrounding streets and sidewalks adjacent to space___________________

18. Diversity of Space Use in Buildings Facing the Space
Offices:
BPE18A: Total no of floors in buildings facing space _____________
BPE18B: No. of floors predominantly used as offices in buildings facing space, per total no of floors in buildings facing space _____________
Residential:
BPE18C: No. of residences in buildings facing space per linear distance_____________
Institutional:
BPE18D: No. of learning institutions in buildings facing space per unit area________
BPE18E: No. of banks/financial institutions in buildings facing space per unit area ________
BPE18F: No. of religious institutions in buildings facing space per unit area ________
Entertainment/Social:

BPE18G: No. of bars/night clubs in buildings facing space per unit area________

<u>19. Block Pattern around Space</u>
BPE19A: Width(s) of blocks fronting the space in metres____________
BPE19B: No. of streets/lanes to space in between blocks per linear distance_______________
BPE19C: Depth(s) of blocks fronting the space in metres_______________
(PI to calculate Average width of block fronting the space in metres)
(PI to calculate Average depth of block fronting the space in metres)

<u>20. Density of Buildings/Structures around Space</u>
BPE20A: No. of buildings and structures facing space per linear distance
BPE20B: No. of buildings and structures surrounding space per unit area ________________

<u>21. Condition of Buildings/Structures Surrounding the Space</u>
BPE21A: No. of abandoned buildings/structures surrounding space per linear distance________________

<u>22. Orientation of Entrance to Space of Buildings/Structures Surrounding Space</u>
BPE22A: No. of main doors directly facing space per linear distance__________________

<u>23. Set-back of Building from Space</u>
BPE23A: No. of metres between boundary/edge of space and each nearest building façade_______________
(PI to calculate Average no. of metres between boundary/edge of space and nearest building façade)

<u>24. Proximity of Space to Major PSV (Bus/Matatu) Stage</u>
BPE24A: No. of kms from space to nearest major PSV stage via most direct route_______________

<u>25. Visibility</u>
BPE25A: No of doors of surrounding buildings opening onto street per linear distance_______________

<u>26. Enclosure</u>
BPE26A: No. of floors of surrounding buildings per unit area______________
BPE26B: No. of trees surrounding space per linear distance_______________
(PI to calculate Average no. of floors of surrounding buildings per unit area)

<u>27. Depth of Space from Carrier Space</u>
BPE27A: No. of turns in road connecting space boundary/edge and nearest dual carriageway road._______________

<u>28. Constitutedness of Space (Solid>Void Interaction)</u>
BPE28A: No. of doors of surrounding buildings per linear distance_______________
BPE28B: No. of arcades in buildings surrounding space per linear distance_______________

<u>29. Speed of Vehicular Traffic Surrounding Space</u>
BPE29A: No. of vehicular lanes in each roads/streets surrounding space_______________
BPE29B: No. of zebra crossings on roads/streets surrounding space per linear distance_______________
(PI to calculate Average no. of vehicular lanes of roads/streets surrounding space)
<u>30. Security</u>
BPE30A: No. of windows of surrounding buildings facing space per linear distance_______________

<u>31. Size of Sidewalks Surrounding the Space</u>
BPE31A: Length(s) of surrounding sidewalks adjacent to space in metres

BPE31B: Width(s) of surrounding sidewalks adjacent to space in metres
(PI to calculate Area of surrounding sidewalks in sq. metres)

32. Size of Streets Surrounding the Space
BPE32A: Length(s) of surrounding streets in metres
BPE32B: Width(s) of surrounding streets in metres
(PI to calculate Area of surrounding streets in sq. metres)

III) VARIABLES RELATED TO NATURAL PHYSICAL ENVIRONMENT / ECOLOGICAL ASPECTS
Within the Space
33. Vegetation Cover within Space
NPE33A: No. of trees in space per unit area
NPE33B: Length of space covered in grass in metres________________
NPE33C: Width of space covered in grass in metres________________
(PI to calculate Area of space covered in grass as % of total area)

34. Energy Use within Space
NPE34A: No. of lamp-posts in space per unit area________________
NPE34B: No. of operational lamp-posts in space per unit area________________
NPE34C: No. of solar-powered lamp-posts in space per unit area________________

35. Recycling Bins within Space
NPE35A: No. of recycling bins in space per unit area________________

36. Sound Levels within Space (*Requires use of sound level metre)*
NPE36A: No. of sound decibels in space________________
(PI to calculate average no. of sound decibels in space)
(Data to be collected M/W/Sat at 10.00am and 4.00pm)

Surrounding the Space
37. Energy Use in Surrounding Space
NPE37A: No. of street lights in surrounding space per linear distance________________
NPE37B: No. of operational street lights in surrounding space per linear distance________________
NPE37C: No. of solar-powered street lights in surrounding space per linear distance________________

38. Sound Levels Surrounding the Space (*Requires use of sound level metre)*
NPE38A: No. of sound decibels in surrounding space ________________
(PI to calculate average no. of sound decibels in surrounding space)
(Data to be collected M/W/Sat at 10.00am and 4.00pm)

IV) VARIABLES RELATED TO SOCIAL ASPECTS
Within the Space
39. Number of Users within the space (*Requires use of tally counter)*
SA39A: No. of people using the space per unit area________________
('using' covers people doing all types of activities; counting will be of people that are lying down, sitting, standing, walking, running, playing etc.)
(Data to be collected M/W/ Sat at 8.30am; 11.00am; 1.30pm; 3.00pm; and 5.30pm)

40. Diversity of Users in the Space (Integration)
SA40A: Number of men using the space as % total population of users________________
SA40B: Number of women using the space as % total population of users________________
SA40C: Number of children using the space as % total population of users________________
SA40D: Number of elderly using the space as % total population of users________________

(Data to be collected M/W/ Sat at 8.30am; 11.00am; 1.30pm; 3.00pm; and 5.30pm)

Surrounding the Space

41. Frequency of vehicles in Streets/Roads Surrounding Space* *Requires use of tally counter for major roads*

SA41A: No. of vehicles on surrounding streets/roads per unit time_______________

(Data to be collected M/W/Sat at 8.30am; 11.00am; 1.30pm; 3.00pm; and 5.30pm for period of one minute for a total of 5 minutes per timing)

42. Diversity of Users of Streets and Sidewalks Surrounding the Space (*Requires use of tally counter)*

SA42A: Number of men using surrounding sidewalks adjacent to space and streets per unit area_______________

SA42B: Number of women using surrounding sidewalks adjacent to space and streets per unit area _______________

SA42C: Number of children using surrounding sidewalks adjacent to space and streets per unit area ______________

SA42D: Number of elderly using surrounding sidewalks adjacent to space and streets per unit area _______________

('using' covers people doing all types of activities; counting will be of people that are lying down, sitting, standing, walking, running, playing etc.)

(Data to be collected M/W/Sat at 8.30am; 11.00am; 1.30pm; 3.00pm; and 5.30pm)

V) VARIABLES RELATED TO ECONOMIC ASPECTS

Within the Space

43. Diversity of Space Use within Space

Commercial

EA43A: No. of retail shops in space per unit area __________

EA43B: No. of service businesses (barbers, mpesa services, shoe-shiners) in space per unit area _______

EA43C:No. of produce/newspaper/magazine vendors in space per unit area ___________

EA43D:No. of restaurants and eateries in space per unit area _____________

Surrounding the Space

44. Diversity of Space Use on Surrounding Sidewalks

EA44A: No. of vendors (produce, snacks, newspapers) on surrounding sidewalks adjacent to space per linear distance _____________

EA44B: No. of kiosks (charity sweepstake, airtime top-up, shoe-shiners etc.) on surrounding sidewalks adjacent to space per linear distance ________

EA44C: No. of restaurants and eateries on surrounding sidewalks adjacent to space per linear distance _____________

45. Diversity of Space Use in Buildings Facing the Space

EA45A: No. of retail shops on ground floor of buildings facing space per linear distance _____________

EA45B: No. of service businesses (barbers, photo studios, photocopying etc.) on ground floor of buildings facing space per linear distance ________

EA45C: No. of restaurants and eateries on ground floor of buildings facing space per linear distance _____________

EA45D: No. of hotels/lodgings lobbies on ground floor of buildings facing space per linear distance _____________

46. Ownership of Buildings Facing the Space

EA46A: No. of privately owned buildings facing space per linear distance_______________

EA46B: No. of government owned buildings facing space per linear distance_______________

VI) VARIABLES RELATED TO GOVERNANCE ASPECTS

47. Legislation/by-laws

Code: Yes: 1; No: 0.

GA47A: Presence of by-laws, rules or regulations signage in the space_______________

48. Efficiency

GA48A: No. of garbage bins with overflowing garbage per unit area_______________

End of Observation Form

Appendix 4 Interview Schedules

STRICTLY CONFIDENTIAL
JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
CENTRE FOR URBAN STUDIES

Research: "Establishing Factors that Contribute to Sustainability of Public Open Space in Nairobi CBD".

This research investigates urban form in Nairobi, in particular the public open spaces in its Central Business District (CBD). This morphological study analyses public open space and the changes they have undergone over time. It reviews theories and analyses collected data to investigate what design and management issues influence vitality and attractiveness of public urban open spaces in the CBD from social, economic, environmental/ecological and governance perspectives. The research will provide better understanding of the configurations of open spaces in Nairobi today and make recommendations on public open spaces for the future.

The questions contained herein are designed to establish Nairobi City County regulations, capacity, and citizen participation regarding public open space.

Confidentiality Clause: Responses to these questions are voluntary and will be used in combination with those of other people responding to the study.

INTERVIEW SCHEDULE FOR NAIROBI CITY COUNTY DEPARTMENT OF ENVIRONMENT

Date:...Time: ....

Designation of Interviewee:..

(1) What are the main factors that influence people's use of public open spaces (parks, gardens, pedestrian accessible roundabouts and promenades) in Nairobi CBD?

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(2) What hours are public open spaces (parks, gardens, pedestrian accessible roundabouts, promenades, bus termini and car parks) in CBD allowed to operate according to city by-laws?

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(a) Are these hours of operation respected by users of the spaces?

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(b) How are by-laws for public open spaces enforced in the CBD?
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(3) Do citizens participate in upkeep of public open spaces (parks, gardens, pedestrian accessible roundabouts, promenades, bus termini and car parks)?
(a) If yes, how?
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(b)If no, why not?
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(4) What main factors make public open spaces in Nairobi CBD attractive and lively?
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(5) How many hours are lamp-posts in public open spaces in Nairobi CBD turned on per day?
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.... (6) How many hours are streetlights around public open spaces in Nairobi CBD turned on per day?
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....
(7) What percentage of lighting in Nairobi CBD is solar-powered lighting?
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....
....

(8) How frequently are recycling bins used in and around public open spaces in the CBD? (Tick as appropriate)
Not Used............... Rarely................. Quite Frequently.............Frequently..................Very Frequently.......................
(a) Why is this so?

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Name of Space	How many volunteers are involved in maintenance of space?	How many commercial activities within space have NCC authorization?	How many active sponsors support maintenance of the space?	How many NCC employees maintain (i.e. sweep, clean, cut grass) the space?	How many times garbage bins in space emptied per week?	How many NCC employees directly supervise the space?
1. Jeevanjee Gardens						
2. Hilton Hotel Circle						
3. Central Park						
4. Globe Cinema Roundabout						
5. Aga Khan Walk						
6. Railway Stn Bus Terminus						
7. KBS Terminus						
8. Sunken Car Park						
9. Law Courts Car Park						
10. John Michuki Park (Nrb River bank nxt to Muranga Rd at Globe Cinema Rndbt)						
11. Walk between Co-op Bank and NHC						

(linked to AKW South end)						
12. Railways/Easy Coach Parking						
13. Fire Station Roundabout						
14. KICC Parking						
15. Wakulima Market						

.............End of Interview Schedule/Guide.......................

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Research: "Establishing Factors that Contribute to Sustainability of Public Open Space in Nairobi CBD".
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The questions contained herein are designed to establish property values surrounding the research spaces to determine whether such values together with others contribute to the sustainability of the public space.
ConfidentialityClause: Responses of interviewees are voluntary and will be used in combination with those of other people responding to the study.

INTERVIEW SCHEDULE FOR PROPERTY DEVELOPERS/PROPERTY VALUERS

A) Property/Real Estate Developers (to establish property values surrounding the space)

Researcher:.. Date: ....
Person Interviewed:...
Designation:..

Name of Space	EA52A: What is the average cost per acre of buying land surrounding the space?	EA52B: What is the average cost per sq. m. of renting property in surrounding bldgs?
1. Jeevanjee Gardens		
2. Hilton Hotel Circle		
3. Central Park		
4. Globe Cinema Roundabout		
5. Aga Khan Walk		

6. Railway Station Bus Terminus		
7. KBS Terminus		
8. Sunken Car Park		
9. Law Courts Car Park		

.............*End of Interview Schedule*........................