THE INFLUENCE OF URBAN FORMS IN THE USE OF DIGITAL TECHNOLOGY IN URBAN SPACES: A CASE OFNAIROBI CENTRAL BUSINESS DISTRICT

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AND

TECHNOLOGY

2015

The influence of Urban Forms in the Use of Digital Technology in urban spaces: A Case of Nairobi Central Business District

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A thesis submitted in partial fulfilment for the Master of Urban Design in Jomo Kenyatta University of Agriculture and Technology

2015

DECLARATION

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

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DEDICATION

I dedicate this thesis to God who has guided me through my journey of education and to my family for the support they give me each and every day.

ACKNOWLEDGEMENTS

I thank Jomo Kenyatta University of Agriculture and Technology for all the support it has given me during this research. I would like to thank the JKUAT Library for all the resources it has given me towards this study, especially the online journals and books that it has subscribed to. In a special way, I would like to thank the department of Architecture and the Faculty of School of Architecture and Building Sciences.

I thank my sponsors SIU – NOMA in collaborations with the Norwegian Government, Jomo Kenyatta University of Agriculture and Technology and the Eastern Africa Collaborating Universities for granting me the opportunity that has enabled me to study and carry out this study.

I thank my supervisors Prof. Bernard Otoki Moirongo and Dr. Mugwima Bernard Njuguna for guiding me through this study. It has been a big change from undergraduate to post graduate research, but they have been with me all the way.

In a special way I would like to thank all the members of staff in the department of Architecture, for giving me encouragement and support in many ways during the course of this study. Special thanks for the JKUAT library staff, especially special collection section for guidance in formatting this thesis. I thank all my colleagues who have pursued this course before me for their advice and encouragement.

Lastly, I would like to thank my entire family for the great support and blessings that they have given to me during this study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ACRONYMS

ARUD: Augmented Reality based Urban Design

CCTV: Close Circuit Television

EDGE: Enhanced Data Rate for GSM Evolution

GPRS: General Packet Radio Service

GSM: Global System for mobile communications

ICT: Information communication technology

IPhone: Mobile telephone from Apple Inc

IPod: Portable media player by Apple Inc

MPESA: Mobile-phone based money transfer and service for Safaricom and Vodacom

SKYPE: A voice-over-IP and instant messaging service with video conferencing

VLSI: Very Large Scale Integrated Circuit

WIFI: Radio waves that allow electronic devices to connect wirelessly with each other in addition to accessing internet

ABSTRACT

Digital technology has advanced in recent years after many urban spaces have been conceptualized. Information communication technologies have changed the activities that take place in the urban space thereby raising questions on how the physical space is able to accommodate them. The objectives of the study are to establish the digital technology uses in Nairobi Central Business District as well as best practices internationally and to establish the physical characteristics of the urban form so as to investigate the relationship between the two. The study hypothesises that there is no relationship between urban forms and digital technology uses. The study is designed as a survey. The situs is the public spaces in Nairobi Central Business District. The main research method employed in the study is observation whereby observation checklists were used to measure and record the digital technology uses as well as the space characteristics in the sampled convex spaces. Spaces were studied on weekdays between 9:00am and 6:00pm. Stratified sampling was used to select 30 spaces within the study area based on space typology which included open spaces, squares, street space, arcades, passages and lanes. Data analysis involved correlation studies and multiple regression analysis using SPSS version 20. It emerged that the predominant digital technology uses in the study area were mobile telephones calls, texting and surfing. Multiple regression analysis pointed out that the density of people, the land use as well as the sky view tangent in a given space contributed to the density of digital technology usage. The findings show that these characteristics are some of the patterns that could be used to control the digital technology uses in urban spaces. The study therefore recommends that the urban spaces should utilize narrow lanes and passages which should be interconnected and have pedestrian oriented uses at grade level.

Key Words: Digital technology, information communication technologies, urban forms, urban space, Nairobi

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Information communication technologies have changed the meaning of time and space. It is a common scene to find a pedestrian standing by a planter or seated at a bench on a street while at the same time having a conversation with someone, thousands of miles away. Business meetings are conducted between persons in different geographical locations via audio visual interface such as Skype. People are able to send and receive money through their mobile phones as they traverse the urban spaces. Media and information is integrated into urban infrastructure through artworks, sensor networks and surveillance mechanisms such as CCTV cameras (Lambert, McQuire, & Papastergiadis, 2013).

The activities that take place in urban public spaces have been transformed by digital technology. Private and public activities alike are taking place at the same time (Freitas, 2010), while social activities that once took place on squares, streets and piazzas, are now taking place on screens and digital platforms (Iveson, 2007). Such trends have spurred discussions on how the transformations have impacted the urban space with some terming it as worrying (Gencel & Velibeyoglu, 2006).

The uses of digital technology present challenges to planners, urban designers and policy makers who have to plan in consideration of its impacts. This study seeks to establish how the use of digital technology in urban public spaces informs its character

1.2 Problem Statement

Digital technology is a new phenomenon and therefore requires investigation. Urban spaces were conceptualized prior to advancements in digital technology which have now created new networks of interactions between the physical space, the digital and the users. The networks are not bound by geography and traverse both public and private spaces as illustrated in Figure 1.1.The form of networks forged therefore needs to be investigated so as to establish criteria for achieving desirable urban spaces.

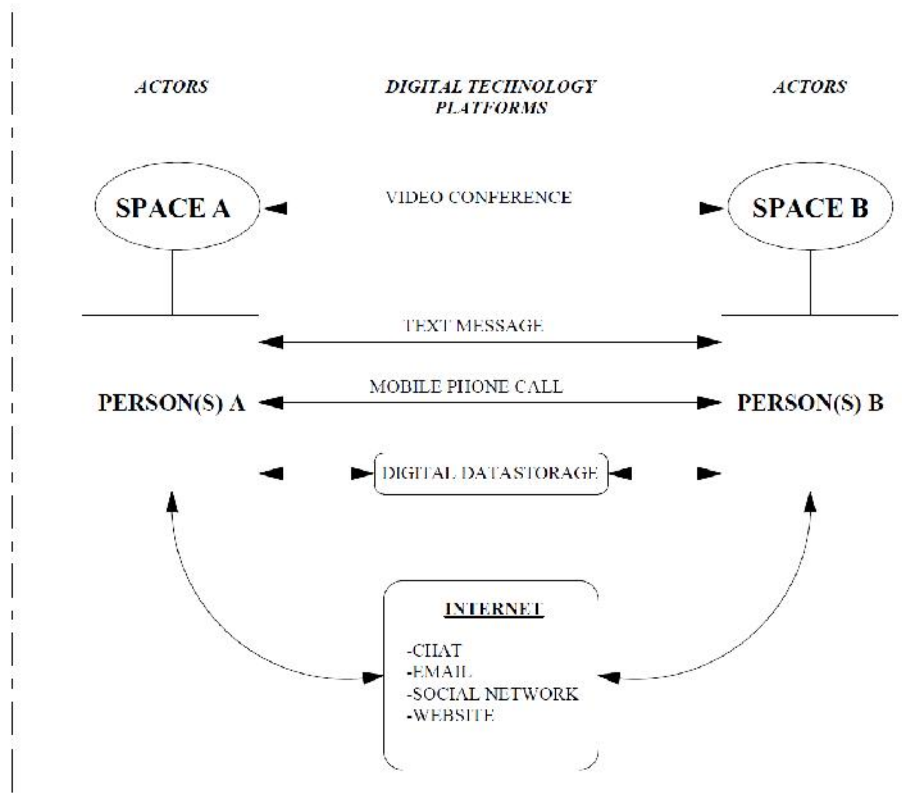


Figure 1.1: Digital Technology Networks

Source: Author (2013)

The current way in which the digital technology is being used has created negative environmental impacts. This includes littering of streets with used mobile phone recharge vouchers and recklessness of pedestrians and motorists alike that immerse themselves fully in the digital space oblivious of their physical surroundings. This has led to loss of lives and damage to property through accidents that have occurred as a result of the recklessness. By having urban spaces informed by digital technology uses, some of the problems may be minimized or controlled. **Plate 1.1**illustrates a mobile phone user who is engaged in the phone call and does not mind standing on the planter.

Plate 1.1:Phone Call on a Street in Nairobi, Kenya

Source: Author (2013)

Plate1.2:Street Digital Screens

Source: Retrieved May 6, 2013 from http://www.timessquare.com

The digital technology use is facing challenges of spatial settings within the current urban space. These include insecurity as well as inadequate infrastructure. Users face the risk of losing their devices and therefore many people would prefer to wait until they were in a more private space. This hinders opportunities that could be exploited from openly engaging in using the digital technology. **Plate1.2** illustrates digital screens that have been used for advertisement purposes. Such opportunities have not been fully utilized locally and therefore the numerous benefits that could emerge from it are lost.

Theory points out that convergence occurs when there is influx of a given item or technology in a given market or industry. The actor-network theory also suggests that networks are formed when the interests of different actors are aligned. Episodes of tourists using digital maps for navigation or businessmen doing email correspondence or having digital personal organizers are among the indicators of convergence occurring between the physical urban space and the digital realm engagements. Latour (1988) argues that as time passes by, a network becomes more obdurate and less reversible. This implies that deliberate efforts need to be put to minimize consequences that might evolve from emerging networks of digital nature.

1.3 Purpose of the Study

The purpose of this study is to investigate the digital technology phenomenon and its challenges in urban spaces so as to recommend design guidelines for urban spaces in Nairobi Central Business District.

1.4 Objectives of the Study:

1. To map out the usage of digital technology in urban spaces
2. To establish challenges faced by digital technology in Nairobi Central Business District
3. To establish best practices of digital technology uses in urban spaces globally.
4. To establish the relationship between usage of digital technology and urban space characteristics in Nairobi Central Business District.
5. To recommend guidelines to design of urban spaces to promote digital technology use

1.5Hypothesis

Null Hypothesis (H_o)*:*urban form does not influence use of digital technology in Nairobi Central Business District

Alternate Hypothesis (H_a)*:*urban form influences use of digital technology in Nairobi Central Business District.

1.6 Theoretical Framework

The theoretical framework for this study comprises three theories as shown on Figure 1.2. The actor network theory and the public social private framework theory explain the forms of digital technology uses and how they relate to the public space. The defensible theory explains the perception of safety in a given space thus encouraging or discouraging use of digital technology.

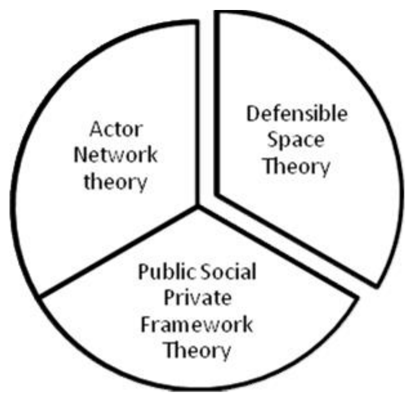


Figure 1.2:Theoretical Framework

Source: Author (2013)

1.6.1 Actor Network Theory

The theory describes technological development as a process in which social and technical elements become linked up with each other in a network. This network is formed and strengthened by the actors who form it. The theory explains the concept of ICT embedding. The different forms of emerging digital technologies together with the physical public realm are actors in the theory. Figure 1.3 illustrates a network formed from the interaction between motorists having a parking access control card which they use to gain access to park their vehicles. The actors in this network comprise the Parking Access barrier, the access control card, the motorist, the vehicle and the car park. Digital technology has embedded the task of controlling access to the car park by affording an automated barrier which is operated via an access control card.

Callon (1995) observes that as the network grows and becomes more interactive, it becomes difficult to reverse its reality. Examples of Actor network Theorists are Michael Callon, Bruno Latour, Madeleine Akrich, John law and Annemarie Mol (Hommels, 2005). Digital technology devices are actors within the networks in urban spaces. Law (1987) advocates that in the process of network formation, social aspects should not be considered at the expense of other factors such as natural, economic and technical due to the irreversibility nature of the networks.

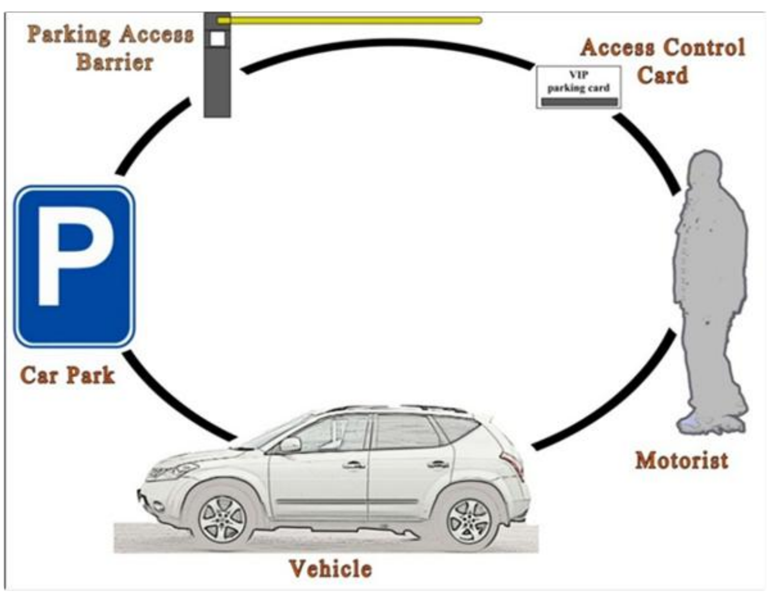


Figure 1.3:Parking Access Network

Source: Author (2013)

1.6.2 Defensible Space Theory

The theory states that commercial and residential environments with large public areas that are accessible from many different paths increase the risk of criminal activity (Newman, 1972). It advocates for territoriality in design of environments to achieve physical characteristics that promote a sense of ownership and responsibility differentiating between private and public spaces.

This theory describes the element of safety in public spaces. Digital technology devices being costly would be used less often in a space that is considered unsafe. This theory advocates therefore that future urban spaces with increased digital technology uses would need to be designed with territoriality in mind so as to promote a sense of responsibility and ownership.

1.6.3 Public Social Private Framework Theory

The theory explains interaction with different kinds of information between users of varied interaction spaces using digital technology. This theory has been adopted from a framework developed by Vassilis Kostakos in 2004 for designing pervasive computing system. The constructs of the theory comprise the space, interaction space and the Sphere (Human Computer Interaction (HCI) Group, 2013).

The space refers to the physical space; the interaction space is the field of participation while the sphere refers to the information being accessed. The theory further suggests that technologies affording these interactions are categorized into three. These include the public, social and private (Kostakos, 2004). In a public setting, the bench on the street provides the interaction; a digital display screen mounted on the space provides the social interaction while the personal mobile phone or laptop would afford private interactions.

Three categories of information transacted are three and include the private, social and public. From Figure 1.4, these levels of information have varying degrees of privacy. The public information can be accessed at all levels while the social information can be accessed by both the social as well as the private parties involved in the interaction. The persons can choose to share the information from the social interaction with the public to make it public. An example of social interaction would be two persons chatting on Facebook while residing in a public space, either walking, standing or seated. Such information is only accessible to the persons involved in the chat. In a private interaction, information is only accessible to the user who has entered it.

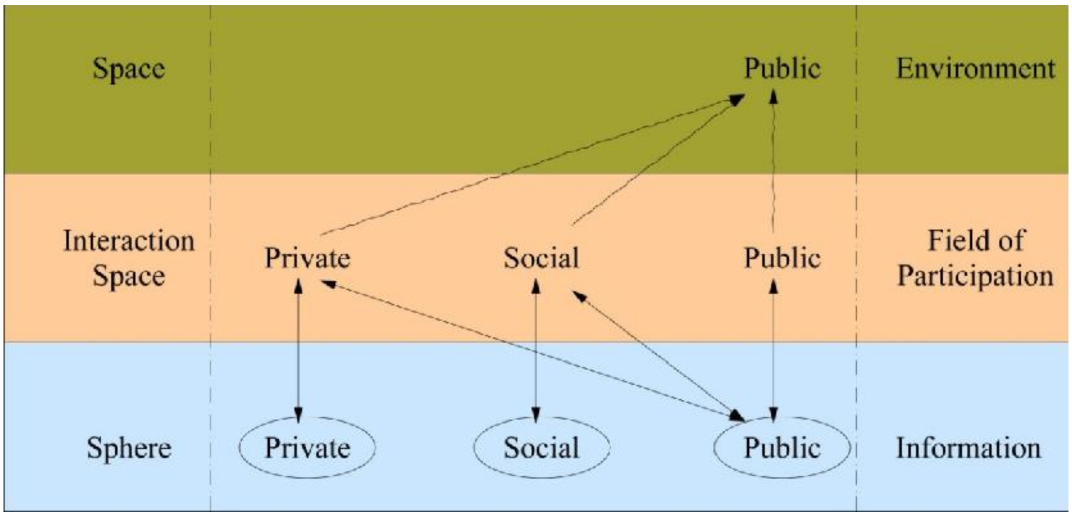


Figure 1.4:Public Social Private Framework

Source: adapted from http://www.cs.bath.ac.uk/~cspaw/PSPD/framework.html , retrieved on10th April 2013

This study fits into this theory by analysing the digital technology uses within urban spaces. These uses are the media through which different information is transacted by the pedestrians through private, social and public interactions that take place in the urban spaces.

1.7 Conceptual Framework

The conceptual framework of this study comprises digital technology uses and how they relate to the physical characteristics of the urban spaces. Concepts looked at include typologies of digital technology uses as well as physical characteristics that define various urban design qualities as shown on Table 1.1below.

Table 1.1: Conceptual Framework

DIGITAL TECHNOLOGY USES		URBAN FORM CHARACTERISTICS
• **Digital Gaming**		• Connectivity
• **Texting/ Surfing**		• Image-ability
• **Telephone Call**		• Enclosure
• **Laptop/ Tablets**		• Human Scale
• **Photography**		• Transparency
• **IPod and Music Players**		• Complexity
• **ATM machines**		• Space Syntax
• **Digital Cash**		
• **Traffic Management**		
• **Security Surveillance**		
• **Digital Transportation**		
• **Neon Signs**		
• **Digital Display**		

Source: Author (2013)

1.8 Definition of Terms

Digital technology uses are the actions of pedestrians within an urban space to engage with a digital technology device. Its operational definition is any instance whereby a pedestrian in an urban space is seen operating, watching or listening to a digital technology device.

The urban form comprises all built and natural elements within a given urban space. The operational definition of urban form is the sum total of physical characteristics of both the natural as well as built up elements that constitute an urban space.

1.9Study Assumptions

The study assumes that all pedestrians have access to digital technology devices and that they desire to use them within the urban spaces.

The statistical assumption of the study are that the digital technology use is distributed according to a normal distribution; the variance of the digital technology use is the same for all values of the urban space characteristics and it equals σ^2 which is unknown; the different observations on the digital technology uses are independent of each other but are conditioned by the observed urban space characteristics.

1.10Study Significance

The study is significant because it has not been done before. The study area is also significant because it deals with a wider population. Digital technology is accessible to a majority of urban users and thus the phenomenon of its usage in urban spaces is of importance. The study is timely as digital technology is aligning itself with urban space and thus major infrastructure and innovation is likely to emerge which will shape urban space design and usage.

1.11Study Justification

The study has been chosen because digital technology is being embraced in urban spaces to the extent of local authorities promoting it within its citizens. Nakuru County in Kenya has set up a free WIFI network in its town in a move to take advantage of the many opportunities available online such as accessible banking services and public participation in county governance (Macharia, 2014). Nairobi has heavy presence of Fibre-Optic cabling, GPRS, EDGE and 3G connectivity.This highlights considerable level of investment from both the public and private sectors that has been injected towards developing the digital technology infrastructure. The Nakuru town WIFI network costs two hundred million Kenya shillings and only covers a radius of five to ten kilometres from the county headquarters (Macharia, 2014). Studies in this technology will provide guidelines for design of urban spaces which will see a return in investment and growth in market outlets for Kenya in addition to having sound urban spaces. This will enhance the competitive nature of Kenyan towns globally. Appendix 4 illustrates Mobile and data usage in Kenya over the periods of October 2010 to December 2011.

The study is beneficial because findings from it can be used to enhance freedom of interaction between the digital and physical realms. The results will benefit the local authorities and county governments to control physical developments with a view to fostering digital technology presence in urban spaces. This will increase trade and promote regional balance due to accessibility of information and markets.

1.12 Study Scope

The theoretical scope of the study comprises the convergence theory of how the information communication technologies is used in every kind of activity and embedded in physical elements. The concepts comprise urban design qualities such as transparency, legibility and complexity. The digital technology uses in urban spaces as well as the physical characteristics of urban public spaces form part of the study.

The methodological scope comprises the survey method. Stratified sampling has been used to select the spaces to be studied. Observation of the built environment is the primary technique that was used in the study.

Plate 1.3: Geographical Scope

Source: Adapted from Government of Kenya & JICA (2005)

The geographical scope comprises the public urban spaces within the Nairobi Central Business District, Kenya which has more digital technology uses (See Plate 1.3). This has also reduced travel costs thereby allowing a more detailed study to be conducted with available funds.

1.13Study Limitations

The study faced limitations in the range of digital technology that pedestrians have access to. Digital technology uses that were analysed therefore were those that were found within the urban spaces of Nairobi Central business district.

1.14Study Organization

The research report is organized into twelve chapters. The first chapter is an introduction explaining the problem under investigation. It covers the background to the study, problem statement, and purpose of the study, the objectives, the hypothesis, the theoretical and conceptual framework, the theoretical and operational definitions of terms, the study assumptions, significance, justification, study scope, and the limitations.

The second chapter is a critical review of existing literature, previous research articles, and paper sand journals. The physical elements of urban spaces are derived from existing literature. The behaviours describing digital technology genres of presence are discussed. This chapter also comprises the theoretical and conceptual frameworks.

The third chapter covers research methodology. It contains the research design and methods. The data collection techniques and the sampling procedures are also outlined. The program for data collection is included in this chapter. Data processing, analysis and presentation methods are discussed. The pre-tests and pilot study as well as the research ethics forms part of this chapter.

The fourth chapter covers the background of the study area. It illustrates the operational definition of dependent and independent variables.

The fifth chapter covers the data analysis. The digital technology uses are compared with the urban space characteristics. The urban design qualities that affect the urban space characteristics that were captured as having a strong correlation with the digital technology uses are discussed. The data collected is processed to establish the influence of digital technology on urban spaces.

The sixth chapter is a discussion of what emerged from the literature review as well as the significant variables that were captured in the data analysis

Chapter Seven presents the findings, conclusions and recommendations of the study in line with the stated objectives. Recommendations are then made.

The project Report has been captured from chapter eight to chapter twelve. Chapter eight forms an introduction part while chapter nine is a comparative study of urban design guidelines that were prepared for two central business districts.

Chapter Ten comprises the site analysis of the study area while chapter eleven consists of the proposed urban design guidelines synthesising the site analysis, thesis recommendations as well as the comparative study for two cities.

Chapter Twelve comprises urban design proposal for the study area based on the proposed guidelines. Finally, a bibliography and appendices are annexed to the research report.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter looks at the urban space in relation to the digital technology uses. It covers the chronological development of digital space and typologies of digital technology uses in urban spaces. The Physical characteristics of urban spaces form part of this chapter.

2.2 Digital Technology

2.2.1Origin of Digital Technology Uses in the Urban Space

The beginning of computing technology was marked by the shift from using gears and levers to using electronic circuits (Haag, Cummings, & Rea, 2004). From the 1930s to date, computing technology has transformed through five generations starting from use of vacuum tubes to the development of artificial intelligence (Figure 2.1).Plate 2.1illustrates the first and second generation computing technology while Plate 2.2illustrates the microprocessor which was in use in the fifth generation.

Portable computers were invented after the fourth generation which was marked by a considerable decrease in computer sizes. This enabled computers to be carried from place to place to perform the various functions needed. The invention of the internet linked computing with communication technologies resulting in increased functionality and need for owning and using the digital technology devices.

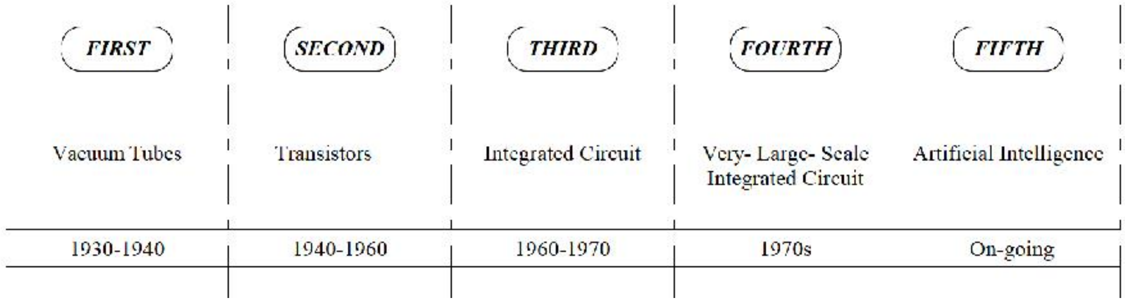


Figure 2.1: Computing Development

Source: Author (2013)

Plate 2.1:Transistor and Vacuum Tube

Source: Retrieved September 18, 2012 from http://www.americanscientist.org

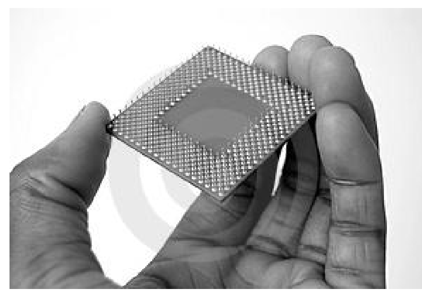


Plate 2.2: Very-large-scale integrated Circuit (Microprocessor)

Source: Retrieved September 25, 2012 from http://www.dreamstime.com

2.2.2Digital Technology Uses in the Urban Space

The current digital technology uses offer platforms for social engagement. Urban space therefore has to be designed to promote environments for social encounters by persons within the same space as well as those who are connected through the digital space. Freitas (2010) argues that Information Communication Technologies (ICTs) has resulted in significant changes in the organization of cities, public spaces and everyday social life. Iveson (2007) describes that social lives can now be lived on screens as much as they once were in squares, streets and piazzas through digital spaces. This phenomenon presents challenges in organization and composition of public spaces as well as cities at large.

2.2.3Challenges faced by the Digital Technology Uses in Urban Spaces

The use of digital technology has redefined public space boundaries leading to concerns in privacy (Freitas, 2010). This is caused by users engaging in private activities such as personal conversations within the urban space which has not been designed to contain personal privacy. The use of internet within the urban space brings out all information, both private and public into the physical space (Forlano L. , 2008).

Policy makers are faced with decisions of striking a balance between the global character brought about by increased connectivity and that of local development (Aurigi, 2006). Some critics have even described the digital technology as out of place elements, comparable to those defined by Yatmo (2008) since they appear at one time and disappear at another.

Digital technology has also faced challenges in legislation, first within the digital space itself (Graham, 2004)and in matters concerning connectivity and access to digital devices and infrastructure within the physical space (Freitas, 2010).

2.2.4Digital Technology Uses Present in the Urban Space

Digital technology has been used in the practice of urban design for both data collection as well as analysis. Simulation environments for collecting feedback about design (De-Lange, 2009), and for mapping out scenarios (Wang & Chen, 2009) have been useful tools in design and implementation of urban design. ICT-based transportation as well as ICT-intensive districts (Audirac, 2005) are concepts that have been developed for ideal cities in recent times. Uses found within the public spaces are discussed below.

 **Plate 2.3: Earphones Use** Source: Retrieved June 10, 2012 from http://images.ctv.ca/archives/ctvnews/img2/20120117	 **Plate 2.4: Headphones use in Nairobi, Kenya** Source: Author (2012)

2.2.4.1 Digital Audible Platforms

These are digital devices that provide sound to the users. They include media players as well as portable radio sets. Ito, Okabe and Anderson, (2007) discuss use of audible platforms to distract oneself from the happenings around them within the public space. The distraction can aid in creating personalized work or leisure environments within the public space (Green, 2002). Plate 2.3shows use of earphones while Plate 2.4shows a pedestrian wearing a pair of headphones.

2.2.4.2 Data Browsing Devices

This involves sending, receiving or interaction with information through digital devices. Technological innovation has provided a wide range of devices that can be used for various different functions. Ito, Okabe and Anderson (2007) argue that data browsing devices are linked to urban spaces with desirable characteristics which the users seek such as internet connectivity, food outlets or distinctive ambiance.

Study shows that an average laptop user, visits the same public space twice a week for a period of between one and two hours and used the internet 75% of the time (Hampton, Livio, & Sessions, 2009). Plate 2.5shows browsing of news, while Plate shows outdoor use of laptop.

 **Plate 2.5: News Surfing in Tahrir Square** source : Retrieved June 10, 2012 from http://www2.macleans.ca/wp-content/uploads/2012/05	 **Plate 2.6: Laptop Use in New York** Source: Retrieved June 10, 2012 from http://www.jazzhostels.com/blog/wp-content/ uploads/2011/11

2.2.4.3 Surveillance Devices

These are devices used for monitoring or recording of observable activities within a given space. Close Circuit Television Cameras are used for monitoring nearby locations while web cameras capture the video and audio situation in a given space and display the contents on a web page or other remote viewing point (Microsoft Corporation, 2003). Plate 2.7illustrates CCTV camera on a store entrance while Plate 2.8illustrates a traffic surveillance camera.

Plate 2.7: CCTV camera in Minneapolis, Minnesota, USA

Source: Author (2013)

Plate 2.8: Traffic Surveillance Camera in Minneapolis, Minnesota, USA

Source: Author (2013)

2.2.4.4 Digital Display Devices

These are digital platforms that provide visual feedback on communication or electronically stored data. Unlike the audible platforms, one is able to enjoy pictorial and video data. Advertisements have taken advantage of this and many displays can be seen on the urban space (see Plate 2.9). Newsstands have also taken advantage of the digital displays (see Plate 2.10) to provide real time updates within the urban space.

Combining concepts of the urban screen with contextual information, digital display can therefore facilitate public understanding of complex local issues (Moere & Hill, 2012). Digital signage has also been found to be an effective stimulus which can add to positive perception of environments and even promote spending behaviour in retail areas (Dennis, Michon, Brakus, Newman, & Alamanos, 2012).

Plate 2.9: Digital Display Advertising in Minneapolis, Minnesota, USA

Source: Author (2013)

Plate 2.10: Digital Display Newsstand

Source: Retrieved June 10, 2012 from http://www.signindustry.com/outdoor/articles/images

2.2.4.5 Digital Transportation Infrastructure

The evolution of transit modes have been fuelled by the need to address challenges in demand, urban environment patterns as well as natural constraints (Alshalalfah, Shalaby, Dale, & Othman, 2012). Digital technology transportation is a phenomenon of urban streets whereby users are able to use digitally controlled transportation vessels. Plate 2.11shows an electric train stop under construction while Plate 2.12shows light trains ferrying passengers between airport terminals.

Plate 2.11: Electric Train Stop in Minneapolis, Minnesota USA

Source: Author (2013)

Plate 2.12: Light Train in Minneapolis-St. Paul International Airport, Minnesota, USA

Source: Author (2013)

2.2.4.6 Digital Urban Space Management Infrastructure

This category of digital technology has brought about the concept of 'smart cities' whereby activities are monitored and responsive measures taken to rectify undesirable outcomes. Digital technology tools are strategically located to collect information and trigger responses towards corrective measures. Townsend (2000) argues that real-time systems with the ability to constantly monitor environmental conditions are vital to the operation of the responsive systems. Examples of urban management include waste management, traffic management and service provision.

Pamula (2011) discusses Intelligent Transportation Systems, which utilize telecommunication technologies as well as estimation and prediction of traffic streams to control traffic movement at junctions. Plate 2.13illustrates a system of traffic lights that control vehicular and train movement at a road junction. Plate 2.14illustrates traffic lights on a one-way street to control vehicular movement in the individual lanes. Transportation planning would therefore take account of digital technology in planning for management of the different transport modes.

Plate 2.13: Junction Traffic Lights in Minneapolis, Minnesota, USA

Source: Author (2013)

Plate 2.14: Parallel Lanes Traffic Lights in Minneapolis, Minnesota, USA

Source: Author (2013)

2.2.5Advantages and disadvantages of the digital technology uses

Pain *et al*. (2005) identifies how mobile phones have enabled young people more freedom in public space by allowing them to experience public space more freely with fewer restrictions and boundaries, whilst still being contactable by parents or care-givers. Willis (2007) argues that wireless communication technologies enable multiple social realities to occur in a single place without the need to physically move from one space to another.

2.3Urban Space

The Urban space is the composition of all elements within a given space. It consists of horizontal and vertical surfaces, barriers, buildings and vegetation defining a given space. Trancik (1986) discusses urban space as falling into two primary categories comprising the hard spaces which are principally bounded by architectural walls and soft spaces that are dominated by the natural environment.

2.3.1 Evolution of digital uses in urban space

Lang (1987) argues that the categorization of the environment recognizes the presence of a potential environment for behaviour and an effective environment that consists of what a person pays attention to and uses. Traditionally, streets have been looked at as means of getting from one place to another. Moughtin (1999) describes a street as a road in a town or village. He states that the emphasis of a street is on movement between places: a two-dimensional ribbon, running on the surface of the landscape, carried over it by bridge or beneath by tunnel. The use of streets however has altered with the emergence of digital technology. This is because a street not only connects physical places, but it also acts as a platform for engaging with digital technology through which there is global connectivity

Technological advancements have altered the meaning of space. Gaffikin, Mceldowney and Sterret (2010) define space in the contemporary city as both a display space where differences based on distinctive and closed identity can be affirmed, as well as a relational space where a greater pluralism of identities and belongings emerge from constantly negotiated collaborations and contestations across divides.

Cities have been regarded as the fulcrum of human communication and as a place of possibilities as well as opportunities, either economic or political (Graham & Marvin, Telecommunications and the City: Electronic Spaces, Urban Spaces, 1996). The multiplicity and versatility of urban functions enhance the possibility of finding something of one's' liking but also to discover hitherto unknown options for self-development (Jantzen & Vetner, 2008). Multiple virtual realities as well as networks are forged with the emergence of digital technology. The digital technology therefore increases the ability of cities to perform their functions by enhancing traditional functions.

Hall's (1966) description of space layouts gives three alternatives: A fixed-feature space which is enclosed by elements that are not easily movable such as solid walls, floors, windows and fittings; A semi-fixed-feature space in which furnishings can be moved around; and an informal Space which lasts for as long as an exchange between two or more people lasts. Lang (1987) adds that adaptable environments afford many activities without restructuring, while flexible environments are easy to change to afford different activities. While networks are formed and established between different physical spaces and digital technology uses, it is worthwhile to put more investment in flexible environments which can afford advancements in the technology. Urban designers should carry out research on spatial layouts to establish the extent of digital technology uses. This would enable them to recommend suitable changes for design of future urban spaces.

2.3.2Urban Design Characteristics

These are qualities that describe the properties of a given urban space. The physical characteristics of the space are categorized based on the feeling they create. These physical characteristics are discussed below.

2.3.2.1 Factors influencing the Enclosure of an Urban Space.

Ewing and Handy (2009) observe that a sense of enclosure results when the lines of sight are so decisively blocked as to make outdoor spaces seem room-like's Plate 2.15illustrates a space that has a sense of enclosure, resulting from the walls surrounding the space. Cullen (1961) argues that the outdoor room instils a sense of position and identity with the surroundings. Alexander *et al*. (1977), argues that an outdoor space is positive when it has a distinct and definite shape of a room and the shape is as important as that of buildings surrounding it. Users of digital technology may require a room-like space within an urban space as opposed to an open space that is exposed in all directions. Plate 2.16shows a lady using a mobile phone on a visually enclosed space.

Duany and Plater-Zyberk (1992) together with other New Urbanists advocate that visual termination points such as prominent buildings, monuments, fountains or other architectural elements also create a sense of enclosure within that street.

Plate 2.15: Street Enclosure in Zanzibar, Tanzania

Source: Author (2013)

Plate 2.16: Mobile Phone Use in Nairobi, Kenya

Source: Author (2012)

2.3.2.2Factors affecting Human Scale in Urban Space

Human scale is the quality of the urban space that allows a person not to feel overwhelmed by either the sizes of structures or the speed of movement. Reid, Otto, Handy, Brownson and Winston (2005) describe it as the size, texture and articulation of physical elements that match the size and proportions of humans. Trancik (1986) recommends that in taller buildings, lower floors should spread out while upper floors stepped back before they ascend, giving human-scale definition to streets and plazas. Plate 2.17shows Hilton Hotel which has a balanced human scale with upper floors stepped back while Plate 2.18shows Ufundi Co-op Plaza which has a gigantic scale with all the floors along the same line. The digital technology use would impact on the human scale if the devices are large or if they display content that moves at a speed that overwhelms the user.

Plate 2.17: Hilton Hotel Nairobi, Kenya

Source: Author (2013)

Plate 2.18: Ufundi Co-op Plaza Nairobi, Kenya

Source: Author (2013)

Kay (1997)discusses human scale as being defined by human speed. She states that elements being designed for the automobile moving at 60 miles per hour overwhelm the senses, creating disorientation when approached by foot. Gehl (1987)argues that personal interaction distances play a role in designing for human scale. He designates distances of intimacy, personal, social and public distances as shown on Plate 2.19below. Digital transportation modes should move users in speeds that maintain the human scale of urban space while urban furniture for digital technology uses should provide desirable distances.

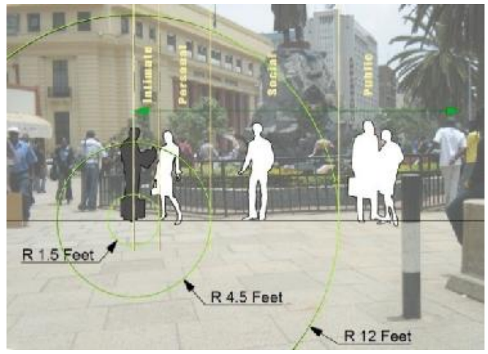


Plate 2.19: Proxemics adapted from Photo of Nairobi, Kenya

Source: Author (2013)

2.3.2.3 The Quality of Transparency in Urban Space

The space quality of transparency creates a sense of activity and eliminates the feeling of being alone in the given space. Reid, Otto, Handy, Brownson and Winston (2005) define transparency as the degree to which people can see or perceive what lies beyond the edge of a street or other public space, particularly human activity. Digital space being in a different realm from the physical environment can disengage one from the happening around them and upon return; a feeling of other persons within the space is reassuring.

Jacobs (1993) observes that streets with many entryways contribute to the perception of human activity beyond the street while those with blank walls and garages suggest that people are far away.

Figure 2.2 illustrates a street that has the quality of transparency while Figure 2.3 illustrates one without. Open spaces within a public realm can use trees and other vegetation to compliment the facades in creating a sense of transparency. Arnold (1993) argues that trees with high canopies create ‘partially transparent tents’ affording awareness of the space beyond while affording a sense of enclosure.

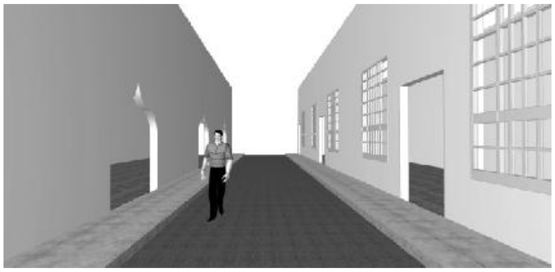


Figure 2.2: Street with Transparency

Source: Author (2013)

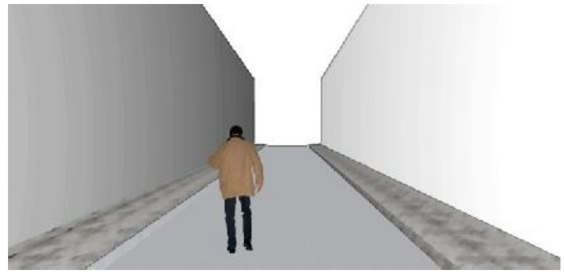


Figure 2.3:Street without Transparency

Source: Author (2013)

2.3.2.4 Factors influencing the Complexity of an Urban Space

This is the visual richness of a place and depends on physical characteristics of the space. Rapoport (1990) concludes that complexity is related to the number of noticeable differences to which a viewer is exposed per unit of time. The environment can have low complexity due to: elements being too few or too similar; elements, though numerous and varied, may be too predictable for surprise or novelty; or elements, though numerous and varied may be too unordered for comprehension (Reid, Otto, Handy, Brownson, & Winston, 2005).Plate 2.20is a photo of uncontrolled development in Nairobi which shows lack of complexity due to disorder in the elements. Plate 2.21shows condominiums in Addis Ababa which have low complexity since the units are similar and hence predictable. Digital technology devices such as the digital displays can increase the content that a user is exposed to thus enriching the space and as a result increase the perceived complexity of a space.

Plate 2.20: Informal Development, Nairobi, Kenya

Source: Author (2010)

Plate 2.21: Condominiums in Addis Ababa, Ethiopia

Source: Author (2010)

Plate 2.22: Dakota County Hall, Minneapolis, Minnesota, USA

Source: Author (2013)

Plate 2.23: A street in Mombasa, Kenya

Source: Author (2010)

Jacobs and Appleyard (1987) argue that narrow buildings in varying arrangements add to complexity, while wide buildings subtract. This is however incorrect since a building can be wide and yet have plenty detailing on its façade resulting in novelty and complexity.Plate 2.22demonstrates complexity that has been achieved from varying elements in the landscape as well as building façade, even though the building in the space is wide and alone. Plate 2.23shows a street in Mombasa whereby high degree of complexity has been achieved from having multiple elements with noticeable differences in which a person in the space experiences. Elshestaway (1997) observes that measurements in complexity as a perceptual quality has been related to changes in texture, width, height and setback of buildings. Gehl (1987) argues that people are attracted by presence of other people. “They gather with and move about with others and seek to place themselves near others. New activities begin in the vicinity of events that are already in progress.” Factors contributing to complexity would encourage social interaction among users of the space or influence a user in the space to contact a person in a different realm using digital technology.

2.3.2.5The Coherence of elements in an Urban Space

A sense of visual order in the environment is referred to as coherence. Reid, Otto, Handy, Brownson and Winston (2005) conclude that the degree of coherence is influenced by the consistency and complementarily in the scale, character, and arrangement of buildings, landscaping, street furniture, paving materials, and other physical elements. Arnold (1993)observes that complexity of earlier eras was given coherence by common materials, handcrafted details and reflections of human use. Due to its current absence, landscaping becomes critical for creating a sense of visual unity; shade trees planted together result in an uninterrupted pattern of light and shade, unifying a scene. This visual order in the environment may encourage use of digital technology by persons seeking to find desirable environment for encampments. Plate 2.24shows lack of coherence caused by incomplete development and dilapidated infrastructure while Plate 2.25shows visual order created by landscaping.

Plate 2.24: Mixed-use settlement in Nairobi, Kenya

Source: Author (2010)

Plate 2.25: Forodhani Park in Zanzibar, Tanzania

Source: Author (2010)

2.3.2.6Space syntax as a tool for analysing the Urban Space

Space syntax is a set of tools that enables perception of space as configurations. It comprises convex spaces as well as axial maps. Hillier (1999) defines the concept of convex space as actual spaces within urban spaces forming a unit of measurement for a single space. The axial maps show strips that correspond to the lines of sight linking the convex elements so as to enable analysis of the pattern of integration (Hillier B. , 1999).

In analysis of strength of axial lines, one needs to look at both the number of axial lines that cross the line as well as the number of loops that go through the axial space. The ring connectivity indicates the number of loops that go through the axial space while the axial connectivity shows the number of axial lines that cross the axial space. The measure of control shows how a given space is segregated from other spaces. The value is computed by summing up fractions of what it receives from other spaces.

The smaller the measure of control, the more it is segregated and hence the more unlikely for a visitor to go through that space. Depth of space is the measure of control. Segregation is the opposite of control. The measure of control of a space show how much influence a space can receive from the other spaces.Figure 2.4 shows the relationship between segregation and control in depth of space. The increment of control leads to the decrease of segregation and vice versa.

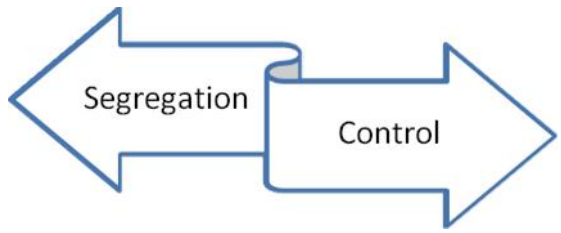


Figure 2.4:Depth of Space

Source: Author (2013)

2.3.3Urban Space Elements

These are spatial units that make up an urban space. They constitute the built and natural elements that enclose a space. In this literature, streets and squares have been analysed.

2.3.3.1 The Street as an Urban Space Element

Moughtin (1999) prescribes use of Vitruvius' descriptions of street scenes as Tragic, Comic or Satyric. Serlio (1982) deduces interpretations of these outlining that the Tragic Scene depicts the classical form of architecture (see Plate 2.26), the Comic Scene depicts Gothic architecture (see Plate 2.27) while the Satyric Scene depicts the landscape style (see Plate 2.28). In this categorization, however, digital technology was absent and therefore its emergence brings new dynamism of street usage and analysis.

		
Plate 2.26: Tragic Scene	**Plate 2.27: Comic Scene**	**Plate 2.28: Satyric Scene**
Source: Moughtin(1999)	Source: Moughtin(1999)	Source: Moughtin(1999)

The street has a definite form that constitutes its shape and configuration this can be straight or curved; long or short; wide or narrow and enclosed or open (Moughtin, 1999). Plate 2.29illustrates an example of a wide road comprising various one way lanes separated by concrete barriers. Cullen (1971) argues that once an enclosure is entered, the scene remains the same as you walk across it and out of it, where a new scene is suddenly revealed. Plate illustrates an enclosed street whereby once you enter it the scene remains the same until you exit it. The form of a street can influence where the digital technology is used. Plate 2.31 illustrates a curved street.

Plate 2.29: Wide Road in Nairobi, Kenya

Source: Author (2012)

Plate 2.30: Enclosed Street in Nairobi, Kenya

Source: Author (2012)

Plate 2.31: Curved Street in Nairobi, Kenya

Source: Author (2012)

Plate 2.32: Street Beneath the surface in Nairobi, Kenya

Source: Author (2012)

The relative position of a street can also be used to describe its characteristics. Moughtin (1999) observes that a street can be on the surface of the landscape, carried over it by bridge or beneath by tunnel (see Plate 2.32)

2.3.3.2 The Square as an Urban Space Element

The Squares serve a number of functions but their sustainability depends on the diversity of uses in the surrounding buildings. Moughtin (1999) summarises that the spaces needed in a city are those providing principal meeting places, places for great ceremonial spaces, for entertainment around buildings such as theatres, cinemas, restaurants and cafes, shopping places such as shopping streets, arcades, markets, settings around offices and spaces for urban traffic. The digital space provides a virtual realm through which all these functions can take place. Its usage in urban space can be looked at in two ways: either as replacing the physical realm functions or complimenting them and thus increasing the diversity.

Lynch (1960) defines nodes as strategic spots in a city into which an observer can enter, and which are the intensive foci to and from which he is travelling. Alexander (1966) observes that every whole must be a centre in itself and must also produce a system of centres around it. Moughtin (1999) argues that the square is the centrepiece of the public realm. Digital technology usage in urban spaces is looked at in terms of how it reinforces or dilutes the centrality characteristic of the square.

2.4Digital Technology and the Urban Space

Digital technology usage is a new phenomenon in the urban realm. Jantzen and Vetner (2008) conclude that urban designers should regard users as key players and only set the stage to allow them to create their own experiences. Digital technology usage forms part of culture in present day. Lang (1987)observes that culture controls much of the human behaviour and evolves over time as people develop approaches to dealing with the problems of survival and growth. The digital technology is thereby controlling human behaviour within the urban space as it addresses contexts of survival and growth both of human beings as well as technology.

2.4.1 Behaviour Attributed to Digital technology Usage

Proposals have been made towards ways of looking at how the environment relates to the human behaviour. Porteus (1977) theorized four basic positions of defining the relationship between the built environment and behaviour. These are: free-will whereby the environment has no impact on it; possibilistic whereby the environment affords a set of opportunities for behaviour upon which action may or may not be taken; deterministic in which the relationship is that of cause-effect; or probabilistic in which the uncertainty of the systems within which the behaviour as a whole takes place and within which environmental designers act.

The technological advancements in a given urban space should coincide with the people's desire to use it. Lang (1987) observes that one has to take into consideration the predispositions and motivations of the population concerned because in the absence of the desire for interaction, then the behaviour is unlikely to take place irrespective of the environmental affordances, unless there is an accompanying change in social and administrative environment. The desire to use a particular type of digital technology is presently driven by fashion trends.

2.4.2Public Space in the Framework of Emerging Digital Technology

Affordance describes the ability to allow certain behaviour to take place. Gibson (1979) argues that the affordance of anything enable it to be used in a particular way by a particular species or an individual member of that species. Lang (1987) concludes that the affordance of the environment thus limits or extends the behavioural and aesthetic choices of an individual depending on its configuration. The urban space can therefore afford digital technology activities or inhibit them.

The emerging phenomenon of digital technology usage in urban realms has been met with mixed reactions. Akcan (1994) observes that through digital technology, the communication space of a person is expanding while the physical space is shrinking since multiple functions are carried out within the same space. This shows that the urban space is changing in terms of its functions and setting with the emergence of digital technology. Virilio (1986) argues that the city is no longer geography by itself but a 'world-city' whereby people connecting virtual cities are able to shape their lives and relations.

The digital technology infrastructure has re-organized the land use patterns leading to very active and premium networked areas while at the same time leaving areas characterised by depression and decay. Page and Philips (2003) observe that many intense users of Information Communication Technologies choose urban locations with mixed use functions, leaving those without it as deserted of human activity. Gencel and Velibeyoglu (2006) argue that the quest to meet the demand of high intense digital infrastructure has led to development of building complexes that house multiple mix use activities leaving areas outside them to suffer depression and decay caused by basic activities like walking, talking and eating something being eliminated.

Technological developments in history have led to rapid developments resulting in instant cities. Augé (1995) hypothesises ‘Non-places’ as spaces that cannot be defined as relational, or concerned with identity such as shopping centers, airports, holiday villages and theme parks. Gencel and Velibeyoglu (2006) observe that the relations in the non-places are simulated, the identity created, and the historical fact disappears within a constant perception of the present. Technological advancements therefore have brought up new typologies of cities which are formed within much shorter duration of time as opposed to historical cities.

Development in transport technology has resulted in loss of activity within the streets. Sennett (1992) observes streets in the transportation technology era as ‘dead-space’ acting only as a means for reaching inside. The urban spaces have lost their functions thereby appearing as ‘void’ that is filled with either new buildings or traffic. This presents the possibility of urban spaces losing their functions if digital technology usage increases, unless other action is taken to mitigate it. The development of speed as a result of transport technological advancement, has also transformed the metropolitan region. Ahiska (1992) observes that living in the metropolis require continual movement therefore it is possible to miss something if you stop in a moment. Virilio (1986) argues that speed technology is a political, ethical and metaphysical phenomenon. Digital transportation is hence a means of experiencing speed which alters our understanding of space.

High concentration of economic activity tends to develop at centres where the digital technology infrastructure is highly developed. Ioannides, Overman, Rossi-Hansberg and Schmidheiny (2008) argue in the contrary that Geographic concentration of economic activity occurs in response to transportation costs and therefore in the absence of such costs due to digital technology usage, economic activities would tend to spread evenly over space. This school of thought can only be true if the variable of digital technology infrastructure is held constant. The existing scenario is that often costs for setting up digital infrastructure are high and thus only concentrated in specific regions.

Equality is a persistent concern in public spaces in the era of digital technology. Gencel and Velibeyoglu (2006) argue that social exclusion has been experienced due to the nature of ICT being highly dynamic and selective as well as inequality of access and use caused by different capabilities of people, cities and countries. Digital technology has also enabled territorialisation of spaces through Access control systems and electronic surveillance. Jacobs' (1961) concept of 'eyes on the street' has been substituted by digital surveillance which affords 'virtual eyes' on the street.

If the current trend continues Kenya's urban spaces will undergo transformation as a result of digital technology. The Communications Commission of Kenya (2011) reported that digital technology usage has increased in Kenya, particularly in Nairobi. Mobile data/internet subscription on General Packet Radio Service (GPRS)/ Enhanced Data rates for GSM Evolution (EDGE) and 3G recorded the highest proportion of the total internet data subscription of 6.07 million subscriptions, which was an increase of 13.04%. Observations can be made in Nairobi of pedestrians who leave their work places and while on the walkway, stop for a few minutes to make phone calls or send text messages. These changes in behaviour characterize transformations in the urban spaces.

2.4.3 Best Practices of Digital Technology Phenomena

2.4.3.1 New York Time Square

The Time Square, a central public space in New York, United States of America, symbolizes the power of new media and display technologies (Gencel & Velibeyoglu, 2006). The streetscape has been shaped as a huge entertainment district by finance, media and entertainment conglomerates (Davis, 2004). Digital Display Screens have been used for branding by multinationals and as real-time media platforms that are linked with online weather, news and stock-market-services (Gencel & Velibeyoglu, 2006).

Plate 2.33: Time Square Evening View

Source: retrieved May 22, 2012 from http://www.mountainsoftravelphotos.com

Plate 2.34: Time Square Aerial View

source: retrieved May 22, 2012 from http://www.britannica.com

Plate 2.33illustrates an evening street view. The street has been pedestrianized and urban furniture provided. The high building heights provide shade to the urban space, creating a sense of enclosure. Digital display screens allow users within the urban space to experience a wide range of information. Plate 2.34illustrates an intersection of two streets at Time Square, New York. There are large pedestrian walkways adjacent to the developments. Building facades have been utilized for mounting the digital display screens.

2.4.3.2Tokyo- Shibuya Crossing

It is a dense vibrant commercial district within Tokyo, Japan, It has a large number of mobile phone users and it is also known for the enormously high number of media surfaces and digital screens and neon-signs (Gencel & Velibeyoglu, 2006). The urban context of the public place is not only determined by the height of high-rise buildings or population density but also high volume of information, potential for communication and mobility of its users (Bauer, 2004).

As a 24hour commercial space, Shibuya has new technologies such as display and expression, wireless communication and automated positioning (Gencel & Velibeyoglu, 2006). Plate 2.35Illustrates Shibuya's Crossing Aerial view while Plate 2.36illustrates its street view.

Plate 2.35: Shibuya Crossing Aerial View

http://static.panoramio.com

Plate 2.36: Shibuya Crossing Street View

Source: retrieved May 22, 2012 from

http://theslideprojector.com

2.4.4 Policy Framework for Digital Technology in Urban Spaces

Since the mobility of digital technology, Policies have been developed to guide its usage. This however has not been without challenges such as having a universally accepted definition of what a technological city comprises, resulting in different disciplines coming up with their own interpretations (Ylipulli, Suopajarvi, Ojala, Kostakos, & Kukka, 2013).Where the digital technology infrastructure involves the wireless systems, policies have been formulated prescribing Rights-of-way agreements which give access to city-owned rooftops and pole-tops where antennas, routers and other devices are mounted (Forlano & Powell, 2011). Such policies alter the resultant urban form when infrastructure for digital technology is installed.

Lambert, Mcquire and Papastergiadis (2013) argue that digital technology in urban spaces should foster serendipitous interactions such integrating it with cultural events which facilitate cross-group mingling such as media art exhibitions, performances and festivals. The ICT Policy for Pretoria, South Africa prescribes affordability, availability and accessibility. It states that: communication services need to be provided at affordable prices; it needs to be provided whenever and wherever they are needed including in remote and rural areas; all citizens should be able to use communication services, regardless of location, gender, disability or any other personal characteristics (Communications Department, South Africa, 2014). The Government of Odisha prescribes in its ICT policy, incentives for the development of IT parks at strategic locations of the state due to growing demands for IT space from the IT industry (Information Technology Department, Odisha, 2014).

From these policies it is clear that there is a direct attempt by the governing authorities to promote its use so as to speed up development of other sectors as well. There is an attempt to integrate it with cultural activities on the streets and squares as well as to make it accessible at each and every point to the whole population. The government of Odisha even goes ahead to offer incentives to the private sector for creation of IT parks.

2.5Methodology used by researchers interested in the topic

2.5.1Real Pedestrian Experiment for data collection

Nasar, Hetch and Wener (2007) used real pedestrian experiment to investigate pedestrians' distraction from conversation on mobile phones. The research design involved real pedestrian environment using one hand held mobile telephone. In total sixty pedestrians near a University entrance were stopped and asked to participate, occasionally bypassing a male or female for gender balance. Each individual who agreed to participate was given a mobile phone and instructed that the research was on testing performance of different cell phones from various buildings on campus.

The individual was required to walk a given distance and to expect a phone call. Depending on the category of the pedestrian, he was called and a person talked to them until they reached the other end. Those in the ‘no conversation’ category were not called however they were asked to expect a call and not to worry about it if they were not called. All participants were debriefed at the end of the walk and were asked for consent to participate in the research by recalling out of place objects that had been placed along the walk prior to the study (Nasar, Hecht, & Wener, 2007).The experiment revealed that pedestrians noticed significantly more objects in the no conversation condition than in the conversation condition.

This method provides uniform room for observation as all participants are briefed in the same way. An error in observation may occur if the person under observation would be distracted by the expectation of a phone call that perhaps never came or if the person has poor memory and would thus not recall the objects even if they noticed them. Errors may occur if the person naturally has poor attention to the surroundings such that the person would yield the same result whether or not he received the phone call.

2.5.2Unobtrusive Observation

Nasar, Hecht, and Wener (2007) also carried out a research on safety behaviour of pedestrians using mobile phones and iPods at street crossings. Preliminary investigation had to be done first to establish the streets that met several conditions for the decided time of observation. The streets had to have an adequate number of mobile phone and iPod users to be selected for an observation sample. The streets had also to have adequate flow of traffic to give pedestrians potential conflict and a choice of crossing or not to.

An observation instrument was pretested and refined. It contained rows for each pedestrian observed and columns for the various categories of information observed. Each sheet also had spaces to record the location of observation, date, time and their name. Observers were trained to identify and observe pedestrians walking alone in a situation that the pedestrian can come in to potential conflict with an approaching vehicle. This required observing the speed and distance of the pedestrian from the street as well as the distance of the vehicle from the crosswalk.

Observations were made on behaviour as well as safety of behaviour. The observers carried out the study for two weeks between the peak times, 12:00pm and 2:00pm. Different observers made observations on the same pedestrians for counterchecking the data. The disagreements between the observations were dropped and the remaining ones used for analyses (Nasar, Hecht, & Wener, 2007). This method relied on the observers' ability to make accurate observations. It however yields high reliability due to counter checking of the data. A challenge may be faced on how to keep the observers unobtrusive especially if more than one observer is required to observe the same pedestrians. It emerged from the study that pedestrians with neither a phone nor IPod exhibited safest behaviour while those with mobile phone exhibited most risky behaviour. The highest percentage of pedestrians with mobile phones stopped for a stopped car whereas they walked on an approaching car.

2.5.3 Diary Based Method for Data Collection

Ito, Okabe and Anderson (2007) used a diary based method to establish usage of portable mobile devices. They first conducted an initial interview including a survey of everything participants were carrying in their car, pockets, bags and wallets. The participants were to undertake one or two days of diary keeping by documenting every time they used something out of their mobile kit. The methods of recording varied by site and included self-reporting through paper diaries, voice recorders and mob-logs. This was meant to cause the least amount of intrusion in the city's infrastructural context.

The research also included a 'shadowing' session whereby a researcher accompanied a participant on a normal or routine activity such as shopping, commuting or other trip through the city. A final interview was then conducted, including a review of the diaries and a photo-elicitation exercise. The interviews relied on the diary as primary basis for discussion (Ito, Okabe, & Anderson, 2007).This method also provides uniform observation as the participants in a given region are briefed in the same way. The data may be biased however as the participants may falsify the recordings to reflect a desired lifestyle that may be different from what actually takes place.

The study revealed that the basic mobile kit of phone, wallet and keys as well as the second-order mobile kit of a music player as well as reading material were a constant in all three cities. The study concluded that there were individual-driven efforts at maximizing the process of creating personalized environments using digital technology, i.e. Cocooning as well as that of creating personalized work environments through digital technology within existing urban spaces i.e. camping.

2.6Discussion

Digital technology is a new phenomenon that has manifested itself in the urban spaces over a period of time. From the invention of computers to the present day digital mobile devices, people's lifestyles have been altered. The urban spaces that were conceptualized and formed prior to technological advancements need to adapt so as to take full advantage of the available opportunities. Various governing authorities are already directing their policies towards ICT with a view to speeding up development.

The physical characteristics of the urban space forms the platform through which the digital technology is experienced and used. Policies formulated for development of the urban space, should improve its form to make it more favourable for use of digital technology. The Urban space therefore becomes an IT urban space, offering great benefits to its surroundings

The methodology for studying digital technology usage varies from place to place depending on the specific aspect under study how widespread the technology is as well as on the research budget. Unobtrusive observation appears as an ideal methodology for low budget research since it requires less personnel and equipment to conduct it.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The problem under investigation is that digital technology uses are currently not accommodated by the physical characteristics of the urban space. The study aims to establish the relationship between existing digital technology uses and the physical characteristics of the urban spaces in Nairobi Central Business District. To achieve this, the research design is structured to enable data collection from the study area that will enable mapping out the digital technology uses as well as establish the physical characteristics in those spaces.

3.2 Research Approach

This study adopts descriptive research approach. This is because the approach aims at measuring and describing as precisely as possible, characteristics and their relationship in a group. In this study, the digital technology uses is described further into categories then their occurrence in sampled urban spaces is measured. The physical characteristics of urban spaces are also described and measured as precisely as possible so as to establish their relationship, if any, with digital technology usage in the urban spaces of Nairobi Central Business District.

3.3 Research Design

Survey design has been used in the study. The problem has been defined as lack of accommodation of digital technology uses within the urban spaces of Nairobi Central Business District. The study seeks to learn about relationships between digital technology uses and urban space characteristics in diverse spaces within Nairobi Central Business

District. Survey design was therefore found to be most suitable. Figure 3.1 illustrates the research design in which observed digital technology uses in sampled spaces are tabulated and recorded as well as the urban space characteristics of those spaces. Sampled Urban spaces within the Nairobi Central Business District were observed at pre-determined time intervals to measure digital technology usage as well as urban space characteristics.

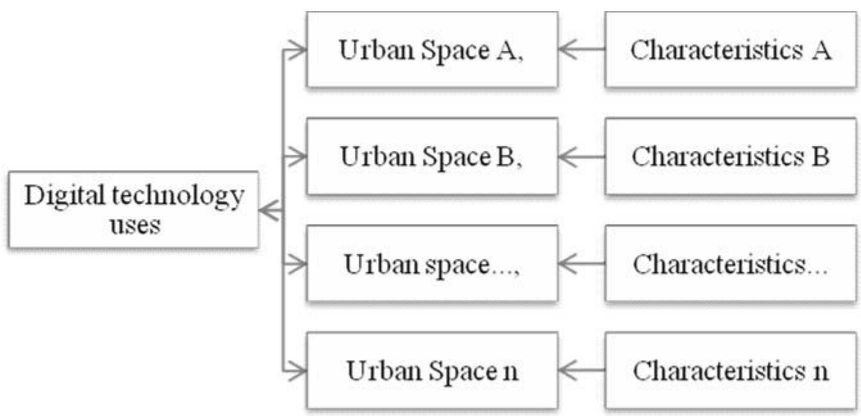


Figure 3.1:Research Design

Source: Author (2013)

3.4 Research Situs

The situs was the natural setting. Digital technology uses were studied in sampled spaces as the observed users went about their daily activities. This setting was chosen because it would be challenging to recreate the numerous spaces with diverse spatial characteristics and have users choose whether or not to engage in digital technology uses of their choice within the scope of this study.

3.5 Research Methods

The methods used in this study comprised observation and archival records. Observations were conducted to map out digital technology usage in Nairobi Central Business District. The physical characteristics of the studied urban spaces were also measured and recorded.

Archival method has been used to obtain documentation of urban spaces with digital technology uses from different parts of the world.

3.5.1 Observation

Observation has been used to record the digital technology uses in Nairobi Central Business District. The observation schedule comprised the researcher walking through a sampled urban space as a marginal participant and tabulating the observed digital technology uses. This data has been used to establish the types and frequency of uses. The data was recorded in durations of 15 minutes per space so as to standardize the data for comparison between different spaces.

Field study was conducted between: 9:00am – 6:00pm between Monday and Friday. This was because the study aimed at studying the uses from weekday urban space users who formed the majority users of the space. The uses were tabulated in different categories as shown in Table 3.1

Table 3.1: Digital technology uses tabulation

Mobile Phone Conversation	: ~~1111111111111111111111111111~~ 11 = 37
Texting/ surfing	: ~~111111111111~~ 111 = 18

Source: Author (2012)

The physical characteristics of the sampled urban spaces were also measured and recorded in pre-coded checklists. These characteristics included scale, transparency, connectivity, enclosure, image-ability, legibility, complexity, coherence and proportion. Appendix one illustrates the research tools that were used for data collection in the field.

3.5.3 Archival Method

Data recorded by others has been used in the study. Literature on existing urban spaces from different parts of the world with digital technology uses have also been used to further study the usage of digital technology in urban spaces. This was useful because not all the digital technology uses were found within Nairobi and therefore further reading was required to draw recommendations.

3.6 Sampling

Sampling was carried out to select the spaces to be studied. Stratified sampling was used to select the number of spaces to be studied in each space category after which simple random sampling was carried out to select the spaces for observation.

3.6.1 Population, Sample Size and Sample Frame

The universe constitutes all the urban spaces. The sampling frame comprised 495 convex spaces as shown on Figure 3.2made up of six open spaces, twenty four squares, Three hundred and forty three street spaces, seventeen arcades, forty four passages and sixty one lanes. Samples were drawn from each of the above space typologies using simple random sampling by the use of tables of random numbers.

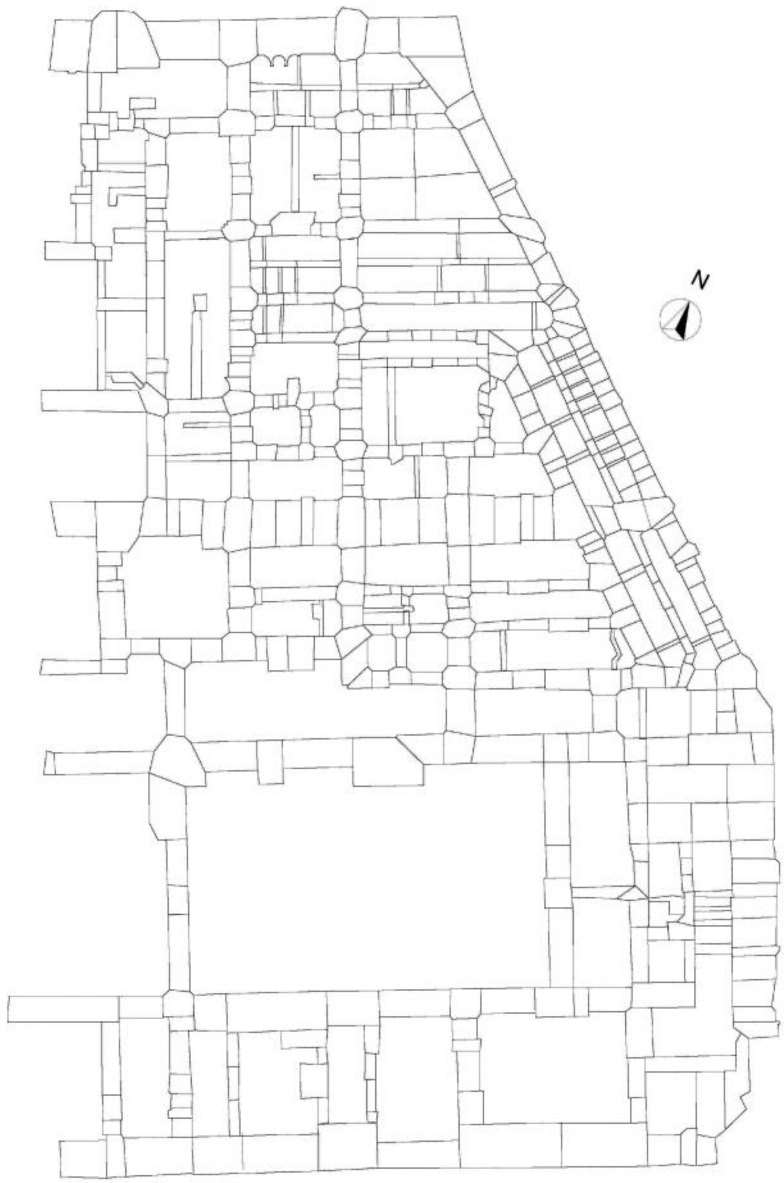


Figure 3.2:Nairobi CBD Convex Map

Source: Adapted from Government of Kenya & JICA (2005), and Otoki (2011)

The Sample size constituted 30 urban spaces within the Nairobi Central Business District. Table 3.2lists the number of spaces selected from each space typology. The sample size is adequate according to the Central Limit theory which states that for a normal distribution, a sample size larger than thirty (n>30) is necessary (Kothari, 2011). The sample is reflective of the population.

Table 3.2: Sample size

Space Typology	Open Space	Square /Plaza	Street Space	Arcades	Passages	Lanes	**TOTAL**
Cases	6	24	343	17	44	61	**495**
Samples Drawn	3	7	7	3	3	7	**30**

Source author (2013)

3.6.2 Sampling Unit

The convex space has been used as the sampling unit. The spaces were numbered according to typologies after which simple random sampling was done to select the cases to be studied. The sampling units were named by letters denoting the space type followed by numeral at the end starting from the top left hand corner of the map, following the street grid towards the right then downwards covering all the spaces. The space names were as follows: open space OS(X); square or plaza SQ(X); Street Space ST(X); Arcade AR(X); Passage PA(X); Lane LA(X).

The following spaces were chosen: AR(1), AR(11), AR(2), LA(13), LA(14), LA(18), LA(34), LA(46), LA(52), LA(9), OS(1), OS(3), OS(6), PA(14), PA(39), PA(5), SQ(18),

SQ(2), SQ(22), SQ(24), SQ(4), SQ(7), SQ(9), ST(111), ST(121), ST(186), ST(234), ST(296), ST(44), ST(8)

3.7Data Collection Program

A research permit was obtained from the National Council of Science and Technology so as to be able to carry out the study in Nairobi Central Business District. The permit lasted for a period of one year during which the field work was carried out.

3.8Data Processing

This involved the editing, coding, classification and tabulation of collected data in the office before analysis. Editing of observation checklists from the field was conducted to ensure that the total score is equivalent to the tallied score. The sampling units were also cross-checked to ensure that they corresponded to the spaces that were selected during the sampling procedure. Data from the urban space characteristics were standardized before data entry.

3.9Data Analysis and Presentation

Data analysis was carried out using SPSS Version 20. This involved the process of carrying out correlation studies as well as multiple regression analysis on processed data to determine relationships or differences supporting or conflicting with the hypothesis. The vector β of the regression model was subjected to analysis of variance to determine the validity with which the data can indicate the conclusions. Thereafter, the null hypothesis was tested using the F statistic.

Presentation of data was done using multiple regression model tables as well as correlation tables. For each of the analysed digital technology use, a formula has been written as a summary of the multiple regression models.

3.10Pre Tests and Pilot Study

A pilot study was conducted in the study area to test the tools for data collection. This was carried out in 10 urban spaces and the data collected was coded and subjected to analysis so as to improve the tools for collection and analysis.

3.10.1 Pilot Study

Observation was carried out on 10 urban spaces so as to test the tools for the Study. Observation took a total of 15 minutes per space in which 3 observation checklists were filled by the observer. The total number of people in a given space was first counted and recorded before observation commenced.

The observation protocol involved counting and recording the total number of people in the given space; during a period of 5 minutes, all digital technology uses and conflicts were observed and tabulated; the urban space characteristics were then measured and recorded; finally the wireless device would be switched on and the observer would walk with it throughout the entire space, tabulating the number of different wireless networks that were identified in bunches of 5.

The number of wireless networks was recorded by the observer turning on a digital technology portable device with enabled wireless connectivity and walking with it throughout the entire space. This allowed wireless networks that were present to be recorded. All wireless networks available were tabulated, whether or not they required a password to access it. For standardization, the same digital technology device, IPhone Model MA501LL, version 3.1.3 was used to establish the number of wireless networks in all the sampled urban spaces.

3.10.2Pre Tests Findings

The observation unit within a given urban space was reduced to fit that which is observable within a single viewing point. This was because some of the spaces taken were large and it required the observer to move from one point to another in order to observe the space. Reduction of the observation space allowed the researcher to record all observable occurrences in the same manner and from the same point for each of the sampled urban space. A convex space was therefore set as the sampling unit.

The coding of parameters was modified to include the name of the parameter being measured for ease of identity. This enabled easier coding, viewing and analysis of the data. The measurement of conflicts between the digital technology and urban space was removed from the study.

Urban space qualities that had similar parameters of measurement were combined to avoid duplication of tasks. All parameters of measurement of the urban space characteristics were also redefined so as to have the output as a standardized value. This enabled cross comparison between spaces of varying sizes and hence the correlation and multiple regression analysis could be applied.

Space syntax parameters were also introduced to summarize a number of other parameters. This included ring connectivity, axial connectivity and the depth of space which eliminated such as opportunities for activity and number of entry and exit points to the space.

3.11Research Ethics

All works that have been referred to in this study have been properly cited and their authors acknowledged. Data that has been presented is as a result of the field work that was carried out. All subjects in the study have been kept anonymous, only occurrences of digital technology uses have been noted with the persons engaging in them kept anonymous. No methods of data collection have put the researcher or the subjects in any danger. The privacy of the subjects was protected. There was informed consent where photographs were taken of buildings surrounding the public spaces.

The findings of this research are published as a thesis in the partial fulfilment of a master's degree in urban design and therefore are available for public use. The research funds have been fully utilized to carry out the research in an honest and legal manner.

3.12Reliability

The assessment tool used in the study of obtrusive observation of the urban spaces produces stable and consistent results. If the observation is repeated after a period of time and the observation time intervals are maintained the study is highly likely to yield the same result. If the observation is also carried out by the same person, there is consistency in data obtained and therefore the analysis will produce similar results.

The sampling and measurement procedure employed is therefore reliable. The table of random sampling is used to select the spaces to be studied and observation is carried out for 15 minutes on a single convex space.

3.13Validity

The research is sound and the data collected represent the phenomenon of digital technology use in urban spaces. The research design allows different typologies of urban spaces to be measured and the observed digital technology uses present tabulated. Through unobtrusive observation therefore, the existing scenario of digital technology usage is therefore tabulated and analysed.

The validity of findings is achieved because the digital technology uses that are investigated are those that have been observed in the spaces during the time of study. The urban space characteristics that are analysed are those measured in the spaces where the digital technology uses have been observed.

CHAPTER FOUR

STUDY AREA BACKGROUND

4.1 Introduction

This Chapter contains a brief history of Nairobi. The sampled spaces have been listed and the independent variables used in the study have also been defined.

4.2Historical Background

Nairobi was formed as a railway town, owing to construction of Kenya Uganda railway that reached Nairobi in 1899. It was chosen as a resting point due to its gentle terrain before the descent into the rift valley. The area was also midpoint between Mombasa and Lake Victoria and it also has an altitude of about 1700m above sea level which was considered suitable for Europeans.

An early plan was prepared by Church Fredrick Arthur, an assistant railway engineer in 1898. He planned two streets, wide enough for turning three-axled ox-cart transport-Victoria street, presently Tom Mboya street, and a Station road, presently Moi Avenue (Mills, 2006). Off station road, he planned 10 avenues, and along Victoria Street, he marked 13 commercial plots which he called the European Bazaar. At a distant area from that, he cited the Asian trading area called the Bazaar, presently Biashara Street. At this point in time, Nairobi was considered a Railway town and nothing more (Mills, 2006).

4.3Sampled Convex Spaces

Figure 4.1 illustrates the sampled convex spaces. The space names and typologies are shown on Table 4.1

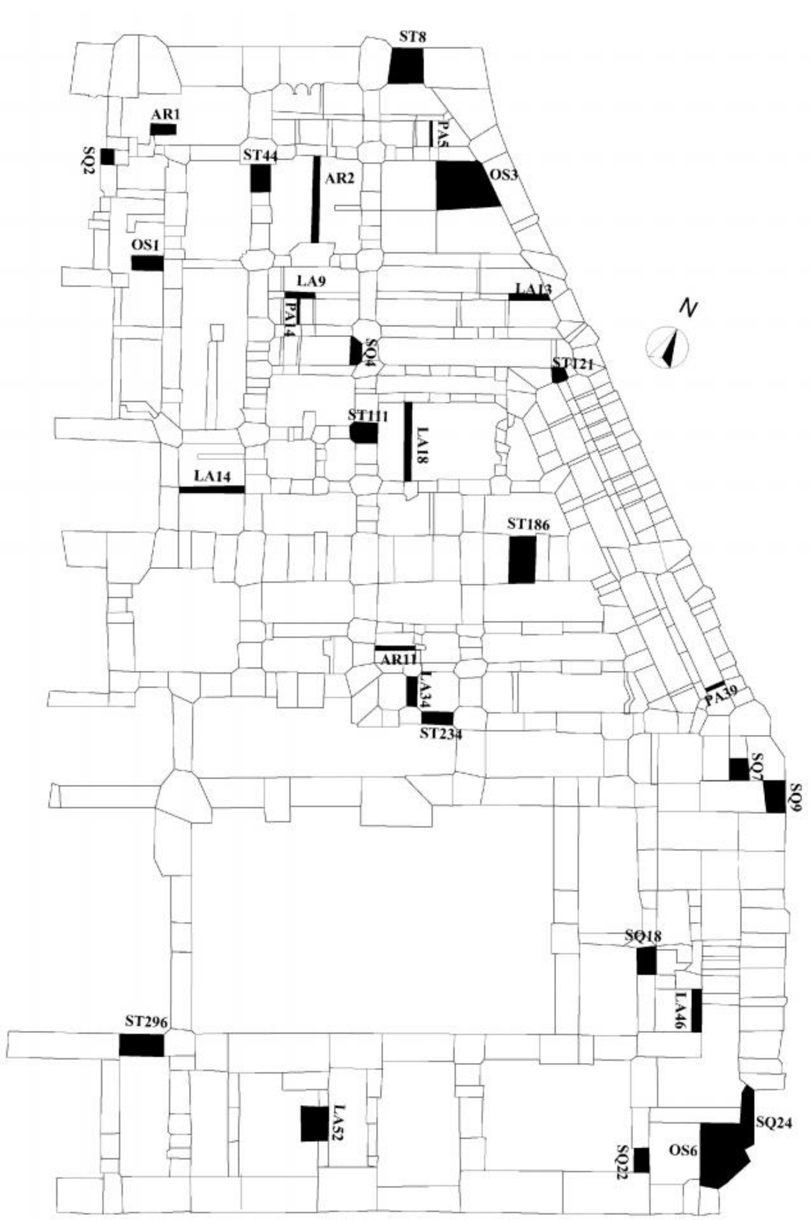


Figure 4.1:Sampled Convex Spaces

Source: Adapted from Government of Kenya & JICA (2005), and Otoki (2011)

Table 4.1: Sampled Convex Spaces

	Space Type	Code	Space Name
1	Arcade	AR(1)	Anniversary towers arcade
2	(3 No.)	AR(11)	Eco Bank Towers Arcade
3		AR(2)	Nakumatt Lifestyle arcade
4	Lane	LA(13)	Njugu lane next to Ufundi plaza
5	(7 No.)	LA(14)	Banda Street
6		LA(18)	Play House Lane
7		LA(34)	Gen. kago street
8		LA(46)	Nkurumah lane
9		LA(52)	Haile Selassie Lane next to Agip house
10		LA(9)	Njugu Lane, Near Koinange Street
11	Open Space	OS(1)	Utalii Street open Space
12	(3 No.)	OS(3)	Jevanjee gardens part 2
13		OS(6)	August 7 Memorial Park
14	Passage	PA(14)	Ngamia lane
15	(3 No.)	PA(39)	Safi lane
16		PA(5)	Tai Lane
17	Square or Plaza	SQ(18)	Aga khan walk Uchumi supermarket
18	(7 No.)	SQ(2)	Outside view park towers
19		SQ(22)	Aga khan walk ex-telecom house
20		SQ(24)	Moi Ave. Haile Selassie junction
21		SQ(4)	MuindiMbingu Street, next to city market
22		SQ(7)	Hilton Square part 3
23		SQ(9)	Moi Ave. National Archives
24	Street Space	ST(111)	Market st. junction with MuindiMbingu street
25	(7 No.)	ST(121)	Tubman Road, Outside the Bazaar
26		ST(186)	Kenyatta Ave. Cameo Cinema
27		ST(234)	Mama Ngina Street
28		ST(296)	Harambee Avenue
29		ST(44)	Koinange street outside kengeles
30		ST(8)	university way-windsor and central police

Source: Author (2013)

4.4 Independent Variables used

The following independent variables were used. They describe the physical characteristics of the urban space that bring about the urban design qualities.

a. Axial Connectivity is an index that gives the number of intersections of pedestrian paths that cut through a given urban space, indicated by the longest line of sight within the urban space. The higher the number of intersections, the higher the probability of finding a higher density of people who may pass through as they cross from one urban space to another. The value can be obtained from an axial connectivity map of the urban space under study (See Appendix 2).
b. Ring Connectivity is an index that gives the number of loops of a pedestrian path that go through a given urban space. The higher the number of loops, the more likely it is for a pedestrian to use the space as they go about their daily activities. The value can be obtained from a ring connectivity map of the urban space under study (See Appendix 2).
c. The Depth of Axial space from carrier space is an index that shows how many urban spaces you have to go through in order to arrive at a given space when coming from the feeder road or space. The higher the depth of the axial space, the further inwards a space is and therefore the harder it is for pedestrians to freely access the space. The value can be obtained from an axial depth map of the urban space under study (See Appendix 2).
d. The Control of Space is an index that marks the number of spaces that are connected to a given urban space. Spaces linked to many spaces tend to have activities spill over from them and therefore they have a higher index for control of space. The value can be obtained from a convex control map of the area (See Appendix 2). The axial connectivity, the ring connectivity,

the depth of axial space and the control of the space are all concepts derived from space syntax.

e. The Proportion of Historic Buildings is a variable that indicates how much of the urban space is enclosed by historical buildings. It is a measure of image-ability of the space. It is measured by taking the perimeter of the space that is enclosed by a historic building, divided by the total perimeter of the urban space.
f. The Proportion of pedestrianized space is a ratio that indicates how much of a given space has been set aside for pedestrian activity. It is a measure of image-ability and Human Scale of the urban space. It is obtained by dividing the area set aside for pedestrian activity to the area of the whole space.
g. The Proportion of greenery is a ratio of how much of the urban space is covered by greenery. It is a measure of Human scale and Image-ability of the urban space. It is measured by dividing the area having greenery by the area of the entire urban space.
h. The Proportion of space reserved for outdoor dining is a measure of how much space has been left for eateries as compared to a the whole urban space. It is a measure of the complexity of a given urban space. The ratio is obtained by dividing the whole area set aside for outdoor eateries with the area of the given urban space.
i. The Proportion of buildings with non-rectangular silhouettes is a ratio of the perimeter of a given urban space that is enclosed by buildings having non-rectangular silhouettes. This is a measure of complexity and is an indication of how interesting the buildings enclosing a given space are. It is obtained by dividing the perimeter enclosed by buildings with non-rectangular silhouettes with the entire perimeter of the given urban space.
j. The Proportion of street wall is a ratio indicating how much of the edges enclosing a given urban space is covered by walls. It is a measure of

enclosure and is obtained by dividing the perimeter covered by walls with the entire perimeter of the given urban space.

k. Sky view angle tangent is an index showing how much sky is visible from a given urban space. It is a measure of enclosure showing the proportion of sky across the street. It is obtained by dividing the average height of buildings enclosing the urban space with the width of the given urban space.

l. The Proportion of available sitting space is a measure of how much area has been set aside for sitting within a given urban space. It is a measure of presence of urban furniture which indicates the Human scale of a given space. It is measured by dividing the area set aside for sitting with the area of the given urban space.

m. Transparency between public space and adjacent buildings is a measure of visual continuity between the public space and the private space surrounding it. It is a measure of transparency and is obtained by dividing the area of facades with windows and doors with the area of the entire façade.

n. The Density of people is the ratio of pedestrians in a given urban space to the area of the space. It is a measure of complexity and is obtained by counting the total number of people in the space and dividing it by the area of the space

o. Intensity of buildings defining the space is a measure of how much the edges of a given space are defined by buildings. It is a measure of complexity and is computed by dividing the perimeter of the space defined by buildings with the perimeter of the entire space.

p. The Proportion of accent colours is a ratio of accent colours on facades enclosing the space. It is a measure of complexity and is computed by dividing the perimeter of the space enclosed by buildings with contrasting colours with the perimeter of the entire space.

q. The proportion of pieces of public art is a ratio of how much of a given urban space has public art. It is a measure of complexity and is computed by dividing the area with public art with the area of the given urban space.

r. The proportion of social places in the space is a measure of how much of the land uses enclosing the given urban space is pedestrian oriented. It is measured by dividing the perimeter of the edges containing social spaces with the perimeter of the given urban space.

s. Number of wireless networks present is a measure of how many wireless networks are available in a given urban space. It is computed by turning on a wireless network device and walking across the given urban space to tally the number of wireless networks that are detected.

CHAPTER FIVE

5.0DATA ANALYSIS AND FINDINGS

5.1 Introduction

This Chapter contains the analysis of the coded data from fieldwork. Analysis has been carried out using SPSS Version 20. A frequency distribution table was deduced to establish dominant digital technology uses after which multiple regression analysis was conducted between these dominant uses and the urban space

5.2Digital Technology Usage Frequency Distribution

Table 5.1below shows the frequency distribution of digital technology uses in the sampled spaces. Appendix 3 illustrates this frequency using a bar chart.

Table 5.1: Digital Technology Use in Nairobi CBD

Digital Technology Use	Number of Spaces with uses
Texting/Surfing	30
Telephone Call	30
Laptop/ Tablets	1
Earphones	20
ATM Machines	2
Digital Cash	2
Traffic Management	2
Security Surveillance	3
Digital Transportation	1
Neon Signs	1
Digital Display	1

Source: Author (2013)

The analysis comprised digital technology uses that were present in more than 5 spaces. These included texting/ surfing, telephone calls and earphones as shown inTable 5.1.

5.3Factors influencing Texting and Surfing in urban space

Texting is the act of sending and receiving short messages using a mobile phone, while Surfing is a general term that defines accessing information on the internet using a digital device. Factors that were found to be significantly varying in study include the density of people, the sky view angle tangent and the proportion of pedestrianized space.

Three models were formulated to explain the change in the variable texting/ surfing. Model 3 was preferred since it could explain 85% variance as opposed to the other two models which could only explain 81.7% and 63.2%as shown onTable 5.2 below.

Table 5.2: Summary of Model 1,2 and 3

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.795[a]	.632	.618	.0156679
2	.904[b]	.817	.803	.0112634
3	.922[c]	.851	.833	.0103555

Source: Author (2013)

a. Predictors: (Constant), density of people

b. Predictors: (Constant), density of people, sky view angle tangent

c. Predictors: (Constant), density of people, sky view angle tangent, Proportion of pedestrianized space

Table 5.3: Model 03 ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
3	Regression	.015	3	.005	47.582	.000[d]
	Residual	.003	25	.000		
	Total	.018	28			

Source: Author (2013)

From this model, the Null Hypothesis is rejected since F = 47.582 as shown on Table 5.3 above.

Table 5.4: Model 3

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
3	(Constant)	.005	.003		1.424	.167
	density of people	.411	.048	.833	8.489	.000
	sky view angle tangent	.003	.001	.476	5.906	.000
	Proportion of pedestrianized space	-.016	.007	-.238	-2.400	.024

Source: Author (2013)

The model explains 85.1% variance in the dependent variable texting/surfing.

Texting/surfing = **0.005+ 0.411***density of people***+ 0.003***sky view tangent***– 0.016***proportion of pedestrianized space***+/- 0.0103555**

The above findings suggest that, density of people; sky view angle tangent and proportion of pedestrianized space are among other patterns that could be used to control the digital technology uses of texting and surfing in urban spaces.Table 5.4illustrates the Model.

Density of people is defined as the number of people per square meter. With increase in density, digital technology uses also increased. The model above therefore suggests that a pedestrian would generally feel more inclined to text or surf, when there are many people within the urban space. This may be as a result of crowding and therefore loss of privacy to the pedestrians who in response turn to their digital technology devices to create a personalized environment.

The sky view angle tangent is determined by the ratio between the average heights of buildings enclosing the space to the width of the space. Spaces having high height to width ratio generally feel more enclosed. From the model above, narrower spaces with tall buildings will lead to more people texting and surfing.

The proportion of pedestrianized space as used in this study is defined as the ratio of the spaces set aside for pedestrian activity to the area of the entire space. These spaces include paved spaces, areas provided with benches or monuments for pedestrian consumption. From the field study it emerged that those spaces having large proportions of pedestrianized space have reduced uses of texting and surfing. It could also imply that pedestrians would feel more comfortable to text or surf once a large pedestrianized space is broken down to smaller spaces or activity pockets.

5.4The Urban Space as a setting for Mobile Telephone Call

The intensity of people engaged in mobile telephone calls is found to be significantly predicted by the presence of digital cash infrastructure per unit area as explained in model 6. This is because it is the only variable that has a high coefficient of 15.83 and the model explains 66.7 per cent of the variations in intensity of people engaged in mobile telephony as shown on Table 5.5.

Table 5.5: Summary of Model 4, 5 and 6

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
4	.654[a]	.428	.407	.0125033
5	.778[b]	.606	.575	.0105765
6	.817[c]	.667	.627	.0099133

Source: Author (2013)

a. Predictors: (Constant), density of people

b. Predictors: (Constant), density of people, sky view angle tangent

c. Predictors: (Constant), density of people, sky view angle tangent, Digital

Table 5.6: Model 06 ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
6	Regression	.005	3	.002	16.692	.000[d]
	Residual	.002	25	.000		
	Total	.007	28			

Source: Author (2013)

From this model, the Null Hypothesis is rejected in this model since F = 16.692 as shown on

Table 5.6 above

Table 5.7: Model 6

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
6	(Constant)	.005	.003		1.842	.077
	density of people	.184	.038	.584	4.895	.000
	sky view angle tangent	.002	.000	.439	3.702	.001
	Digital Cash	15.830	7.385	.249	2.144	.042

Source: Author (2013)

Model 6 explains 66.7% variance in the dependent variable telephone call.

Telephone Call = **0.005+ 0.184***density of people***+ 0.002***sky view angle tangent***+ 15.830***digital cash* **+/- 0.099133**

The above findings suggest that, density of people; sky view angle tangent and digital cash are among other patterns that could be used to control the digital technology uses of telephone calls in urban spaces.

Digital cash infrastructure includes vendors who dispense vouchers for airtime in addition to acting as agents for monetary transactions through the mobile phones. Spaces offering the service would generally have increased usage of mobile telephone calls. The phenomenon of mobile money transactions also attracts larger densities of people which are also a variable that is significantly varying with the intensity of people using mobile telephone calls. From the model, spaces having higher densities would also have higher number of users making mobile telephone calls as opposed to spaces with lesser densities. The sky view angle tangent also emerged to significantly vary with the mobile telephone calls. Spaces having higher proportions of height of buildings to the width of the space are found to have more persons making mobile telephone calls.

An urban space acting as a setting for mobile telephone calls would therefore have considerable spaces within it offering digital cash infrastructure, it would also have a high ratio between the heights of buildings enclosing it to the width of the space. Such a space would be such that it attracts higher densities of pedestrian.

5.5Factors affecting the use of Earphones in Urban Space as a Digital Technology use

A pair of earphones is the observable characteristics of use of digital devices to provide personal audible output. Although the range of digital devices that could be used with earphones is numerous, this study limited itself to only identifying the pair of earphones because it is the only characteristic that could be observed unobtrusively. Model 9, which explains 75.6 of the variations in use of earphones, picks out the density of people, the presence of security surveillance as well as the proportion of buildings with non-rectangular silhouettes as shown in Table 5.8 .

Table 5.8: Model 7, 8 and 9 Summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
7	.768[a]	.590	.575	.0077950

8	.824[b]	.679	.654	.0070288
9	.869[c]	.756	.727	.0062511

Source: Author (2013)

a. Predictors: (Constant), density of people

b. Predictors: (Constant), density of people, Security Surveillance

c. Predictors: (Constant), density of people, Security Surveillance, proportion of buildings with non-rectangular silhouettes

Table 5.9: Model 09 ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
9	Regression	.003	3	.001	25.817	.000[d]
	Residual	.001	25	.000		
	Total	.004	28			

Source: Author (2013)

The Null hypothesis is rejected since F = 25.817 as shown on

Table 5.9 above.

Table 5.10: Model 9

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
9	(Constant)	-.004	.002		-2.314	.029
	density of people	.210	.024	.902	8.673	.000
	Security Surveillance	-1.291	.388	-.340	-3.330	.003
	proportion of buildings with non-rectangular silhouettes	-.047	.017	-.285	-2.806	.010

Source: Author (2013)

The model explains 75.6% variance in the dependent variable earphones use.

Earphones use = **–0.004+ 0.210***density of people* **–1.291** *security surveillance***–0.047** *proportion of buildings with non-rectangular silhouettes*+/- **0.0062511**

The above findings suggest that the density of people, security surveillance and proportion of buildings with non-rectangular silhouettes are some of the patterns that could be used to control the digital technology uses of earphones in urban spaces. Table 5.10 illustrates the model.

The density of people in a given space varies proportionally to the use of earphones. Spaces having more people were found to have increased number of people who are using the earphones. It can be argued that where there are many people, a loss of privacy is felt, and in an attempt to restore it, earphones are used to create personalized environments to barricade the external sounds.

The presence of security surveillance as well as an increased intensity of buildings with non-rectangular silhouettes has been found to lead to a reduction of earphones use. Security surveillance is carried out through use of cameras that are mounted at different points in the space. Spaces having security surveillance are found to have less use of earphones. Buildings with non-rectangular silhouettes generally create more interest in the space. The use of earphones has been found to reduce with increase in proportion of buildings with non-rectangular silhouettes.

5.6Factors affecting the Density of People in Urban Space

The variable density of people has been captured as varying significantly with the above three digital technology uses. It is thus worthwhile to investigate the factors that affect it. Model 12 explains 65.6 per cent variance in the density of people in the urban space (see Table 5.11). The variables captured include the Proportion of pedestrianized space, presence of digital transportation as well as the area of the space.

Table 5.11: Model 10, 11 and 12

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
10	.614[a]	.377	.354	.0412717
11	.754[b]	.568	.535	.0350341
12	.810[c]	.656	.615	.0318654

Source: Author (2013)

a. Predictors: (Constant), Proportion of pedestrianized space
b. Predictors: (Constant), Proportion of pedestrianized space, Digital Transportation
c. Predictors: (Constant), Proportion of pedestrianized space, Digital Transportation, space area

Table 5.12: Model 12 ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
12	Regression	.048	3	.016	15.906	.000[d]
	Residual	.025	25	.001		
	Total	.074	28			

Source Author (2013)

Table 5.13: Model 12

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
12	(Constant)	.048	.013		3.548	.002
	Proportion of pedestrianized space	.048	.018	.350	2.649	.014
	Digital Transportation	1.802	.510	.438	3.535	.002
	space area	-1.713E-05	.000	-.323	-2.535	.018

Source: Author (2013)

The model explains 65.6% variance in the dependent variable density of people.

Density of People = **0.048+ 0.48***proportion of pedestrianized space* **+1.802** *digital transportation***–0.00002** *space area***+/- 0.0318654**

The above findings suggest that the proportion of pedestrianized space, digital transportation and the space area are some of the patterns that could be used to control the density of people in urban spaces (see Table 5.13).

Spaces with high proportion of pedestrianized space have higher density of people. This implies that spaces having higher proportions of spaces set aside for pedestrian uses have more people using them. Digital transportation includes lifts and escalators, electric trams as well as street conveyor belts. Spaces having digital transportation have been found to have higher densities of people in them. This would be explained as resulting from large number of people coming towards or from the destinations served by the digital transportation.

The area of the space is found to be negatively varying as the density of people. This phenomenon is mathematical in nature since the density of a space is computed through division by the area of the space. If you therefore increase the area of a given space, there would be a marked reduction in density of people, unless more people come to the space.

CHAPTER SIX

6.0 DISCUSSION

6.1Introduction

The variables of Urban Space that have emerged significant from the analysis of data include the sky view angle tangent, the density of people in a given space as well as the proportion of pedestrianized space. Digital cash emerged to strongly control telephone calls while security surveillance negatively impacted use of earphones. This discussion focuses on urban space characteristics that are represented by these significant variables.

6.2 Plot Ratio and its role in digital technology usage in Urban Spaces.

The Plot ratio is a numerical relationship between the total area for all the floors in a building and the plot area. Higher values of plot ratio lead to greater building height because more floor area can be accommodated within the same parcel of land. A plot ratio for a given piece of land determines how much more urban space is on the vertical dimension. This directly influences how many people can be accommodated within the same piece of land. Parcels of land having more persons translate to increased digital technology use according to the study findings. The points of entry and exit of the building tend to have larger volumes of people because they form points of convergence and divergence to and from the building, leading to vibrancy within the urban space.

The plot ratio is used to control the size of developments that can be put up in an area. This is proportional to the services provided by the authority such as electricity, sewerage, water as well as access roads. An area with wider roads, adequate sewerage service as well as water supply is able to accommodate medium to large size developments. To have vibrancy in the public urban spaces, it is necessary to have higher plot ratios so that the public space can benefit from the variety and diversity of the population that frequents the developments. The core of Nairobi Central Business District, which constitutes the study area, has a plot ratio of 600%. This means that each parcel of land can have up to a maximum floor area of six times the plot area. If the plot coverage was 100% then it would set the general building height to six floors since that gives a total area that corresponds to a ratio of 600%. If the coverage is less than 100%, then the number of floors increases for the same plot ratio.

Once used strategically, the plot ratio increases the land value and as a result attracts high-end client and funding institutions. Digital technology uses would be abundant with such a setting since the high-end client and funding institutions dictate spatial requirements for the surrounding spaces in terms of landscaping and appearance. Such requirements are the same ones that would attract digital technology uses. With increased size of development, there is a higher likelihood of greater return on investment and hence justifies the initiative for corporates to engage in community development initiatives such as paving the streets, lighting, provision of urban furniture as well as public washrooms.

6.3 Plot Coverage and digital technology usage in urban spaces.

The plot coverage is a percentage or fraction that indicates how much of the parcel of land can be occupied by the building. Plot coverage of less than 50% leaves more open space while that above 50%has the development occupying a bigger portion of the land. The size and shape of the open space is also guided by the building line which determines how far back the building should be set from the boundary with the road. A well prescribed plot coverage and building line leaves pedestrian spaces that are sustainable and functional where digital technology uses can flourish.

The study area has ground coverage of 80%. This means that only 20% is left for pedestrian activity. Ground coverage is easier to conceptualize when it is compared to the plot sizes. Nairobi Central Business district prescribes a minimum lot size of 0.05 hectares. With ground coverage of 80%, therefore, a developer can only build up to 400 square meters on the ground floor. Factoring in the circulation and services on the ground floor leaves very little space for commercial purposes. On-plot parking on such a plot is also very difficult because the space occupied by parking ramps would leave almost no room for car park as well as other uses. Amalgamation of narrow plots offers a solution to on-plot parking and the much needed open space at grade level. By taking up the minimum plot size to 0.15 hectares, and to have ground coverage as 75%, a much larger open space is left and the size of development on the ground floor is still large enough to accommodate on-plot parking. This results in higher digital technology use.

6.5 Land Use Patterns for Digital Technology uses (mix, diversity and Context)

The context of the land uses surrounding pedestrian spaces would either encourage or discourage the use of that space. Uses that are pedestrian oriented and even flowing into the pedestrian space increase the density of people using the space and hence digital technology usage. Examples include eateries, cafeterias and entertainment spaces such as theatres and cinemas. If the same spaces also offer digital technology services such as mobile money transactions as well as sale of airtime, there would be a marked increase in digital technology uses such as texting, surfing and mobile telephone calls as shown from the field study findings.

Zoning of land uses such as banking and related establishments that require heavy security presence and are not pedestrian oriented at upper floors leads to increase of digital technology use. Such establishment have introverted facades which discourage pedestrian activity in addition to security surveillance which this study has shown limits digital technology use. Land uses that should be located at grade level should only be those that are extroverted and flow into the pedestrian spaces.

Land use mix and diversity provides complimentary uses that attract large volumes of pedestrians seeking to satisfy different interests. It also increases the probability of a pedestrian frequenting the space since they are able to satisfy more than one need in a single trip. An example of land use mix and diversity is how large retail outlets such as malls and supermarket often require large parking spaces to serve it. They also have eateries and fast food outlets within them for diversity. An international example is how Walmart supermarkets in the United States have Subway Fast-food establishment within it. Local cases include Uchumi and Naivas Supermarkets which offer readymade food in addition to other retail products.

Digital displays work better at night due to more clarity with reduced lighting in the surrounding. For them to be operational therefore public spaces have to be in use in the evenings, night times as well as early mornings. This however is challenging in a homogeneous land use such as Nairobi Central Business District whereby people commute to it during the day and head back to the residential areas in the evening, leaving the city deserted and hence insecure. To have digital displays in use therefore, it would be worthwhile to introduce land use that enable urban dwellers to reside within the city centre. This would be in form of residential units or accommodation spaces on upper floors. The dwellers within the city centre would be able to utilize the social spaces such as cafeterias and restaurants and therefore provide the much needed density within the urban spaces for digital technology use.

Table 6.1: Design Interventions

Objective	**Intervention**	**Projected effect**
Adequate pedestrian space	Allow more Plot ratio	Allow more plot ratio so that developments can leave More space on Grade level for pedestrian activity
	Allow Amalgamation	With increased plot size, developments are able to surrender more space for pedestrian activity and still have a functional

		development
	Reduce Ground Coverage	Leads to more spaces left as pedestrian spaces such as courtyards or increased building frontage
	Remove parking at grade level	Multi-level parking within the buildings
Increase density and activity of people on the pedestrian spaces	Land use: mix and diversity	Prescribe pedestrian oriented land uses with diversity to encourage more people to visit the spaces
		Have land uses that allow the urban dwellers to reside within the urban spaces such as residential or accommodation facilities
	Increase plot ratio	Allows more persons to frequent the building due to increased destinations within the buildings that attract more people through the spaces
		Attracts high-end clients and funding which eventually leads to improved pedestrian space and as a result attracts more people
	Introduce urban furniture and	Allows people to stay longer in a pedestrian space. Includes benches,

	pedestrian infrastructure	drinking water points, paving on paths as well as provision of washrooms
Increase the sky view angle	Increase the plot ratio	Results in more building height therefore higher sky view angle
	Introduce canopies to the streets	Limits the amount of sky that is visible from the pedestrian space hence increased sky view angle tangent

Source: Author (2013)

CHAPTER SEVEN

7.0CONCLUSIONS AND RECOMMENDATIONS

7.1Theoretical Implication

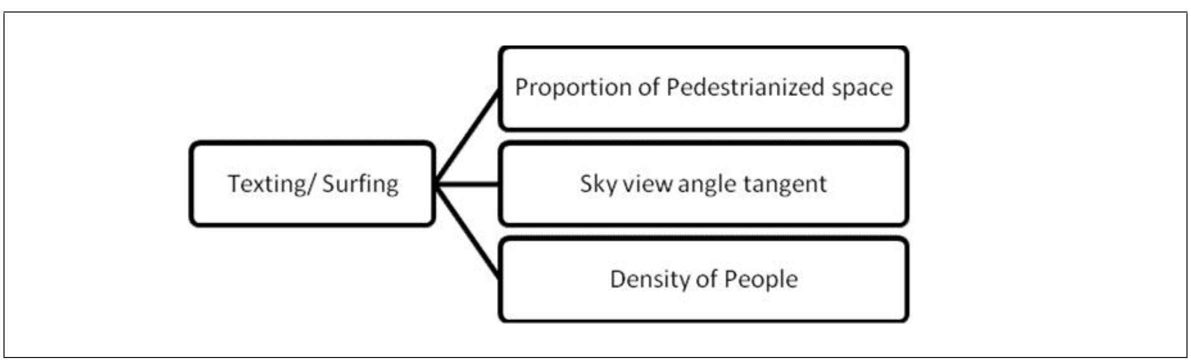
The actor network theory as applied in digital technology uses suggest that the networks undergoing formation in Nairobi central business district involve the physical characteristics of sky view angle tangent, the density of people in a given space as well as the proportion of pedestrianized space, among others, while the digital technology uses are the mobile phone conversations, texting and surfing and the use of earphones as shown on Table 7.1. This does not exhaust all the networks potential within the urban space; it only suggests the pioneering networks that first appear in the advancements of digital technology in urban spaces.

Table 7.1: Digital Technology Actor Network

Digital technology uses	Urban Form Characteristics
• Texting/ Surfing	• Sky view angle tangent
• Telephone call	• Density of people
• Earphones	• Proportion of pedestrianized space

Source: Author (2013)

The Private Social Public Framework theory explains the nature of interactions that have emerged to form networks within the urban space (see Figure 7.1). In all three cases, the interaction space is private but the information sphere is private, social or public. In the current infrastructure, the information is not yet able to be dissipated into the public space. Infrastructural advancements need to take place to enable a user to choose whether or not to share information in public. Such advancements could be digital screens or speaker systems.



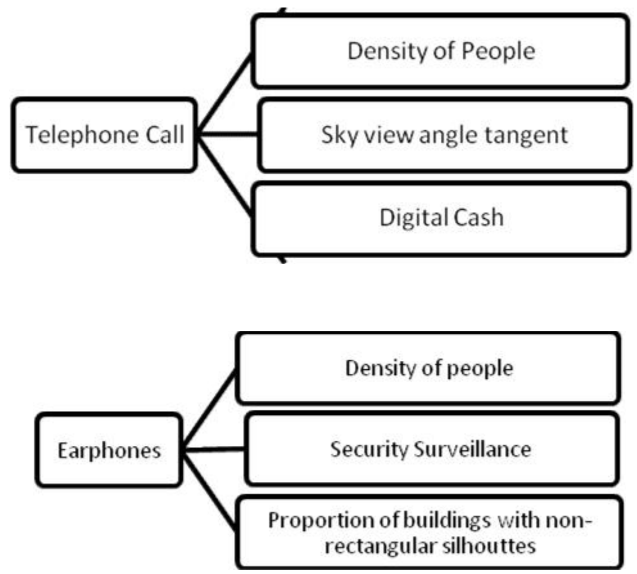


Figure 7.1:Digital Technology Interactions

Source: Author (2013)

7.2Conclusion

Urban design influences use of digital technology in urban spaces. As the digital technology uses embed the day to day uses within the urban space, it has emerged from the fieldwork analysis that certain urban space physical characteristics favour them more than others. That is not to state that the study has taken an environmental deterministic approach for human behaviour because of the fact that the urban space is taken to be pre-existing and the digital technology uses are emerging based, among other factors, on technological advancements. These advancements have enabled portability of the devices as well as provision of infrastructure. Technological innovation has also led to decrease in cost that has resulted in pervasive digital technology usage.

Globalization plays a role in redevelopment of urban space to comply with such technological advancements so as to take advantage of opportunities that are hitherto afforded. By this very reason, the urban space is therefore informed by the digital technology uses. The study set out to find whether or not there were physical characteristics that promoted digital technology uses more than others. Since this was the case, it is therefore justified to argue that the emergence of digital technological innovations would influence development with a bias on those very ‘favourable characteristics’.

This study was conducted within the Nairobi Central Business District and it emerged that the proportion of pedestrianized space as well as the sky view angle tangent played a role in promoting the digital technology uses. The telephone calls were also greatly favoured by presence of digital cash. These take the form of mobile money agents such as MPESA, which offers a number of services, key of which, is selling of vouchers to enable one to continue talking on the phone.

The urban design framework therefore would first deliberately state whether or not it aims to align itself with global trends for whatever reason, before outlining recommendations and development control guidelines. Once it is clear that the framework intends to offer global opportunities, then digital technology would be one way of achieving this and the urban space patterns that have emerged in this study can be applied.

7.3Recommendations

From this study, the following recommendations if implemented would result in achieving a harmonious urban environment whereby digital technology usage is widespread in zones that have been planned for. This would result in profitable direction of investment within the urban space. The recommendations take the form of guidelines for urban space.

Guideline 01: provide functional and attractive pedestrian spaces for digital technology use

- Promote amalgamation of narrow plots so as to provide on-plot parking and free the ground level for pedestrian use

- Reduce ground coverage so as to have more space for pedestrian activity
- Allow more plot ratio in exchange with providing urban furniture, restrooms and other pedestrian infrastructure within the pedestrianized areas
- Have discontinuous building line to allow for harmonious pockets of pedestrian spaces along the street. The internal spaces should however overlook these spaces for safety.

Guideline 02: provide shaded spaces with sense of enclosure for better quality environment for using digital technology

- Utilize lanes and narrow streets for pedestrian activity (see Figure 7.2)

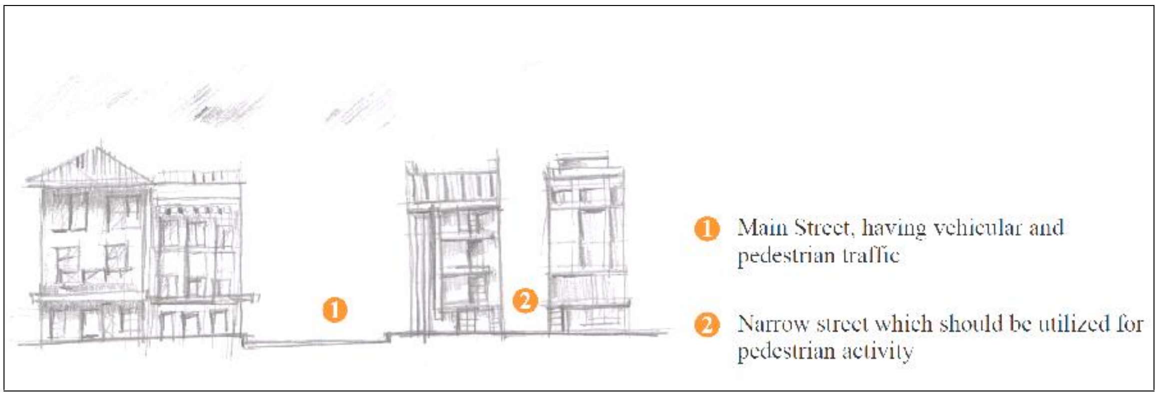


Figure 7.2: Use of Lanes

Source: Author (2013)

- Increase plot ratio around pedestrian spaces to surround it with harmonious development that offer room-like quality

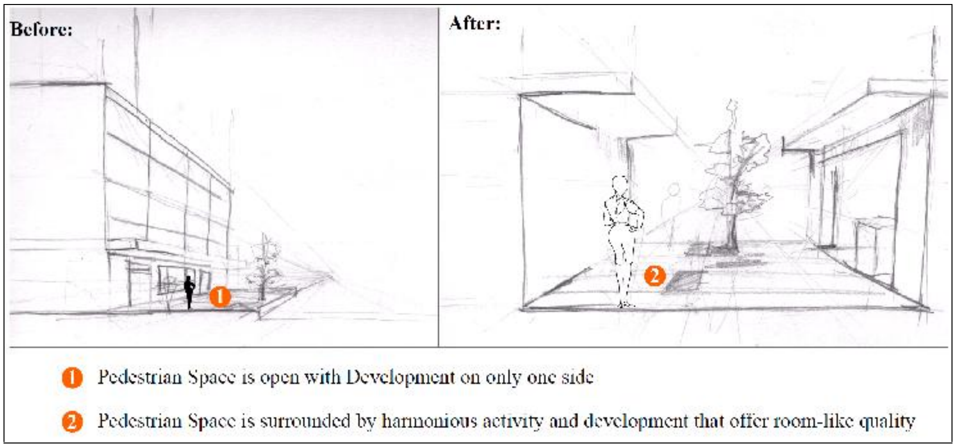


Figure 7.3: Enclosed Pedestrian Space

Source: Author (2013)

- Allow more plot ratio in exchange of providing arcades and other pedestrian outlets at grade level

Guideline 03: provide digital technology infrastructure in urban spaces

- Incorporate temporary and permanent digital displays within urban spaces (see Figure 7.4)

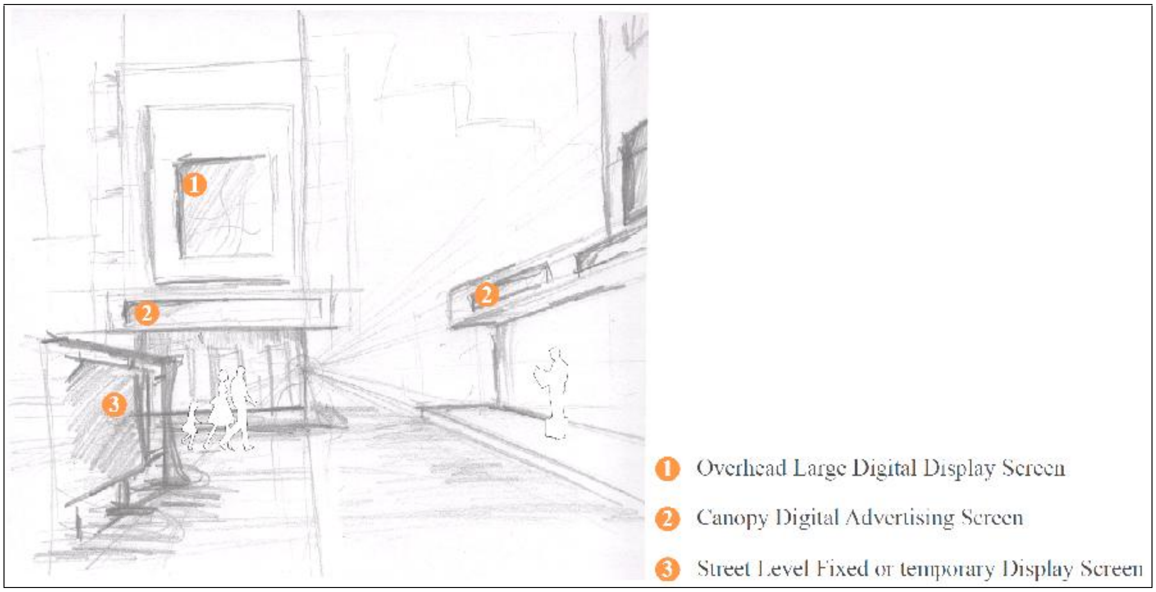


Figure 7.4:Incorporated Digital Displays

Source: Author (2013)

- Provide wireless connectivity for digital devices
- Provide land uses that offer digital technology services
- Provide digital transportation to complement pedestrian movement
- Locate power outlets and digital devices plugins within pedestrian spaces
- Locate public plazas for hybrid environments and urban gaming

Guideline 04: provide vibrant pedestrian spaces for digital technology use

- Increase plot ratio to allow more users to frequent the public spaces
- Zone non-pedestrian oriented land uses above grade level
- Surround pedestrian spaces with land uses that are pedestrian oriented and that flow into the pedestrian spaces

PART II

PROJECT REPORT

Redevelopment of Nairobi Commercial Area for Digital Technology use

CHAPTER EIGHT

8.0 STUDY BACKGROUND

8.1 Introduction

The study area is located within the Nairobi County at the Central Business District as shown on Plate 8.1.

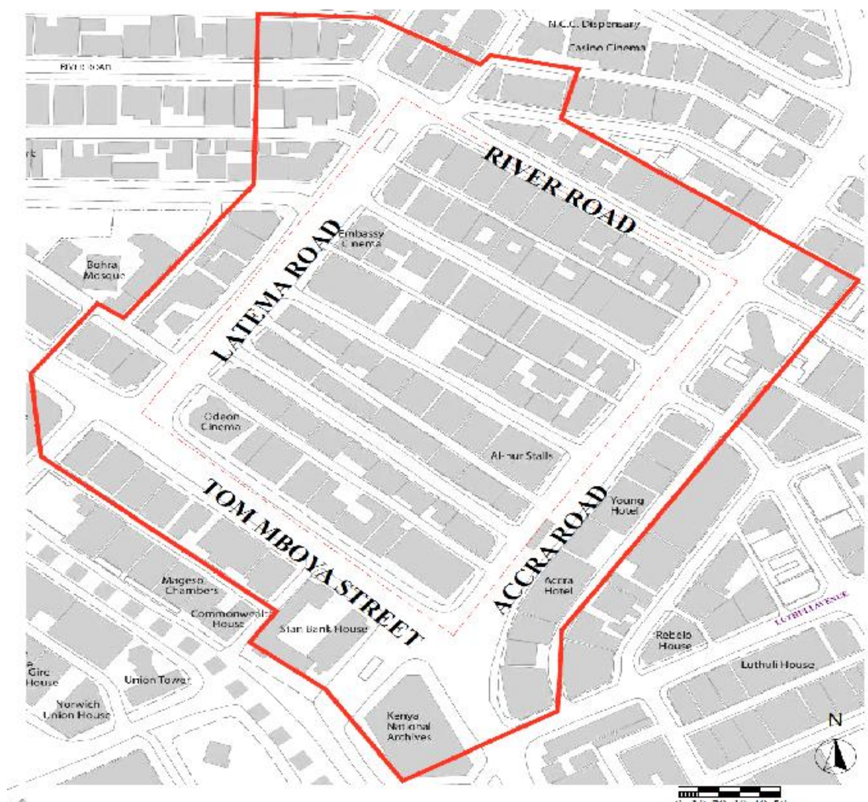


Plate 8.1: Study Area Map

Source: Adapted from Government of Kenya & JICA (2005)

It comprises the region enclosed by Tom Mboya Street to the South West, Latema Road to the North West, River Road to the North East and Accra Road to the South East. The precinct is right outside the main Nairobi CBD Core, and is categorized by homogenous retail activities in low rise developments, mostly up to four floors. It is bordered by public transport termini on two opposite parallel edges. These are Accra Road and Latema Road.

8.2 Problem Statement

The commercial area precinct is organized along a grid structure and is based on the automobile. The pedestrian has not been accommodated in the space and this has led to overcrowding with pedestrians walking on the vehicular roads. Plate 8.2illustrates Tsavo Road in which pedestrians can be seen walking on the vehicular road due to inadequate pedestrian space and Plate 8.3illustrates a section of Dubois Lane which is deserted, since the developments have turned their backs on the lanes. Retail activities are introverted and the vehicular parking has dominated the streets resulting in poorly utilized public spaces

There is recklessness among the few digital technology users causing risk to lives. Pedestrians can be seen using the mobile phone on vehicular roads. The resultant urban structure is characterized by minimal use of digital technology in the urban spaces.

Plate 8.2: Pedestrian use of Roads

Source: Author (2013)

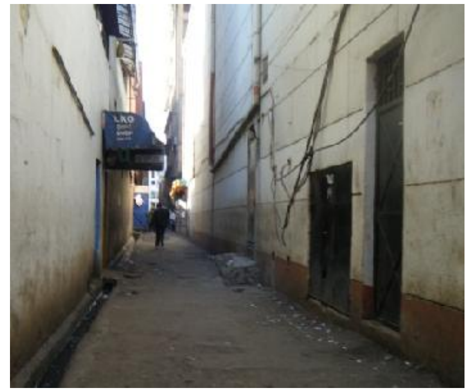


Plate 8.3: Deserted lanes

Source: Author (2013)

Insecurity is also a setback to the use digital technology devices in the area. The urban massing comprises long narrow lanes with no escape routes. A pedestrian is tasked with walking a distance of 160 meters before finding an exit. Plate 8.4illustrates Dubois lane which is long and narrow therefore very deserted. The pedestrian spaces are unlinked and the exposed services such as electricity lines along the streets and lanes for example Timboroalane (see Plate 8.5), are an eye-sore.

Plate 8.4: Long Narrow Lane

Source: Author (2013)

Plate 8.5: Exposed Services

Source: Author (2013)

8.3Objectives

1. To establish the physical characteristics of the space
2. To identify urban environmental problems present in the area
3. To develop policies for urban digital development for the study area
4. To redesign Nairobi Commercial area precinct using the policies developed for digital technology

8.4 Methodology

Observation method was used to obtain data on the study area. Photographs and sketches of existing conditions were taken. Observation checklists were used to record the various spatial uses that were present in the study area.

Urban design guidelines for Central Business Districts have also been looked at with the aim of analyse the strategies adopted to make them vibrant and pedestrian friendly. These have provided useful lessons in developing policies for the study area.

8.5 Study Justification

The study is worthwhile because implementation of the policies developed will result in a pleasant symmetrical environment which leads to an increase in economic activity and efficient utilization of the study area. Various urban centers are embracing digital technology for example Nakuru County (Macharia, 2014). The importance of Nairobi as a Center is threatened by devolution and therefore it should embrace digital technology in its urban spaces so as to maintain its position. The government will generate increased revenue from trading opportunity with global markets afforded by digital technology. The urban users will also derive social benefits from aesthetically pleasant environments as well as cutting-edge digital infrastructure. The end product will be a networked urban space with freedom and opportunity for interaction between the digital and physical realms.

8.6 Study Scope

The geographical scope comprises the public urban spaces within the Nairobi Commercial area, Kenya, as shown in Plate 8.1.The methodological scope comprises using observation to document the existing conditions in the study area.

CHAPTER NINE

9.0COMPARISONS OF CENTRAL BUSINESS DISTRICT DEVELOPMENT GUIDELINES

9.1 City of Richmond: City Centre Area plan Bylaw 7100 Schedule 2.10

This section highlight planning guidelines on the City of Richmond Community plans. It Covers the Schedule 2 Area Plans for Bylaw 7100 as retrieved from the official page http://www.richmond.ca.

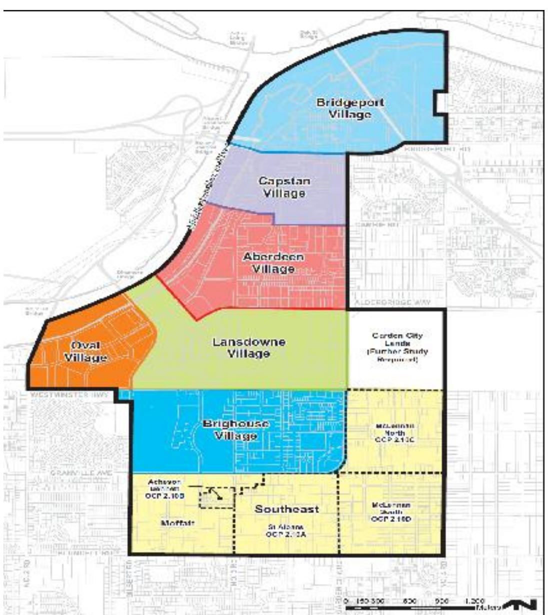


Plate 9.1: Richmond City Map

Source: Retrieved May 10, 2014 from http://www.richmond.ca/__shared/assets/city_centre556.pdf

Plate 9.2: Richmond Street View

Source: Retrieved May 10, 2014 from http://www.richmond.ca/__shared/assets/city_centre556.pdf

9.1.1 Historical Context

Richmond grew as a centre due to favourable conditions for farming and fishing which attracted the Coast Salish people followed by European farmers and fishermen in 1879.The City Centre is approximately 930 Ha in size and has 5.5 km of shoreline along the Fraser River on its north and West Sides. (City of Richmond, 2009). The planned area is illustrated on Plate 9.1. Plate 9.2 shows a view from one of Richmond streets.

9.1.2 Goals for the commercial area

With challenges of restrictive building heights of 47 meters due to the Vancouver International Airport operations, Richmond seeks to encourage office friendly development opportunities through attracting major national and international tenants, who will in turn attract other tenants, and to distinguish itself from other regional town centres and the status quo of small tenancies and office park developments.

The proposed Measures include provision of large flexible sites and high density developments. The city also seeks to have pedestrian oriented retail spaces at grade level along public streets and building frontages. Plate 9.3 illustrates a street café which is a pedestrian oriented use while Plate 9.4 illustrates the high density development. Plate 9.5 illustrates the stepped building façade while Plate 9.6 illustrates the articulated facades with small frontages.

Plate 9.3: Street Cafe

Source: Retrieved May 10, 2014 from http://www.richmond.ca/__shared/assets/city_centre556.pdf

Plate 9.4: High Density Development

Source: Retrieved May 10, 2014 from http://www.richmond.ca/__shared/assets/city_centre556.pdf

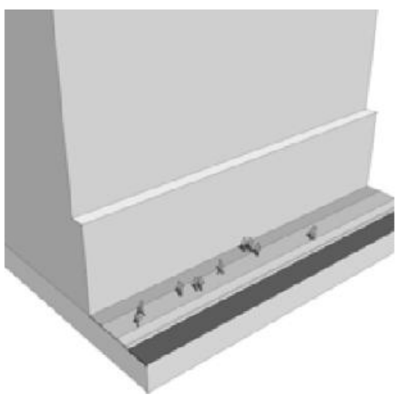


Plate 9.5: Stepped Building Facade

Source: Retrieved May 10, 2014 from http://www.richmond.ca/__shared/assets/city_centre556.pdf

Plate 9.6: Articulated Building Facade

Source: Retrieved May 10, 2014 from http://www.richmond.ca/__shared/assets/city_centre556.pdf

9.2 Southampton City Centre Master Plan

This section highlights the Planning guidelines for the City of Southampton that was developed by David Lock Associates for the City Council.

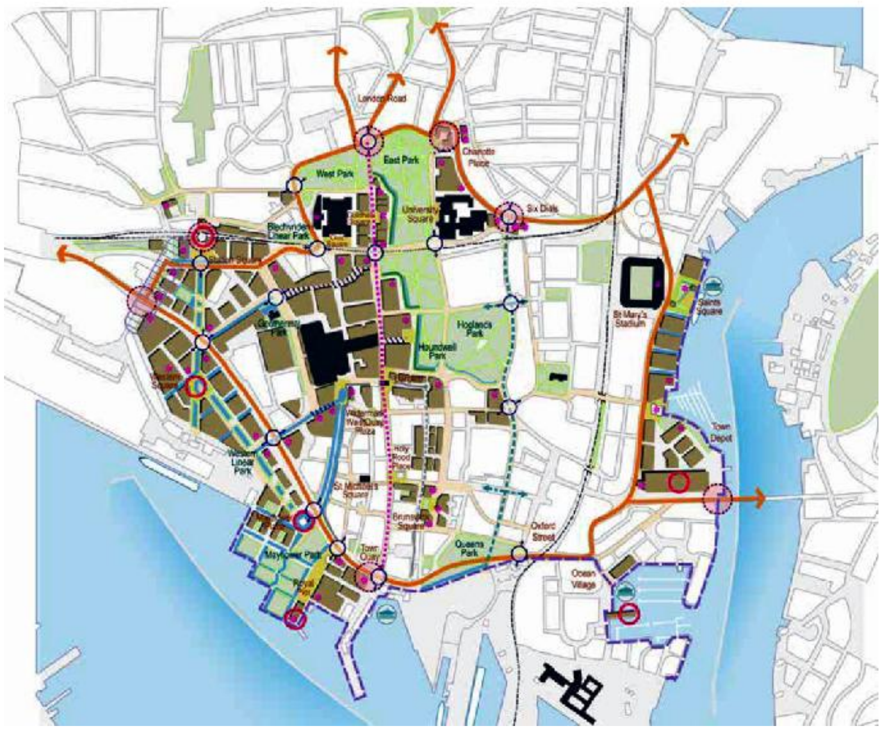


Plate 9.7: Southampton City Center Master Plan

Source: David Lock Associates (2013)

9.2.1 Historical Context

Southampton city is located in the UK. Over the years, it has been characterized by social economic activities such as ship building, military embankment, port and Spa services. Currently, however, the city's strengths are banking, finance and insurance, education as well as the health sectors. It has a population of 236,700 people and a sub-regional catchment of about 850,000 people (David Lock Associates, 2013). Plate 9.7 illustrates the design framework.

9.2.2 Goals for the City Centre

The vision is supported by seven key themes: to make it a great place: for business, to visit, to shop, to live, a greener centre, an attractive and distinctive centre and an easy place to get about (David Lock Associates, 2013).

The specific goals include to have a diverse retail circuit (see Plate 9.8), to create coherence and legibility as well as to enhance important landmarks (see Plate 9.9). Building heights have been set to six floors with upper floors set back to create terraces and gardens. The buildings should have active frontages as shown on Plate 9.10 and Plate 9.11.

Plate 9.8: Multilevel Shopping Street

Source: David Lock Associates (2013)

Plate 9.9: Tall Landmark Building

Source: David Lock Associates (2013)

Plate 9.10: Transparent facade

Source: David Lock Associates (2013)

Plate 9.11: Spill-out Cafe

Source: David Lock Associates (2013)

9.3 Comparative Analyses of Richmond and Southampton City Guidelines.

The two cities were considered ideal since they are in developed countries and are located in two different continents. The cities also have recent urban design plans and are therefore very likely to have considered the aspect of digital technology.

Table 9.1: Comparative Analysis Table

Parameter	Richmond City	Southampton City
Building Height	Allow High-rise development of up to35-45m in prominent locations	Up to 6 floors generally
		Tall buildings to be clustered or placed as landmarks
Land Uses at Grade Level	Dedicated to pedestrian-oriented retail, personal services, restaurants and outdoor cafes	Pedestrian oriented and spills over to the pedestrian space
	A diversity of activities such as shops and restaurants	Mix uses vertically and horizontally
		Establish continuous retail circuit
Land Uses Vertically	Office and similar uses to be situated above the ground floor.	Upper floors to have housing or offices
Pedestrianized Space	Provide continuous pedestrian weather protection along commercial building frontages wherever possible	Provide generous spaces that offer activity and well located street furniture and public art
Building Massing	Building elements higher than 3 storeys to be stepped back a minimum of 1.5m from the building frontage while those above 5 stories to be stepped back a minimum of 3m	Upper floor to be setback to allow terraces and garden spaces and reduce the visual impact at street level
	Articulate building facades vertically and horizontally to visually break up large walls	
Transparency/ facades	A high degree of transparency enabling interaction between	transparent frontages with shop windows and occupied

	activities inside the building and the fronting sidewalk or open space	upper floors that light the street at night and show activity during the day
Retail frontages	Use small unit frontages of maximum 10m to create visual interest and help impart a human scale along the streetscape. Screen large tenant frontages with smaller units or locate them above the ground floor.	spacing entrances regularly and not too far apart
Car Parks	concealed parking lots	Provide gardens, amenity space and parking within the urban block.
Floor-plate/ Plot sizes	Provide Large flexible Sites with large floor-plates	
	Increase building setbacks in some areas to create usable plazas, display gardens and front yards	
Urban Form		create an overall legibility to the centre through built form with gateways, carefully sited tall and landmark buildings
		To have a variety in the skyline and its silhouette

Source: Author (2014)

CHAPTER TEN

10.0 SITE ANALYSIS

10.1 Context

The commercial area precinct is located within the Nairobi County at the Nairobi Central Business District. It is in the planning zone of West of Tom Mboya. Plate 10.1 shows the aerial pictorial view of the precinct.

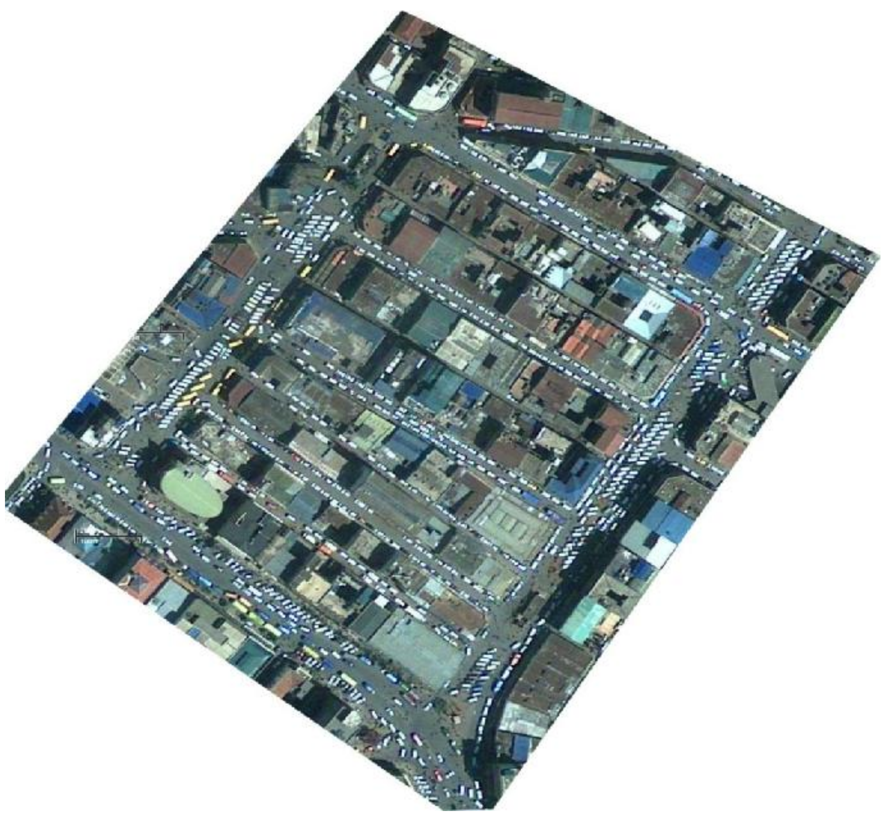


Plate 10.1: Precinct Google Image

Source: retrieved March 6, 2013 from http://maps.google.co.ke

10.2 Land uses

The land use is mostly commercial as shown on Figure 10.1 with retail stalls taking up most of the ground floor spaces. A few accommodation facilities are also available, as well as institution and sacred uses. The open spaces bordering the study area are used as public transport termini.

Figure 10.1:Existing Land uses

Source: Author (2013)

Plate 10.2illustrates the Al-noor market stalls as well as the public transport terminus at Accra Road. Part of Tsavo road is also used as a transport terminus.

Plate 10.2: Tsavo Road, Accra Road Panoramic Photo

Source: Author (2013)

Plate 10.3 illustrates Latema road whereby former two cinema halls can be seen: embassy cinema and Odeon cinema. These however have had adaptive reuse over the years. Embassy Cinema is now a church building, Maximum Miracle Centre, while Odeon Cinema is now an institution building, Nairobi Aviation College. The public Transport terminus at Latema road can also be seen.

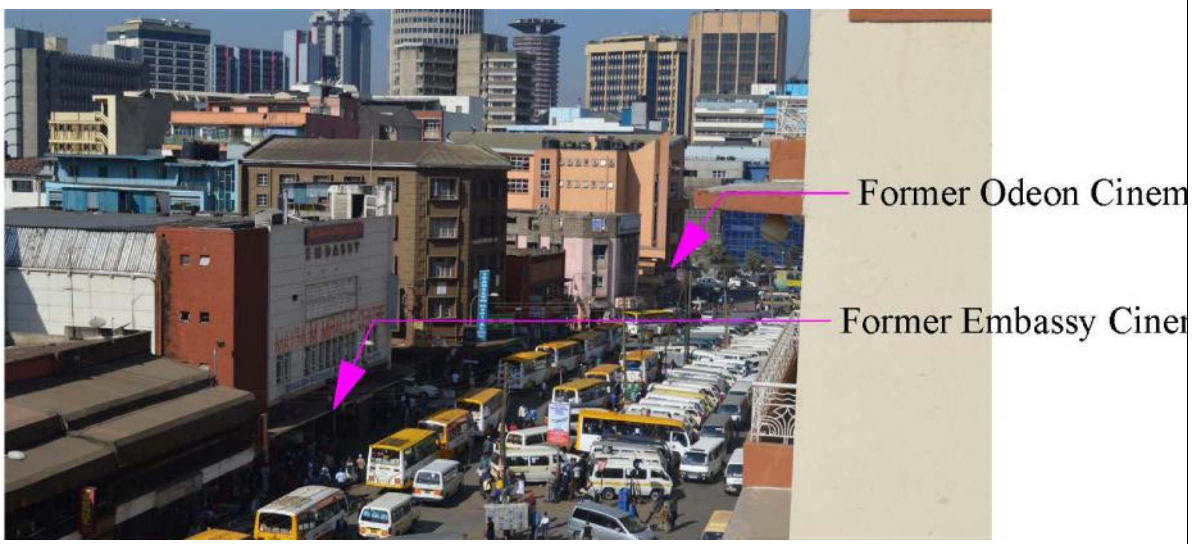


Plate 10.3: Latema Road Photo

Source: Author (2013)

Figure 10.2 illustrates the land uses in the open spaces. It can be seen that within the study area, the use is predominantly on-street car parking while on either sides, there are public transport termini. A few trees have been planted along Tom Mboya Avenue and River Road.

Figure 10.2:Open Space Land Use

Source: Author (2013)

10.3 Circulation Patterns

The primary circulation routes for both vehicular and pedestrian are at the study area boundary. The streets passing though the study area form secondary routes and are therefore narrower. The narrow streets and on-street parking within these secondary routes make them congested and with no room for pedestrian activity and urban furniture as shown on Plate 10.4 below.

Plate 10.4: Dubois Road Photo

Source: Author (2013)

The vehicular circulation pattern is illustrated on Figure 10.3while the pedestrian circulation pattern is illustrated on Figure 10.4. The commercial establishment within the study area are not able to take full advantage of the pedestrian and vehicular traffic that goes around the study area due to the congestion.

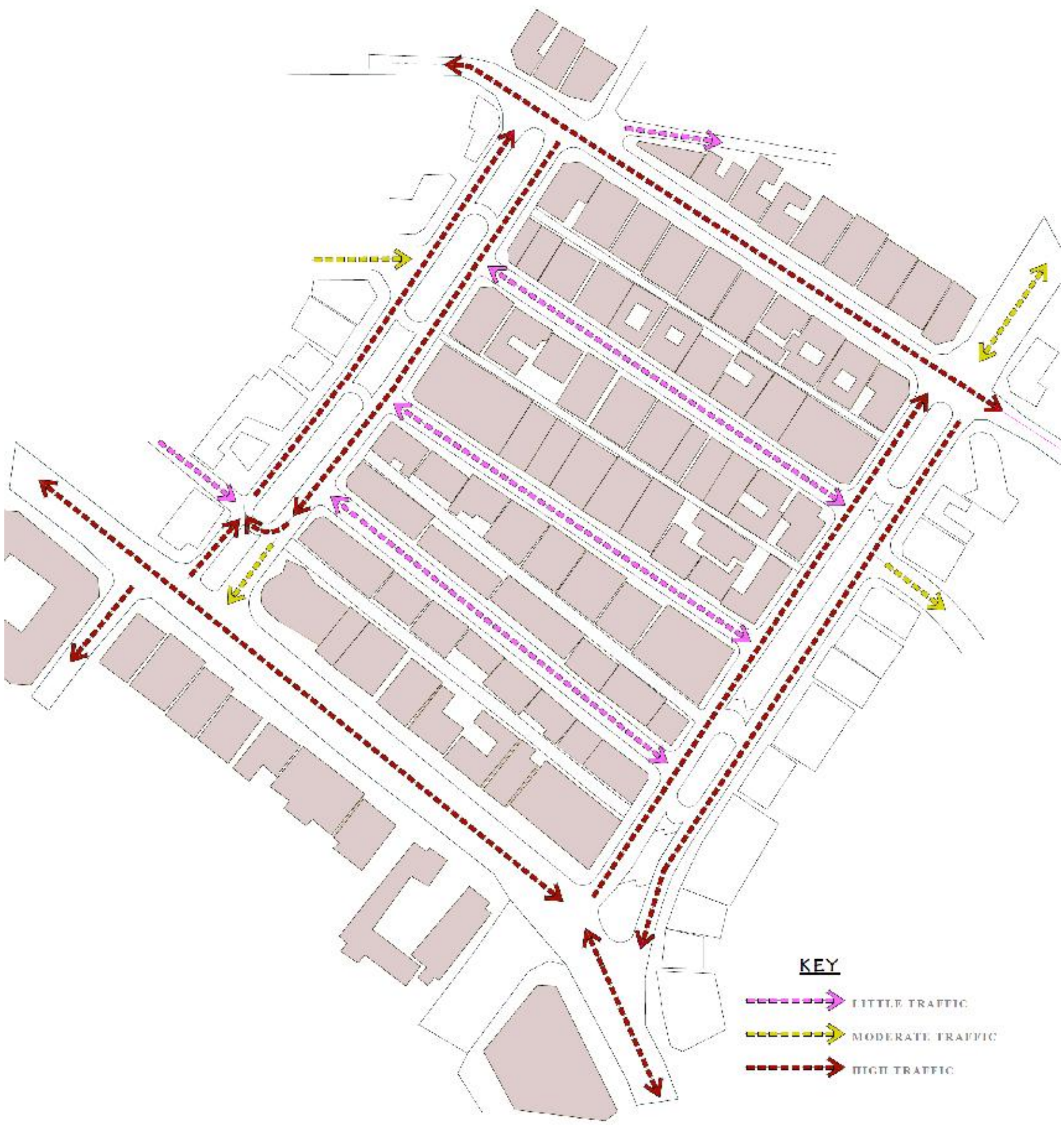


Figure 10.3: Vehicular Circulation

Source: Author (2013)

Figure 10.4:Pedestrian Movement

Source: Author (2013)

10.4 Building Heights and Urban Form

The precinct predominantly comprises building of up to 4 floors. There is no distinct skyline but from higher floors, the Nairobi core CBD building line can be seen Buildings have however not been set back at higher floors leading to a streetscape of high street wall as shown on Plate 10.5.Figure 10.5 and Figure 10.6 illustrate the building heights

Plate 10.5: Taveta Road Street Wall

Source: Author (2013)

Figure 10.5:Height Typology

Source: Author (2013)

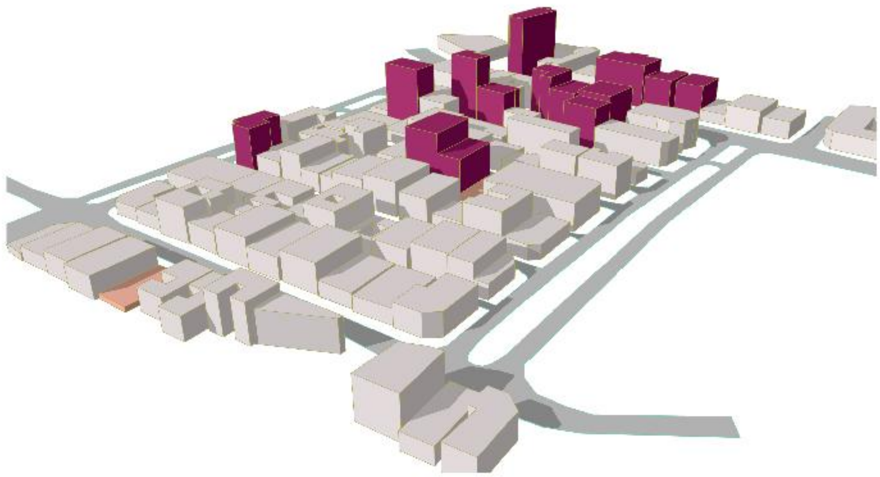


Figure 10.6:Height Typology Axonometric View

Source: Author (2013)

Figure 10.7:Latema Road Elevation

Source: Author (2013)

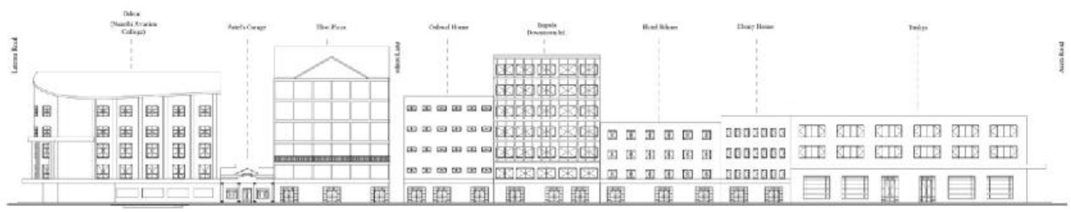


Figure 10.8:Tom Mboya Street Elevation

Source: Author (2013)

The Study area model shows how the uniform building heights has resulted in a flat topped skyline that is dull and lacks clarity. By introducing clusters of tall buildings, the skyline will be more defined. Figure 10.7 And Figure 10.8 are the street elevations while Plate 10.6 shows the study area model.

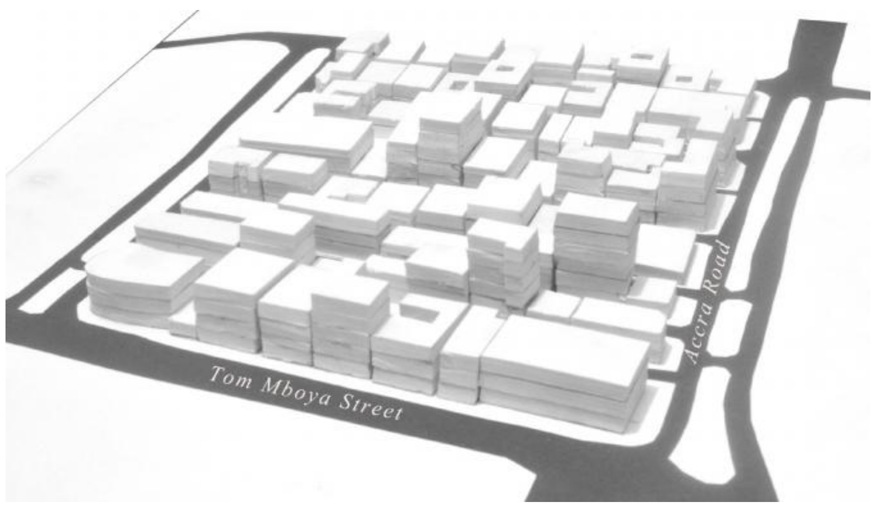


Plate 10.6:Study Area Model

Source: Author (2013)

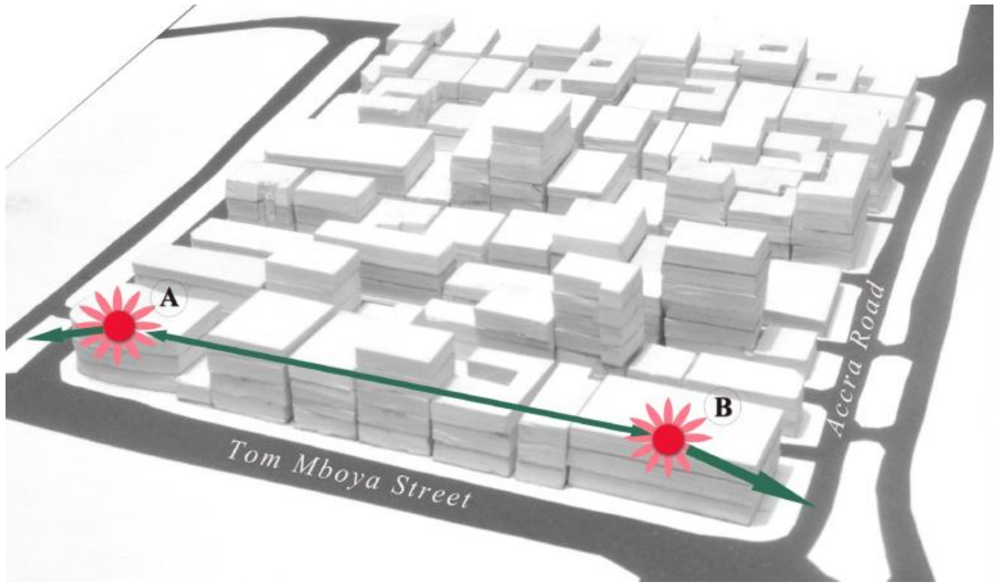
10.5 Nodes

The precinct has two main Nodes along Tom Mboya Street. These are the former Odeon Cinema and Tusyks supermarket. Plate 10.7illustrates the former Odeon Cinema. Since the nodes lie along the same street on the edge of the study area, the site area is unable to benefit from through traffic that frequents the nodes. By introducing Nodes within the study area with good linkages, the area is able to derive more benefit.

2 

Plate 10.7: Tom Mboya Street

Source: Author (2013)



A. Former Odeon Cinema B. Tuskys supermarket

Figure 10.9: Study Area Nodes

Source: Author (2013)

Figure 10.9illustrates the position of the two nodes on the study area model. It can be seen that the rest of the study area is left out of the traffic enjoyed by the two nodes as well as the public transport termini on both Latema and Accra roads.

10.6 Space Syntax Analysis

The space syntax analysis shows that the urban spaces in the study area are long without connectivity. The axial map, Plate 10.8 illustrates streets with very few intersections leading to little chance for pedestrian activity to take place. Plate 10.9illustrates the Ring Connectivity showing that the spaces within the study area have very few pedestrian loops going through them making them less likely to be chosen as a route of movement by a pedestrian. Plate 10.10 illustrates the convex map in which the convex spaces within the study area are long and connect with few other convex spaces. This makes it difficult for activity to spill over to other spaces as a result the entire space becomes dull.

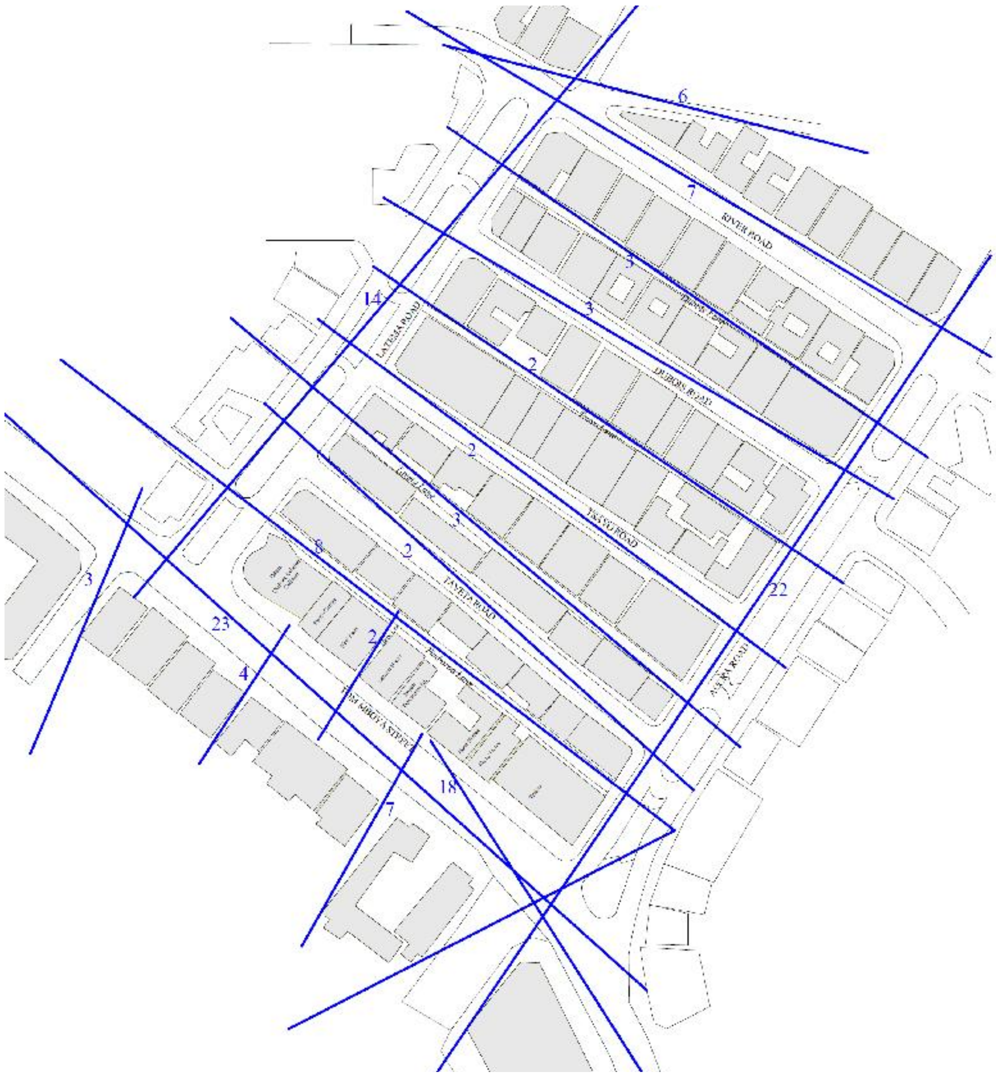


Plate 10.8:Axial Connectivity Map

Source: Adapted from Government of Kenya & JICA (2005), and Otoki (2011)

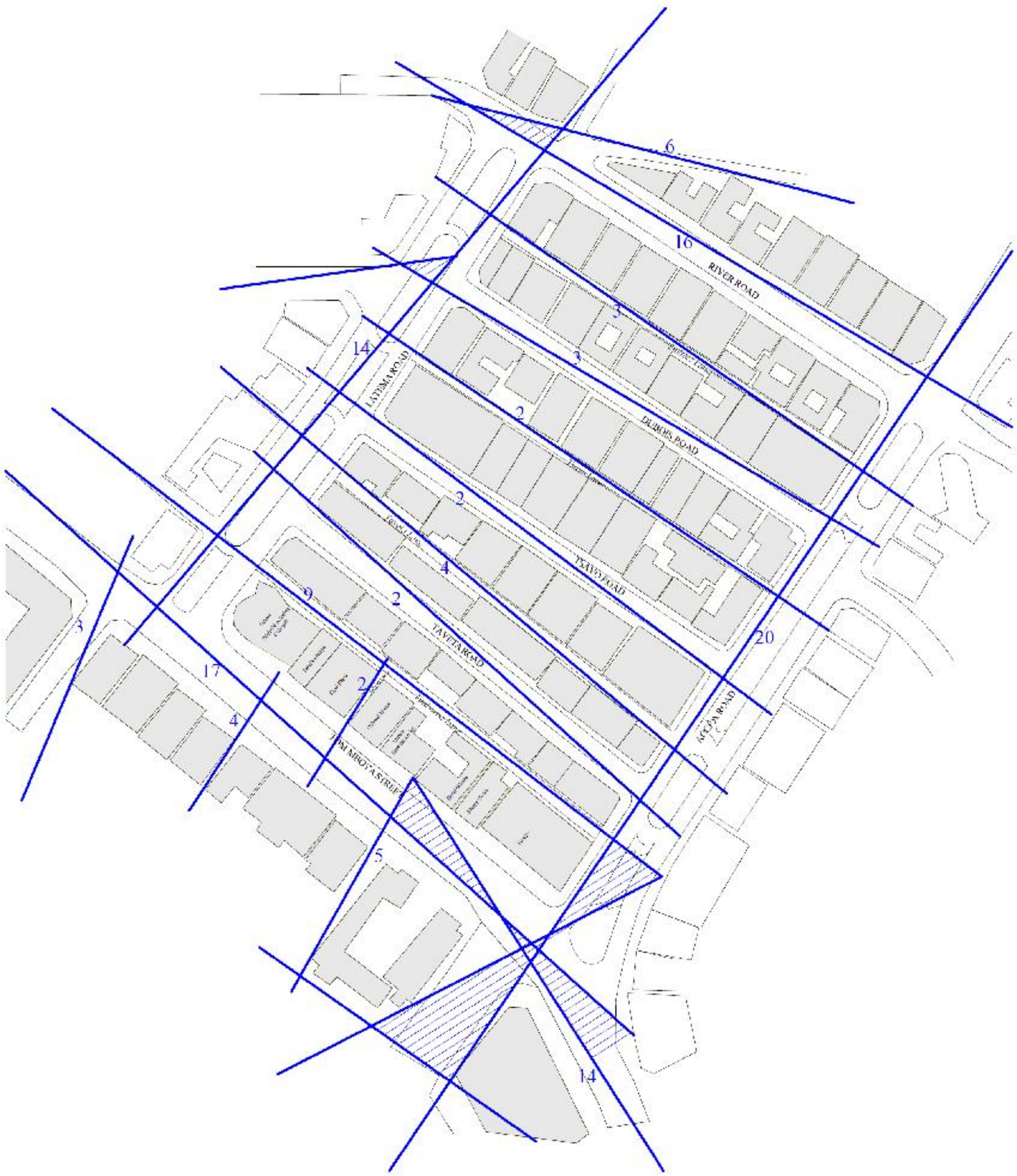


Plate 10.9: Ring Connectivity Map

Source: Adapted from Government of Kenya & JICA (2005), and Otoki (2011)

Plate 10.10: Convex Spaces

Source: Adapted from Government of Kenya & JICA (2005), and Otoki (2011)

CHAPTER ELEVEN

11.0 URBAN DESIGN GUIDELINES

11.1Vision

The vision is to achieve widespread digital technology usage in a harmonious and integrated urban space

11.2Constraints and Opportunities

The precinct contains a number of opportunities due to its strategic location within the Central Business District. The opportunities include

1. Presence of public transport terminus on parallel edges of the commercial area
2. The precinct is strategically located next to the Central Business District Core. This gives it the opportunity to benefit from business and activities that take place within the CBD core.
3. The Presence of variety of uses within the precinct such as religious, institutional and accommodation and retail uses offer an opportunity for a good mix use developments when carefully designed.

The site also has a number of constraints that will pose as challenges in the implementation of the urban design framework. These include the following.

1. Land tenure system. Most of the plots are narrow and owned separately therefore the process of amalgamation and partnerships for the common good may be lengthy and difficult.

2. Most of the roads through the study area are narrow leaving very little space for pedestrian activity unless the motor vehicle is eliminated.

3. The street system is linear and parallel to each other with no links interconnecting them. Private developments will therefore have to create public linkages within their parcels of land in order to achieve a harmonious development.

11.3Urban Design Guidelines

The following guidelines have been developed from the thesis findings which have been adopted in line with site analysis of the Nairobi Commercial area Precinct as well as the comparative study of the design. They include the following.

11.3.1 Physical Planning Regulations

Objective: to have resultant urban spaces that provides room for digital technology uses.

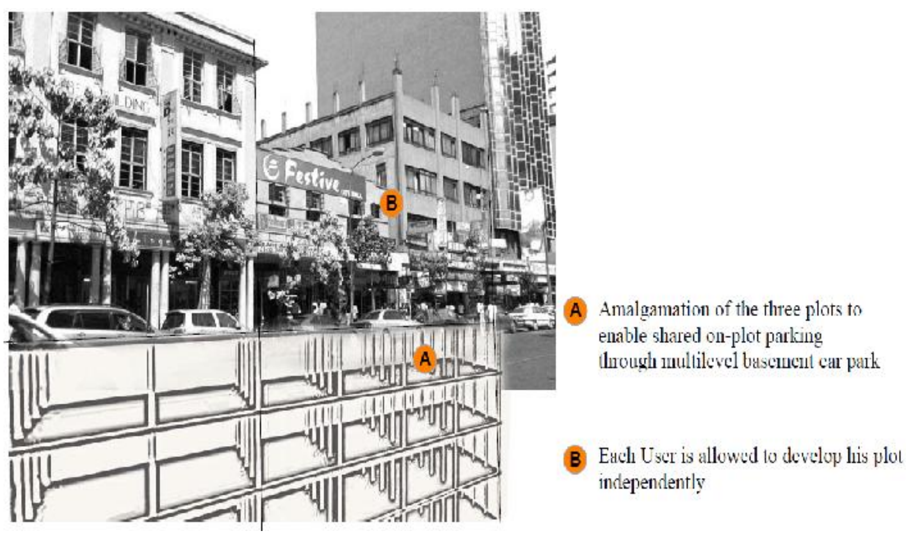


Figure 11.1:Basement Parking

Source: Author (2014)

Guideline 01: Promote amalgamation of narrow plots to have minimum plot size of 0.15 hectares enabling on-plot parking that encourages high densities of digital technology users in public spaces (see Figure 11.1). The multi-level concealed parking will eliminate on-street parking thereby freeing more space for pedestrian uses at grade level.

Guideline 02: Reduce ground coverage to 60% so as to create more space for digital technology use at grade level. Open spaces within the parcels of land to be such as to allow routes through blocks that will link up lanes and streets. This will provide increased pedestrianized space that can be utilized for urban furniture and pedestrian oriented activities including digital technology uses.

Guideline 03: Allow more plot ratio from 350% to 800% in exchange with providing urban furniture, restrooms and other pedestrian infrastructure within the pedestrianized areas that will allow digital technology users to spend more time in the urban spaces (see Figure 11.2). Tall buildings should be allowed in clusters of about 10 buildings so as to achieve a skyline with clarity of form.

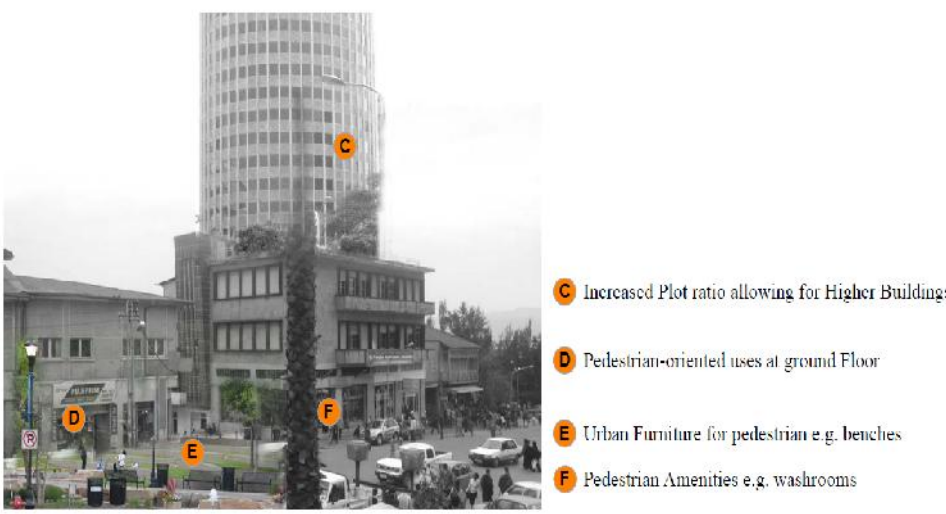


Figure 11.2:Increased Plot Ratio

Source: Author (2014)

Guideline 04: Have discontinuous building line to allow for harmonious pockets of pedestrian spaces along the street which provides room for digital technology use. Developments on wide plots should have articulated facades with smaller unit frontages.

11.3.2 Land Use Patterns

Objective: to promote land uses that favour digital technology uses.

Guideline 05: Developments to create continuous pedestrian-oriented retail circuit within arcades and multilevel shopping spaces which will in turn favour increased digital technology use in exchange for increased plot ratio for their developments.

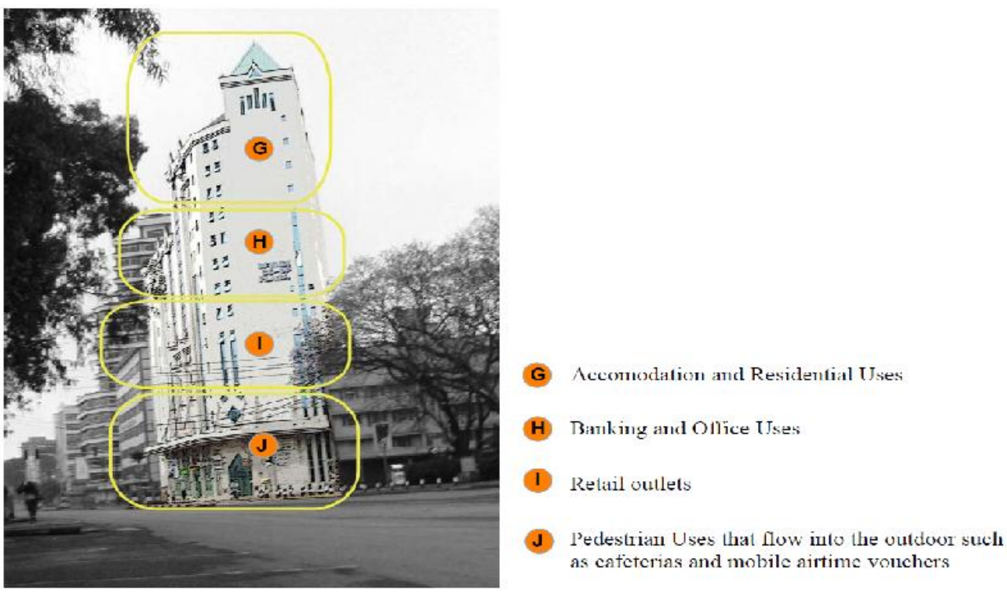


Figure 11.3:Vertical Zoning of Uses

Source: Author (2014)

Guideline 06: Zone non-pedestrian oriented land uses above grade level to free it for pedestrian oriented uses (see Figure 11.3). These include offices and accommodation facilities. Development should however mix uses horizontally and vertically within the block to provide diversity.

Guideline 07: Retail outlets bordering pedestrianized space should offer digital technology services such as airtime vouchers and mobile money transfer and they should also spill out to populate the pedestrian spaces thereby creating activity. Such retail frontage should be transparent to visually connect the activities inside the retail space with the pedestrian space.

11.3.3 Streetscape and Public spaces

Objective: to provide attractive public spaces that support digital technology uses.

Guideline 08: Pedestrianize lanes and narrow streets because they are well shaded and conducive for digital technology uses (see Figure 11.4). Provide weather protection to pedestrianized spaces in wider streets.

Guideline 09: Increase plot ratio around pedestrian spaces to create enclosure within the spaces that is conducive for digital technology use. The tall buildings façade facing the pedestrian space to be stepped back a minimum distance of 1.5 meters after 3 floors and 3m after 5 floors to maintain a human scale.

Guideline 10: provide digital technology infrastructure in pedestrianized spaces

Guideline 11: upper floors to have terraces and roof gardens and to be accessible by the public to provide opportunity to enjoy views and engage in digital technology uses.

K Creation of Arcades with retail outlets

L Pedestrian oriented outlets that spill over to the pedestrian spaces

M Pedestrianization of the Lanes by removal of the motor vehicle

N Outdoor dining areas with Digital technology infrastructure such as WIFI

O Urban Furniture for pedestrian use such as benches, garbage bins, and landscaped areas

Figure 11.4:Pedestrianized Lane

Source: Author (2014)

CHAPTER TWELVE

12.0 URBAN DESIGN PROPOSAL FOR THE COMMERCIAL AREA PRECINCT FOR DIGITAL TECHNOLOGY USE

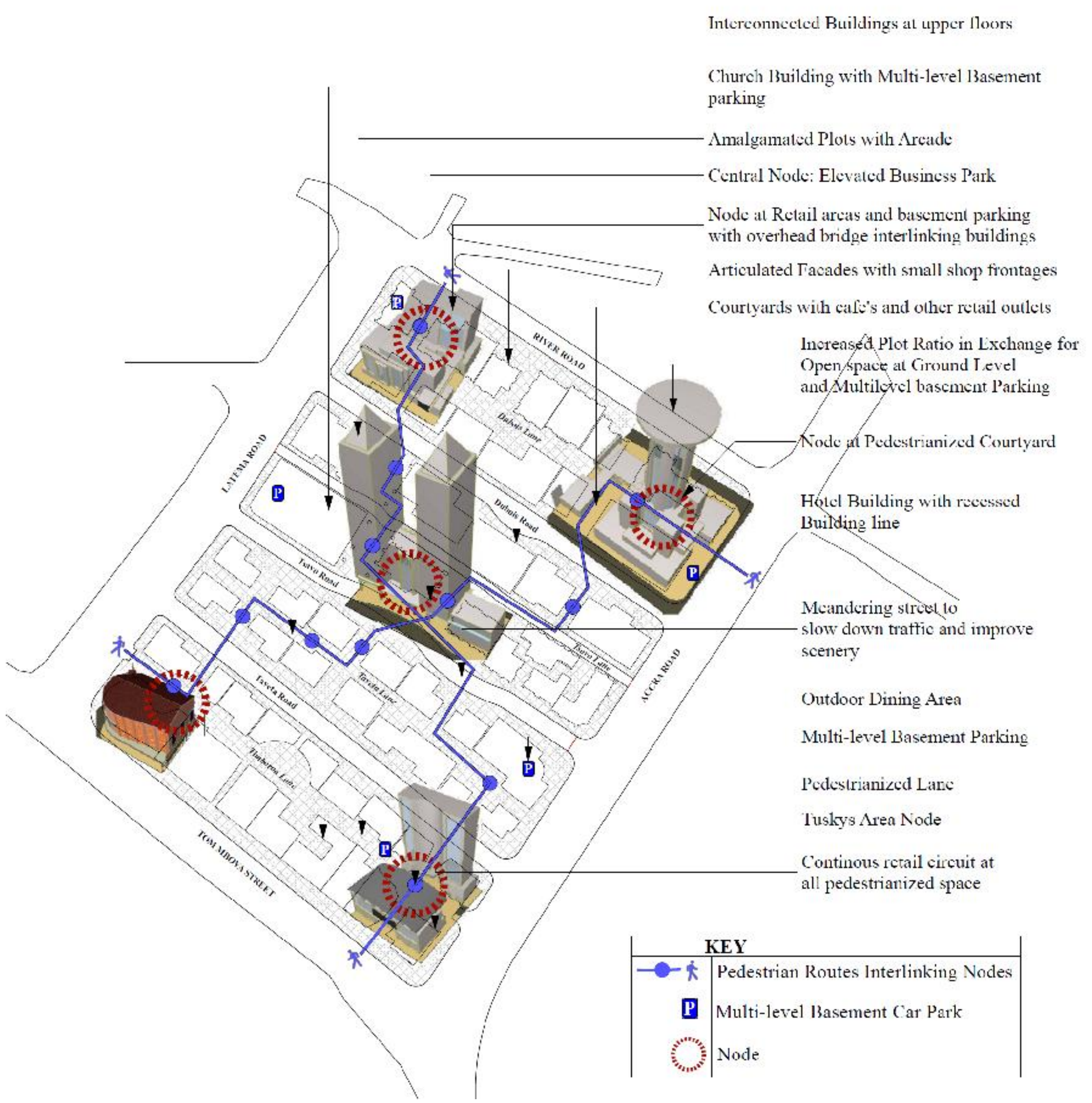


Figure 12.1:Proposed Master Plan

Source: Author (2014)

This section is a summary of the design interventions for redevelopment that have been formulated for the study area precinct for promoting digital technology use. Figure 12.1illustrates the master plan in which three new nodes have been introduced in order to promote pedestrian movement across the urban space so as to have increased digital technology uses. Two nodes are located along River Road and have amalgamated plots with multi-level basement and increased plot ratio (see Figure 12.2). The individual owners of the amalgamated plots are free to develop their plots individually but they share the basement parking. This will allow more motorists to come into the precinct and therefore increase the digital technology uses.

Figure 12.2:Proposed Amalgamated Plots with Basement Parking

Source: Author (2014)

A third proposed node is located at the centre of the precinct area and contains an elevated business park whereby the ground level is left for pedestrianized activities, including digital technology use (see Figure 12.3). The proposal prescribes an increase of plot ratio in exchange for arcades and pedestrian oriented-uses and amenities on ground floor. The freed spaces on the ground floor serve as routes through the plots in order to link the pedestrian spaces (see Figure 12.6). Digital technology users are therefore able to access digital technology infrastructure that is offered in newly linked urban spaces including digital displays. Amenities such as public washrooms are also provided by such developments therefore allowing the digital technology users to spend more time in the urban space.

Figure 12.3: Proposed Freed Ground Space for Increased Plot ratio

Source: Author (2014)

The Design proposes a reduction of ground coverage to 60% so as to increase the available space for digital technology uses (see Figure 12.4). The freed space is utilized for urban furniture and pedestrian use.

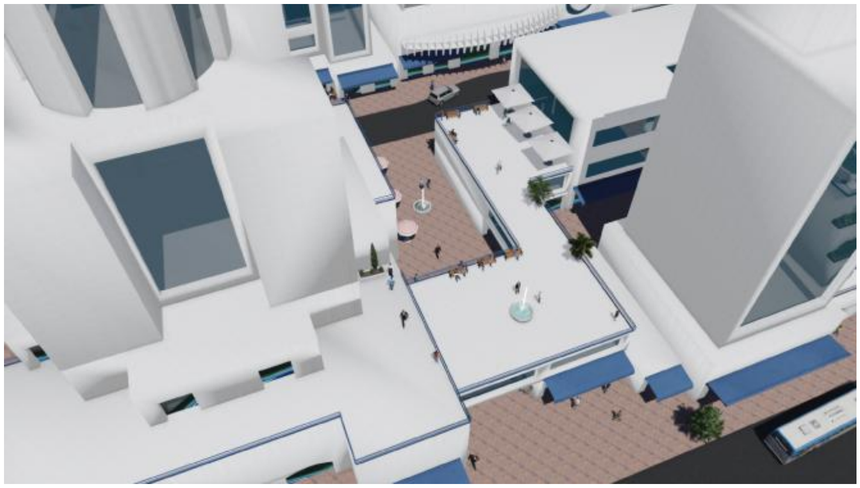


Figure 12.4:Reduced Ground Coverage

Source: Author (2014)

The facades have been articulated into small shop frontages of less than 10 meters each so as to create pockets of pedestrian activities where digital technology uses can take place (see Figure 12.5). The proposal has addressed the challenge of inadequate pedestrian space by removing on-street parking. This has been achieved by promoting amalgamation of narrow plots which has enabled on-plot parking on multi-level basement car park.

Figure 12.5:Articulated Facades

Source: Author (2014)

Digital technology infrastructure has been installed within the site. This includes power outlets, wireless networks to enable connectivity to the internet, digital display screens with real time social updates, news as well as advertising, retail outlets offering digital technology maintenance services in addition to airtime vouchers and money transfer tellers. Tall buildings have been clustered with higher plot ratios provided to plots adjacent to the nodes. This creates a variable skyline as opposed to a plateau of tall buildings.

The land uses at grade level are pedestrian oriented and therefore a continuous circuit of retail outlets that favours digital technology use (see Figure 12.7). Offices and other non-pedestrian oriented uses are zoned into the upper storeys. The overall environment realized in the new design is a harmonious urban space that promotes digital technology usage. It is a pleasant urban environment that attracts a large customer base for the many retail outlets that have much variety and quantity to offer to both the local community as well as the enthusiastic travellers who wish to experience the digital environment opportunities.

Figure 12.6: Pedestrian Links through Urban Block

Source: Author (2014)

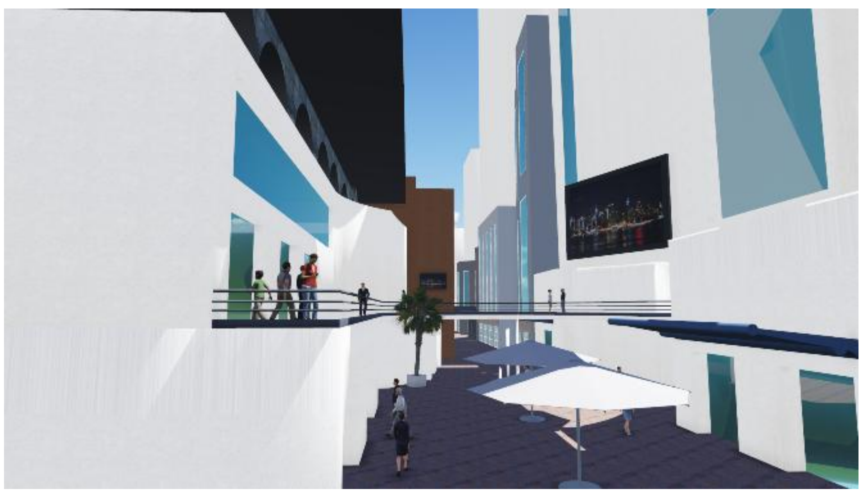


Figure 12.7:Proposed Multi level Shopping Spaces

Source: Author (2014)

The development proposes mix use developments for the precinct area. Offices and other non-pedestrian oriented uses are zoned into the upper storeys (see Figure 12.8). Tall buildings have been stepped back by 1.5 meters after 3 floors to maintain human scale at grade level.

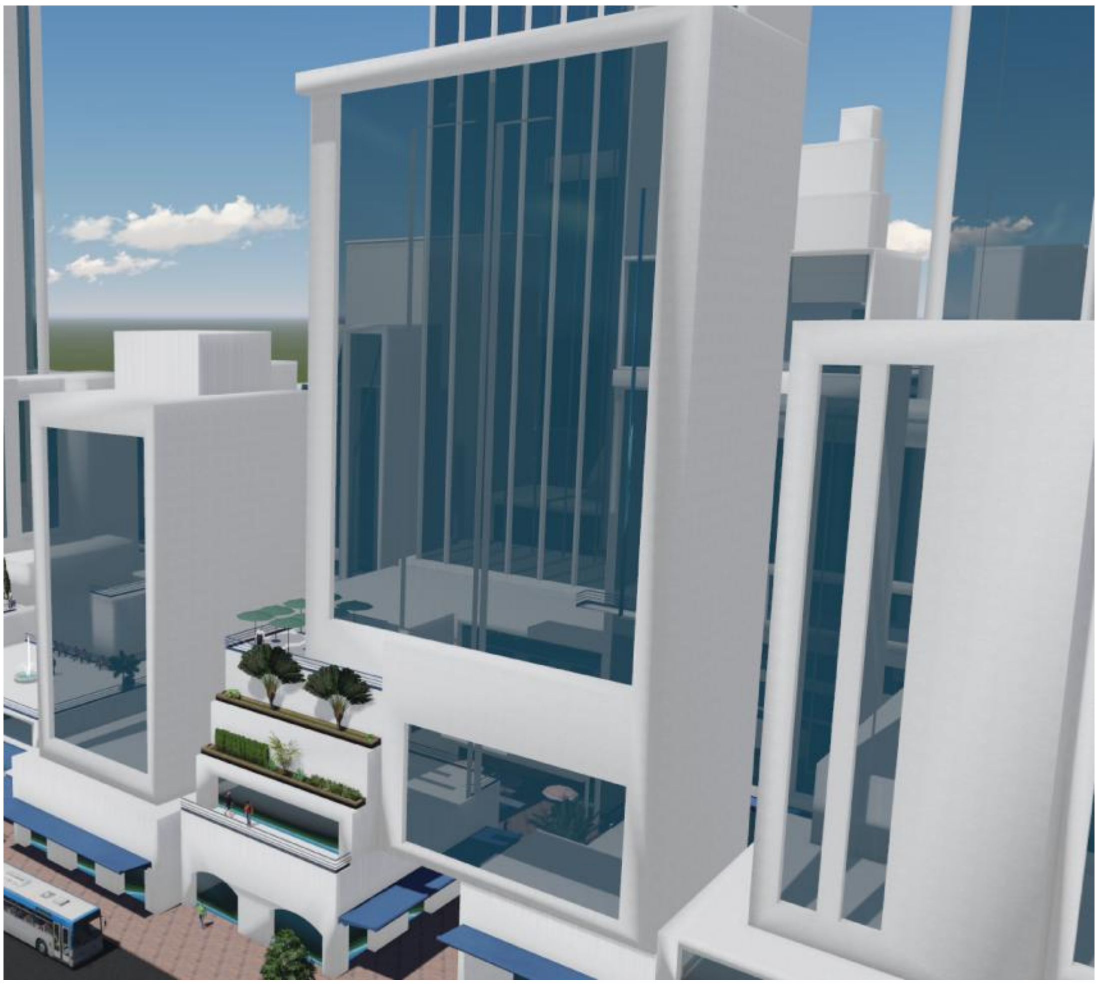


Figure 12.8:Proposed Mixed use Development

Source: Author (2014)

The design also proposes utilizing lanes and narrow streets for pedestrian activity (see Figure 12.9). These are well shaded and therefore ideal for digital technology use. The proposal has also made the upper floors of buildings to have terraces and roof gardens that are accessible to the public (see Figure 12.10). This acts as ideal places to engage in digital technology uses while enjoying the views.

Figure 12.9:Pedestrianized Lane

Source: Author (2014)

Figure 12.10:Pedestrianized Terraces

Source: Author (2014)

The overall design layout is illustrated below. Figure 11.11 illustrates the Proposal top view of the precinct while Figure 12.12, 12.13, 12.14 and 12.15 illustrate the elevations.

Figure 12.11:Proposed Top View

Source: Author (2014)

Figure 12.12:Proposed Accra Road Elevation

Source: Author (2014)

Figure 12.13:Proposed River Road Elevation

Source: Author (2014)

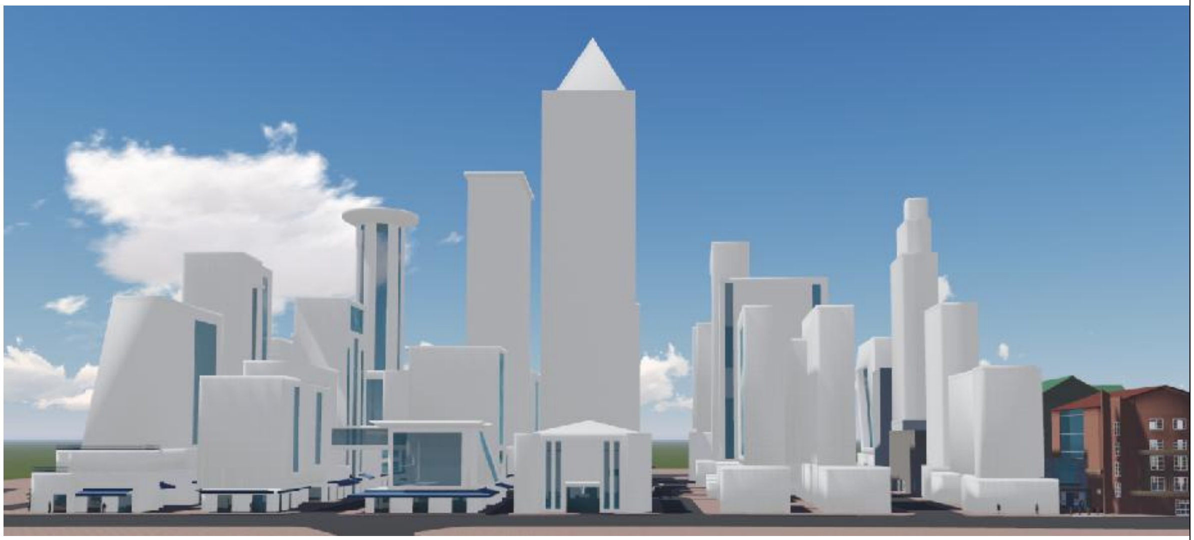


Figure 12.14:Proposed Lusaka Road Elevation

Source: Author (2014)

Figure 12.15:Proposed Tom Mboya Street Elevation

Source: Author (2014)

The proposed interventions will result to urban redevelopment of the study area. It is projected to be implemented over a period of time beginning with issues of amalgamation of parcels and agreements between adjacent plots on ways to have a common multi-level basement parking, followed by negotiations with the authorities on ways to reduce ground coverage so as to free more space for pedestrian uses.

The resultant product will be an integrated urban space that is well connected and with the benefit of being conducive to digital technology usage.

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APPENDICES

Appendix1: Research Tools

Table 13.1: Sample Digital Technology Observation Checklist

Observed Digital Technology Usage	**Tally in Bunches of Five (e.g. ~~IIIIIII~~ III)**	**Total (e.g. 13)**
Digital Gaming -*(digit_gam)*		
Texting/ Surfing –*(Text_surf)*		
Telephone Call –*(Telephone)*		
Laptop/ Tablets –*(laptop_tab)*		
Photography –*(photogr)*		
Earphones –*(Earphones)*		
ATM machines –*(atm_mach)*		
Digital Cash –*(digital_cash)*		
Traffic Management –*(Traff_mng)*		
Security Surveillance –*(Sec_surv)*		
Digital Transportation – *(Digit_trans)*		

Neon Signs –*(Neon_sign)*		
Digital Display –*(Dig_displ)*		
Time Interval:	Sample Space Name:	Remarks:

Source: Author (2013)

Table 13.2: Standardized Variables Sheet for Urban Space Characteristics

CHARACTERISTIC	MEASUREMENT	Value
Axial Connectivity –*(axial_conn)*	Axial connectivity map	
Ring Connectivity –*(ring_conn)*	Ring connectivity map	
Depth of Axial space from carrier space	Axial depth map	
Control of Space –*(control_space)*	Convex control map	
Proportion of Historic Buildings –*(hist_bld)*	Per running meter	
Proportion of pedestrianized space –*(pedest_space)*	Per square meter	
Proportion of greenery –*(greenery_prop)*	Per square meter	
Proportion of space reserved for outdoor dining –*(out_dinning)*	Per square meter	
Proportion of buildings with non-rectangular silhouettes –*(non-rect_silh)*	Per running meter	
Proportion of street wall –*(street_wall)*	Per running meter	
Sky view angle tangent –*(sky_view)*	(average building height ÷ space width)	
Proportion of available sitting space –*(sitting_space)*	Per square meter	
Transparency between public space and adjacent buildings –*(transparency)*	Percentage of facades with windows and doors	
Density of people –*(people_density)*	Per square meter	
Intensity of buildings defining the space –*(building_intensity)*	Per running meter	
Proportion of accent colours –*(accent_colours)*	Contrasting colours per running meter	

proportion of pieces of public art –*(public_art)*	Proportion of public art	
proportion of social places in the space –*(social_spaces)*	Per running meter	
Number of wireless networks present –*(wireless_networks)*	Number of WIFI networks	
Space area:	Façade area	
Sample Space Name:	remarks:	
space code:		

Source: Author (2013)

Table 13.3: Sample Observation Checklist for Urban Space Characteristics

CHARACTERISTIC	MEASUREMENT	Value
Total perimeter of the space enclosed by historic buildings	Meters	
Total Perimeter of the space enclosed by buildings	Meters	
Total area of space set aside for pedestrian activity	Square Meters	
Total area of the space	Square Meters	
Total area of space with greenery	Square Meters	
Total area of space with outdoor dining	square Meters	
Total perimeter of space enclosed by buildings with non-rectangular silhouettes	Meters	
Total perimeter of the space	Meters	
Width of the space	Meters	
Tally the number of buildings and their heights	Number for buildings, Height in Meters	
Total area of space set aside for sitting	Square Meters	
Area of windows and doors on façades enclosing the space	Square Meters	
Area of façades enclosing the space	Square Meters	
Number of people in the space	Number	
total perimeter of space enclosed by facades with contrasting colours	Meters	
number of pieces of public art in the space	Number	

Perimeter of the space enclosed by social places	Meters	
Number of wireless networks present	Number	
Sample Space Name:	remarks:	
space code:		

Source: Author (2013)

Appendix 2:Space Syntax Maps Used

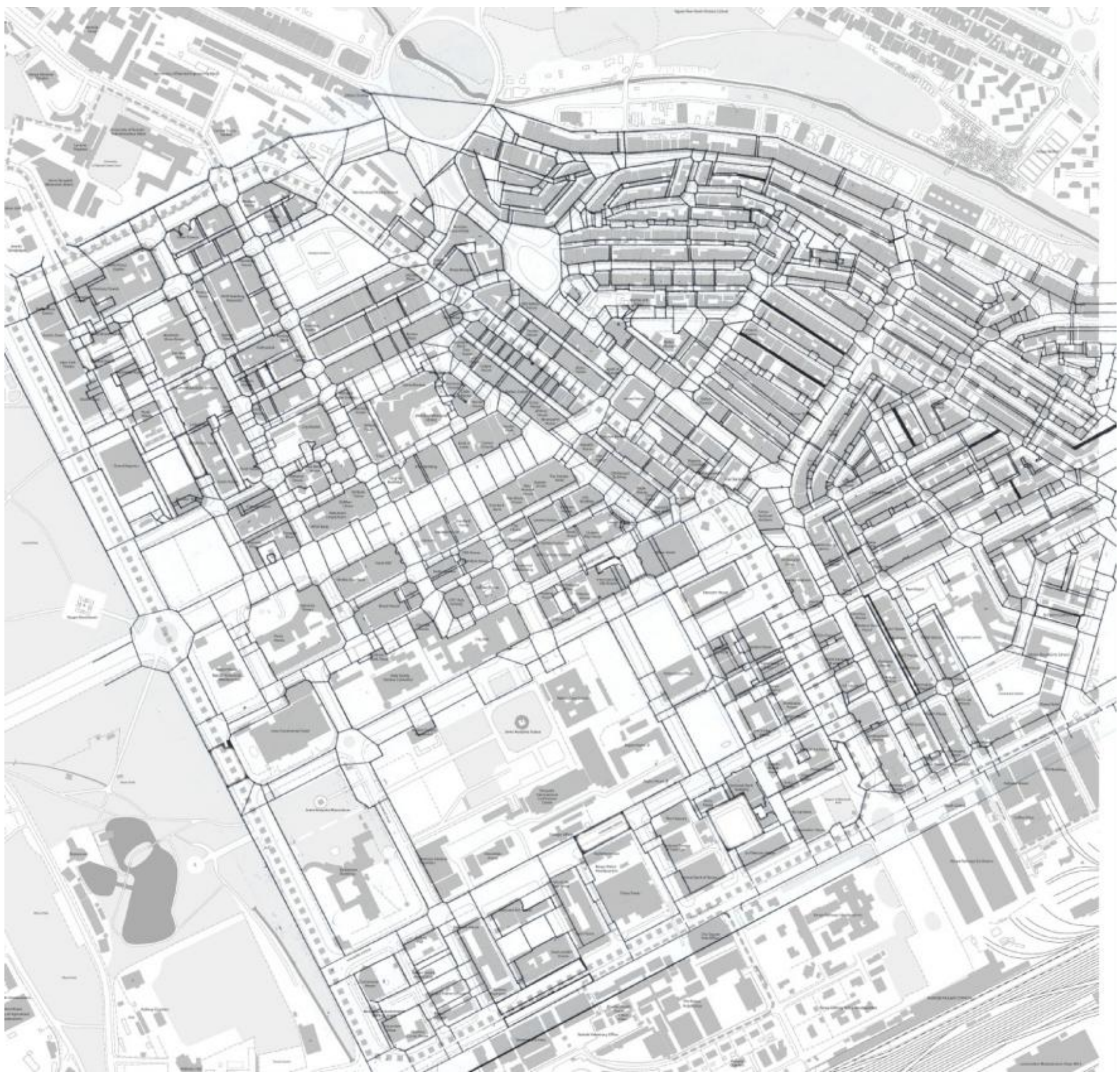


Figure 13.1:Convex CBD Map

Source: Adapted from Government of Kenya & JICA (2005), and Otoki (2011)

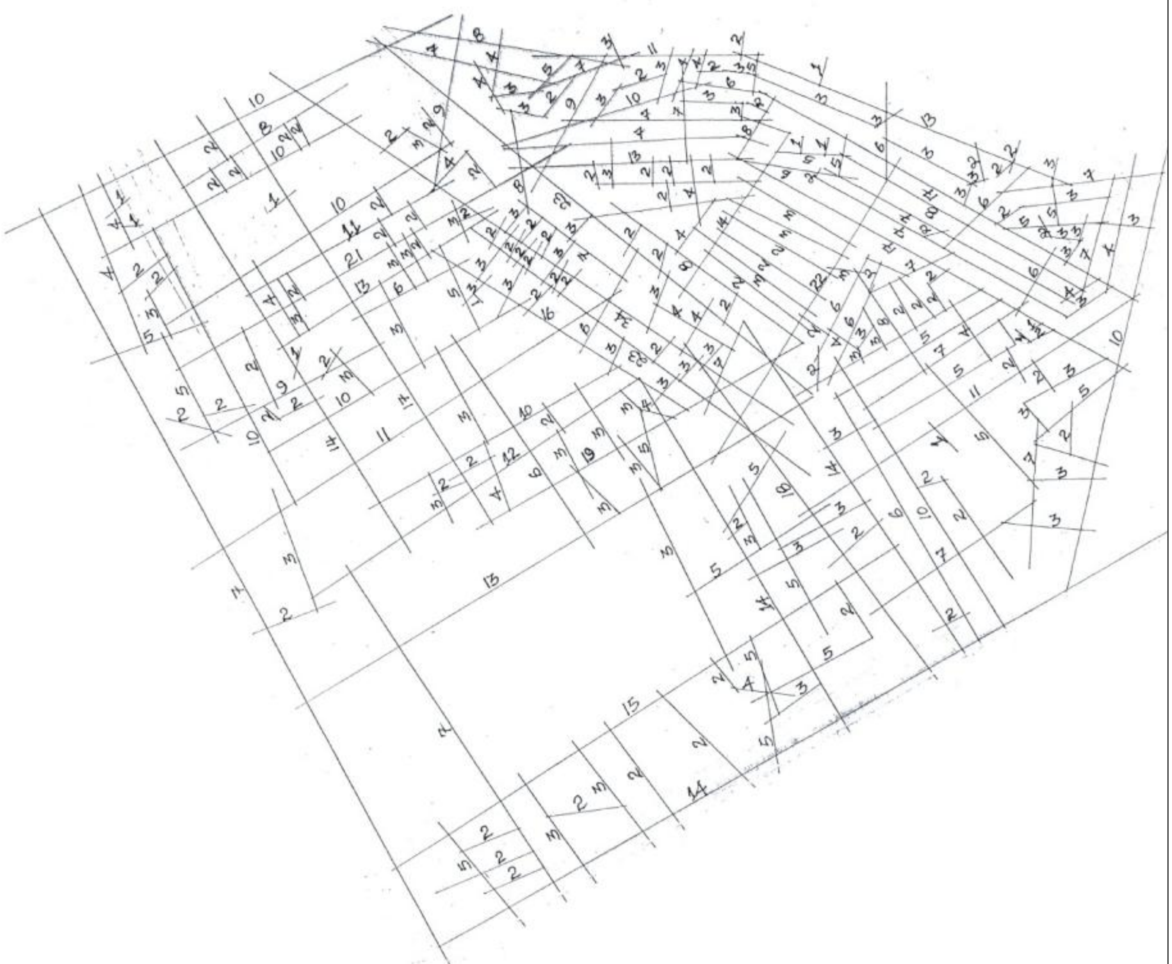


Figure 13.2:Axial Connectivity Map

Source: Otoki (2011)

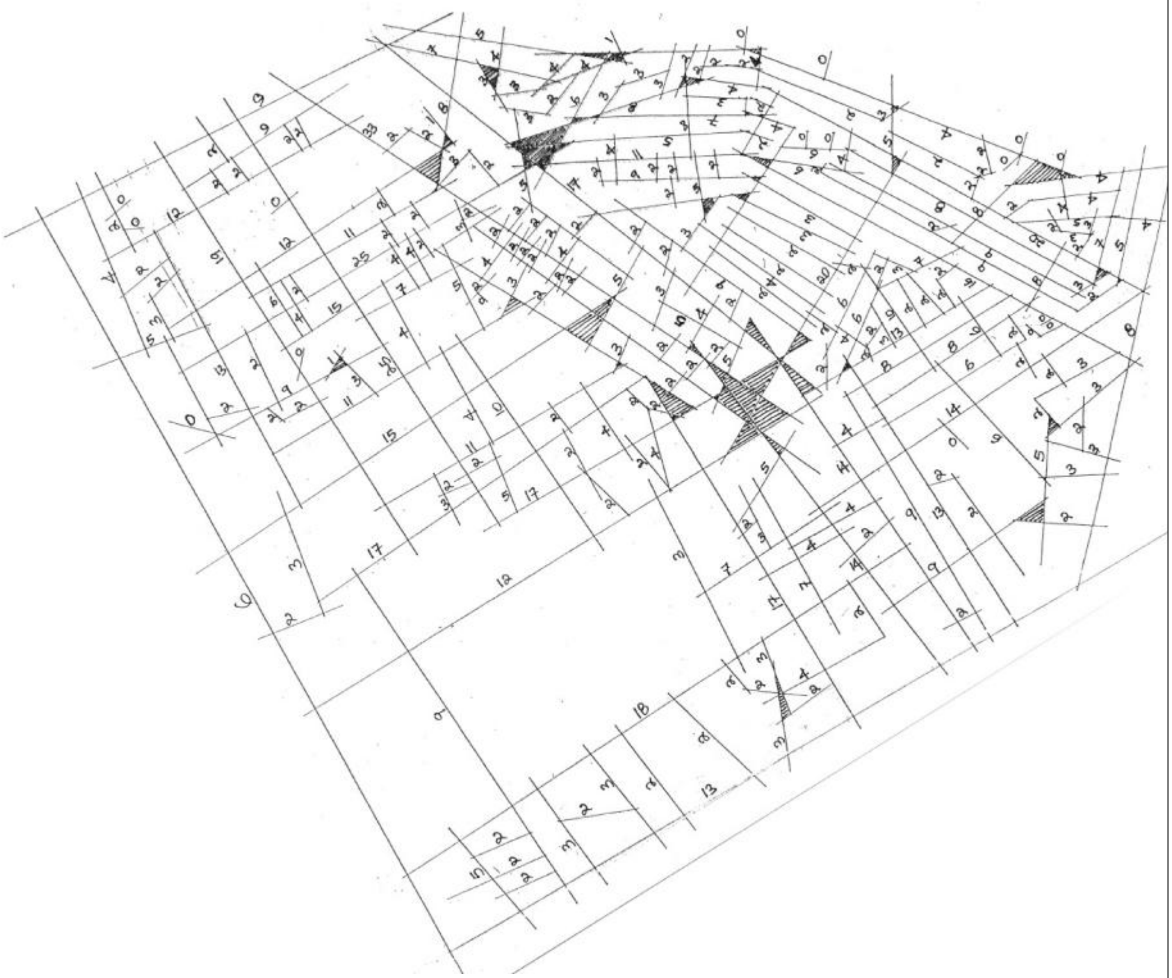


Figure 13.3:Ring Connectivity Map

Source: Otoki (2011)

Figure 13.4:Axial Depth Map

Source: Otoki (2011)

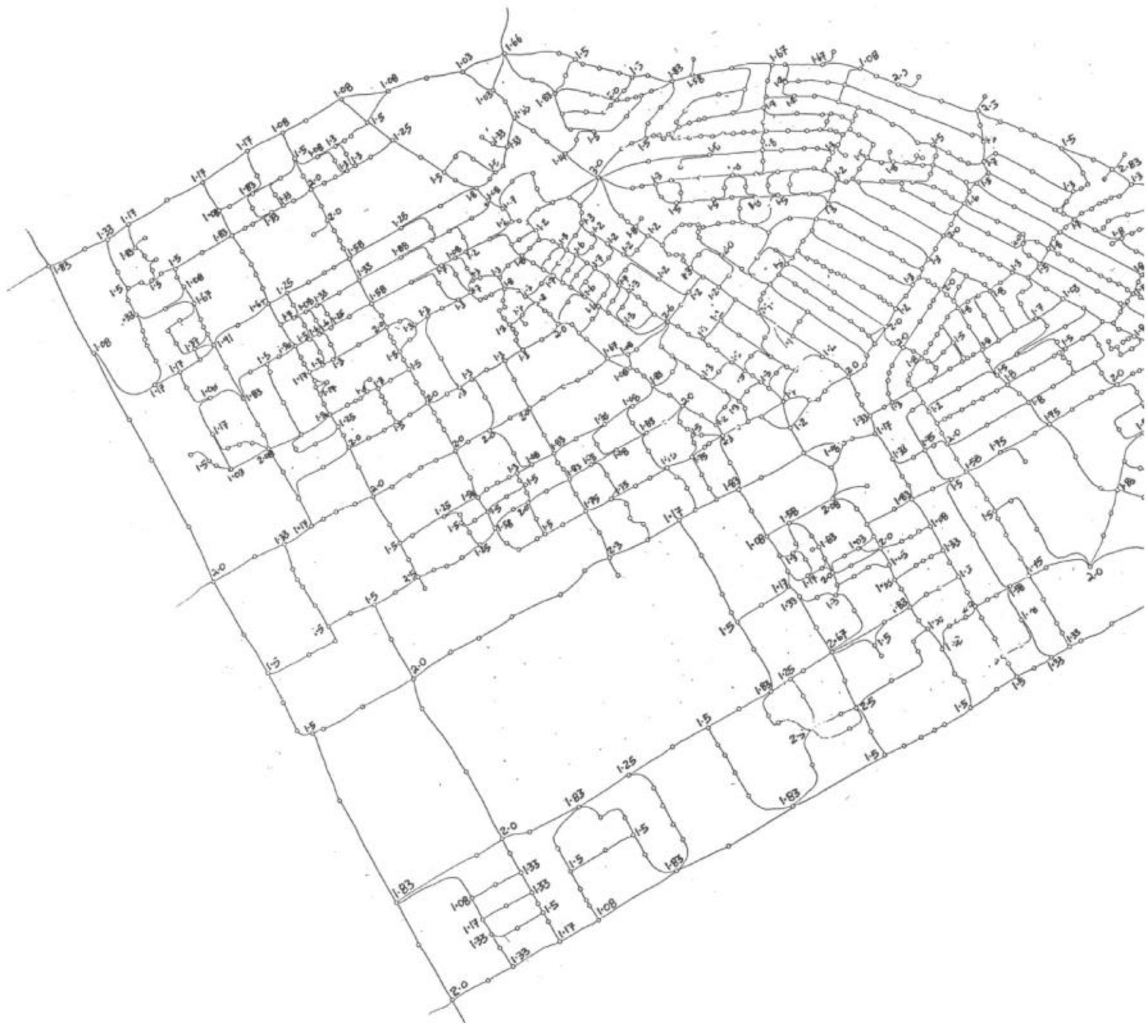


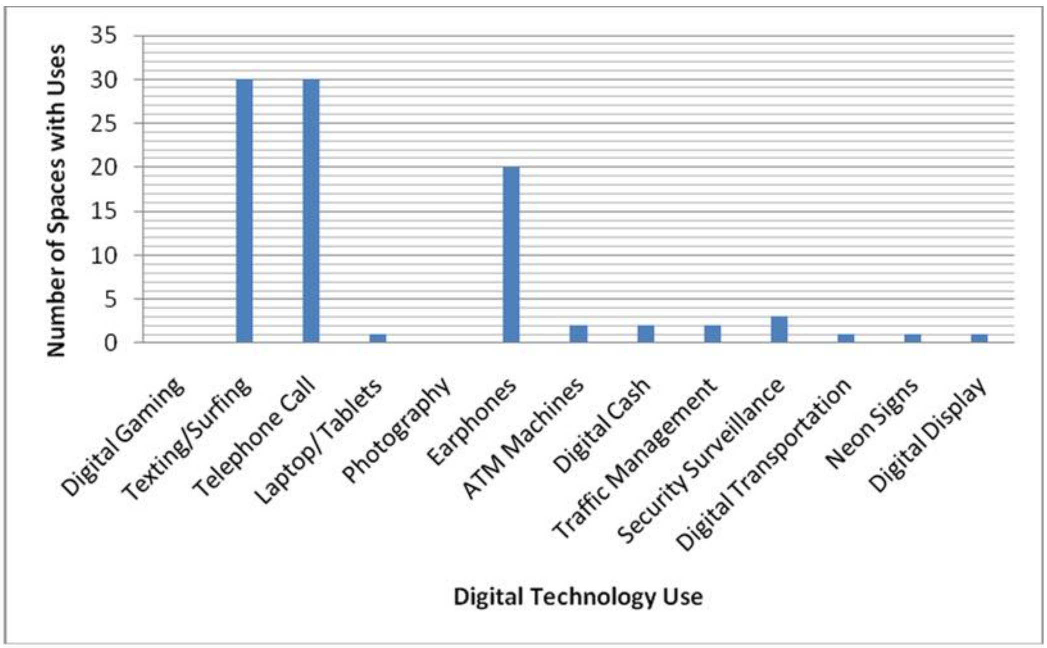
Figure 13.5:Convex Control Map

Source: Otoki (2011)

Appendix 3: Digital technology usage

Digital technology is still a new phenomenon that is developing within the streets of Nairobi. As illustrated in **Error! Reference source not found.**, it emerged from the field study that only three out of the thirteen uses were present in more than 5 spaces.

Table 13.4: Digital Technology Uses in Nairobi CBD



Source: Author (2013)

Appendix4: Telephone and Internet Data Usage

Table 13.5: Local Mobile Traffic in Minutes

Mobile money transfer	Oct-Dec 11	Jul-Sep 11	Quarterly Variation (%)	Oct-Dec 10	Quarterly Variation (%)
By traffic Origin(Outgoing traffic)					
Own network Own network	5,870,570,860	6,580,097,875	-10.78	5,078,132,578	15.60
Own network to other mobile networks	789,197,560	498,957,125	58.17	668,911,201	17.98
Mobile network to fixed network	42,171,413	19,357,556	117.86	19,904,340	111.87
Total traffic origination(Outgoing)	**6,701,939,833**	**7,098,412,556**	**5.58**	**5,766,948,119**	**16.21**
By traffic termination(Incoming traffic)					
Own network –Own network	5,870,570,860	6,580,097,875	-10.78	5,078,132,578	15.60
Other mobile networks to own network	839,328,628	492,244,117	70.51	689,193,407	21.78
Fixed network to mobile network	32,281,989.00	29,857,148	8.12	40,300,255	-19.90
Total traffic termination(Incoming traffic)	**6,742,181,477**	**7,102,199,140**	**5.07**	**5,807,626,240**	**16.09**

Source: CCK (2012)

Table 13.6: Short Messaging Service

Mobile money transfer	Oct-Dec 11	Jul-Sep 11	Quarterly Variation (%)	Oct-Dec 10	Quarterly Variation (%)
On-net SMS	768,270,544	1,292,847,167	-40.56	480,154,343	-60.00
Off-net SMS	133,733,880	91,640,192	45.93	91,511,760	46.14
Total SMS sent	902,004,424	1,384,487,359	-34.85	571,666,103	57.79
SMS per Subscriber per month	10.71	17.42	-38.52	7.63	40.37

Source: CCK (2012)

GLOSSARY

Arcade: in this study, an arcade will be taken as a spatially integrated space with a roof supported by buildings on both sides

Lane: it is a narrow, open to sky linear space formed between two or more buildings to provide linkage between urban spaces and affords limited vehicular traffic

Open space: this is a large space whose main content is Nature (Otoki, 2011).

Passage: it is a narrow, open to sky linear space formed between two or more buildings that provides linkage between urban spaces and is not wide enough to allow motor vehicles to go through

Square or Plaza: it is a non-linear discontinuous space with a variety of forms

Street Space: it is a linear space defined by building walls, curbs, gutters, crosswalks and at times by independent arcades (Otoki, 2011).

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