

**The Role of Spatial Planning in the Environmental Management of  
Public Spaces of Residential Neighbourhoods in the City of Nairobi,  
Kenya**

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**A thesis submitted in fulfillment of the degree of Doctor of  
Philosophy in Landscape Architecture in the Jomo Kenyatta  
University of Agriculture and Technology**

**2012**

## DECLARATION

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

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## **DEDICATION**

To Drusilla, Japheth, Emmanuel and Joseph

## **ACKNOWLEDGEMENTS**

I would like to express my gratitude to my principal supervisor, Prof. Bernard Moirongo of Jomo Kenyatta University of Agriculture and Technology (JKUAT) for his important directions and criticism that kept me in focus in the course of this research and thesis writing. In a special way, I thank Prof. Caleb Mireri of Kenyatta University for his guidance and input which ensured that I remained fine-tuned in the doctoral programme. It was a humbling experience to work with a team of dedicated advisors who always created time for me whenever I needed their direction. My appreciation also goes to the academic colleagues in the School of Architecture and Building Sciences of JKUAT whose useful criticism helped in sharpening this research.

In a special way, I wish to acknowledge the support I received from Sunday Abuje and Allan Nandwa in collecting data from the ten residential neighbourhoods in the study area. The exercise was demanding in terms of time, concentration and precision but I thank them because they ably surmounted them. Creating time from their schedules to assist me in this work is not something I take for granted.

I am indebted to JKUAT for granting me study leave and research funds to undertake this doctoral programme. The whole process would have been burdensome without this kind gesture. My many thanks also go to the National Council of Science and Technology for research authorization, the Provincial Administration – Nairobi Province, and the Town Clerk – City Council of Nairobi for allowing me to carry out the research in their areas of jurisdiction.

My heartfelt appreciation goes to my wife Drusilla for the support and encouragement she gave me while undertaking this study. Together with my sons Japheth, Emmanuel and Joseph, she endured the long hours I spent away from them to carry out the work whose culmination is this thesis. Whereas I have observed utmost care in the writing of this thesis, I take sole responsibility for any errors it may contain.

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## **ACRONYMS**

<b>PSEM</b>	Public Space Environmental Management
<b>WCED</b>	World Commission for Environment and Development
<b>CCN</b>	City Council of Nairobi
<b>NEMA</b>	National Environmental Management Authority
<b>GLM</b>	General Linear Model
<b>ANOVA</b>	Analysis of Variance
<b>NUSG</b>	Nairobi Urban Study Group
<b>MGS</b>	Metropolitan Growth Strategy
<b>NCBDA</b>	Nairobi Central Business District Association
<b>AAK</b>	Architectural Association of Kenya



## **ABSTRACT**

This study examines the role of spatial planning in securing public spaces in residential neighbourhoods whose environmental status accords a suitable place to operate in. The study focuses on the City of Nairobi where environmental quality in the public space system of residential neighbourhoods is in a degraded state. This manifests itself in problems such as solid waste accumulation, vehicular-pedestrian conflict, defective storm water drainage system, neglect of greenery and destroyed road network. The role played by neighbourhood spatial planning in countering these problems in the public spaces has not been focused on by research in the city's built environment.

The objectives of the study involve establishing the extent of the relationship between spatial planning and environmental status, establishing how spatial planning has failed in regard to public space environmental status and how it can be made effective towards delivery of residential public spaces that are environmentally sustainable. The study employs quantitative research strategy in data collection and analysis. Quantitative data is generated from neighbourhood maps and through spatial analysis of the physical, social and economic environment of the residential public space. Fundamentally, axial spaces of the public space system in residential neighbourhoods form the specimen for detailed inquiry. In this regard, the study adopts space syntax method as the conceptual framework guiding the study. Through multiple regression analysis, the extent to which public space environmental variables are explained by spatial planning variables is established. Analysis of variance is used to test the significance of the relationship at 95 percent confidence level.

The results of the study reveal a significant relationship between spatial planning variables and environmental status variables. The study establishes that spatial planning has contributed to public space environmental problems by creating public spaces that are characterized with inaccessibility from the boundaries that define them, little regard to human scale, poor distribution of public space, remarkable break-up, imbalance in the dynamic equilibrium between natural processes and the human populace, low density of settlement, homogeneity of land use functions and dominance of the car rather than the pedestrian. Further, the study establishes nine spatial planning patterns whose utilization is recommended in layout of residential neighbourhoods so as to minimize public space environmental problems and therefore enhance environmental

sustainability. These patterns include relationship of public space with boundaries that constitute it, scale, connectivity, control, integration, ecological balance, land use, transportation planning and public space services. The study concludes that spatial planning plays a significant role in realization of desirable public space environments and that co-interaction of the patterns needs to be considered in layout of residential neighbourhoods in order to realize a public space system that is environmentally sustainable.

**Key terms:** Spatial planning, residential neighbourhood, public space, environmental status, sustainability.

# CHAPTER ONE

## 1.0 INTRODUCTION

### 1.1 Introduction

Spatial planning is concerned with how space is created and arranged, in essence, how it works. In this regard, spatial planning provides a blueprint to orient future development. In the layout of a settlement, it is the function of planning to define a network of public spaces, in relation to buildings and other activities, which in turn contributes to the settlement's spatial form. According to Hillier and Hanson (1984), a settlement's spatial structure presents patterns which carry social information and content. Spatial planning thus, in giving shape and form to the physical world, structures the system of space in which people live and move. In doing so, it has a direct relation, rather than a merely symbolic one, to social life. Spatial planning sets the conditions for patterns of movement, encounter and avoidance, not only of people but also social outcomes of their use of space. The social outcomes of a spatial plan are fundamentally environmental and can make a public space in a settlement either suitable or unsuitable to live in.

Recent urban policy focus on issues of sustainability, social exclusion, economic competitiveness, place image and culture reveals an increasing awareness of the multidimensional nature of the challenges facing cities, their managers and inhabitants (Magalhaes and Carmona, 2009). This permeates our understanding of the roles of the built environment in general and public spaces in particular, partly explaining the renewed global policy interest in the quality of public spaces. From civic, leisure or simply functional spaces with an important part to play in cities and urban life, public spaces have become urban policy tools of a much wider and pervasive significance. This wider understanding of public space and its urban policy role has led to a closer attention to the processes through which its qualities and its ability to fulfill all those functions are created and maintained, and through which rights and obligations are established. Various management regimes determine the shape and use of public space, and hence its environmental quality.

Urban residential neighbourhoods, as living environments, are one of the principal means through which national development policies and programmes are channeled. Considering that the global urban population has exceeded the 50 percent mark (Clark, 1996), the housing sector plays a

central role in urban development through provision of shelter. Payne (1984) points out that housing, in this regard, means more than shelter in that it provides a secure base from which residents can pursue their activities and ensure their own survival. In development terms then, urban housing is both 'social' and 'economic'. In view of this, residential neighbourhoods need to be suitable and sustainable living environments. Housing issues, which include environmental problems in public spaces, are both universal and inherently specific to a given time and place (Vliet, 1990). All countries, whether developed or developing, are grappling with their own housing problems.

The quality and management of public spaces of residential neighbourhoods in the developed and developing worlds differ markedly. In the former, a larger population dwells in urban areas and housing development is more advanced. In Britain, for example, over 80 per cent of the population lives in towns and cities (Towers, 2005). Frameworks for public space environmental management are in place and see effective participation of the state, private sector and users. The resulting quality of the shelter fabric and public space is good and according to Towers (2005), it has been realized and sustained partly by effective institutional capacity development and management efforts for enforcement of necessary controls for environmental management. Conversely, urban housing pattern in the developing world is such that majority of the population resides in slums and unplanned settlements, and the quality of public space is characterized by diverse environmental problems. The few planned residential neighbourhoods have not been spared of environmental problems either. Public space in the neighbourhoods is in a state of decay and therefore an undesirable environment to operate in.

In Kenya, development of residential neighbourhoods has received attention of the government but not much success has been realized in putting to control environmental problems in the settlements. The contribution of spatial planning, in the context of configuration, to promotion or prevention of environmental problems in public spaces of residential settlements has not been explored.

## **1.2 Spatial Planning Vis-a-Vis Environmental Management**

Spatial planning in a traditional city was carried out with a lot of keenness on its implications to the environment. According to Broadbent (1990), any development was implemented while

ensuring that it caused least harm to dwellers. Craftsmen worked in their own shops, made things with pleasure and enjoyed personal transactions in selling them to others. They had an active social life within the street and lived literally over or behind the shop. Industrial activity was harmoniously integrated with city living. Trancik (1986) points out that with the advent of the mechanical elevator and new technologies of construction, the modern city has spatially become an environment of high-rise towers removed from street life. Activities on the street have little to do with the functions of the high-rises above. This criticism of the form of the modern city is not to imply that the spatial planning of the modern city has been an utter failure or the works of many great planners should be rejected out of hand. According to Trancik, the blame is on functionalism, which laid the ground work for the loss of the traditional space. Being obsessed with efficiency, the historical movement was most concerned with meanings and the problems of giving man an existential foothold but not on the environment of the street.

With the growth of industry in the modern city, the physical and political homogeneity previously characterizing the traditional city was destroyed (Broadbent, 1990). In essence, the fundamental structure of the city based on absolute identity between dwelling and workplace within the same building was destroyed. Progressive industrialization provoked the definitive split between residence and work, with the division becoming even greater with the commencement of individual means of transportation, in particular the motor car. Trancik (1986), on the other hand, points out that the social and communal role of the traditional street has been further undermined by such Modern Movement spatial features as enclosed malls, midblock arcades, and sunken or raised plazas. These have siphoned shopping and entertainment off the street, which no longer functions as a gathering place.

The pre-industrial city was a place for walking which in effect implies no vehicular pollution and accidents. In reflecting on the values and environmental status of this city, Hough (1995) points out that the amount of usable open space throughout its existence was greater per head of population than on any later form of city. Within limits of available technology, it was built and operated on solar power. Variations of climate, topography, agricultural soils and water supply shaped its form. Open spaces were functional, producing a variety of fruit and vegetables, and their grass kept trim by livestock. Houses were grouped around greens and courtyards on the basis of functional necessity to conserve heat, minimize winds and to provide sunlight and space.

Broadbent (1990) adds that streets were not exposed to winds, and arcades surrounded and opened to plazas. The streets were laid out in either straight or curving patterns with a fundamental aim of promoting security and safety. Both scenarios illustrate the inextricable link between spatial planning and environmental management.

Chapman (1996) points out that the modern city dweller is forced to create a social life on personal, controllable territory instead of engaging in a communal existence centred on the street. As a consequence, individual attitudes towards the use of public urban space have been radically altered, bringing to the fore the impact spatial planning has on environmental behaviour or public space use patterns. With the loss of a collective sense of the meaning of public space, there has also been lost the sense that there are rules for connecting parts through the spatial planning of outdoor space. In the traditional city, the rules were clear and in particular, buildings were subordinate to the more powerful collective realm.

The loss of traditional qualities of urban space has also been the result of zoning policies and urban renewal projects. According to Trancik (1986), these closely allied approaches were well-intentioned responses to urban decay. The impulse was to clear the ground, sanitize and promote human welfare through the segregation of land uses into discrete zones and the substitution of high-rise towers for ground level density. He notes that urban renewal projects rarely corresponded in spatial structure to the evolved community pattern they replaced, nor did they respond to the social relationships that gave meaning to community existence. Zoning legislation, on the other hand, had the effect of separating functions that had often been integrated. Discrete districts segregated living space from working space. Both zoning and urban renewal substituted functional for spatial order and failed to recognize the importance of spatial order to social function. It is in the face of this decline in spatial order that the developed world awoke to strengthen its spatial planning through establishment of more control measures aimed at improving environmental management in their cities. In the developing world, on the other hand, cities have continued to experience decay and dilapidation in various sections such as residential neighbourhoods.

In the City of Nairobi, public space in residential areas suffers from social misuse of open spaces, air pollution, inefficient disposal of wastes, excessive noise and visual clutter, crime, traffic

congestion and uncontrolled spread of residential development. According to the Director of City Planning, City Council of Nairobi,

*Planning in Nairobi has been in a mess for long. Informality has grown faster than expected...We are a city experiencing a lot of exclusion where the benefits of the city are enjoyed by a few. We need to ask ourselves whether urbanization is urban sprawl or properly organized cities (The Standard, Thursday, September 22, 2011).*

Nairobi is a sprawling city and according to Moss (2000), this is pronounced along Thika Road which is to the north-east and Mombasa Road to the south-east of the Central Business District. This spreading out is not guided by a development plan despite existence of frameworks for spatial planning. Spatial planning in this regard has made the city environmentally unsustainable. A lot of time is spent on travelling to work or to the market owing to this sprawling character. Whereas government policies form the basis of all planning and environmental management, the Director of City Planning points out that:

*We need to change to policy regimes that will offer development options. Currently, we have some public policies, which instead of intervening, tend to lubricate the problems bedeviling urban planning (Ibid.).*

There is a blame game between urban planning and urban management over the environmental problems in the city. This is based on the argument that the function of planning is limited to provision of blueprints to guide future development, and that plan implementation is the jurisdiction of urban management (Esho, 2011). Whereas there is merit in the position taken by planners in the city, it is this study's position that persistence of environmental problems in the city could largely be due to the nature of spatial planning. In its current practice, spatial planning follows the laid down physical and site planning considerations in evolution of layout plans of residential settlements but there is failure to consider spatial configurations in shaping the final outcome. The actual contribution of spatial planning to environmental management needs to be established otherwise, spatial planning will continue to point an accusing finger at urban management for environmental problems in the city's settlements and residential neighbourhoods in particular.

### **1.3 Definition of Key Terms and Concepts**

A number of terms and concepts are referred to now and again in this study. It is important to point them out at this early stage and briefly explain what they mean in the context of the study. These include spatial planning; residential neighbourhood; public space; public space structure; public space environment; environmental problems; environmental management; and sustainable development. Some of these concepts are discussed in the subsequent chapters of this study but in this section, their brief explanation is as follows:

#### **1.3.1 Spatial Planning**

Spatial planning is a method of ensuring orderly distribution of people and activities in a settlement's spatial system. This entails two levels of activity which include formulation of policies by the planning agency, and actual layout of land or space for the settlement under consideration. The fundamental purpose of spatial planning is to create spatial harmony among the different land uses and to achieve a suitable and sustainable environment for people to operate in. Spatial planning achieves this by providing blueprints to guide future development.

#### **1.3.2 Residential Neighbourhood**

This is a geographical unit of an urban area designated for residential function. A residential neighbourhood has a name, definite boundary, peripheral road and internal street systems.

#### **1.3.3 Public Space**

Public space in a settlement is a space whose access is not limited to anyone. Krier (1979) identifies two basic spatial elements that constitute public space. These include the street and the square. In terms of orientation, a street is one-dimensional whereas a square is two-dimensional. In the category of interior space, though not a subject of this study, the elements are respectively analogous to the corridor and the room.

The category of public space that this study focuses on is the street space in residential settlements. This includes alleyways, pedestrian streets and vehicular-cum-pedestrian streets. An alleyway is a narrow passage between buildings or plots. A pedestrian street is wider than an alleyway and has houses and other forms of buildings on one or both sides and is exclusively for



use by pedestrians. A vehicular-cum-pedestrian street is like a pedestrian street save for the use by both vehicles and pedestrians.

Informed by the space syntax theory, the plan space of a street in a settlement can be broken down into a series of units of space extending in one dimension. Each unit of space is the axial space and forms the subject of analysis in this study. In this respect, analysis of the public space system of a residential neighbourhood starts with a representation of the street layout as a system of axial spaces. A representation of a neighbourhood's street layout as a system of axial spaces is the axial map. The process of preparing an axial map is described in chapter three.

### 1.3.4 Public Space Structure

This is a pattern formed by the public space system of a residential neighbourhood as represented by an axial map (Figure 1-1). It is important to note that this is different from a settlement's public space structure represented by a linkage diagram (Figure 2-5).

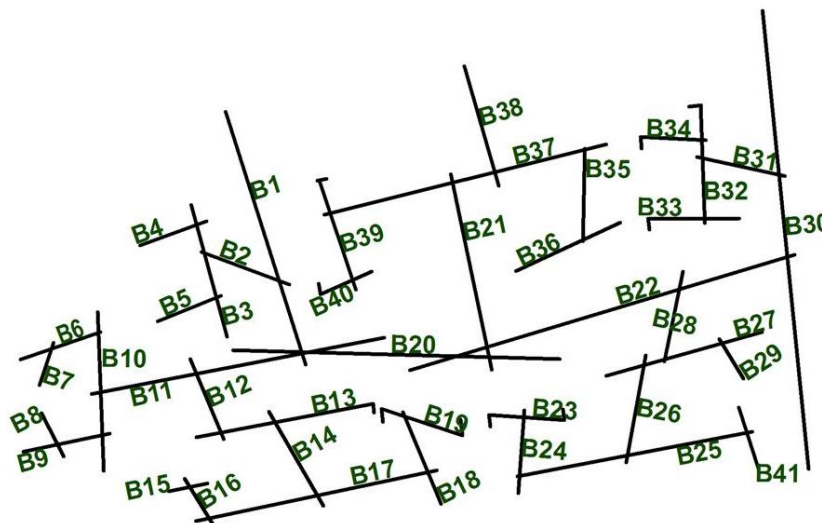


Figure 1-1: Public space axial map for Buru Buru V neighbourhood. Source: Author, 2011.

### 1.3.5 Public Space Environment

Public space environment refers to the conditions in a space that affect its quality and hence its desirability as a place to use. In this regard, the public space environment is made up of

conditions such as intensity of greenery, pollution levels, distribution of people, vehicular use and quality of road network.

### **1.3.6 Environmental Problems**

When a public space environmental condition presents itself in such a manner that makes it undesirable to use the space, then the condition is an environmental problem. An undesirable status in the social function of a public space, such as absence of people, has been attributed to weaknesses in the physical and economic conditions in the space (Jacobs, 1961). On the other hand, a decline in the physical environmental conditions, such as solid waste accumulation and destruction of greenery, is due to economic and social conditions in the space. This suggests that environmental problems come into being when there is conflict among the conditions that make up the public space environment

### **1.3.7 Public Space Environmental Management (PSEM)**

This is a set of processes and practices aimed at ensuring that public space fulfills all its legitimate roles. It is about solving or preventing environmental problems in public space. It entails managing the interactions between, and impacts of, the multiple functions in a way that is acceptable to its users. PSEM is concerned with legitimization of the different roles of public space, what is acceptable and what is not, who decides and who are the users of the space. This study demonstrates that PSEM is made possible by a city's political governance system and the layout pattern of the settlement plan system.

### **1.3.8 Sustainable Development**

Moirongo (2011) has documented various definitions of sustainable development. For instance, according to WCED (1987), sustainable development is development that meets the needs of the present without compromising the ability of the future generations to meet their own needs. Plessis (1997) defines sustainable development as development that delivers basic environmental, social and economic services to a community without threatening the viability of the natural, built and social system. De La Court (1990), on his part, outlines the following six principles of sustainable development:

- a. **The principle of cultural and social integrity of development.** This means that development must grow within, and not be slapped from the outside.

- b. **The ecological principle.** Development must be compatible with and restore diversity and rely on sustainable forms of resource use.
- c. **The solidarity principle.** Development must provide the basic necessities of life and secure living conditions for all people, promote equity, and provide unequal exchange.
- d. **The emancipation principle.** Development must foster self-reliance, local control over resources, empowerment and participation by the underprivileged and marginalized and opportunity for action people can feel is fulfilling.
- e. **The non-violence principle.** Development must be peaceful, both in the direct sense (the non-use of physical violence) and in the structural sense (violence as embodied in the institutions of society).
- f. **The principle of error friendliness.** Development must allow for mistakes without endangering the integrity of the immediate ecosystem and resource base.

Sustainable development in a public space results in a sustainable public space environment.

#### **1.4 Problem Statement**

Public spaces in residential neighbourhoods provide a physical setting for people to socialize, move from one place to another, engage in business activity or participate in recreational activities. The setting also accommodates infrastructure facilities such as road carriageway, sidewalks, street lighting and storm water drainage channels. Despite these important roles, public spaces of residential neighbourhoods in the City of Nairobi have continued to experience various environmental problems thus making them not fulfill the roles ascribed to them. Some of these problems include conflict between vehicles and pedestrians, parking in undesignated areas, dust and odour pollution, solid waste build-up, defective storm water drainage, neglect of greenery, destroyed road network and low encounter rates of people in the public space system.

Key management agencies that determine the environmental status of public space have not been able to realize the desirable environmental quality, thus making environmental problems a hallmark of residential public spaces. The agencies have failed in this expectation despite the existence of elaborate institutional and legal frameworks guiding their operations. In this respect, there is the City Council of Nairobi (CCN), the Ministry of Lands and Settlement, and the National Environmental Management Authority (NEMA), with each having a well-defined mandate to ensure a good quality public space environment. However, the institutions have not managed to

deliver the desirable public space environment. For instance, the CCN collects garbage, repairs roads, works out the storm water drainage system and plants and maintains trees in public space but the problems have remained insidious. The Central Government, through the Ministry of Lands and Settlements, has availed guidelines on physical planning of settlements but this has not succeeded in arresting the public space problems. Similarly, NEMA has established stringent guidelines towards realizing environmental sustainability but unfortunately this has not borne the much needed public space environment either. Existence of the problems and the resulting decline in environmental quality of residential public space is a puzzle that needs to be solved. This in effect casts a question on relying only on the effectiveness of the existing institutional and legal arrangements in managing environmental problems in public space.

Spatial planning, on the other hand, could be having an influence on environmental status of public space but the actual role it plays in either minimizing or promoting environmental problems in residential neighbourhoods is an area that has not been established by research in the city's built environment. This presents a gap in knowledge that this study seeks to fill. Previous studies in the built environment have focused their attention on areas such as urban renewal and rationalization of residential densities no research has been carried out on the relationship of neighbourhood public space planning with environmental status. In this regard, it is necessary that the spatial dimension of public spaces in residential neighbourhoods in the city be looked at by investigating the extent to which it explains public space environmental status. In view of this, the question which this study seeks to answer and which constitutes statement of the problem is, "How can the spatial dimension of public space be formulated functionally to be an object of intervention in minimizing environmental problems in residential settlements?" Information generated in this study forms a basis for evolution of an alternative approach to spatial planning whose utilization contributes to sustainable residential public space environments.

### **1.5 Objectives of the Study**

The broad objective of this study is to suggest an alternative approach to spatial planning, which, when applied to layout of residential neighbourhoods in the City of Nairobi, results in sustainable public space environments. Specific objectives are:

- a. To establish the extent to which spatial planning relates with environmental status of public spaces of residential neighbourhoods in the City of Nairobi.
- b. To establish how spatial planning influences public space environmental status in residential neighbourhoods of the City of Nairobi.
- c. To infer how spatial planning can be effectively applied as a tool for public space environmental management in residential neighbourhoods of the City of Nairobi.

### 1.6 Model Formulation

This study is designed as a survey whose interest is on two areas. These include the strength of the relationship (denoted by the multiple correlation coefficient, R) between a set of independent public space variables and a dependent environmental variable, and the predictive ability of the independent variables on the dependent measure. In the light of this, multiple regression becomes the relevant statistical technique to apply (Pallant, 2005). Multiple regression indicates how much of the variance in the dependent variable can be explained by the independent variables. The model also expresses the relative contribution of each of the independent variables. Statistical tests under this technique, such as analysis of variance (ANOVA), aid in determining the statistical significance of the results, both in terms of the model itself, and the individual independent variables.

A model is a way of representing a particular system and aids understanding of people, events and conditions therein (Hinton et al, 2004). A general linear model (GLM) underlies a wide range of statistical tests, in particular multiple regression and ANOVA. Tremendous flexibility in analysis is possible with the GLM. This is because we can have as many variables as we want in diverse analyses and yet the same basic model structure underlies all the analyses. The GLM is hinged on the argument that the relationship between independent and dependent variables is linear, and the reason as to why some points on a plotted line graph do not follow a straight line is due to 'error'. In such a case, the GLM expresses the relationship that should have occurred had there been no error.

Mathematically, a straight line of a GLM is expressed by the formula

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + \dots + b_nX_n +/- S_e$$

where,

- $Y$  is the dependent variable; the environmental problem being predicted.
- $a$  is the constant; the intercept on  $Y$ -axis. The constant is equivalent of the dependent variable if there are no predictor (independent) variables influencing the dependent variable.
- $b_n$  is the coefficient of the independent variable. It is also called the slope as it gives the value of the slope of the line, assuming all the other independent variables are constant.
- $X_n$  is the independent variable;
- $S_e$  is the value of the standard error of the estimate

### **1.7 Assumptions of the Study**

The study is underlain by two assumptions which are grounded in the space syntax theory and method. These are discussed in the sub-sections that follow.

- a. The spatial planning dimension of public spaces of residential neighbourhoods in the City of Nairobi does carry environmental information and content. This implies that any configured space in a settlement must be put to use. Social use of space has outcomes which have an effect on the space's environmental status.
- b. The environmental status of public spaces of residential neighbourhoods in the City of Nairobi varies transpatially according to spatial, social and economic patterns of the neighbourhoods. This implies that any given use of space is distributed in a settlement; it is not localized.

### **1.8 Theoretical Framework**

The study sets out to establish the extent of the relationship between spatial planning and environmental status of public spaces of residential neighbourhoods in the City of Nairobi, Kenya. It postulates that the environmental management of the spaces, which has failed to cope with environmental problems therein, is due to their underlying spatial planning characteristics. This inquiry is embedded in a number of theories, concepts and other related studies that demonstrate a link between spatial planning and environmental management.

Citywide spatial planning concepts of Garden City, Radiant City and Broadacre City address the environmental problems of the automobile, filth, pollution and overcrowding in cities. At the level

of the neighbourhood, spatial planning concepts of the Neighbourhood Unit, Radburn Layout and the Corbusian Vertical Neighbourhood similarly address the environmental problems. Spatial variables in the planning concepts which are used to respond to the environmental problems in the settlements include circulation, buildings opening into public space, spatial continuity, buildings and other activities bringing people into space, and size of space under consideration. From these concepts, it is clear that spatial planning can curb or minimize environmental problems. However, the dilemma lies in establishing whether and to what extent the spatial planning variables influence environmental variables. If this is to be accomplished, the answer lies in measurability of the spatial planning variables which then would be regressed against each environmental variable in order to explain the relationship. Unfortunately, both the city and neighbourhood spatial planning concepts are unable to do this.

The theories of Urban Space, Territoriality, and Site Planning and Human Behaviour have their spatial planning variables in close relation to those of the above concepts. Territoriality theory, for instance, points out that the creation of spatial domains that have people identifying with them has power to prevent crime. Spatial quality, which is a creation of variables such as circulation patterns and buildings opening into space, affects user behaviour. Despite the relationship of spatial planning to the environment as advocated by these theories, there exists the dilemma of describing spatial planning in a manner that can explain environmental outcomes. The theories fail to provide a means of measuring spatial planning variables which otherwise would allow for a prediction of environmental variables in order to infer any relationship.

Space syntax theory, just like the above theories and concepts, has spatial planning variables that have a bearing on the status of the environment. It is unique however in the sense that its spatial planning variables can be measured and the quantities used to explain movement, land use and social performance in a settlement. Besides being a theory, space syntax is thus a method of spatial analysis which puts it on a higher platform when compared with other theories and concepts. On this strength, space syntax theory forms the conceptual framework guiding this study. The interrelationship among the spatial planning variables and environmental variables in the theoretical framework is as shown in Figure 1-2 below:

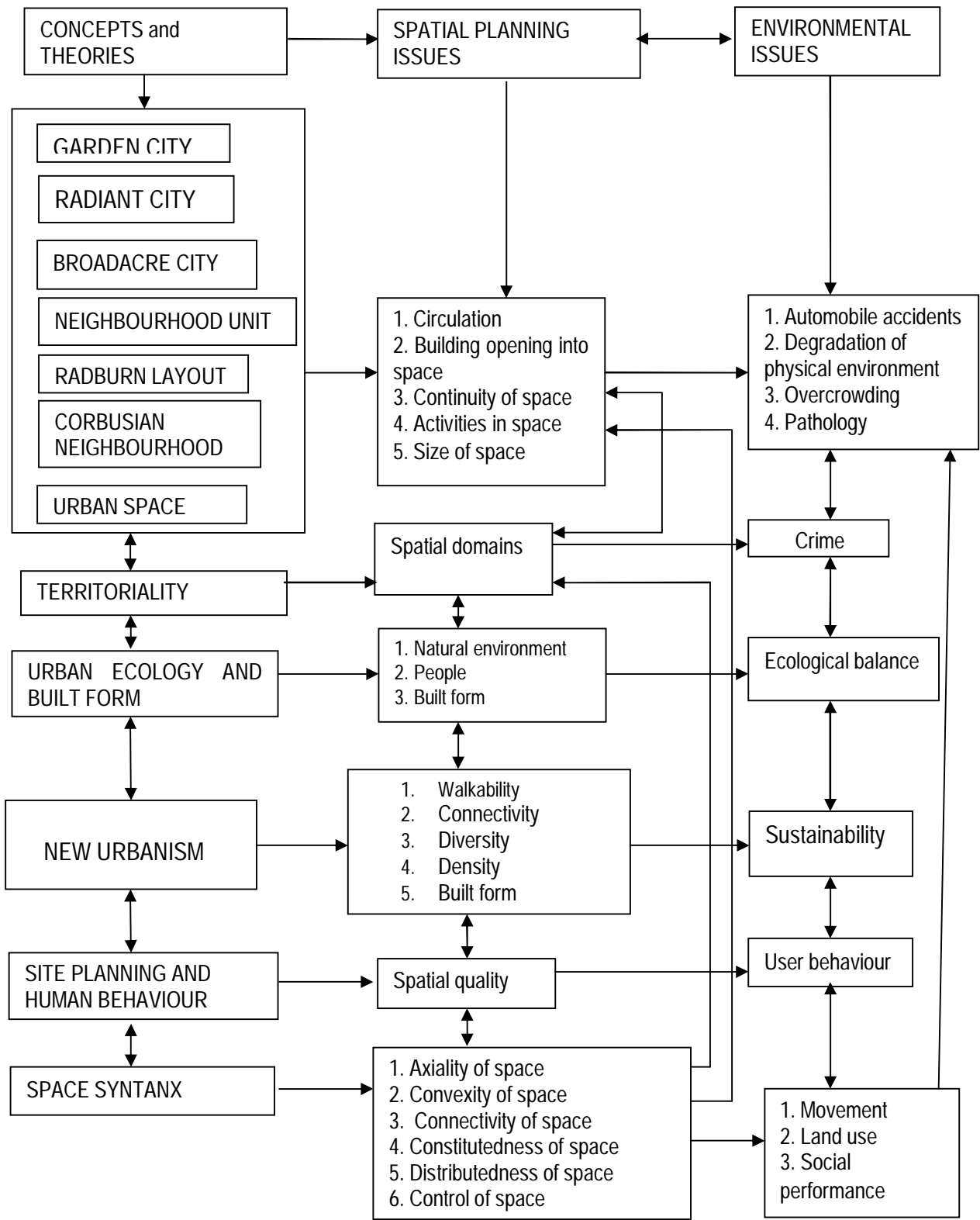


Figure 1-2: Theoretical framework.

Source: Author, 2012.



The problem under investigation in this study has a relationship to other previously undertaken researches. Baran et al (2008) looks at the relationship between syntactic properties (control and integration) as correlates of walking behaviour in a New Urbanist and Suburban neighbourhoods in North Carolina, USA. The study establishes that residents of streets with higher connectivity and control, and greater local and global integration exhibit more walking behaviour than residents of other streets. The research finds out that the New Urbanist neighbourhood has more globally accessible streets while the conventional neighbourhood has more locally segregated streets. It establishes that both neighbourhoods have similar control values and that street spatial characteristics affect walking behaviour. In this, residents of streets that provide high control on the permeability of their neighbouring streets and are more globally accessible exhibited more leisure walking and utilitarian walking whereas residents of streets that are locally more accessible exhibited less leisure walking.

Alfonzo et al (2008) has documented features of the neighbourhood built environment that have an association with walking in the city of California. Accordingly, factors associated with walking and non-motorized transportation among adults include high population density; mixed land uses; sidewalk continuity; good pedestrian infrastructure and overall neighbourhood walkability (characterized by high density, mixed land use, high connectivity and adequate walk/bike design, for instance, continuous sidewalks). The study identifies micro-scale features in individuals' use and experience of neighbourhood environments as including the presence of street trees, sidewalk width and the presence of abandoned buildings. Additional environmental factors linked to physical activity include presence of facilities, travel distance, access to facilities, presence of sidewalks and bike lanes, safety and quality of sidewalks or bike lanes, traffic and other safety features and the availability of pleasant routes. Features that have been associated with walking and other forms of physical activity include urban sprawl; public transit; intersection density; perceived walkability at neighbourhood level; traditional neighbourhood design; trails, streetlights, and access to places for physical activity; perceived access to recreational facilities; and distance to, attractiveness and size of public open spaces

Min (1993), in looking at housing layout and space use in Swedish and Chinese neighbourhoods, investigates how spatial morphology influences pedestrian movement. He specifically examines how spatial configurational properties of neighbourhoods affect the presence of pedestrians in

space. The research finds out that overall neighbourhood integration has no direct connection with the overall density of movement. In a number of cases, spaces with low syntactic values tend to be associated with very low encounter rates, often even completely deprived of any moving people. In five of ten cases investigated, the integration of neighbourhood layouts correlates relatively strongly with encounter rate. It also associates moderately strongly with movement density in four other cases whereas in the remaining one case, the variable displays a weak relation to encounter rate. Global choice structures of neighbourhood layouts, which are readily inferred from reading the connectivity of spaces, directly correlate with movement density. In other words, the study finds out that the higher the connectivity of a space, the higher the encounter rate of pedestrians.

Moirongo (2006), in his research titled 'Urban Public Space Patterns Vis-à-vis Solid Waste Accumulation in Nairobi CBD', investigates how syntactic, social, cultural, economic and physical properties of public space influence solid waste accumulation problems. The study measures solid waste in terms of area, height and quality and then correlates them with the public space properties. He finds out that if a public space is very deep or segregated from the urban system and the adjacent buildings provide no physical or visual access to it, then with time it would be completely covered with solid waste. It also establishes that 'unconstitutedness' of space, least maintained pavements and terrains that do not support washing away of waste by rain water lead to solid waste build-up. The study further finds out that spaces with strong control have worst quality of space in regard to solid waste, whereas those with weak control have a relatively better quality.

Jacobs (1961), Alexander (1977) and Hillier (1988), in their documentations, have made informative contributions to the subject of humanization of public space. Fundamentally, they unravel human encounter patterns and associated social behaviour as a consequence of spatial plan structures. Jacobs (1961) points out that higher encounter rates are associated with lower crime risk. Alexander (1977) adds that when a public space is devoid of human movement, it becomes dangerous. Hillier (1988), on the other hand, presents empirical evidence that confirms Jacob's assertion. Basing his study on the public space of housing estates in Britain, he establishes that the higher the number of people in a public space, which is measured as an encounter rate, the lower the burglary rate. He further establishes the association between

encounter rate and spatial plan properties of integration and constitutedness. In this, he finds out that the more integrated the space, that is, the shallower it is in the settlement system, the higher the number of people or encounter rate and therefore the lower the burglary rate. Conversely, the more segregated a space is, that is, the deeper it is in the settlement system, the lower the encounter rate and therefore the higher the burglary rate. On the constitutedness property of a plan, he finds out that encounter rate is lower in spaces fronted with walls that have no openings and consequently, burglary rate is higher. This confirms Alexander's assertion that buildings should have entrances onto the street in order to increase life in the street. From this discourse, it emerges that fabrics of residential settlement plans are a means of generating social intercourse in public space. However, not all settlements do it the same way. How they generate contact and the kind of pattern they engender is critical, and largely this is created by the manner in which the settlement creates a pattern of integration. Hillier (1988) points out that the pattern of movement in a town, as a correlate on integration properties of a plan, is the same as that of a residential neighbourhood and that cultural variations in urban spatial forms is immaterial. In other words, it is the structure of the spatial plan itself that explains a bulk of the natural pattern of space use and movement, and that this decides the general level of use of the constituent spaces of the plan. He emphasizes that the location of facilities and 'magnets' is important, but it is less influential in creating overall levels of space use than the settlement plan itself. He adds that integration values, among all the other properties of a settlement plan, are the best predictors of encounter rates of individual spaces. Given that integration is a measure which relates each space to every other space in the plan, this implies that the encounter rates of individual spaces are in the main a function of their position in the 'global' structure of the plan, not the more 'local' properties of the space.

Oscar Newman (1972) and Alice Coleman (1985) suggest that in settlement planning, it is better to segregate space and reduce encounter rate. However, Hillier (1988) convincingly contests this position. On the basis of his empirical findings that segregated spaces have a higher crime rate, he casts quite fundamental doubts on the whole concept of 'defensible space', at least insofar as one of the main assumptions behind it is that the elimination of natural movement and encounter within housing estates will increase safety. He points out that advocates of defensible space seem to believe that criminals are part of the passing crowd, and that strangers are therefore in principle dangerous. Interestingly though, as he argues, the converse happens to be the case.

The natural presence of people may be the primary means by which space is policed naturally. The more this is eliminated, the more the danger is created once a potential criminal has appeared on the scene. He concurs with Newman that people behave 'territorially' in segregated spaces, but alludes this behaviour to the segregated nature of the spaces whereby the people who identify with them are bound to query the presence of strangers. Hillier associates this behaviour with feeling more unsafe. On the contrary, he points out that the natural presence of strangers in a street increases the sense of security.

From these related researches, it emerges that no study has been carried out to investigate the relationship of spatial planning with environmental status of public spaces in residential neighbourhoods of the City of Nairobi. The present study is designed to contribute to this research gap and provide a platform for application of the space syntax theory and method to aid inference on the relation between spatial planning and public space environmental management in the residential neighbourhoods. Given that the regimes for public space governance and management have not been able to secure public spaces of desirable environmental quality, the study is also designed to contribute to the philosophy (theory and approaches) of public space environmental management.

### **1.9 Hypotheses of the Study**

Failure to consider spatial relations in creation of public spaces in residential neighbourhoods in the City of Nairobi could be the reason why environmental status is poor. In this regard, the null and alternative hypotheses are:

H<sub>0</sub>: There is no relationship between spatial planning and environmental status of public spaces of residential neighbourhoods in the City of Nairobi.

H<sub>A</sub>: There exists a relationship between spatial planning and environmental status of public spaces of residential neighbourhoods in the City of Nairobi.

#### **1.9.1 Hypothesis Testing**

Analysis of Variance (ANOVA) at 95 percent confidence level is used to test the significance of the relation between the independent and dependent variables of this study. Independent variables comprise the spatial plan characteristics of neighbourhood public spaces whereas

dependent variables consist of the environmental variables in the public spaces. ANOVA tests the null hypothesis which posits that the multiple correlation coefficient,  $R$ , is equal to zero. A rejection of the null hypothesis implies that spatial planning can be used to predict public space environmental status and therefore is a useful guide in environmental management.

Some precautions have been taken by the study to ensure sufficient control of Type 1 and Type 2 errors. These errors are about a possibility of reaching a wrong conclusion from the hypothesis testing. Type 1 error is the error that may be made in rejecting the null hypothesis when it is, in fact, true. This occurs, according to Pallant (2005), when one thinks there is a difference between the independent and dependent variables, but there really isn't. This possibility is minimized by taking the appropriate alpha level. Out of the two levels often used, that is, 0.05 and 0.01, this study has used the former in hypothesis testing.

Type 2 error occurs when one accepts the null hypothesis when it is, in fact, false (Hinton et al, 2004). This happens when one believes that there is no difference between the groups, when in the actual sense there is. Pallant (2005) points out that the two errors are inversely related. This implies that an attempt to control for Type 1 error increases the likelihood of committing Type 2 error.

Ideally, it is expected that tests used in hypothesis testing correctly identify whether there is a difference between the two categories of variables. This is referred to as power of a test (Hinton et al, 2004) and ANOVA meets this requirement. The power of a test is very dependent on the size of the sample used in the study. According to Stevens (1996), when the sample is large, for instance 100 or more, then power is not an issue. However, when the sample size is small (say  $n = 20$ ), then there is a possibility that a non-significant result may be due to insufficient power. Stevens suggests that when small group sizes are involved, it may be necessary to adjust the alpha level to compensate (for instance, 0.10 or 0.15 instead of the traditional 0.05). In this study, power of a test is not an issue given that the sample size is greater than 100.

### **1.10 Justification of the Study**

Nairobi, the capital city of Kenya, is notably characterized by rapid population growth. According to Otiso (2005), Nairobi has attained primate-city status given that its population is at least twice

as large as the combined population of the second and third cities. The city's high population is a point of concern as its pressure on the spatial system, such as neighbourhood public spaces, has posed challenges to spatial planning and environmental management. In view of the fact that the call to integrate development and environment is an important agenda at the national level (Kenya, 1999), the study of this area becomes timely so as to save the prevailing conditions from continued decline.

Residential settlements occupy a greater percentage of land in an urban area than does any other use (White, 1988). Because of this omnipresence, housing has come under the purview of planners. It is not just a local issue but plays a role in the national economy and is a component of national social policies. Provision of shelter for urban populations is a priority issue and the greatest challenge being how to cope with the increasing numbers without compromising environmental quality. Vision 2030 (Kenya, 2007) underscores provision of urban housing as priority area. The City of Nairobi is selected because it is one area that presents residential neighbourhoods whose integral public spaces manifest a wide scope of environmental degradation. Findings of the research based on the study area provide a platform to guide studies in other urban areas of Kenya.

Lynch (1984) points out that conscious organization of land is crucial for quality living in any given environment and that careless disturbance of the landscape causes harm. Bruton and Nicholson (1987) underscore the fact that it is the responsibility of spatial planners to not only produce plans but also ensure that a system of environmental management is in place. In this regard, neighbourhood spatial plans that have an in-built system of environmental management are critical to achieving suitable living environments.

### **1.11 Significance of the Study**

The findings of the study are a contribution to resolution of the problem of environmental degradation in public spaces of residential neighbourhoods. They inform spatial planners on the value of environmental management inherent in their blueprints for proposed residential schemes is expected to stimulate efforts to regenerate neighbourhoods through urban renewal.

Documentation of the findings of the study is resourceful to those yearning for knowledge and conducting research on environmental management in residential neighbourhoods. This adds to the pool of available reference materials in libraries and other resource centres.

If planned public spaces of residential neighbourhoods are to be availed, appreciated, protected, enhanced and sustainably utilized, then knowledge of the spatial planning dimension of neighbourhood public spaces and its role in enhancing environmental management is of paramount importance. In this respect, the study's findings are a useful contribution to formulation of spatial planning policies whose application to layout of residential neighbourhoods results in sustainable public space environments.

## **1.12 Scope of the Study**

### ***1.12.1 Geographical Scope***

The geographical scope of this study is limited to Nairobi's residential neighbourhoods. The neighbourhoods for detailed inquiry are picked from the planned low-income, middle-income and high-income categories based on the Survey of Kenya topographical map of 1995 (Figure 3-2).

### ***1.12.2 Theoretical Scope***

This study is limited to spatial planning concepts at the citywide and neighbourhood levels. Citywide concepts include Garden City, Radiant City, and Broadacre City. On the other hand, neighbourhood level concepts include Neighbourhood Unit, Radburn Layout, and Corbusian Vertical Neighbourhood. The study is limited to the theories of Territoriality, Urban Space, Urban Ecology and City Form, Site Planning and Human Behaviour, and Space Syntax. The study embraces a conceptual framework which derives variables from space syntax theory and also from the physical, social and economic characteristics of public space. Space syntax variables are two-dimensional and therefore present a narrow scope in understanding a residential public space system. To make the study holistic, other variables from the public space characteristics are included in the framework, some of which are the third dimension of space.

### **1.12.3 Methodological Scope**

The study is limited to space syntax, observation, interviewing, and literature review as methods of empirical investigation.

### **1.12.4 Public Space scope**

Public space consists of streets and squares but this study is limited to streets. An axial space forms the basic unit of observation and analysis in this study.

### **1.13 Public Space Variables**

Public space variables investigated in this study fall in two categories; variables due to spatial characteristics and variables due to the environmental problems in space. The former are the independent variables whereas the latter are the dependent. It is the relationship of these two categories of variables that this study is keen on, that is, establishing the extent to which a set of independent variables explain variance in a dependent variable.

The endeavour by this study to relate spatial characteristics with environmental characteristics of a space is not the first one of its kind. For example, as already highlighted under the theoretical framework, Alfonzo et al (2008) has established built environment features that have an association with walking. Min (1993) and Baran et al (2008) has established a link between syntactic variables and walking in a residential neighbourhood. Whereas these studies have established the association between spatial and environmental variables through correlation analysis, Moirongo (2006) has used multiple regression to analyse the predictive ability of diverse spatial variables on the environmental variable of solid waste accumulation in the urban space of Nairobi CBD. These previous studies serve to indicate that spatial characteristics do explain environmental problems in space, and that by representing the relationship as a GLM, the environmental problems can be increased or reduced through manipulation of spatial characteristics of a public space.

Spatial variables used in this study are informed by the existing theory on space and fall into two categories – syntactic variables and non-syntactic variables. On the other hand, environmental variables are derived from the residential public space system of the study area through an



environmental survey. A description of these variables is given in detail in the subsections that follow.

### **1.13.1 Spatial Variables**

Spatial variables are due to the physical characteristics of a public space and, as mentioned above, fall into syntactic and non-syntactic categories. Syntactic variables are generated from an axial map using the space syntax method (Hillier and Hanson, 1984). The focus of the space syntax method is on how space works in its relation to other spaces of the plan system. Alpha-analysis, a methodology of assessing exterior space (as opposed to interiors of buildings), is used to generate quantitative data for various syntactic variables.

Syntactic variables are derived at a two-dimensional level of an axial map. For a comprehensive study of public space, this scope of variables is not adequate as it leaves out spatial variables that present themselves at the third dimensional level of the space. It is in this perspective that this study, in addition to syntactic variables, includes other spatial variables so that in all, a public space has a holistic description. The other spatial variables fall into physical, social and economic categories. It is important to note that the list of spatial variables is very lengthy (Appendix 2) and not all variables are found to be significant in explaining the dependent variables. In this section therefore, only the significant spatial variables are listed on the basis of the categories they fall under.

#### **1.13.1.1 Syntactic Variables**

These are listed as per the dimensions that have been used to analyze public space and include constitutedness-unconstitutedness, distributedness-nondistributedness, and symmetry-asymmetry.

##### **(i) Constitutedness-Unconstitutedness**

Constitutedness of a space is said to exist when adjacent buildings and other bounded areas, such as inhabited plots, gardens and parks, are directly or indirectly permeable to it (Hillier and Hanson, 1984). Permeability refers to access between the enclosed and public space environments. If a space is not accessible from the adjacent buildings or boundaries, it is said to be unconstituted. This access can be either physical through doors or gates, or visual through

windows or transparent areas of a perimeter wall. This then suggests that constitutedness is defined by the degrees of permeability, enclosure and transparency. Fundamentally, constitutedness deals with the quality of the boundaries that define public space which, according to Jacobs (1995), play the role of keeping eyes on and in the street and making it a place. Variables that measure constitutedness of public space include:

- i. Degree of adjacency and permeability, measured as the number of buildings or inhabited plots per square metre of space;
- ii. Degree of adjacency and permeability, measured as the number of buildings or inhabited plots per metre of space;
- iii. Degree of adjacency and impermeability, measured as the number of buildings or inhabited plots per square metre of space;
- iv. Degree of adjacency and impermeability, measured as the number of buildings or inhabited plots per metre of space;
- v. Building space index, measured as the number of buildings or inhabited plots that are adjacent and permeable to it;
- vi. Percentage of space length fronted with fronts of buildings/inhabited plots;
- vii. Average height of space boundary, measured in metres; and
- viii. Percentage of building wall length that is transparent.

### ***(ii) Distributedness-nondistributedness***

A spatial system is said to be distributed if there is more than one non-intersecting route from one space 'a' to another space 'b' and routes always form rings. In a nondistributed system, there will never be more than one route between 'a' and 'b'. This suggests that a distributed system has diffusion of spatial control whereas a nondistributed system is unitary and with superordinate control. The degree of distributedness of a public space is indicated by its measure of control and connectivity.

The measure of control of a space by other spaces is a summation of the shared contribution it receives from the neighbouring spaces. Each public space has a certain number  $n$  of immediate neighbours. Each space therefore gives to each of its immediate neighbours  $1/n$ , and these are then summed for each receiving space to give the control value of that space. This means that control takes into account relations between a space and its immediate neighbours. According to

Hillier and Hanson (1984), spaces with a control value greater than 1 are strong control spaces whereas those whose value is below 1 are weak control spaces.

Connectivity of a public space is a value indicating the number of axial spaces that are directly connected to it. Variables that measure this dimension of public space include:

- frequency of intersections within the space, measured as number of intersections per metre of space;
- frequency of vehicular road intersections in the space, measured as number of vehicular road intersections per metre of space; and
- frequency of pedestrian roads making a junction with the space, measured as number of pedestrian roads making a junction with the space per metre of space

### ***(iii) Symmetry-asymmetry***

A relation between two spaces 'a' and 'b' is said to be symmetric if the relation of 'a' to 'b' is the same as the relation of 'b' to 'a' (Hillier and Hanson, 1984). The relation between the two spaces will be asymmetric if an intermediate space 'c' is introduced between them. This means that for one to move from 'a' to 'b', he has to pass through 'c'. However, the relation between 'a' and 'c' or between 'b' and 'c' is symmetric given that there is no intermediate space between either of them. We may note then that asymmetric relations always involve some notion of depth (Ibid.). In view of this, the relationship that is of focus in the study of spatial relations in a settlement layout system is that of asymmetry. The degree of asymmetry of an axial space is therefore looked at in terms of how deep the settlement system is from the space, or how deep it is from the carrier space. This brings to the fore two variables that measure the symmetry-asymmetry dimension of public space:

- Relative depth. This is the measure of integration of a public space. It is also referred to as relative asymmetry. The relative depth value for a given public space indexes how deep or shallow the settlement system is from that point. Least depth exists when all spaces are directly connected to the original space, and most depth when all spaces are connected in a unilinear sequence away from the original space, that is, every additional space in the system adds one more level of depth. Calculation of relative depth entails working out the mean depth of the system from the space by assigning a depth value to

each space according to how many spaces it is away from the original space, summing up these values and dividing by the number of spaces less one (the original space). Relative depth is then computed using the formula,

$$\text{Relative depth} = \frac{2(\text{MD} - 1)}{K - 2}$$

where MD is the mean depth and K the number of spaces in the system.

This gives a value between 0 and 1, with low values indicating a space from which the system is shallow, that is, a space which tends to integrate the system, and high values a space which tends to be segregated from the system. The mean value of the individual relative depths gives the general measure of integration for the settlement system. This however was not calculated for each sample neighbourhood since the focus of the study is only on a few spaces.

- Depth from Y, the carrier space. The value of depth from Y, assigned to each public space, indicates the number of steps it is from Y in the axial map. The carrier, Y, is given the value 0, and for any settlement, this needs to first be identified. In the sample neighbourhoods for this study, the peripheral road system is used as the carrier space.

#### ***1.13.1.2 Non-Syntactic Variables***

Non-syntactic variables of public space fall into physical, social and economic categories. As already underscored, their inclusion in the study is necessary in order to permit a comprehensive study of public space. In this section, only the spatial variables established to be significant in the prediction models presented in chapter four are listed. A comprehensive list of study variables is in Appendix 2.

#### ***(a) Physical Variables***

These are variables which are related to the physical and ecological environment, building setback, plot ratio and transportation. They are:

##### **(i) Physical and Ecological Environment**

- Width of the space;

- Percentage of road surface that is curved;
- Percentage of space area that is flat;
- Percentage of space area that is paved;
- Percentage of space area that is tarmacked;
- Density of trees in space, measured as number of trees per square metre of space;
- Average tree canopy clearance from the ground, measured in metres; and
- Percentage of space area that is covered with grass.

(ii) Building Setback:

- Average number of storeys per metre of space;
- Average number of storeys per square metre of space;
- Plot ratio for the space;
- Density of buildings with setbacks, measured as number of buildings per square metre of space;
- Frequency of buildings with setbacks, measured as number of buildings per metre of space;
- Proportion of buildings with setbacks, measured as a ratio of number of buildings with setbacks to total number of buildings.

(iii) Plot Ratio:

- Average number of storeys per metre of space;
- Average number of storeys per square metre of space;
- Plot ratio for the space.

(iv) Transportation:

- Frequency of vehicles using the space, measured as number of vehicles per metre of space;
- Density of vehicles using the space, measured as number of vehicles per square metre of space;
- Total number of vehicular movement lanes;
- Width of road (carriageway);

- Total width of sidewalks.

### ***(b) Economic variables***

These are variables related to distribution of business activities. They include:

- Frequency of informal business activities, measured as number of informal business activities per metre of space;
- Frequency of chemists, measured as number of chemists per metre of space;
- Frequency of institutions fronting the space, measured as number of institutions per metre of space;
- Intensity of mix of activities in the space, measured on a scale of 1 to 4;
- Frequency of retail shops, measured as number of retail shops per metre of space;
- Frequency of bookshops, measured as number of bookshops per metre of space;
- Proportion of buildings with social places, measured as a ratio of number of buildings with social places to total number of buildings.

### ***(c) Social Variables***

These are variables related to space use and provision of public space services. They include:

- Frequency of outdoor seating, measured as number of amenity seating points per metre of space;
- Frequency of people seated/lying down, measured as number of people per metre of space;
- Intensity of taking care of planting, measured qualitatively on a scale of 1 to 7;
- Intensity of private security patrols, measured qualitatively on a scale of 1 to 7;
- Intensity of garbage collection, measured qualitatively on a scale of 1 to 7;
- Intensity of Kenya Police patrols, measured qualitatively on a scale of 1 to 7;
- Frequency of outdoor lighting fixtures (posts and luminaries), measured as number of fixtures per metre of space;
- Frequency of advertisement/display lighting, measured as number of advertising points per metre of space.

### **1.13.2 Environmental Variables**

Environmental variables in the residential public space are due to environmental problems characterizing the spatial system. These are the variables the study seeks to establish the extent to which they are explained by spatial variables. The variables are listed according to the environmental problem they are associated with.

#### **(i) Variables related to vehicular – pedestrian conflict**

- Frequency of interruption of pedestrian flow by vehicular traffic, measured as number of interruptions per metre of space;
- Density of parking on paved areas (pedestrian walkways), measured as number of vehicles parked on paved areas per square metre of space.

#### **(ii) Variables related to undesignated parking in public space**

- Density of parking on grass, measured as number of vehicles parked on grass per square metre of space;
- Density of parking on carriageway, measured as number of vehicles parked on carriageway per square metre of space;
- Density of parking on bare soil, measured as number of vehicles parked on bare soil per square metre of space;
- Overall density of parking on undesignated areas, measured as number of vehicles parked on all undesignated areas per square metre of space.

#### **(iii) Variables related to public space pollution**

- Dust pollution, measured qualitatively using a scale of 1 to 5;
- Odour pollution, measured qualitatively using a scale of 1 to 5;

#### **(iv) Variables related to solid waste accumulation in space**

- Area of space occupied with solid waste, measured as a ratio of area of space occupied by solid waste to total area of the space;
- Maximum height of solid waste, measured in metres;

- Quality of solid waste, measured qualitatively using a scale of 1 to 5.

**(v) Variables related to defective storm water drainage in public space**

- Area of space commonly occupied with stagnant storm water, measured as a ratio of area of space commonly occupied with stagnant storm water to total area of space.

**(vi) Variables related to neglect of greenery**

- Area of neglected greenery, measured as a ratio of area of space with neglected greenery to total area of space;
- Quality of greenery, measured qualitatively using a scale of 1 to 5.

**(vii) Variables related to destroyed road network**

- Length of destroyed road, measured as a ratio of length of destroyed road to total length of the space;
- Area of destroyed road, measured as a ratio of area of destroyed road to total area of the space.

**(viii) Variables related to humanization of public space**

- Frequency of people in space, measured as number of people per metre of space.

## **1.14 Research Methodology**

Central in the methodology employed in this study are data needs, collection methods and data analysis. A brief highlight of these aspects is presented in the subsections below whereas an elaborate discussion of the same is presented in chapter three.

### **1.14.1 Data needs and Collection Methods**

Data needs for the study include both primary and secondary data. Secondary data is collected through review of literature, both broad and focused. Broad literature review is generally on the city environment insofar as its origin, planning and emerging issues are concerned. This is important as it aids in conception and formulation of the research problem. Focused literature review is on underlying theoretical works on spatial planning and environmental management in urban settlements. Review of literature is presented in chapter two.



Primary data, on the other hand, is on the twin aspects of spatial planning and environmental status of public spaces in residential neighbourhoods. This is collected through survey of the residential public space system. Data on spatial planning is both syntactic and non-syntactic.

***(i) Syntactic data***

Syntactic data is collected through alpha-analysis, a technique of the space syntax theory and method. Axial maps based on an up-to-date layout of the neighbourhoods are used in generation of this category of data.

***(ii) Non-syntactic data***

Non-syntactic data, that is, data on the physical, social and economic characteristics of space, is collected through survey of the public spaces, observing and measuring each variable appropriately. Some variables are measured by use of a measuring tape or wheel, others by use of hand-held tally counters, while others are measured qualitatively by use of a Likert-like scale. The measurements are recorded in an observation schedule which is administered to each public space. Some characteristics of public space, in particular the recommended ground coverage and plot ratio for various neighbourhoods, necessitated their collection from the CCN, department of City Planning and Architecture.

***(iii) Environmental Data***

This is data on variables describing environmental problems in public space. Just like non-syntactic data, environmental data is collected through survey of the study area. Each environmental variable is appropriately measured by using either a measuring tape or a qualitative score based on a Likert-like scale. Where an environmental problem is not evident in space, the space's users are interviewed to establish a clear picture and hence the right score on the true status of the space.

***1.14.2 Data Analysis***

The Statistical Package for Social Scientists (SPSS), Version 16.0, is used to aid synthesis of primary data. Multiple regression is applied, using the stepwise method, to establish spatial variables that significantly predict environmental variables. For each dependent variable, two regression models are generated; the first illustrating the influence of only syntactic variables

whereas the second one illustrates the influence of all independent variables. The intent of this approach is to build a basis for utilizing a comprehensive conceptual framework to undertake a public space study.

Spatial variables in each regression model are discussed in regard to how they relate with the environmental variable, that is, how they promote or minimize it. Considering all the regression models, the spatial variables are many and using each as an object of intervention in environmental management may be untenable. The pragmatic approach is to infer patterns that emerge from the interaction of the spatial variables. Related spatial variables repeatedly reflect a certain quality in spatial planning of a settlement which, in this case, is the pattern. For instance, variables on area of space covered with tarmac, grass, bare soil, pavement and trees point to the pattern of ecological balance. In other words, ecological balance is seen in each of the variables thus forming a pattern. The emerging spatial planning patterns are discussed on how they interact among themselves and how they ought to be applied in layout of residential neighbourhoods so as to attain sustainable PSEM.

#### **1.14.3 Data Presentation**

Various forms are used in presentation data once it is analyzed. These include predictive models, tables, and an analysis report.

#### **1.15 Philosophical Orientation of the Study**

This study embraces positivism as its epistemological position. According to Bryman (2004), the doctrine of positivism advocates for the application of methods of the natural sciences to the study of social reality and beyond. Positivism is taken to entail the following:

1. The principle of phenomenalism. This stipulates that only phenomena and hence knowledge confirmed by the senses can genuinely be warranted as knowledge.
2. The principle of deductivism. This stipulates that the purpose of theory is to generate hypotheses that can be tested to so as to allow explanations of laws to be assessed.
3. The principle of inductivism. This requires that knowledge be arrived at through gathering of facts to provide the basis for laws.
4. Objectivity. Science must be conducted in a way that is value free.

5. There is clear distinction between scientific statements and normative statements and a belief that the former are a true domain of the scientist. This principle is implied by the first because the truth of normative statements cannot be confirmed by the senses.

### **1.16 Organization of the Study**

This study is presented in six chapters. Chapter one gives an introduction to the study. It is in this chapter that the failure of spatial planning in regard to public space environmental status is conceived. The chapter as well presents a statement of the research problem, objectives and hypotheses underlying the study. It highlights the study's justification and significance, scope and the research methodology.

Chapter two broadly provides a theoretical underpinning of spatial planning and environmental management. Various concepts and theories on spatial planning and environmental management in which the study is embedded are examined, giving rise to a conceptual framework guiding the study.

Chapter three presents the overall research approach. It presents various characteristics of the setting of the study, which is the City of Nairobi, and the design of the methodology employed in empirical investigation. Chapter four discusses public space environmental problems as predicted by spatial variables. It is in this chapter that spatial patterns with a bearing on PSEM are identified.

Chapter five discusses the emerging spatial planning patterns and how they ought to be applied in the layout of residential neighbourhoods so as to realize sustainable PSEM. Finally, chapter six presents the conclusions and recommendations of the study. The chapter presents results of hypothesis testing, highlights how spatial planning has failed in regard to the residential PSEM and spells out measures that should be applied to realize sustainable public space environments. The chapter also suggests areas for further research and advances implications of the study in regard to theory, methodology and practical aspects.

## **CHAPTER TWO**

### **2.0 SPATIAL PLANNING AND PUBLIC SPACE ENVIRONMENTAL MANAGEMENT**

#### **CONCEPTS AND THEORIES**

#### **2.1 Introduction**

This chapter looks at various concepts and theories in urban spatial planning and environmental management of public space in human settlements. Specifically, it focuses on cities and residential neighbourhoods. Initially, the concepts of spatial planning and public space environmental management are individually reviewed before examining theories and other concepts that demonstrate the relationship between them. This theoretical framework is reviewed with the intention of identifying an appropriate conceptual framework to guide the study.

#### **2.2 The Concept of Spatial Planning**

##### **2.2.1 Definition**

Spatial planning is a broad concept that generally refers to the methods used by the public sector to influence the distribution of people and activities in spaces of various scales. It encompasses all levels of land use planning including urban planning, regional planning, environmental planning, and national development planning. It is at the same time a scientific discipline, an administrative technique and a policy directed towards physical organization of space according to an overall strategy (<http://en.wikipedia.org>, accessed August 2009).

According to Akatch (2001), spatial planning is the exercise of ensuring an orderly arrangement of land uses. The ultimate goal of spatial planning is not only to create spatial harmony amongst the many different land uses but also to satisfy the environmental, social, economic and physical requirement of the spatial residents on a short term and long term basis.

Within the confines of the physical conditions of a settlement, Larsson (2006) defines spatial planning as the arranging of physical space in a suitable way. He underscores that comprehensive spatial planning must take into consideration the social, economic and physical conditions and the interrelationships that exist among them. Otherwise, spatial planning remains addressed only in part. Hillier and Hanson (1984) synonymously use spatial organization to refer to the creation and arrangement of space. He points out that buildings order space and the

manner in which this ordering is achieved lies at the heart of what is wrong with the built environment today.

In the context of this study, the concept of spatial planning is limited to the physical conditions of an urban residential settlement. In this regard then, spatial planning refers to the orderly layout of the space of a residential neighbourhood while taking into consideration the social, economic and physical conditions to satisfy the environmental requirements of residents. It is about arrangement or organization of space through distribution of discrete entities which enter into different kinds of relations in that space. A spatial plan layout therefore has solids suitably arranged in space, informed by social, economic and physical considerations, and defining the complex public open space system. In this regard, spatial planning presents a basis for urban design. The focus of urban design is on creation of people places through articulation of outdoor spaces whose distribution is actualized through spatial planning.

### **2.2.2 Spatial Planning Goals**

Larsson (2006) underscores sustainable development as the primary goal of spatial planning which, to a great deal, is concerned with land. He outlines specific goals of the broad perspective of spatial planning in an urban environment as follows:

- i) Healthy and sanitary living conditions. In urban connections, this means ordered systems of streets, water, sewage, green spaces, aesthetic buildings and other surroundings – generally things which improve living conditions, and physical and mental health.
- ii) Economic use. Economic use of land requires that areas are allocated priorities according to how well they are suited for a certain purpose.
- iii) Meeting social needs. This requires a public body to strive to satisfy the needs of people, be they habitations, services of different kinds, transport facilities or recreational areas.
- iv) Accessibility. By improved transport facilities, physical distance as a barrier to human interaction is moved further away. Provision of accessibility should be well coordinated at the national, regional and local levels.
- v) Preservation of environment. Environmental consequences are a major concern in development that spatial planning seeks to avoid.
- vi) Public-private participation. Activities should be well planned and implemented in dialogue and participation with concerned land owners and citizens. Planning agencies

should employ a coordinated approach, both horizontally and vertically, in addressing the society's needs.

Considering the number and diversity of the goals, this study focuses only on the goals of environmental preservation and attainment of healthy living conditions.

### ***2.2.3 Trends in Spatial Planning***

The system of spatial planning, in its broad scale, varies from one country to another (OECD, 2001; Larsson, 2006). However, there exists a marked difference in its practice among the developed and between the developed and developing worlds. Larsson (2006) bases these dissimilarities on the general attitudes in society to public involvement and steering. The developed world has put a lot of emphasis on public involvement in the spatial planning system.

The United States of America, with its ideological stress on individual freedom, public involvement in spatial planning seldom goes very deep. In France, with its tradition of central administration, public planning goes deeper into details but still gives plenty of room for private development initiatives and for public-private participation. In the communist Russia, the public always decides land use and development. Larsson (2006) indicates that the degree of public involvement in spatial planning, implementation and control varies significantly even among this cadre of developed countries. In Netherlands, for example, both planning and implementation of the physical structure is mainly a responsibility of the public, however in active consultation with institutions and citizens. In the United Kingdom, the public just constitutes a frame, within which the further development planning and implementation is a matter devolving on the landholder or developer, however under firm public control.

The performance of spatial planning in the developing world and Africa in particular, is comparatively lower than the developed world and is faced with serious challenges. Akatch (2001) cites some of the challenges facing African countries as including deep economic recession compounded by external debt crisis, sky-rocketing population explosion, and urbanization problems. Most regions in Africa have experienced rapid urban growth without a corresponding growth and development of the urban infrastructure facilities and services. Unfortunately, municipal governments in these countries have been unable to cope with these challenges. According to Larsson (2006), the usual problem in developing countries is that most

authorities, perhaps with the exception of the big cities, do not have adequate resources to administer both detailed development planning and realistic framework planning. The solution is usually to concentrate directly on detailed planning. This is unlike the situation in the developed world where there is plenty of resource to attend to both detailed and broad aspects of spatial planning.

From the foregoing, it emerges that success in the practice of spatial planning is dependent on the resource capacity of local authorities to drive and sustain the process. Strengthening local authorities in developing countries may ensure that comprehensive spatial planning is carried out, but it is the argument of this study that this approach is narrow, be it in the developed or developing worlds, when it comes to minimizing environmental consequences due to social use of public space. Considering that availability of economic resources is limited, a spatial planning approach that does not consider spatial configurations at the scale of a neighbourhood is not environmentally sustainable.

## **2.3 The Concept of Public Space Environmental Management**

### **2.3.1 Definition**

Public space, in its broad definition, encompasses all those parts of the built and natural environment where the public has free access. This includes all the streets, squares and other rights of way; the open spaces and parks; the 'public/private' spaces where public access is relatively unrestricted. According to Magalhaes and Carmona (2009) all public spaces, no matter how inclusive, democratic and open, require some form of environmental management so that they can accomplish their diverse roles effectively. Linked to these roles is a diverse collection of stakeholders who are concerned that public spaces meet their own requirements. Some of the stakeholders include providers of infrastructure, motorists, pedestrians, retail operators and park users. The potential for conflicts of interests in the daily usage of public space is thus quite significant, and, in a sense, inextricably linked to the very 'publicness' of such spaces.

Public Space Environmental Management (PSEM), in this regard, is the set of processes and practices that attempt to ensure that public space can fulfill all its legitimate roles, whilst managing the interactions between, and impacts of, those multiple functions in a way that is acceptable to its users (Magalhaes and Carmona, 2009). In this very broad definition, there are

clear issues concerning who legitimizes the different roles of public space, what is acceptable and what is not, and who decides; as well as who are the users – the owners, defined groups or wider society.

Public space environmental management is therefore the governance sphere where stakeholder demands on, and aspirations for, public space are articulated into sets of processes and practices. Given the multi-functionality of public space, the variety of stakeholders whose actions contribute to shape its overall quality and the plurality of elements that constitute it, it is clear that the environmental management of public space is a complex set of activities, that often goes well beyond the remit of those organizations, public or private, formally in charge of delivering it.

### ***2.3.2 Dimensions of Public Space Environmental Management (PSEM)***

The environmental management of public space, according to Magalhaes and Carmona (2009), can be conceptualized as being made up of four interlinked processes:

- (a) *The regulation of uses and conflicts between uses.* The use of public spaces and the conflicts between uses have always been regulated, either formally through bylaws, and other prescriptive instruments, or informally through socially sanctioned practices and attitudes. Regulation defines how public spaces should be used, sets a framework for solving conflicts between uses, determines rules of access and establishes acceptable and unacceptable behaviour. How regulation is conceived, adhered to, and how it adapts to changing societal needs is a vital dimension of public space environmental management.
- (b) *The maintenance routines.* These ensure the ‘fitness-for-purpose’ of the physical components of public space. Public spaces and the infrastructure, equipment and facilities vested in them need to be maintained in order to perform the functions that justify their existence. This concerns anything from ensuring that public spaces are usable, uncluttered, clean and safe, maintaining the surfaces of roads, street furniture, lighting, vegetation and facilities of all types; to removing anything that might deface or offend the symbolism invested in civic spaces; to occasional capital intensive replacement of parts of the public realm.
- (c) *The new investments into and ongoing resourcing of public space.* Regulating uses and conflicts and physically maintaining public spaces requires resources – financial and



material. The degree to which regulatory instruments and maintenance routines can be effective is linked to the amount of resources devoted to those activities. Moreover, resources can come from several sources, each of them with a different combination of limitations and possibilities. This involves both ongoing revenue funding, for day-to-day management tasks, but also significant capital funding from time to time as and when significant re-design and re-development is required.

- (d) *The co-ordination of interventions in public space.* Because regulation, maintenance and resourcing are likely to involve a wide array of people and organizations, directly or indirectly, there is a necessity to co-ordinate mechanisms to ensure that the agents in charge of those activities pull in the same direction. This need for coordination applies equally to units within an organization, such as departments of a local authority, as it does to different organizations. The need for co-ordination has been made all the more important by the fragmentation of the 'command and control' state and the emergence of 'enabling' forms of urban governance.

These four dimensions apply whether public space environmental management activities are undertaken primarily by public sector agencies, by voluntary bodies or community organizations, or by private sector companies (Figure 2-1).

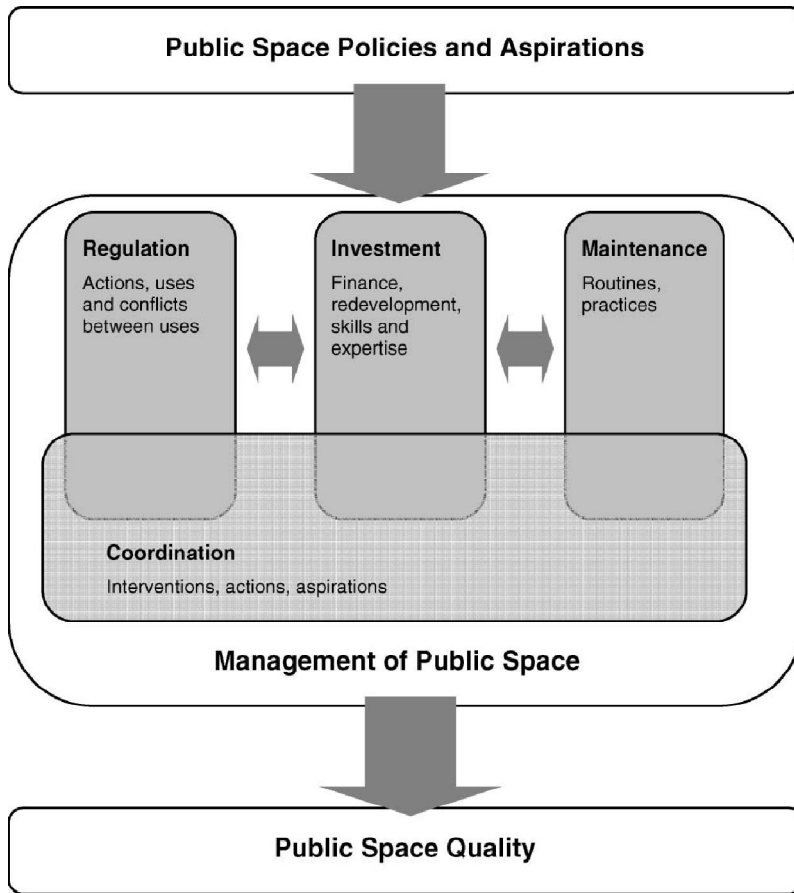


Figure 2-1: Conceptual Model of Public Space Environmental Management.

Source: Magalhaes and Carmona, 2009.

Public space environmental management is a dynamic process. Even if the key dimensions of management were broadly constant, management responsibilities change enormously, therefore making it impossible to refer to an ideal pattern of responsibilities over public space. Traditionally, direct ownership and management of public space by the state has intuitively appeared as normal or correct approach to embrace but over time, change is taking effect.

The practice of environmental management from the perspective of this model is important in ensuring that desirable public space environments are achieved. However, in residential neighbourhoods of developing countries, the contribution of this model has not translated into optimal reduction in public space environmental problems. This implies that there is need to embrace other approaches to complement this model in minimizing public space environmental

problems. It is for this reason that this study investigates the actual contribution accorded by spatial planning.

## **2.4 The Public Space Environment of Residential Neighbourhoods**

Inhabitants of a neighbourhood aspire for a good quality environment in public spaces. To achieve this, the governance sphere environmental management is guided by established environmental standards on space planning and use.

### **2.4.1 Environmental Standards**

Environmental standards for public spaces and buildings are formulated and enforced by local authorities in their capacities as lead agencies in delivery of urban services. The power of local authorities to formulate and enforce regulations is entrenched in a country's constitution.

Broadbent (1990) traces the genesis of the prescription of minimum standards for urban living to Britain in the 19<sup>th</sup> century. Public Health Acts were formulated with a view to improve the appalling living conditions of the poor, most of them factory workers. The Acts required that local authorities formulate, and enforce, regulations on the following:

- I. With respect to the level, width and construction of new streets and the provision of sewerage thereof.
- II. With respect to the structure of walls, foundations, roofs and chimneys for securing stability and the prevention of fires and for the purpose of health.
- III. With respect to the sufficiency of space about buildings, to secure a free circulation of air, with respect to ventilation of buildings.
- IV. With respect to the drainage of buildings, from water closets, earth closets, privies, ash pits, and cesspools in connection with buildings, or parts of buildings, unfit for human habitation and to prohibit their use for such habitation.

### **2.4.2 Characteristics of Residential Public Space Environment in Kenya**

Application of the phenomenon of spatial planning to minimization of environmental problems in residential neighbourhoods is limited to physical and site planning considerations. Site planning considerations entail a planner carrying out an analysis of a site with a view to identify and respond to various constraints and potentials for residential neighbourhood development. This is

intended to achieve functional efficiency and at the same time minimize occurrence of environmental problems due to, for instance, location of activities in unsuitable areas of land. Embracing this approach in layout of residential settlements is successful insofar as preserving the quality of land by suitable zoning of activities is concerned. However, this approach does not address environmental decline due to social use of space.

On the other hand, physical planning guidelines spell out desirable qualities in the public spaces of residential neighbourhoods. The guidelines, spelt out in the Physical Planning Handbook (Kenya, 2002), are for consideration in evolution of layouts of residential neighbourhoods and include:

- i) Estate or neighbourhood character: This is described as a spatial planning unit, which is adequately provided for in terms of basic community facilities, served by peripheral and through roads and has an identity. The service centre which forms the focal point of the estate satisfies the minimum walking distance from the perimeter. The population of the estate should be of such a size that local services can support. It recommends that an estate should have a hundred households on the average.
- ii) Density of development: the guidelines stipulate that care should be taken so as to create in spatial and functional meaning an independent system of the built-up area well provided with day-to-day services, recreation and communication network. Table 2-1 below indicates the recommended densities for residential development:

**Table 2-1: Recommended Densities for Residential Development.**

<b>TYPE OF DWELLING</b>	<b>No. OF DWELLINGS PER HECTARE</b>	<b>SPACE ALLOCATION PER DWELLING (SQ. METRE)</b>
<b>BUNGALOW DETACHED</b>		
(i) Low density	10	1000
(ii) Medium density	16	500
(iii) High density	35	285
<b>SEMI-DETACHED AND ROW HOUSING</b>		
(i) Low density	20	417
(ii) Medium density	32	433
(iii) High density	70	250
<b>MULTI-FAMILY DWELLINGS</b>		
(i) Low density	50	200
(ii) Medium density	60	167.6
(iii) High density	70	142.8
(iv) Special density	133	75

Source: Kenya, 2002.

- iii) Plot Coverage: Plot coverage, as applied to building, means the portion of the horizontal area of the site of the building permitted to be built. The essence of fixing plot coverage is to ensure a healthy environment and allow for expansion and improvement of infrastructural facilities and social amenities. The handbook recommends the following maximum plot coverages based on type of residential development (Table 2-2):

**Table 2-2: Recommended Plot Coverages**

<b>TYPE OF RESIDENTIAL DEVELOPMENT</b>	<b>MAXIMUM PLOT COVERAGE IN PERCENTAGE</b>		
	<b>DETACHED HOUSING</b>	<b>SEMI-DETACHED</b>	<b>ROW HOUSING</b>
1. Slum rehabilitation/upgrading	50	65	65
2. Low cost housing	50	60	65
3. Medium and high cost housing	40	50	60

Source: Kenya, 2002.

- iv) **Building Lines (Set-back lines):** The principal value of building lines is either to achieve a visual effect or reserve a certain access of area of ground. It is not necessary to set uniform lines; they may be flexibly drawn to produce spatial coherence and variegated character. The handbook recommends that in prime locations, it may be necessary to set minimum as well as maximum line. Table 2-3 below presents the minimum distance of a building from a plot line (boundary line).

**Table 2-3: Minimum setback of a dwelling from a plot line.**

TYPE OF RESIDENTIAL DEVELOPMENT	MINIMUM SETBACK IN METRES		
	FRONT	SIDE	REAR
1. Slum rehabilitation and upgrading schemes	2.5	1.5	3
2. Low cost housing	3	1.5	4.5
3. Medium and high cost housing	4.5	3	6

Source: Kenya, 2002.

- v) **Street Width:** The handbook stipulates that the width of streets or access lanes in a residential area should be determined by the number of dwelling units or plots to be served. It further recommends that the street network should be hierarchical so that in the future urban areas will have a high rise urban morphology in residential areas. Table 2-4 shows the minimum street width for a given number of plots.

**Table 2-4: Minimum Street width per given number of plots.**

NUMBER OF PLOTS	STREET WIDTH IN METRES
1-20	9
21-50	12

Source: Kenya, 2002.

Despite existence of the guidelines, it is important to mention that environmental problems in public space have remained persistent. Provisions in the Physical Planning Handbook are not consistent with the practice on the ground. For instance, building lines have been violated by constructing buildings to the edge of the plot fronting a public space, raising concern as to

whether this intervention promotes or minimizes environmental problems in public space. The provision of spatial requirements per dwelling in various residential density zones in the City of Nairobi is also much higher. In this respect, the handbook recommends 285 square metres for a detached bungalow in a high density zone whereas in reality it is between 70 and 100 square metres. Whether the provisions actually minimize or promote public space environmental problems is an area that requires inquiry and forms a basis for this study.

## **2.5 Urban Space Structure and its Representation**

Urban space structure has to do with the way different activities are distributed in space. According to Hillier and Hanson (1984), architecture structures the system of space we live and move in, thus giving it shape and form. He points out further that spatial structure has a direct relation to social life in that it sets the material preconditions for patterns of movement, encounter and avoidance, as well as sometimes serving as the generator of social relations. Trancik (1986), in comparing the spatial structures of the traditional and modern city forms, points out that the traditional city is laid out in an orderly manner whereas the modern city is fragmentary. In the traditional city, urban blocks direct movement and establish orientation whereas in the modern city, the fragmentary and confused structure creates disorientation.

In an attempt to bring to the fore the physical manifestation of urban space structure, Trancik (1986) advances three theories of urban space planning and design, two of which are useful in its representation. He denotes them as figure-ground theory, linkage theory and place theory.

### **2.5.1 Figure-Ground Theory**

The Figure-Ground Theory is founded on the study of the relative land coverage of solid masses (the figure or buildings) and open voids (the ground or streets and squares). An urban fabric, in spatial planning terms, is composed of a predominant field of solids and voids (Figure 2-9).

The Figure-Ground approach to spatial planning and design is essentially an attempt to manipulate the solid-void relationships by adding to, subtracting from, or changing the physical geometry of the pattern. The figure-ground drawing is therefore a graphic tool for illustrating mass-void relationships; a two-dimensional abstraction in plan view that clarifies the structure and order of urban spaces.

According to Cuthbert (2007), the two-dimensional concept of Figure-Ground Theory is allied to the idea of Gestalt where black and white, positive and negative, solid and void, are formed by the opposites that define the other. He writes that architects have for centuries used the concept of Gestalt as a method of seeing their designs more clearly.

In the Figure-Ground relationship, the spaces tend to predominate thus heightening the impact of the public realm. Trancik brings out an acceptable situation as that in which space is conceived as a positive entity, much figural, in an integrated relationship with the surrounding solids. Unfortunately though, the modern concept of space-building relationship is the opposite of this in that buildings are figural, freestanding objects, and space is an uncontained void. Trancik enunciates six typological patterns of solids and voids (grid, angular, curvilinear, radial concentric, axial and organic) as a method whereby some more analytical rigour can be obtained.

### ***2.5.2 Linkage Theory***

Trancik (1986) describes linkage theory as the organization of lines that connect parts of a city. In spatial planning and design, these lines are a determinant force on a site and provide a datum on which a spatial plan or design is created. Fundamentally, linkage theory is derived from lines connecting one element to another. These lines are formed by streets, pedestrian ways, linear open spaces (such as river fronts), or other elements that psychically connect parts of the city. Figure 2-5 illustrates a linkage diagram based on streets.

The spatial planner or designer applying the linkage theory tries to organize a system of connections, or a network, that establishes a structure for ordering spaces. The theory places emphasis on circulation diagram rather than the spatial diagram of the figure-ground theory. Movement systems and the efficiency of infrastructure take precedence over patterns of defined outdoor space.

### ***2.5.3 Place Theory***

In advancing place theory, Trancik (1986) argues that for architects to create truly contextual places, they must more than superficially explore the local history, the feelings and needs of the populace, the traditions of craftsmanship and indigenous materials and the political and economic



realities of the community. Essentially, advocates of the place theory give physical space additional richness by incorporating unique forms and details indigenous to its setting. In place theory, social and cultural values, visual perceptions of users and an individual's control over public environment are as important as principles of figure-ground and linkage.

In overall, Trancik has been hailed for advancing theories that clearly expose ideas through which he configures his approach to spatial planning and design. According to Cuthbert (2007), his theories serve to sustain the normal practice of recycling concepts and practices of Modernism all of which embraced the philosophy of physical determinism while paying lip service now and then to social and other factors. He denounces the theories as being theories in a meaningful sense considering that they are detached from any larger picture of society, and explanations as to how such forms come about. He points out that there are no assumptions of any significance that can be made from figure-ground apart from throwing geometry, form and structure into higher relief, none of which means anything without some supporting concepts. However, taken together, figure-ground and linkage theories are useful devices used by architects in spatial arrangements. They stand as good expositions of spatial planning and design techniques but in no sense do they constitute theory in any meaningful way. Place theory, on the other hand, is almost wholly detached from the first two, and tentatively suggests that cultural and human characteristics might have some relevance, without actually defining what these might be.

## **2.6 City Concepts**

### **2.6.1 Garden City Concept**

The Garden City concept was conceived by Ebenezer Howard in the London of 1880s and 1890s with the intention of ameliorating environmental problems that were prevailing in the Victorian City at that time (Hall, 1996). Hunt (2005), in his lecture paper titled "The Rise and Fall of the Victorian City: Lessons for Contemporary Urban Renewal", points out that the Victorian era, which was a period of urban development in Britain in the 19<sup>th</sup> century, expressed itself in an urban form that was in an awful state and had appalling living conditions. The 1820s and 1830s saw migration, urbanization, and the absence of any basic infrastructure leave the city authorities wholly unable to cope with the filth, pollution, overcrowding and disease. Hall (1996) indicates that people lived in abject poverty in cities that were industrializing.

According to Broadbent (1990), Howard's major concern was to stem the drift of population from rural to urban areas. He was to achieve this through establishment of garden cities in the countryside, far enough from the main city. He presented his options as town and country magnets, with each featuring its attractions and corresponding disadvantages. Tables 2-5 and 2-6 below illustrate this.

**Table 2-5: Characteristic Attractions and Disadvantages of Town.**

Attractions	Disadvantages
Social opportunity; places of amusement; high wages; chances of employment; well-lit streets; palatial edifices.	Closes out nature; distances from work; high rents and prices; excessive hours of work; the army of unemployed; fogs and droughts; costly drainage; foul air; murky sky; slums; gin palaces.

Source: Hall, 1996.

**Table 2-6: Characteristic Attractions and Disadvantages of Country**

Attractions	Disadvantages
Beauty of nature, wood, forest and meadow; fresh air; low rents; abundance of water; bright sunshine.	Lack of society; lack of work; land lying idle; long hours; low wages; lack of drainage; lack of amusement; no public spirit; the need for reform; crowded dwellings; deserted villages.

Source: Hall, 1996.

Howard's Garden City concept, presented in plan form (Figures 2-2 and 2-3), combines the advantages of both town and country while eschewing their disadvantages (Hall, 1996; Broadbent, 1990; Trancik, 1986). His concept was for a town of limited size surrounded by agricultural lands and clearly delineated open spaces within. It was in response to the decay and density of the post-industrial city. The benefits of urban and rural existence would be balanced in a self-contained, self-sufficient community.

Howard's proposition was that any actual plan would have to be comprised against the form of the particular site. Despite this, his notional plans clearly illustrate a firm layout on which his ideas are based (Figure 2-2):

- a central garden of some five acres about which all of the city's main functions are grouped concentrically.

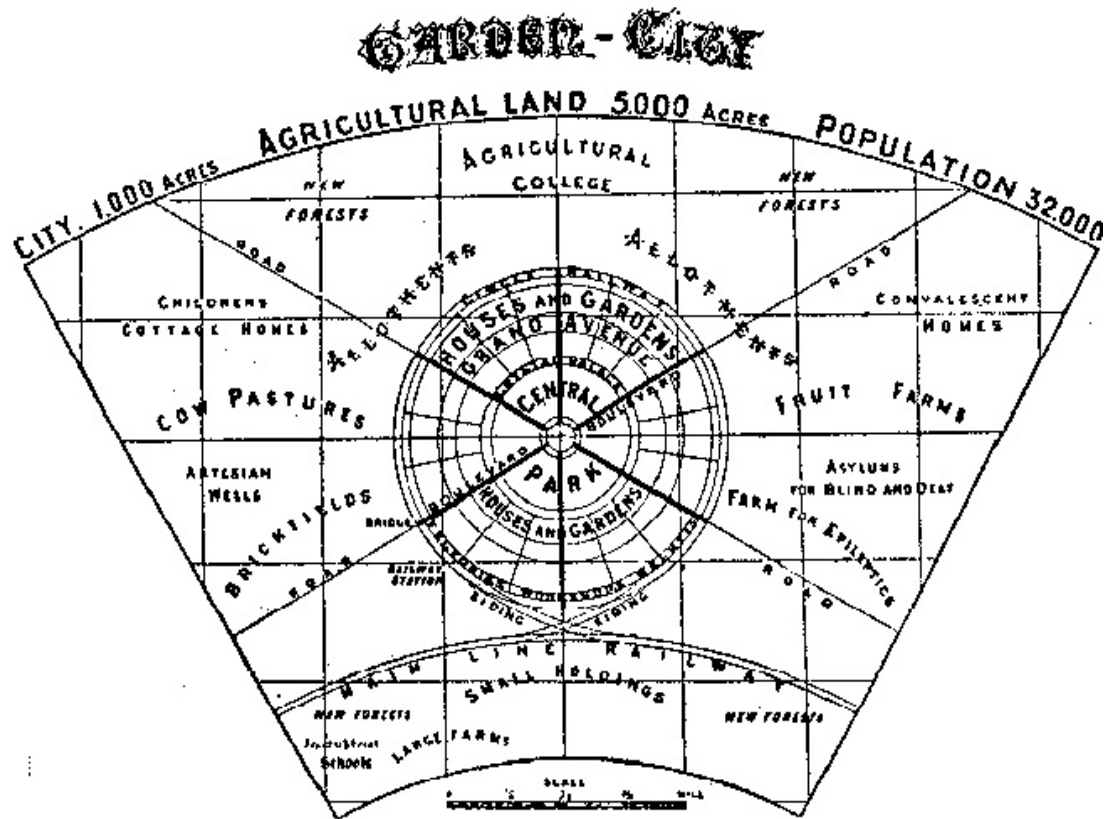


Figure 2-2: Ebenezer Howard's comprehensive plan for the Garden City

Source: Broadbent, 1990.

- The first ring around the central garden: This consisted of public buildings – the town hall, concert and lecture halls, a theatre, library, museum, picture-gallery and hospital.
- A ring of parkland surrounded the first ring of public buildings. The ring of parkland is cut through radially by the six principal boulevards
- Crystal Palace: This was a wide glass arcade which surrounded the ring of parkland. This had openings to the parkland and was one of the favourite resorts of the people. It was a setting for display of manufactured goods for sale. This urban wonder combined in one building all the functions of a Greek Agora, a Roman Forum, and a twentieth century fun palace.

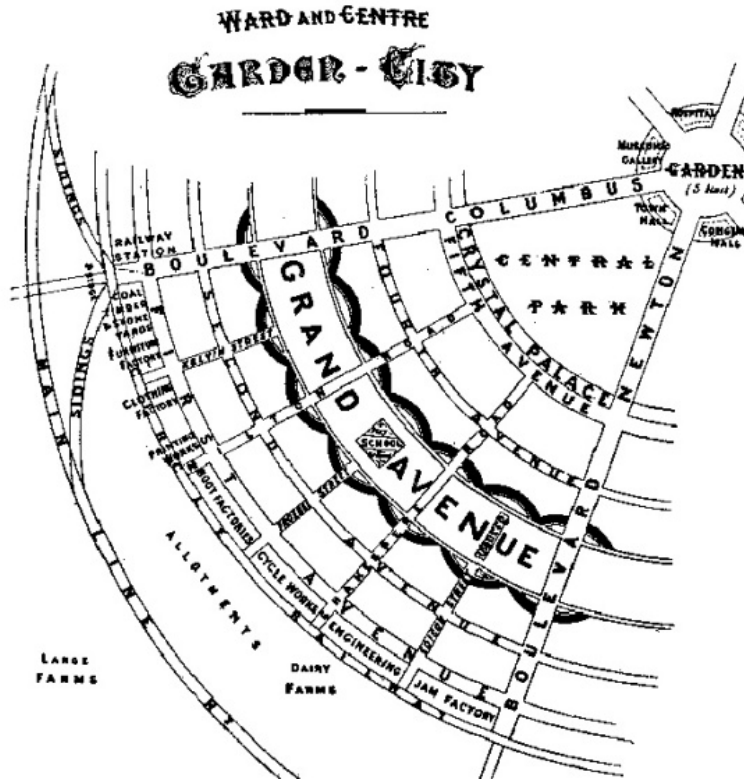


Figure 2-3: Ebenezer Howard's part diagram for the Garden City.

Source: Trancik, 1986.

- A broad ring of houses: this surrounded the Crystal Palace. The houses were to relate with the circulation routes by facing the various avenues (that is, the circulation roads) or fronting the boulevards and roads which all converge to the centre of the town.

There were some 5500 building lots, averaging 130x20 feet, for a population of some 30,000 with a further 2,000 housed on the agricultural estates around the town. He underscores the role of the municipality in allowing people to build houses to their tastes whilst exercising the strictest possible control over proper sanitary arrangements.

- A Grand Avenue: this surrounds the main ring of housing. It was 420 feet wide and formed a 'belt of green' – an annular park, dividing the main part of the town into two concentric belts. The Avenue itself would be divided by the six radial boulevards into six segments, occupied by the public schools, their surrounding playgrounds and gardens, whilst other sites along the Avenue would be reserved for churches. The Avenue itself

was to be bonded by inner and outer concentric roads, themselves lined by houses in looping crescents, thus ensuring a longer line of frontage on Grand Avenue.

- Factories, warehouses, coal yards, timber yards, etc.: these occupied the outer regions of the town, immediately after the outer ring of housing. They were all to have access to circular railway lines which, surrounding the town, enabled goods to be loaded or unloaded at any point for shunting to or from the main line.
- Agricultural uses: some of these included large farms, small holdings, allotments and cow pastures, and occupied the area beyond the railway line.

Howard proposed that once a garden city reached its planned limit, another would be started a short distance away. Thus, over time, there would develop a vast planned agglomeration, extending almost without limit. Each garden city would be connected to the others by a rapid transit system (inter-municipal railway) thus giving all the economic and social opportunities of the giant city. Howard called this polycentric vision Social City (Figure 2-4).

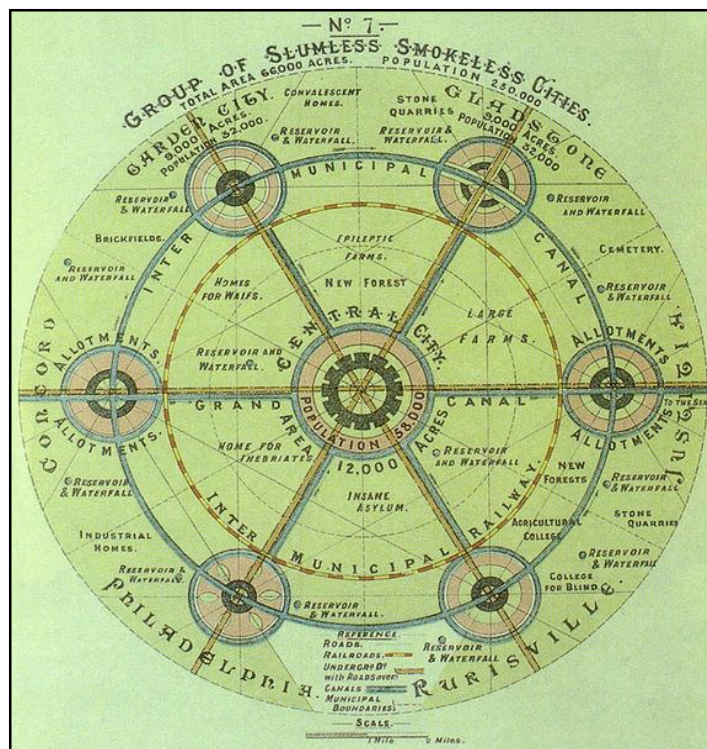


Figure 2-4: Howard's polycentric vision of urban development.

Source: Hall, 1996.

Howard recognized that certain functions – theatres, picture galleries, libraries, universities and so on – could not be sustained, at an adequate metropolitan level, by his Garden City of 32,000 people. He therefore postulated the idea of a Central City – planned much like his Garden City, but with a population of 58,000 – connected to a ring of Garden Cities by a railway-based rapid transit system. Thus residents of Garden Cities would access such central facilities in the Central City within a short period of time.

The spatial plan resulting from Howard's vision reveals a structure of a well-knit interconnected circulation system granting continuity of space (Figure 2-5).

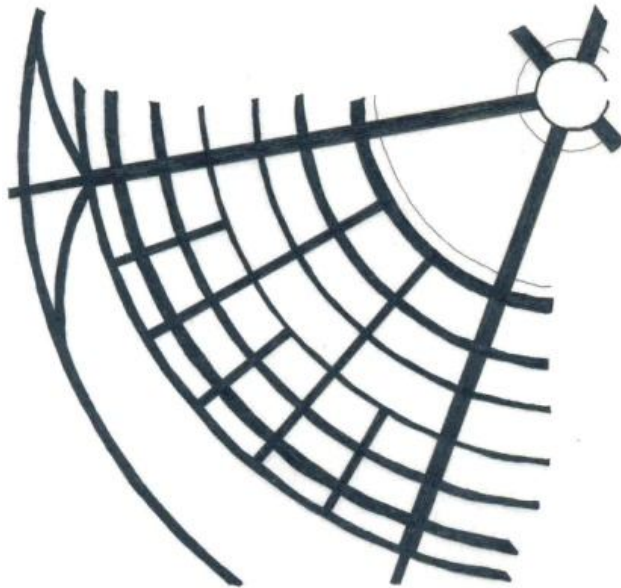


Figure 2-5: Linkage diagram of Howard's Garden City.

Source: Author, based on Trancik, 1986.

The ringy structure segregates motorised and non-motorised transport systems though it is not clear how he articulates points of intersection of the two. Buildings in his envisioned plan relate with circulation routes and open spaces by opening into them (that is, they constitute the public open space). There is continuity of space both within and among the garden cities.

Howard's Garden City concept was a precursor to the Garden City Movement which, according to Broadbent (1990), was a great set of planning conventions. He indicates that these planning

conventions had hardly any effect on the internal planning of existing cities. However, they were intended to free the pressures of such cities by decanting populations to new and much smaller towns, built well outside the city in virgin countryside.

The Garden City concept has had profound influence on the emergent practice of spatial planning. Murakami (1998) writes that the garden village, garden suburb, satellite town and new town were international variants built on the conceptual foundations of the Garden City concept. He points out that Howard's spatial planning concept addressed the subject of sustainability, in its very context of use as from early 1990s. This is seen in his proposed settlements that were of a walking scale within which no one needs a car to go anywhere; high population densities by modern standards, thus economizing on land; and an entire settlement suffused by open space both within and outside, thus sustaining a natural habitat. Murakami (1998) however criticizes the idea in the sense that the method of getting to his invention of a new form of urban development was crude and simple – migration from old cities.

Jacobs (1961) attacks the Garden City concept on the ground that its prescription for saving the city was to do the city in, by defining wholesome housing in terms only of suburban physical qualities and small town social qualities. She criticizes the concept on the basis that it conceived of planning as essentially paternalistic if not authoritarian. She notes that Howard looked at the slums of London and concluded that to save the people, city life must be abandoned. However, her prescription amounted to keeping the inner-city neighbourhood more or less as it was before the spatial planners had got their hands on it. The argument she advances has spatial dimensions to it and include provision of mixed functions, and hence land uses, in neighbourhoods to ensure that people were there for different purposes on different time schedules; provision of conventional streets on short blocks, provision of blocks that are of a mix of different age and condition; and ensuring that a neighbourhood has a dense concentration of people, for whatever reason they are there, including dense concentration of residents.

With regard to description of a settlement layout pattern so as to allow prediction of the likely environmental condition, Howard's spatial planning concept is deficient. Even though the concept can be applied in evaluating functional performance of a settlement spatial plan, it is not a substantial theory that can shed light on similarities and differences of different settlement plans

as far as the relationship between spatial planning pattern and the environmental decay are concerned.

### ***2.6.2 Radiant City Concept***

The Radiant City concept was envisioned by Le Corbusier, an Architect born in Switzerland but migrated to Paris. Hall (1996) highlights Le Corbusier's argument that the evil of the modern city was its density of development, and that the remedy was to increase that density. He advocated for decongestion of city centres by increasing their density - a paradox that has come to be famously associated with him. Other spatial planning factors he advocated for were an improvement in vehicular circulation and an increase in the amount of open space. Fundamentally, Le Corbusier was responding to what he had described as the evil of the street which was to the effect that it was always full of people and also full of rapidly moving vehicles which posed death threats (Broadbent, 1990).

Le Corbusier proposed a resolution of the paradox through a vertical dimension of spatial planning which entailed building high on a small part of the ground area (Hall, 1996). Le Corbusier, in criticizing Howard's Garden City, argued that nature got destroyed under the invasion of roads whereas houses and the promised seclusion became a crowded settlement. His prescription for this weakness lay in the vertical garden city (Broadbent, 1990).

In his quest for orderly development, Corbusier pointed out that the city was dying because it was not constructed geometrically. To solve the environmental challenge of traffic, Corbusier called for total demolition and spatial re-planning of towns. With business being conducted in the centre, it meant that wide avenues had to be driven through the centres of towns.

Corbusier's principles were fully developed in his proposed spatial plan of La Ville Radieuse (Figures 2-6 and 2-7), known as 'The Contemporary City for Three Million Inhabitants', planned for central Paris. It was planned to accommodate as many as six times the population of Central Paris at that time (Broadbent, 1990; Trancik, 1986; Montavon et al., 2006).



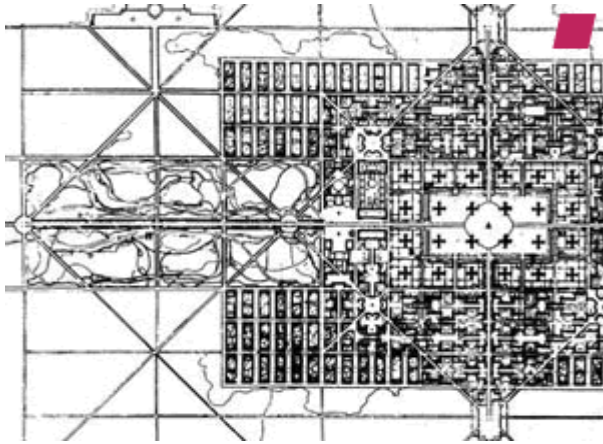


Figure 2-6: Spatial plan for La Ville Radieuse.

Source: <http://www.mediaarchitecture>, accessed Nov. 2009.

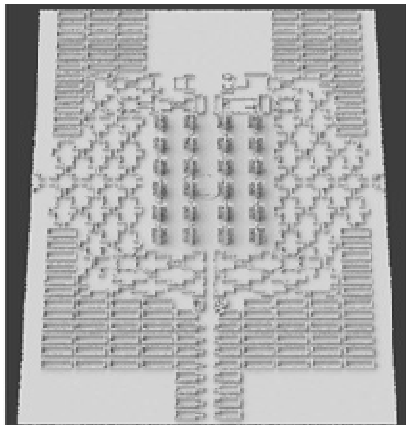


Figure 2-7: 3D rendering of La Ville Radieuse.

Source: Montavon et al., 2006.

According to Montavon et al. (2006), the design of La Ville Radieuse was to address the chaos and inefficiency in many cities in the early twentieth century. The proposal had the following objectives:

- Provide effective means of communication
- Provide a large amount of green area
- Provide a better access to the sun
- Reduce urban traffic
- Accommodate urban population

Instead of being a city *with* gardens of the kind which Howard had proposed, this was to be a City *in* a garden based on four fundamental principles: freeing the centre from traffic congestion,

enhancing the overall densities, enhancing the means of circulation and augmenting the area of planting. Broadbent (1990) further points out that his thoughts were concerned with two aspects of geometric order: the straight line and the right angle. According to him, man walks in a straight line because he has a goal and knows where he is going, whereas the right angle is, as it were, the sum of forces which keep the world in equilibrium. The spatial structure of his plan has the following characteristics:

- a) Rectangular grid: With his views on the right angle, it is therefore not surprising that Le Corbusier's La Ville Radieuse is rigorously Cartesian (Figure 2-6) in its spatial structure. It is drawn within a strict, rectilinear grid (he calls it Cartesian), although like cities such as Washington, has major diagonals.
- b) Central area: There is a central area surrounded by sections within the grid, each measuring 400 yards square.
- c) Streets for fast movement of traffic: Corbusier was preoccupied with the need for designing cities so that traffic could move fast. He proposed new forms of street to facilitate fast movement of traffic. The spatial plan therefore includes elevated motorways, each some 120 feet wide, running straight in the north-south and east-west directions.
- d) Railway station: The City was centred on an underground railway station, with an airport, or at least a landing platform for air-buses and air-taxis – which were supposed to thread their ways through his office towers – on top (ground level). There would also be a large, central intersection there of his motorways (Figure 2-8). Montavon et al (2006) calls this platform the 'Central Terminus' and was an access point to the subway at the lower deck of the underground system and trains at the upper deck of the underground system. The ground level was to be left open to the air-buses and air-taxis.
- e) A Park: The Central Terminus (Transportation Core) itself was to be surrounded by a park, some 2400 by 1500 metres within which 24, 60-storey skyscrapers would be located, spaced some 250 metres apart (figure 2.5). These skyscrapers of the central business district, because of their strict rectilinear geometry he also called Cartesian, were to be cross-shaped in plan. These would be office buildings and at their feet, between them, there would be buildings of two or three storeys in the form of stepped terraces containing restaurants, cafes and luxury shops. There would also be theatres, concert halls and other urban facilities not to mention parking both at ground level, open

to the sky and in multi-storey car parks. Montavon et al (2006) adds that each skyscraper with dimensions of 190m x 190m and a height over 200m were designed to house five to eight hundred thousand people. They point out that Le Corbusier's intention was for this central part of the site to become the civic centre and headquarters of all the leading firms.

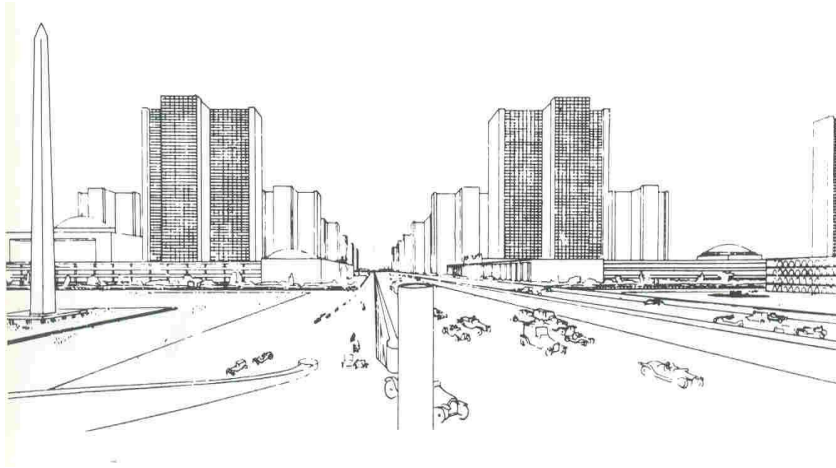


Figure 2-8: Centre of the Ville Radieuse with transport interchange.

Source: Broadbent, 1990.

- f) Public buildings: There would be large public buildings to one side of the centre such as the town hall, museums and other public facilities.
- g) Terraces and apartment blocks: He proposed these two kinds of housing immediately around the City Centre. The terraces would consist of six-storey maisonettes crossing the parkland in rectilinear ribbons and beyond these there would be his apartment blocks: in his familiar form of maisonettes with adjoining balconies (Figure 2-9). Montavon et al (2006) writes that this residential district would provide accommodation to people who work at the skyscrapers in the central business district.
- h) Warehouses, industrial zones and goods yards: These would be built underneath the motorways.
- i) Service zone, forest and grass land: These in turn would surround the city.
- j) A large belt of houses with gardens: Beyond the service zone, forest and grass land, he again proposed a large belt of houses with gardens.

In his Radiant City ideas, characterized by vast glass and concrete tower and apartment blocks, Le Corbusier lay opposed to dispersionist planning. In his conversion of a city into a park, buildings at the city centre would occupy some five percent of land whereas in the residential zone they would occupy some fifteen percent (Broadbent, 1990).

Broadbent (1990) and Hall (1996) write that Le Corbusier's grandiose city planning visions revolve around the themes of the city as a park with (individual) buildings standing within it, the use of a rectilinear (Cartesian) grid as the basis of city planning, and the city designed around a transport interchange.

Trancik (1986) outlines three important principles behind Corbusier's influence on modern urban space:

- a) The linear and nodal buildings as a large-scale urban element – a principle applied physically to define districts or social units. This is especially clear in his figure-ground diagram of Plan Voisin designed in the 1920s though never constructed (Figure 2-9).

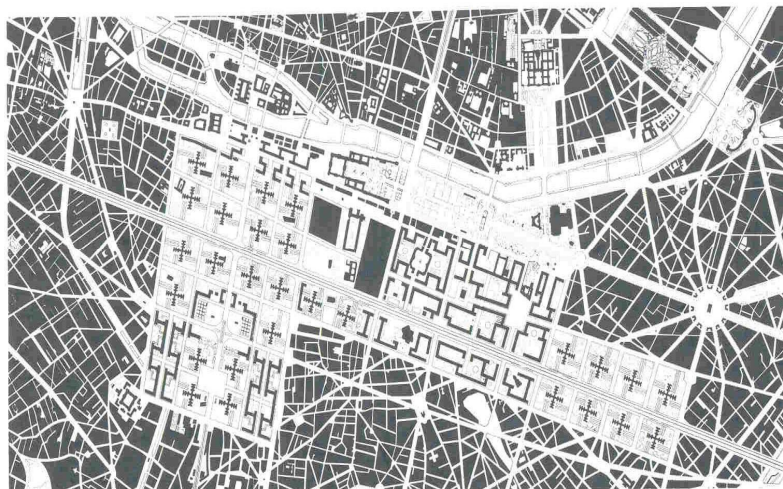


Figure 2-9: Plan Voisin. Figure-ground diagram.

Source: Trancik, 1986.

- b) The vertical separation of movement systems. Le Corbusier was fascinated by the idea of segregated traffic systems and with the emerging transportation technologies of the twentieth century
- c) The opening up of urban space to allow for free-flowing landscape, sun and light (Figure 2-10).

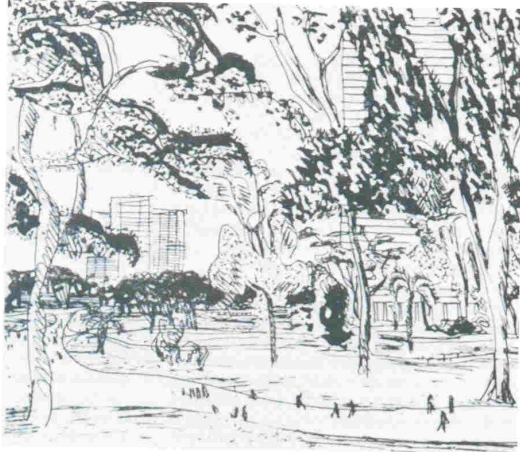


Figure 2-10: La Ville Radieuse. Perspective sketch. 1930.

Source: Trancik, 1986.

Montavon et al. (2006) write that in La Ville Radieuse, the Business District, the Residential District, the Transportation Core and the high street shopping area are organized in a Cartesian way where all elements as a whole function like a 'living machine'.

Despite the richness in Corbusier's grandiose urban visions, none saw light of day, except in the planning of the city of Chandigarh in India. The concept has been criticized by Jacobs (1961) whereby she vilifies it on grounds of egotism. Projects carried out under this concept presented a visible ego telling of someone's achievement. However, she supported the principle of high densities in settlements by arguing that there was nothing wrong with high urban densities of people so long as they did not entail overcrowding in buildings. A good urban neighbourhood, she argued, actually needed 100 dwellings, equivalent to perhaps 200-300 people per acre.

The Radiant City concept presents spatial planning guidelines and considerations which can be used to evaluate the functional performance of a settlement layout. However, they cannot be applied in description of a settlement layout pattern to permit inference on likely environmental implications of the spatial pattern. The concept is also silent on the need to relate buildings to the open space system in order to counter environmental problems such as insecurity. Otherwise, a city can have a large amount of open space that is practically lost.

### **2.6.3 Broadacre City Concept**

The Broadacre City concept was envisioned by Frank Lloyd Wright in 1924. His three-dimensional model exhibited in 1935 at an industrial arts exposition in New York was a revolutionary departure from the concentrated population centre that was still the hallmark of the American city (Fishman, 1977; Hall, 1996; Nelson, 1995).

The philosophy underlying Wright's Broadacre City was a response to the environmental problems prevalent in the centralized modern city. The problems he cites include an overcrowded city due to an overabundance of skyscrapers which accommodate many people; a concentration of traffic within the city due to the higher concentration of citizens inhabiting the city; and a city overwhelmed by pollution due to the traffic problem (Wright, 1958).

As a critic of centralized urban patterns, Wright believed that the large cities of his time, with their limited space, congestion, and "economic artificiality" promoted dehumanizing values, robbed people of their individuality and jeopardized their democratic lifestyle. He felt people would reap the full benefits of the Machine Age only by returning to their natural home, the land (Ibid).

Nelson (1995) points out that Wright's Broadacre City applied the principles of urban decentralization, economic self-sufficiency and individualism. The traditional city, with its masses of buildings, was replaced by small homes dotting the rural landscape. In essence, the city had gone to the countryside since the Broadacre concept eliminated the distinction between urban and rural land uses. The built environment would be distributed over the open countryside and would be so constructed that the inorganic building masses are fused with organic or natural surroundings for harmony.

Individualism was a crucial element of Wright's vision of Broadacre City. According to Nelson (1995) and Rosenbaum (1993), he owed much of this vision to the Jeffersonian democratic value of rural self-reliance. Thomas Jefferson argued through his political life that the foundation of American democracy was rooted in the physical and economic independence of its citizens (Wright, 1958).

Hall (1996) points out that the tenets underlying the Broadacre City concept are by and large the same as those of Ebenezer Howard's Garden City. These include a rejection of the big city, rejection of big government, reliance on the liberating effects of new technologies, organization of residential areas as homesteads, and a return to the land. However, there do exist differences. Wright claimed to liberate men and women not in order to join in co-operation but to live as free individuals. He desired not to marry town and country but to merge them. Above all, Wright had the notion that the new technological forces could recreate in America a nation of free independent farmers and proprietors.

The Broadacre City (Figure 2-11), brings to the fore a well differentiated spatial structure in which various activities lie in their distinct zones. The principal spatial plan features include the following:

a) Usonian home

Wright proposed a Usonian home on a one-acre lot. Nelson (1995) points out that each individual in Broadacre City would be guaranteed one acre of land allowing for a garden or small farm next to the house.

b) Size

Once built, Broadacre City would cover an area of four square miles or 2560 acres and would support a population of approximately 5,000 people in 1,400 homes (Nelson, 1995).

c) Housing for families

Families would be housed in small apartments, single family cottages, worker quarters, or larger hillside houses. Scattered throughout the city would be twelve 15-storey towers designed to contain 33 apartments each. Each person would reside within walking distance of work (Nelson, 1995).

d) Automobile transportation

This would be primarily used to move within and from one Broadacre city to another. Internally, connectivity of different functions would be achieved by a network of roads and highways whose

structure is gridiron. A single freeway and railroad system would provide access to other Broadacre Cities (Nelson, 1995).

e) Institutions

All institutions of advanced society, including factories, schools, store, professional buildings, and cultural centers are scattered among the small farms of the community. Local hospitals, clinics, office buildings, churches and gasoline stations would be located in the midst of farmland and forest, all linked by an extensive network of roads and highways.

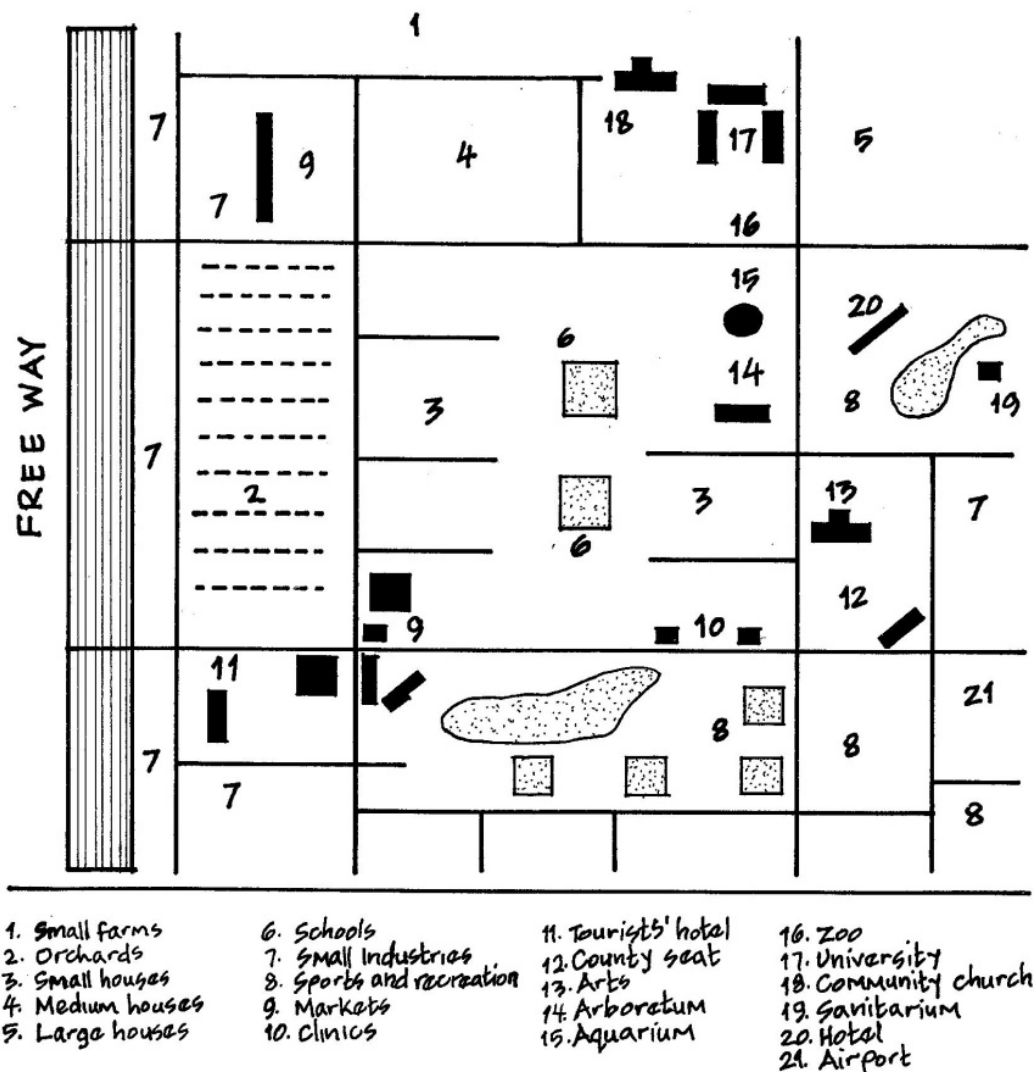


Figure 2-11: The Broadacre City.

Source: Author, based on Nelson, 1995.



f) Continuity of space

There is continuity of space, both within and among Broadacre Cities, provided by the transport infrastructure. Hall (1996) writes that this circulation system providing connectivity is spacious and links various functions such as farm units, roadside markets, garden schools and dwelling places, each sited on its acres of individually adorned and cultivated ground. This vision, making use of elaborate transport infrastructure to achieve aesthetics (through fusion of the organic and the inorganic) and integrate the otherwise segregated functions, is what Wright termed "Usonian" (Wright, 1945).

g) Relationship of public space with private space

In Broadacre City, the various functions on their acres of land (private space) were connected to the automobile circulation system (public open space). Functions in the private space therefore constituted the public open space system.

Broadacre City has been described by Nelson (1995) as having been prophetic of the present-day city. He recommends its application to managing urban sprawl, though with appropriate modifications such as increasing its population to levels that can sustain its functions such as higher education. Its fusion of pre-modern agrarian life and the modern industrial life is successful in managing pollution and congestion. Grabow (1977) criticizes Wright's Usonian Vision for naivety, for architectural determinism, for encouraging suburbanization, for wasteful use of resources, and for lack of urbanity.

In its application to spatial planning, Broadacre City concept can only be seen as set of planning considerations. Its approach to dealing with environmental problems is too simplistic to constitute a model that can be used to predict environmental outcomes of a plan proposal. For instance, the fusion of agriculture with industry is an approach that has an impact in the control of air pollution but cannot be precisely applied in the use of spatial planning to manage the problem given that there is no quantitative relation between the two variables.

## 2.7 Neighbourhood Concepts

### 2.7.1 Perry's Neighbourhood Unit

The idea to plan an urban residential area in the form of a neighbourhood unit was originally put forward by Clarence Perry in the 1920s (Min, 1993; Hall, 1996; Walters, 2007). Perry was a sociologist-planner based in New York. His model was a diagrammatic plan, as shown in figure 2-12 below, proposed for such a residential unit in a city planning hierarchy and it first appeared in his survey of housing planning in the New York Region (Walters, 2007).

According to Min (1993), Perry's model was a result of two motivations. One was to provide some geographical basis for the planning of amenities and traffic layout in association with housing development in modern American cities. Another was an attempt to achieve some social objective mainly through physical planning, that is, by promoting informal, face-to-face contact and interaction among the inhabitants of a local area. He considered this interaction to be fundamental in forming the social nature and ideals of the individual and was especially important in the dense, highly fragmented life of the modern city. Walters (2007) adds that his background as a sociologist made him appreciate the importance of cohesive neighbourhoods as political, social and moral units of a city.

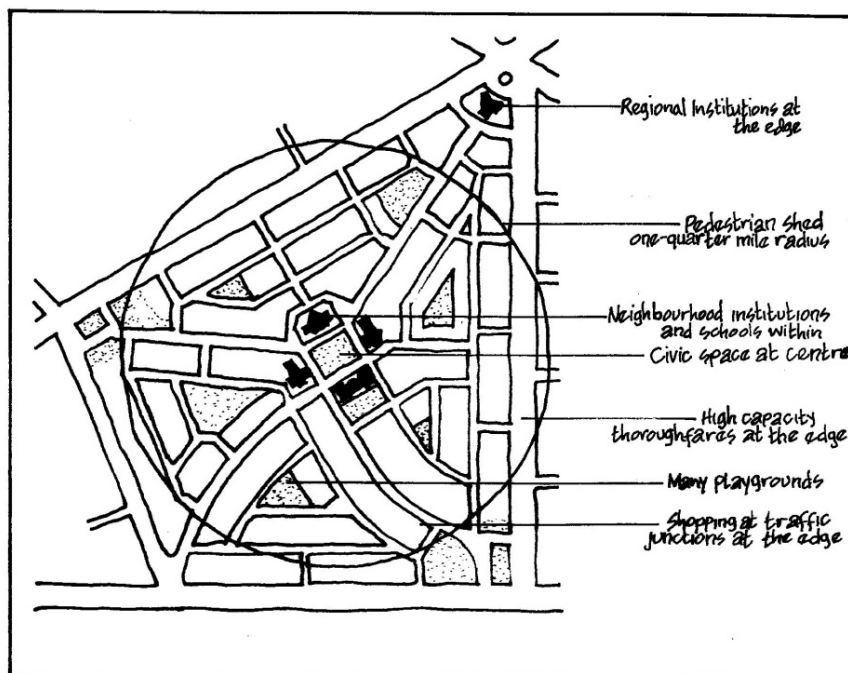


Figure 2-12: Schematic plan of Perry's neighbourhood unit.

Source: Walters, 2007.

In order to create a neighbourhood unit which can satisfy the functional and social objectives, Perry formulated a few spatial planning principles and parameters for its realization:

- (i) Boundaries: He proposed that a neighbourhood unit should be defined on all sides by arterial streets planned to carry all through traffic. The arteries will form the boundaries of the neighbourhood and thus make it a distinct entity.
- (ii) Size: The population of a neighbourhood should be no greater than what is required for supporting an elementary school.
- (iii) Institutional sites, especially schools, should be grouped together to build up a community centre and having equal walking distances (preferably one-half mile) from the farthest dwellings.
- (iv) Internal street system: The street system should be created and disconnected from the surrounding areas. It is specifically to facilitate circulation within the neighbourhood and discourage through traffic.
- (v) Open spaces: Each neighbourhood should have an adequate and integrated network of small parks and playgrounds, planned for its recreational and play needs. The open (green) areas should preferably be 10 percent of the total site area of a neighbourhood.
- (vi) Local Shops: One or more shopping areas sized to serve the neighbourhood's population should be sited along the main streets at the edges of the neighbourhood

From Perry's principles, which have a bearing on space, one can infer the environmental challenges he was responding to. Social fragmentation in urban living was a major challenge he sought to overcome from planning concept. Walters (2007) points out that Perry saw vehicular traffic as a menace that needed to be managed by being segregated from residential areas. Presence of vehicles in residential areas has a bearing on environmental pollution and safety of neighbourhood users. The location of institutions and shopping areas in proximity to dwelling units minimized walking distances and so promoted safety of residents.

The structure of Perry's Neighbourhood Unit, as seen in the Linkage diagram below (Figure 2-13), brings to the fore a number of spatial planning characteristics:

- a) There is continuity of space within the neighbourhood. This is in stark contrast to spatial discontinuities evident in Islamic settlements of the Medieval era in which circulation routes ended up in cul-de-sacs.

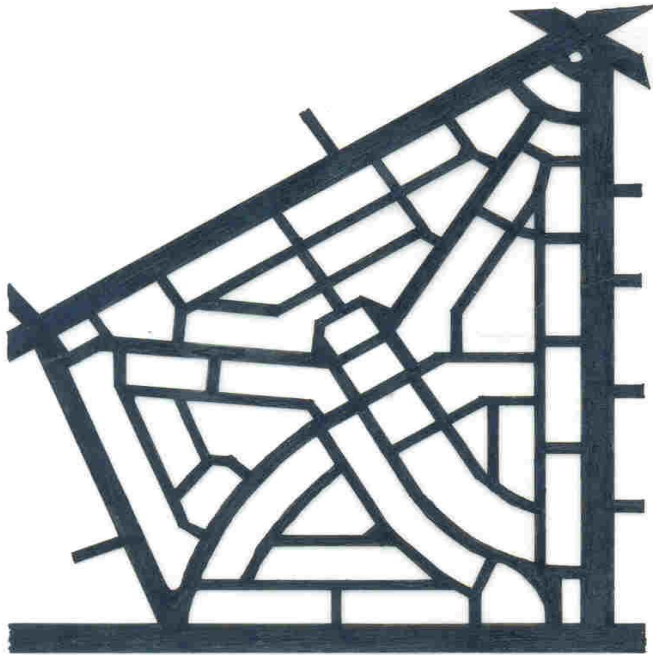


Figure 2-13: Perry's Neighbourhood Unit. The Linkage diagram.

Source: Author, based on Walters, 2007.

- b) There is direct relation of buildings to the public open space; the street. Wherever buildings are sited, the circulation system flows around them.
- c) Disconnectedness in vehicular and pedestrian routes: There is evident distinction in the hierarchy of the circulation system. Vehicular routes are wider and limited to the periphery of the neighbourhood. However, a few pedestrian routes serve as connectors of the motorized route to the rest of the internal pedestrian circulation system.
- d) Control of neighbourhood functions: There is a high degree of control of neighbourhood functions, achieved through boundarization (which promotes social cohesion) and segregation of vehicular and pedestrian circulation.
- e) Presence of people in space: By avoiding the vehicle in the internal space of the neighbourhood, any unfamiliar face therein will be readily noticed. This has its concomitant benefits such as promotion of safety and alleviation of crime.

Since Perry formulated his neighbourhood unit scheme, the neighbourhood unit planning concept has had a world-wide appeal to spatial planning practice (Min, 1993; Chapman, 1996; Hall, 1996; Walters, 2007). Its widespread appeal to urban spatial planning theory and practice is well reflected in the extensive practice of the concept in Britain immediately after World War II (Goss, 1961, in Min, 1993) and in the building of suburban neighbourhoods in African cities, such as Nairobi, ensuing from the process of colonization (Nevanlinna, 1996).

Despite the importance of the concept in neighbourhood spatial planning practice, it cannot be applied to the description of a layout pattern resulting from a spatial planning process, or even allow drawing of inference from any kind of description some knowledge about the environment determined by that layout pattern. Given some welfare targets set by housing authorities or developers, the requirements and parameters of the Neighbourhood Unit model can be used as a criterion for evaluating certain functional performances of neighbourhood spatial layout patterns. However, this approach to neighbourhood spatial layout study hardly contributes to a clarification of differences and similarities between different spatial plans, in terms of the relationship between spatial pattern and observable patterns of use. This is because the spatial form of a neighbourhood has never been a part of the formulation of the functions of a housing development.

### ***2.7.2 Radburn Layout***

Radburn, the 'town for the motor age', was created in 1929 in response to the problems industrialization had resulted to in the United States after World War I. According to Gatti (1989), there was a dramatic growth of its cities in the 1920s owing to migration of people from rural areas, leading to a severe housing shortage. The automobile, which was becoming a mainstay in the American life, added a new problem to urban living. Drastic changes in urban spatial planning were thus necessary to provide more housing and to protect people from the car.

Radburn was planned by Architects Clarence Stein and Henry Wright. The driving guideline was the need to evolve a settlement that guarantees its inhabitants security and happiness. Birch (1980) points out that evolution of the final plan of Radburn (Figure 2-14) was a result of a planning process. First, the planners formulated goals, then collected data, developed and selected a plan, implemented that plan, and later evaluated it.



Figure 2-14: The final plan for Radburn.

Source: Broadbent, 1990.

Spatially, Radburn occupies 149 acres which include 430 single family homes, 90 row houses, 54 semi-attached houses and a 93 apartment unit, as well as a shopping centre, parks and amenities (Gatti, 1989). The primary innovation of Radburn was the separation of pedestrian and vehicular traffic. Distinctive spatial plan characteristics include:

a) The Superblock

This is a large block of land surrounded by main roads (Figure 2-15). The innovation of the superblock replaced the traditional gridiron street pattern and its use in planning was intended to accomplish the separation of vehicular and pedestrian traffic.

b) Cul-de-sacs

The houses in a superblock are grouped around small cul-de-sacs, each of which has an access route connected to main roads. Traffic highways border the superblock. The houses face the front

yards and parks rather than the street. The cul-de-sac roadways are service drives and give access to the rear of the houses. Traffic passes by rather than among the houses.



Figure 2-15: Linkage diagram of Radburn.  
Source: Author, based on Broadbent, 1990.

### c) Park area

The remaining land inside the superblock is the park area and it forms the backbone of the neighbourhood (Figure 2-16).

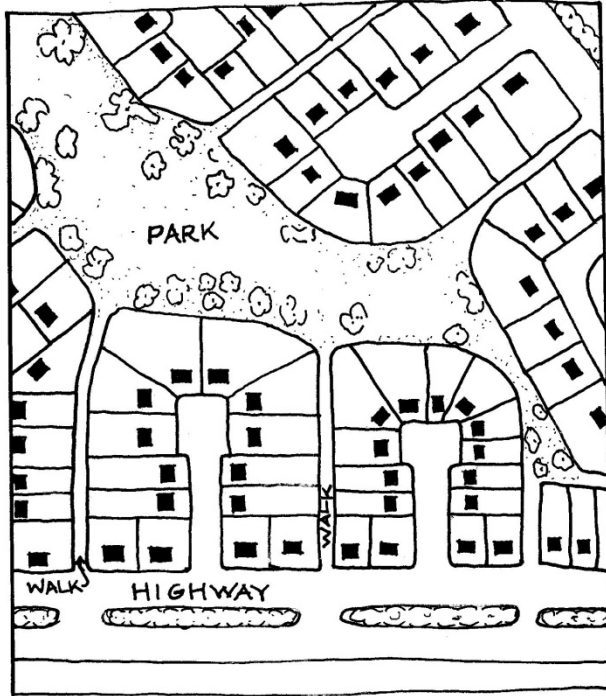


Figure 2-16: The Radburn plan. Relationship of buildings to circulation and park spaces.

Source: Birch, 1980.

d) Relationship of houses to circulation routes and parks

The living and sleeping sections of the houses in Radburn layout face toward the garden and park areas, while the service rooms face the access road (Figure 2-17).



Figure 2-17: The Radburn Layout - Model.

Source: <http://www.artistsdomain>, accessed November 2009.

e) Pedestrian walks

Pedestrian pathways surrounding cul-de-sacs on the garden side of the houses divide the cul-de-



sacs from each other and from the central park area (Figure 2-18).

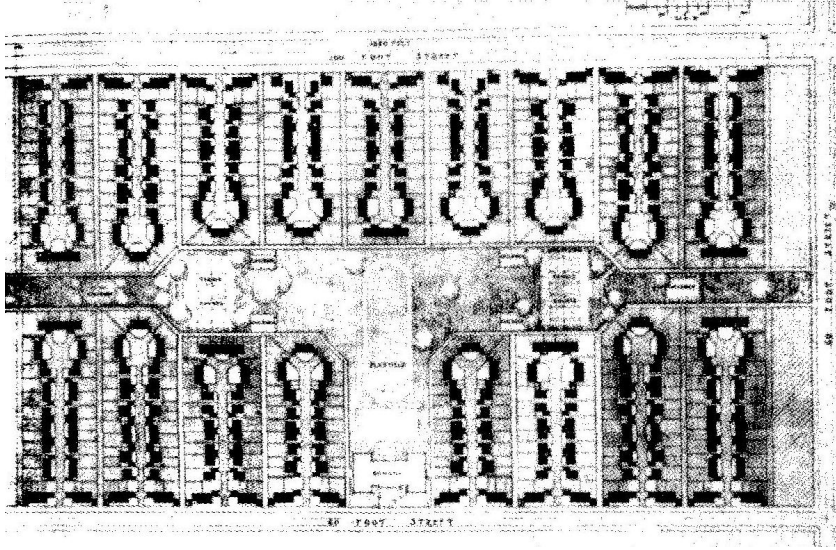


Figure 2-18: Radburn Layout. A theoretical study of residential courts.

Source: Broadbent, 1990.

f) A pedestrian underpass and an overpass

These were provided to link the superblocks in order to further maintain the separation of vehicular and pedestrian traffic (Figure 2-14).

g) Connectivity of circulation space

Pedestrian and vehicular circulation routes in Radburn layout were each interconnected. The pedestrian system, for instance, was so devised that one could start at any given point and proceed on foot to school, stores or church without crossing a street used by automobiles.

h) Continuity and discontinuity of public open space

There is continuity of public open space except in the cul-de-sacs (Figure 2-15).

The spatial plan of Radburn has been hailed for its inspiration to planners and architects in the United States and abroad (Hall, 1996). According to Lavelle (2009), Radburn was unique because it was envisioned as a town for better living, and it was the first example of city planning which recognized the importance of the automobile in modern life without permitting it to dominate the environment. He points out that it had a strong community focus with residents

participating in environmental management. The residents paid a membership fee towards year-round recreation programme and maintenance of parks and a community centre. The spatial planning of Radburn managed well the environmental problem of motor accidents. It also allowed for natural surveillance of the open space system within vicinity thus promoting security.

Despite the strengths inherent in the Radburn spatial model, Lavelle (2009) outlines its characteristic shortcomings as follows:

- i) Cul-de-sacs: There is profusion of dead ends resulting in spatial discontinuity, disconnectedness and a lack of legibility.
- ii) Alleyways: These have no natural surveillance.
- iii) Management and maintenance: There are large amounts of anonymous public space, and an obligation for communities to pay a great deal for the upkeep of such space. The spatial layout therefore has difficulties as far as effective management and maintenance is concerned.
- iv) Concentration of predominantly disadvantaged people: Such include poorer social tenants, the elderly and single parent households.

According to Martin (2009), the inward focus of Radburn layout presents difficulty in wayfinding for visitors unfamiliar with the inner connections that residents understand. Its other problem is the ambiguity presented by reversed houses that subvert conventional behavioural norms regarding front and back doorways.

Lavelle (2009) writes that some spatial interventions have been advanced with a view to uplift Radburn estates. These include various combinations of reconfiguring estates; reversing layouts, infilling new housing, deconcentrating estates, and replacement of public space with private gardens in order to boost the residents rights to buy the properties. He however notes that privatization of open space implies a reintroduction of street patterns and a reintegration of cars and pedestrians on shared routes. He also notes that heavy costs will be incurred in rerouting of services that comes with reversing layouts of housing, that is, making backs into fronts and vice versa).

The above shortcomings notwithstanding, the Radburn layout has informed residential

neighbourhood planning world over. This is especially the case when it comes to avoiding traffic hazards. However, insofar as description of a spatial planning pattern and using it as a functional formulation of environmental management, the Radburn model is deficient.

### **2.7.3 Corbusian Vertical Neighbourhood Unit**

Le Corbusier's motivation for vertical neighbourhoods lay in what he felt of Howard's Garden City – nature melting under the invasion of roads and houses and the promised seclusion turning into a crowded settlement. Broadbent (1990) notes that in his proposed Radiant City, the residential district of vertical neighbourhoods surrounded the City Centre (Figure 2-7). He documents that these consisted of two kinds of housing: terraces and apartment blocks. The terraces consisted of six-storey maisonettes crossing the parkland in rectilinear ribbons whereas the apartment blocks beyond consisted of his familiar form of maisonettes – with adjoining balconies hollowed into the facades of the blocks. He points out that the whole arrangement was intended to open up day-to-day living to sunlight, fresh air and greenery (Figure 2-19) in a way which was quite impossible in the narrow streets of the medieval city, or even the wider streets of the 19<sup>th</sup> century city. For there, even if the sun could penetrate at certain times of day, the houses faced into each other and there could be no privacy.



Figure 2-19: Vertical neighbourhood unit.

Source: Broadbent, 1990.

In managing the issue of privacy, Le Corbusier's apartment blocks were to be wide-spaced in his parkland; and this, not to mention the trees, would afford sufficient privacy for one to pursue his activities in his balcony, free from the prying eyes of distant neighbours.

Le Corbusier's lower-rise setback housing would consist of two-storey maisonettes varying from six to twelve storeys high. Broadbent (1990) writes that they would meander across the parkland in a Cartesian arrangement of open, U-shaped courtyards with connecting blocks. He notes that Le Corbusier gave considerable thought to, among other things, the separation of his fast motor tracks, slower access roads and pedestrian routes.

Buildings in the residential district occupied some fifteen per cent of the land, leaving the rest for open green courtyards. Montavon et al. (2006) underscore that with this approach, formation of concrete canyons could be avoided and inhabitants would be able to enjoy the large amount of gardens and open green spaces provided. Moreover, the apartments would have full daylight access and the urban noise problem would be reduced to the minimum. They note that inside the housing blocks, known as apartment-villas, each duplex has its own hanging garden and according to Le Corbusier, each apartment is a house on its own.

The Corbusian vertical neighbourhood has the strength of accommodating a high density of population without compromising on the open space needs. However, it is just a spatial planning idea that does not yield a spatial planning description that can be used to formulate environmental function. He fails to address the issue of spatial relation of the neighbourhoods with the public space – one of the factors that could have led to the collapse of the Pruitt-Igoe housing, conceived under this line of thought.

#### ***2.7.4 Pruitt-Igoe Housing Scheme***

Pruitt-Igoe was an award winning 1955 project in St. Louis, America, which was designed by distinguished architect Minoru Yamasaki along the Corbusian Model. Hall (1996) documents that it achieved notoriety by being blown up seventeen years after it was built (Figure 2-21). Initially a design showpiece (Figure 2-20), the high-rise flats became one of the worst urban slums in the United States.



Figure 2-20: Pruitt-Igoe as looked for a short while at the start.

Source: Hall, 1996.



Figure 2-21: Pruitt-Igoe at the moment of its demolition in 1972.

Source: Hall, 1996.

According to Hall (1996), the environmental condition of the public housing project was abhorring. He describes the project as weak in design, badly equipped, inadequate in size, badly located, unventilated, and virtually impossible to maintain. Newman (1972), in also recognizing design weakness as the first culprit, indicates that the architect was concerned with each building as a complete, separate and formal entity, exclusive of any consideration of the functional use of grounds or the relationship of a building to the ground area it might share with other buildings. Failure to consider these spatial relations could have contributed to the awful environment at Pruitt-Igoe. Hall (1996) notes that in this scheme, glass, rubble and debris littered the streets. Abandoned automobiles had been left in parking areas, street lights were inoperative and abandoned rooms were receptacles for all manner of waste. Mice, cockroaches and other vermin thrived in the open areas.

For Jacobs (1961), the Pruitt-Igoe project represented an architect's ego-trip. Just like other

Corbusian layouts in American public housing projects, the buildings were freely positioned in the landscape, invariably with entry from the grounds and not from the streets. According to her, this feature, plus the long high-level across docks, created the maximum possible area of what Newman (1972) calls indefensible space. Such spaces soon became vandalized and feared. Jacobs recommendation for avoiding the environmental problems of vandalism and fear in space entailed spatial consideration of the relationship of buildings to the streets.

The kind of families that lived in Pruitt-Igoe housing project contributed to the resultant environmental condition. Newman (1972) argues that the worst deterioration occurred when government policy was changed to admit problem families, many from rural backgrounds, into public housing in 1965. He records that in the next seven years, the high-rise buildings to which they were admitted underwent systematic decimation. The root cause, according to him, was that very poor welfare families, with large numbers of children, with a deep fatalism about the power to influence their environment, could not cope with this kind of building nor, it with them. He adds that the income level of a family is critical to comfortable living in such environments. He recommends this housing situation to middle- and upper-income families, with a proportion of children that did not exceed 5 per cent. He notes that while a middle-class family will not perform too differently in one building type versus another, the performance of a welfare family proves to be greatly influenced by the physical environment; for them, he recommends that the high-rise apartment building should be strictly avoided.

Newman quickly draws a conclusion that high-rise developments are not appropriate for welfare families, basing his assertion on what happened in one housing scheme. His statement is simply normative as it lacks any empirical basis. It is necessary that the influence of a physical setting on social use of space is scientifically established in order to inform decisions on spatial interventions.

## **2.8 Urban Ecology and City Form Concept**

This approach to spatial planning of cities was envisioned by Ian McHarg (McHarg, 1969) and later advanced by Michael Hough (Hough, 1995). The central theme of this concept is that of ecological determinism. The authors demonstrate that the bio-physical processes that shape the physical landscape are deterministic; they respond to natural laws and are form-giving to natural

adaptations. In this spatial planning approach therefore, nature is a fundamental force that determines the morphology of cities and human endeavours.

In contextualizing ecological determinism to the urban environment, urban ecology is recognized as a force that shapes human environments, both physical and social. This force comprises the total urban landscape and the people who live there, including the unstructured spatial and social environments.

According to this approach, the perceptual distinction between city and countryside is the root cause of many social and environmental conflicts being experienced. With the presence of cheap energy, the modern city is shaped and sustained by a technology whose goals are economic rather than social or environmental. This has led to alienation of city and country and a misuse of urban and rural resources. Its various processes, such as storm water drainage and sewage disposal, have contributed to pollution loads of an already overstressed environment. There exists a preoccupation with aesthetic design conventions that are more concerned with 'pedigreed' landscapes than with the forms that have evolved from the necessity of conservation. Consequently, the city has failed to become environmentally and socially healthier, and a civilizing place in which to live.

To counter the above environmental challenges, Hough (1995) recommends urban ecology as an indispensable basis for spatial planning. This entails application of planning and design principles, responsive to urban ecology, to the opportunities the city provides through its underlying bio-physical determinants which consist of nature and its various processes.

The ecological approach to spatial planning of cities is an essential determinant of urban form and environment. However, with regard to understanding the relationship of space and environment, the approach is limited though it spells out factors that a spatial planner will need to consider when evolving a human settlement. Whereas the way urban spaces are used is a measure of the attitudes and values of people in relation to the places they live in, the approach does not delve into explaining this relationship. However, the criterion can be used to indicate and compare environmental performances of different settlements on the basis of ecological parameters.

## **2.9 New Urbanism**

New Urbanism is an urban design movement that derives its principles from design standards of the traditional city. The movement arose in the United States of America in the early 1980s and has since had impact in reforming many aspects of spatial planning at different scales: city, region, neighbourhood and single buildings. The Congress for New Urbanism, founded in 1993, is the organizing body for New Urbanism ([www.Wikipedia.com](http://www.Wikipedia.com), accessed October 2011).

### **2.9.1 Principles of New Urbanism**

New Urbanism is characterized by a number of principles:

1. **Walkability.** The principle advocates for a 10-minute walking between home and work. It supports a pedestrian-friendly street design consisting of buildings close to a street; porches, windows and doors; tree-lined streets; on-street parking; hidden parking lots; and narrow, slow speed streets.
2. **Connectivity.** New urbanism advocates for an interconnected street network which distributes traffic and eases walking. The circulation network, which is predominantly pedestrian, is characterized by a hierarchy of streets such as boulevards and alleys.
3. **Mixed use and diversity.** This entails a mix of shops, offices, apartments and homes on the same site. The movement supports mixed use within neighbourhoods, blocks and buildings. The people planned for are diverse in regard to age, income level and culture. Housing is of mixed typologies and sizes in proximity to one another.
4. **Quality architecture and urban design.** The movement advocates for aesthetics, human comfort and sense of place; allocation of civic uses and sites within community; and human scale architecture and beautiful surroundings to nourish the human spirit.
5. **Traditional neighbourhood structure.** A neighbourhood should have a discernible centre and edge, public space and a range of uses and densities within a 10-minute walk.
6. **Increased density.** A settlement should be accorded convenient and enjoyable places to live in. This is realized by having more residences, shops and services closer together for ease of walking.
7. **Smart transportation.** Cities, towns and neighbourhoods should be served with a network of high quality trains to achieve interconnectivity. The movement favours pedestrian-friendly layouts that encourage greater use of bicycles, scooters and walking as a means



of meeting daily transportation needs. According to Haas (2012), cities planned and designed in keeping with the principles of New Urbanism are described as smart cities. They are smart in the sense that they are able to adapt to new technologies of the twenty-first century.

8. Sustainability. The movement favours minimal environmental impact of development, eco-friendly technologies, energy efficiency, less use of finite fuels, more local production, less driving and more walking.
9. Quality of life. The principles collectively add up to a high quality of life and create places that are desirable

Newman et al (2012) describes cities whose planning and design reflect the principles of New Urbanism as resilient. Accordingly, besides being smart, the cities are secure and sustainable. They are secure in the sense that they have built-in systems that enable them to respond to extreme events as well as being built to last. They are sustainable in that they are part of the solution to the big questions of sustainability such as how to protect biodiversity.

Generally, New Urbanism spells out considerations for realizing livable and environmentally sustainable settlements. However, the considerations are merely normative statements whose empirical basis is lacking. With regard to description of a settlement layout pattern in a manner that permits prediction of outcomes of social use of space, the approach is deficient.

## **2.10 Theory of Site Planning and Human Behaviour**

According to sociologist Robert Gutman (Gutman, 1966), there is something special about a site plan which distinguishes it from other phenomena whose relation to behaviour usually is studied by the behavioural sciences. He calls this feature the spatial quality of the site plan and indicates that it is what removes it out of the ontological category of social facts and into the realm of non-social facts.

In order to study a site plan, Gutman advances a perspective that should first make a distinction between the "non-social" and "social" aspects of the site plan, that is, a distinction between the site plan as a physical variable and the activities, or "social and psychological variables". In order to describe a physical variable like site plan, such that its relation to different behaviour variables

can be systematically investigated, Gutman considers that a kind of typology which allows description in greater precision of the spatial properties of a plan is needed.

### **2.11 Theory of Territoriality**

The theory of territoriality was conceived by Oscar Newman and seeks to relate the spatial dimension in urban form to social behaviour. It sees the spatial structure of human settlements essentially as a hierarchy of territorial claims.

The central tenets of the theory are twofold: first, the organization of space by human beings is said to have originated in and can be accounted for by a universal, biologically determined impulse in individuals to claim and defend a clearly marked territory, from which others will be – at least selectively – excluded. Second, this principle can be extended to all levels of human grouping in that, all significant human collectives will claim and defend a territory in the same way an individual will. The theory proposes in effect that there will always be a correspondence between socially identified groups and spatial domains, and that the dynamics of spatial behaviour will be concerned primarily with maintaining this correspondence. The theory asserts by implication that space can only have social significance by virtue of being more or less unequivocally identified with a particular group of people. He points out that the whole approach to urban pathology has grown out of the alleged breakdown of territorial principles in towns and cities (Newman, 1972). Accordingly, Newman points out that the most typical embodiment of this theory is found in spatial planning studies which find that the definition of space and spatial relations has the power to prevent crime. In this regard, the theory advocates for differentiation of urban space essentially as a series of domains with different degrees of accessibility, namely the public, semi-public and semi-private, and private continuum.

Hillier (1988) points out that the territoriality theory has had a profound influence upon people's views about spatial morphology. He alludes this scenario to the simplistic nature of the model offered by this theory as far as the relation between space and society is concerned. The model is easy to conceptualize in spatial form. Despite these merits, he raises two problems of territoriality theory in its application to research, spatial planning and design. The first problem is whether complex physical phenomena like settlement layouts could be thought of primarily as a

hierarchy of crudely defined socio-spatial domains. He notes that in some modern housing settlements, especially in those where some clear, hierarchical correspondence between dwelling groupings and spatial definitions were pursued without any explicit reference to the territoriality theory, it is probably true that the public/private continuum does seem to apply to certain morphologies. In most urban settlements with more complicated layout patterns, however, it will be far more difficult to describe these patterns according to the oversimplified scheme, without generating too many contradictions as regards which spatial domain exactly coincides with which social domain. Hillier and Hanson (1984) point out that some forms of group organization lack a territorial dimension. The second problem is that the theory represents a view which denies the morphological diversity of urban settlements and the richly overlapped uses brought about by this morphological diversity.

According to Hillier and Hanson (1984), an obvious trouble with the territoriality theory is that, because its assumption is of a universal drive, it cannot in principle account for the evidence. If human beings behave in one spatial way towards each other, the theory becomes limited in accounting for the fundamental differences in physical configuration, let alone the more difficult issues of the degree to which societies order space and give significance to it. In other words, it is unable to explain a variable by a constant.

Hillier and Hanson (1984) locates the territoriality theory among cognitive theories. In such theories, what are at issue are 'models in individual minds' of what space is like: models that condition and guide reaction to and behaviour in space. They have argued that if territoriality is a theory of fundamental similarity, cognitive theories tend to be theories of cultural or even individual difference. They note that the cognitive approach is less ambitious theoretically because it does not aim to provide a universal theory of space; rather it is concerned to provide a methodology of investigating differences. Studies along these lines are therefore extremely valuable in providing data on differences in the ways in which individuals, and perhaps groups, cognize their environment. The order that is being sought lies in the mind and not in the physical environment itself and certainly not in the social structuring of the physical environment. Cognitive studies then, where territoriality theory falls, provide a useful method, but not a theoretical starting point for an inquiry into the social logic of space itself.

## 2.12 Theory of Urban Space

Krier (1979), in an attempt to describe urban space in some European historic cities, builds a spatial typology of urban squares. This description is based on a number of streets intersecting a square and the mode of such connection, thus singling out the topological properties of these squares as some criteria for classification.

In dealing with urban space, he argues that we must seek a social foundation for urban form for the simple reason that while historically derived urban forms may be defined and used rationally as a vocabulary, their meanings are wholly contextual. The implication behind this, as brought out by Cuthbert (2007), is that meanings are not given to buildings and urban spaces by designers, but are semanticized by populations in the local context.

Krier, in his theory of urban space, identifies the environmental challenges in the city's public open space as being twofold – pollution and the ubiquitous car. He points out that the problem of urban hygiene is as old as the city itself and that in the pre-car days, pollution in the city was by horse manure, stinking sewage, and uncollected refuse. With the advent of the car, the air is polluted by exhaust fumes and scarcely by horse manure. On the other hand, he writes that the automobile continues to occupy streets, consequently excluding all other users. Krier however does not recommend the separation of pedestrians and vehicular traffic as this carries with it the danger of the isolation of the pedestrian zone. He instead advocates for solutions which are carefully worked out to keep the irritation of traffic noise and exhaust fumes away from the pedestrian, without completely distancing one zone from the other. He prefers an overlap of these functions which should be achieved with considerable investment in the technological sphere. He also underscores that the number of cars, and their speed, remains a source of anxiety in the urban area.

Krier (1979), in his theory of urban space, argues for both historical and contextual. In recognizing that spatial form and meaning should be interpreted in the context of culture, he underlines the position of social foundation in spatial planning. With an architectural inclination, however, Cuthbert (2007) observes that he adopts a wholly functionalist stance to his analysis of

urban form. Despite this, Cuthberth (2007) underscores that his theory is one of the most sophisticated attempts to combine the social with the physical.

This theory seems to be preoccupied more with the local relationship of urban spaces rather than the open space continuum of settlements as wholes. Krier, accordingly, has not bothered to develop some theoretical framework for examining urban spatial plan forms in terms of the principles or regularities which may have governed the dynamic relations between local changes and the formation of some overall patterns or structure.

### **2.13 Space Syntax Theory**

Space syntax theory describes and measures quantitatively the relational properties of urban space (Baran et al, 2008). It was conceived by Hillier and Hanson at the University College London (Hillier and Hanson, 1984).

The theory advocates for a research which directly addresses the physical and spatial complexity of the built environment itself as the main variable of interest, and explores any effects it may in itself have on the functioning of the urban system (Hillier, 1998). For such research to be effective, the theory requires that the physical complexity variable must be controlled at the level at which spatial planning decisions are made. Space syntax research thus attempts to do this by treating built environments as systems of space, analyzing them 'configurationally', and trying to bring to light their underlying patterns and structure.

The theory is hinged on addressing the subject of spatial 'complexity' in human settlements as far as their description is concerned. According to Hillier (1998), space syntax research is an answer to the challenge of describing the physical complexity of a settlement with sufficient rigour and consistency to permit it to be controlled as a variable in research. The question addressed by space syntax research is always, "What, if any, is the effect of the built environment itself on what happens in cities?" The approach is contrasted with policy-oriented urban research which seeks to understand what variables, including the built environment variables, are involved in seeking overall social goals, the answers to which are more likely to be found in regulation or behavioural change rather than through change to the built environment.

Space syntax theory uses spatial representations as a basis of describing human settlements. It analyses the spatial representations of the settlements to try to understand their structure, and then investigates how this structure is related to observable function. Space syntax is therefore a general means for investigating the relation between the structure and function of human settlements. Aspects of function which the space syntax theory and method has been used to predict include movement (Hillier, 1998; Baran et al., 2008), land use patterns, social and economic performance, among others (Hillier, 1998). Syntactic measures that are largely used in settlement plan analysis include axiality, convexity, distributedness/non-distributedness, symmetry/asymmetry, constitutedness, integration, connectivity, choice and control (Hillier and Hanson, 1984; Baran et al., 2008). Such relational properties rest on assumptions, for instance, that longer lines of sight, fewer turns, higher connectivity and a high ability to reach points from every other point in space are desirable (Baran et al., 2008) and thus enhance environmental management in a settlement.

In description and analysis space, space syntax seeks to understand the emergent structure of an urban settlement and to account for its constructive its functional impacts. Space syntax, when applied to description of a settlement plan, makes possible prediction of likely outcomes of social use of space. In this regard, and in comparison with the other theories, space syntax defines a better platform on which to study spatial planning of residential neighbourhoods.

## **2.14 Conceptual Framework**

From the theoretical framework, this study appreciates that spatial structure of a settlement has an impact on observable function – in this case, the resulting quality of environment. Other than the space syntax theory, all the other theories and concepts are limited as far as it concerns the description of spatial plan structure in a manner that permits prediction of likely functions. Space syntax theory presents a framework for structuring the public space system into smaller spatial units that permit systematic analysis. In this regard then, space syntax is adopted as the conceptual framework to guide this study. Spatial planning variables in the space syntax theory which are used in this study include constitutedness, connectivity, integration and control. However, space syntax variables, on their own, present a narrow scope in the endeavour to understand the influence of spatial planning on environmental status. In view of this, other public space variables are drawn from the physical, social and economic characteristics of space so as

to aid a holistic understanding of the relationship between spatial planning and environmental status. Save for space syntax variables, the other public space variables are based on theories in the theoretical framework. These variables collectively form the independent variables for the study. On the other hand, dependent variables are drawn from the environmental problems in public space. Independent variables are regressed against dependent variables to establish the extent to which the latter are explained by the former. Both the independent and dependent variables are reflected in the observation schedule presented as Appendix 2.

### **2.15 Conclusion**

This chapter has elucidated the concepts of spatial planning and environmental while bringing out the link between them. The current practice of environmental management in the city of Nairobi is guided by normative statements in the form of physical planning guidelines whose empirical basis is lacking. The chapter realizes a conceptual framework largely underlain by the space syntax theory and method as its guide. The overall approach to the inquiry of the city's residential public space environment is presented in the next chapter of the study.

## CHAPTER THREE

### 3.0 OVERALL RESEARCH APPROACH

#### 3.1 Introduction

This chapter provides the overall approach and method adopted to study public spaces of sample residential neighbourhoods in the City of Nairobi. It looks at various aspects of the study area with a view to provide the setting of the subject under inquiry. These include the locational context, emergence and growth of the City of Nairobi, climatic and physical characteristics, and the housing situation in the city. Further, the chapter formulates and presents the methodology embraced to study the spatial characteristics and environmental problems of the public space system of sample residential neighbourhoods in the study area. Central in the methodology is sampling design, methods and techniques of data collection and analysis and interpretation of data. The neighbourhoods include Lavington, Parklands, Mitini, Buru Buru V, Otiende, Pangani, Tena, Umoja II, Madaraka and Ofafa Maringo.

#### 3.2 The Study Area in Context

This study is set in the City of Nairobi. Various aspects characterizing the city include its location, history and growth, climate, topography, soils, infrastructure and services, spatial structure and housing. These are discussed in the subsections that follow.

##### 3.2.1 Location

Nairobi is the capital city of Kenya. According to the Atlas of Nairobi (Herzog et al, 2007), the city lies at an altitude of 1670 metres above sea level and is situated at longitude 36°50' east and latitude 1°17' south. It covers an area of 695.1 km<sup>2</sup>. It is located 495 kilometres away from the port city of Mombasa on the Indian Ocean and 338 kilometres away from the city of Kisumu on Lake Victoria to the west (Figure 3.1).

The city's spatial plan character is such that it has planned and unplanned zones. Residential neighbourhoods focused on in this study are located within the planned zone. Their locations in relation to the Central Business District (CBD) are as shown in Figure 3-2 below.



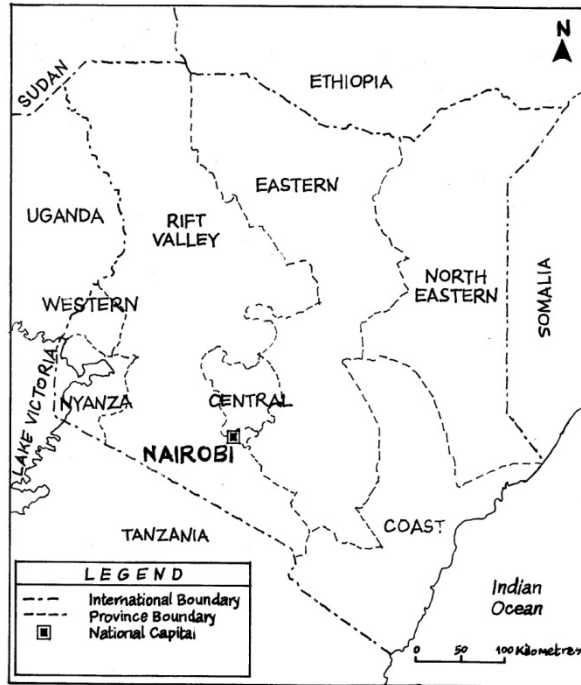


Figure 3-1: Location of Nairobi: National context.

Source: Author, based on [www.mapsofworld.com](http://www.mapsofworld.com), accessed September, 2011.

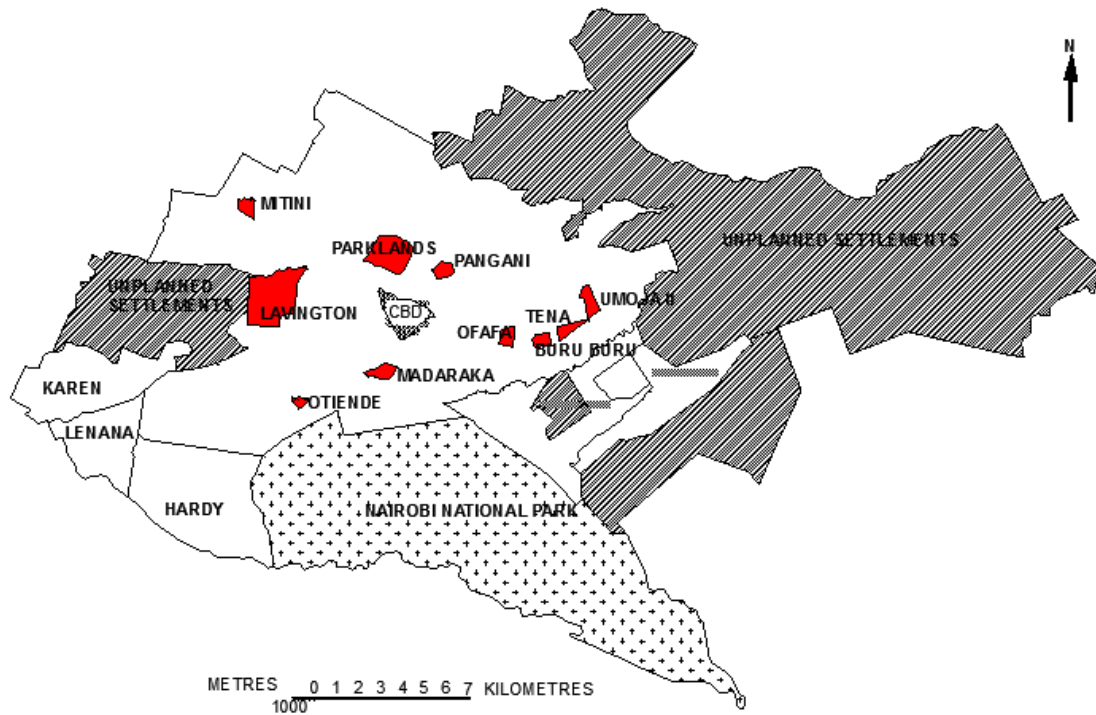


Figure 3-2: Location of sample residential neighbourhoods in the City of Nairobi.

Source: Author, based on Survey of Kenya, 2002.

### ***3.2.2 History and Growth of the City of Nairobi***

Nairobi owes its birth and growth to the Uganda Railway. The Town was first established as a railway station, which later grew up to become an administrative centre. The site was chosen by the railway constructors in June 1899 because it offered many advantages. It was mid-way between Mombasa and Kisumu and hence a suitable stopping place before continuing with the railway construction over the difficult terrain which lay ahead in form of the steep Rift Valley slopes. Other advantages which the site offered included the availability of an adequate supply of water from the nearby Nairobi River and Mbagathi streams; ample level land for railway tracks, sidings and other requirements of a railway; an elevated cooler ground to the west suitable for residential purposes; and an apparently deserted land offering freedom for land appropriation (Hake, 1977).

The new settlement was named after the Maasai name "Enkare Nairobi" which means "a place of cold waters". The railhead reached the site in June 1899 and by July it had become the railways headquarters which had moved from Mombasa (Boedecker, 1936; Foran, 1950).

By 1900, Nairobi had already become a large and flourishing place with settlements consisting mainly of the railway buildings and separate areas for Europeans and Indians, the latter being mainly the labourers employed on the construction of the railway. According to Thornton (1948), there was practically no African settlement and by 1906, the original railway depot and camp had grown to a town of 11,000 people.

By 1907, Nairobi was accepted as the official capital of Kenya. Its position became firmly established during the First World War when it was used as a military base for operations in East Africa. After the completion of the railway and the influx of more non-African settlers, Nairobi's growth and importance grew in full tone to a population of about 15,000 in 1919 when it became a Municipal Council with full corporate rights. By 1909, much of the internal structure of Nairobi was already established (Obudho, 1988). Land speculation, according to Thornton (1948), had also set in because large tracts of land were acquired by speculators outside the town boundaries with the hope of making profits if the boundary was extended.

The boundary of Nairobi was extended in 1927 to cover 30 square miles as a result mainly of rapid growth of the town both in terms of population and infrastructure. At the time of independence in 1963, Nairobi, then a city, had swelled its population to approximately 300,000 people. At this time, the Africans who were the majority of the total population lived in the Eastern region of the CBD while the Europeans and most of the Indian population lived in the city's Western suburbs with generally better services than those of African areas (Situma, 1988). Table 3-1 below shows the spatial and population growth of the City of Nairobi since its establishment to the turn of the century.

**Table 3-1: Spatial and Population growth of Nairobi.**

YEAR	TOTAL AREA (ha)	RESIDENTIAL AREA(ha)	POPULATION (000)	GROSS DENSITY (Persons/ha)	NET DENSITY (Persons/ha)
1900	792.0	475.2	11.5	14.5	24.2
1940	8216.0	4930.0	108.9	13.3	22.1
1963	69,000.0	41,400.0	345.0	5.0	8.3
1969	69,000.0	41,400.0	500.0	7.2	12.1
1979	69,000.0	41,400.0	800.0	11.6	19.3
1989	69,000.0	41,400.0	1350.0	19.6	32.6
2000	69,000.0	41,400.0	2100.0	30.4	50.7

Source: Shihembetsa and Olima, 2001.

In the table above, gross density is the total population of a city divided by its area while net density includes just residential area accounting for about 60 percent of the total land use. The net area includes all land set aside for housing, infrastructure and public purpose within the residential land use.

In 1963, the boundary of Nairobi was extended to cover an area approximately 69,000 hectares, making the city's population density to fall to its lowest (Table 3-1). The population density then increased gradually and has continued to increase every year. The expansion of the city boundary, it is argued, was not based on comprehensive growth strategy with regard to the necessary infrastructure and services (Shihembetsa and Olima, 2001). By the year 2000, the population of Nairobi was estimated to be above 2.5 million with the growth attributed to rural to urban migration (Moss, 2000).

Results of the 1999 and 2009 Kenya population and housing census reveal that the population for the city stood at 2.1 million and 3.1 million respectively, with an inter-censal growth rate of 3.8 percent (Kenya, 2010). As shown in Table 3-2, the population for males in the city is slightly higher than that of females. When compared with the second and largest cities, that is, Mombasa and Kisumu respectively, the status of Nairobi as a primate city stands out. According to Otiso (2005), a primate city is that whose population is at least twice as large as the combined population of the second and third cities. In this respect, the population of Nairobi is 3.4 times the combined population of Mombasa and Kisumu.

**Table 3-2: Urban Population Distribution for Nairobi, Mombasa and Kisumu in 2009, based on Sex, Number of Households, Area and Density.**

City	Male	Female	Total	Households	Area in Sq. Km.	Density
Nairobi	1,605,230	1,533,139	3,138,369	985,016	695.1	4,515
Mombasa	268,038	255,145	523,183	140,535	126.2	4,144
Kisumu	198,015	199,081	397,096	98,845	281.4	1,411

Source: Kenya, 2010.

The impact of the population on the city is alarming, as provision of urban services by the CCN has become fully stretched. Herzog et al (2007) points out that the city is experiencing drab sprawl along Thika Road which is to the north-east and Mombasa Road to the south-east of the CBD (Figure 3-3).

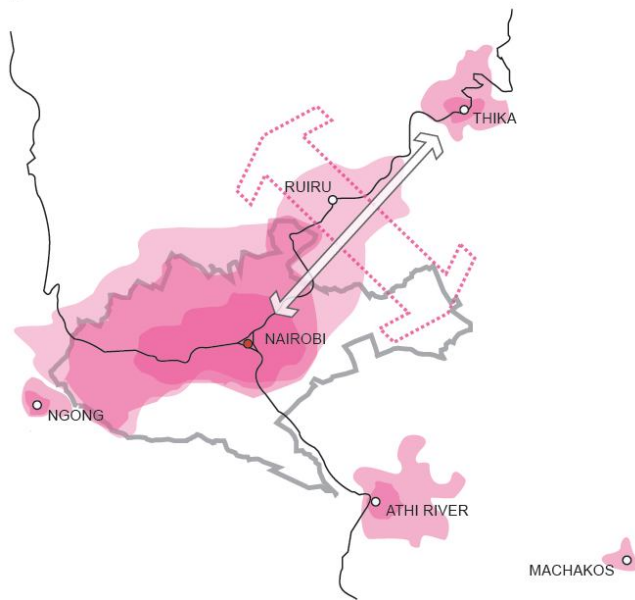


Figure 3-3: Orientation of drab sprawl in the City of Nairobi.

Source: Herzog et al, 2007.

### **3.2.3 Spatial Planning of Nairobi in Retrospect**

Endeavours to prepare a spatial plan for Nairobi date back to 1906 when the colonial masters saw the need to have a well-ordered railway town. Subsequently, master plans for the city were prepared in 1927, 1948 and 1973. The latest master plan has since expired and currently the city is developing without a plan.

#### **3.2.3.1 The 1906 Plan for a Railway Town**

There was a need for a plan for a railway town before the railway actually reached Nairobi in 1899. The location was preferred because of its flat topography which was ideal for the construction of shunting areas, depots, workshops for European staff and commerce. The city then had a population of 11,000 people and the plan only took into consideration the European employees of the railway and the European and Asian traders. The city boundary covered 18 km and was extended in 1920 to 25 km. The plan completely ignored Asian labourers and the Africans (Herzog et al, 2007).

The spatial planning pattern showed segregation between the commercial centre (CBD) and European, Asian and African residential areas. This implies that the town's functions were directly expressed by notions of segregation, class and race.

### **3.2.3.2 The 1927 Plan for a Settler Capital**

The plan for a settler capital was drawn by F. Walton Jameson and planned by Eric Dutton, a key planner in the British African Empire. The plan proposed extensive traffic regularizations to access the increased land areas, drainage and swamp clearance, building and density regulation and the attempt to furnish Nairobi with a monumental administrative centre.

A major aspect of this plan was the inflated land price in the Asian and African residential areas, also a result of the prohibition of the racial segregation between Europeans and Asians. The racial segregation turned into class segregation, which was in the complete agreement with the interest of the settler class. A whole 90 percent of the territory belonged to Europeans while 10 percent belonged to Asians. For the male Africans, the only legal way to live in the city was in the squatter settlements.

### **3.2.3.3 The 1948 Master Plan for a Colonial Capital**

Nevanlinna (1996) and Herzog et al (2007) point out that the 1948 master plan was drawn by first time academic planners: *L. W. T. White*, Architect, town planner and Head of Department of Architecture at the University of Cape Town; *P. R. Anderson*, Civil Engineer, Senior Town Planning Engineer; and *L. Silberman*, Sociologist and Lecturer in the Department of Social Studies at the University of the Witwatersrand, Johannesburg. The master plan is founded by the Municipal Council of Nairobi and by the Railway Authorities. The master plan envisaged a city of 35 square miles with a population of 250,000 – 270,000 by 1975. Between 1940 and 1963, the city registered massive boundary expansion from 8216 hectares to 69000 hectares.

A main feature of the plan is functionalism whereby Nairobi was classified in zones; Kenya Center, official buildings, business and commerce, industry, railway, residential, official housing, open space, and also in forest reserve and park zones (Figure 3-4). The main spatial structure of the plan was to establish neighbourhood units for the working class, a segregation strategy for purposes of surveillance and dominance. The main aim of the master plan was to make Nairobi more attractive to industrial investments. As capital of Kenya and East Africa it became centre for tertiary and quaternary industries (service sector and intellectual service sector).

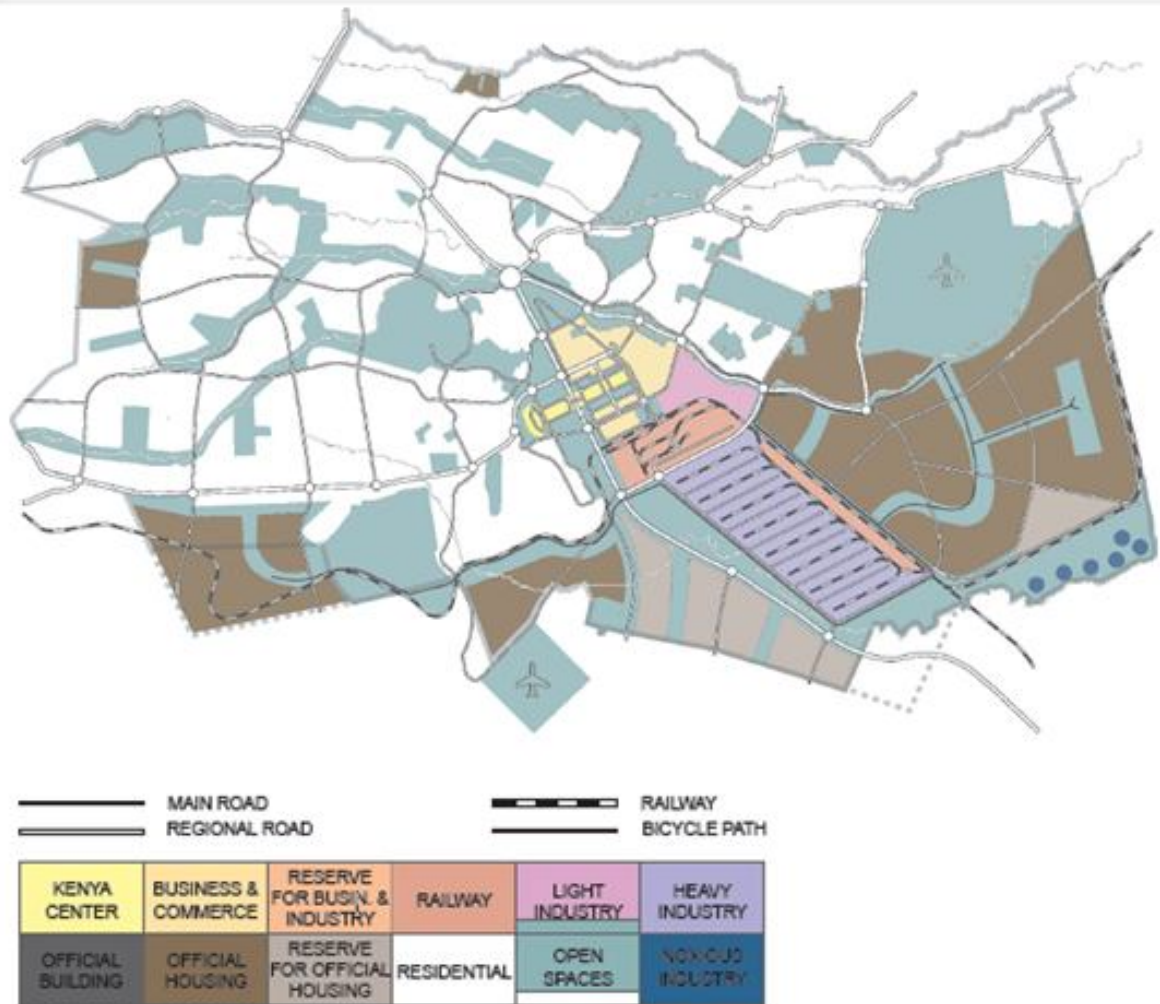


Figure 3-4: The 1948 Master Plan.

Source: Herzog et al, 2007.

The 1927 and 1948 developed plans have never been fully realized as the amount of capital outlay that was required for their implementation was never allocated. Marginalization of the African urban majority and propagation of informal urbanization in the town's periphery was the result.

### 3.2.3.4 The 1973 Metropolitan Growth Strategy (MGS)

The MGS is founded by the City Council of Nairobi (CCN), the Kenya Government, the World Bank and the United Nations but worked out by the Nairobi Urban Study Group (NUSG). Main features of this plan include strategies on the following areas:

- decentralization of service centres,
- transportation,
- housing,
- industry and commerce,
- the old city area and
- upgrading of the city into a metropolitan region.

The strategy recommended the decentralization and the development of alternative service centres within the different districts of the city to reduce the high density of employees in the central area. There was anticipation that the new secondary centres could develop as major settlements which would be independent of the central city for many services, as they would have their own industrial, residential, commercial and administrative sub-zones. The fact that almost 25 percent of the total trips will still be made on foot or bicycle shows the importance of having employee areas in proximity to the residential areas.

Through the upgrading of the major routes from Mombasa, Thika and Nakuru, a comprehensive network of roads and public transport routes is proposed by the strategy. The roads are in the form of a modified grid, thereby providing maximum accessibility between residential, industrial and commercial areas. The proposed three bus routes are to serve both existing and major new areas of development.

With regard to housing, the major areas for development would be Dagoretti, Karen-Langata, the eastern area and the areas outside the north-eastern city boundary around Ruiru. Associated with each of the main areas on new housing would be one or more industrial areas and a large commercial centre. The industrial centres are located in proximity to the main roads and where possible, next to the railway to offer a good accessibility by road and rail.

The Study Group proposed that the land of Eastleigh Airport should not be continued with its present use because of danger and noise. It recommended that the land should become available for urban development as it is very close to the city centre, well serviced with water and accessibility to the adjacent major roads.



Upgrading of Nairobi into a metropolitan area would entail the city's expansion to the west and to the north-east along the axis of the Thika Road and at the same time, the encouragement of growth of Thika, Athi River and Machakos (Figure 3-3). Through population forecasts by the Ministry of Lands and Settlements, a continuation of growth was estimated which brought up the eventuality that Thika and Nairobi could fall in the same metropolitan area. The strategy therefore proposed the expansion of the city along a corridor of development, which gives flexibility to react to changing growth rates.

Despite the noble ideas in the MGS, it is unfortunate that it was not implemented due to lack of political goodwill.

### ***3.2.3.5 The 1993 Nairobi City Convention on Actions Towards a Better Nairobi***

The 1993 Nairobi City Convention on Actions towards a better Nairobi was held and according to Herzog et al (2007), is the nearest the city authorities have come to addressing the urban question of Nairobi. There have been efforts by the Nairobi Central Business District Association (NCBDA) to streamline management of the city's affairs whereas there has been an attempt by the Architectural Association of Kenya (AAK) to craft a master plan for Nairobi.

### ***3.2.3.6 Nairobi Today - A City without a Valid Master Plan***

The city of Nairobi is using a master plan developed in 1973, which legally expired in 2003. A master plan is valid for between 20 and 30 years, which means that structures constructed in Nairobi since the year 2003 are technically illegal. The main goals for the 21st century hinge on solid waste management, water and sanitation supply, air pollution, provision of energy, housing, land use planning and the rise of urban agriculture.

## ***3.2.4 Climate***

With its close proximity to the Equator and lying almost at an altitude of 1700 metres above sea level, Nairobi's temperatures are altitude modified tropical, but not scorching (Situma 1988). The months of July and August are distinctly cool as are the hours of the darkness throughout the year. The mean annual temperature is 19°C and the mean daily maximum and minimum are 23°C and 14°C respectively (Figure 3-5).

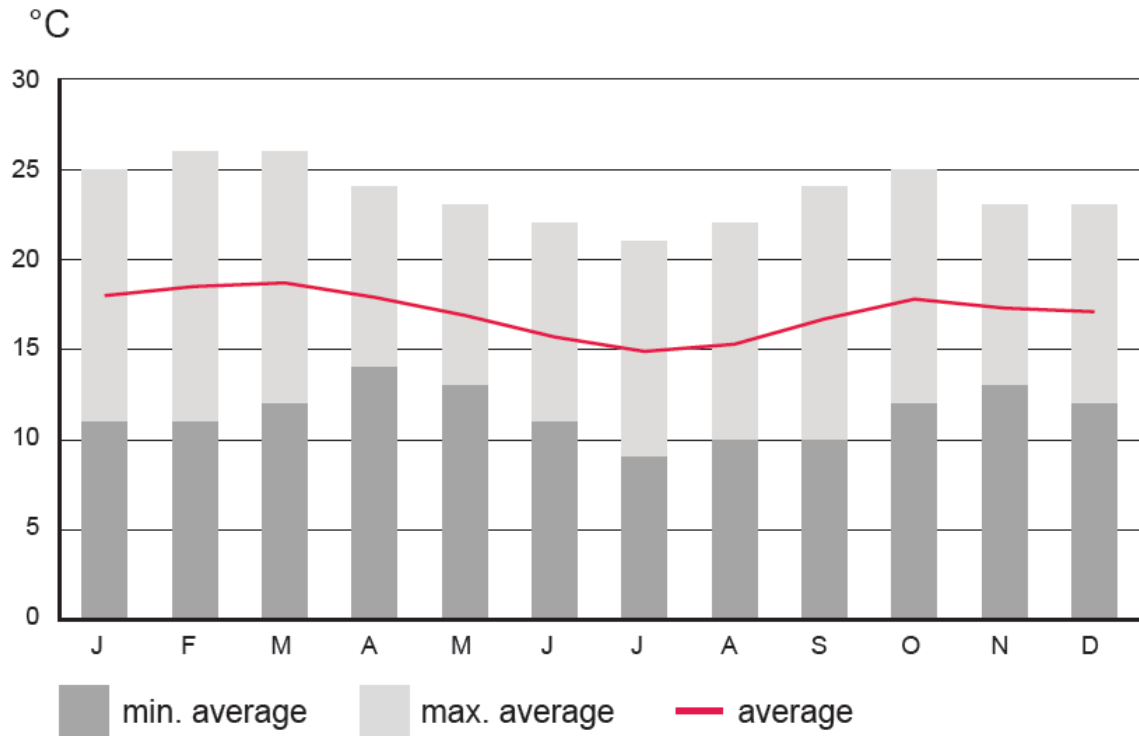


Figure 3-5: Temperature characteristics for the City of Nairobi.

Source: Herzog et al, 2007.

Despite the mean temperatures, there is the urban heat island (UHI) that one experiences when traveling in and around the city centre from the suburbs. The city centre is considerably warmer than the surrounding suburbs and countryside. This warmth is caused by the increased absorption of solar radiation by built mass and hard surfaces in conjunction with black roof tops due to their excessive heat storage capacity, the lack of vegetation with its potential of utilizing incoming energy for evapo-transpiration, and the increased air pollution of different kinds leading to additional heat absorption by the atmosphere. The heat islands are on the upward trend as more and more of the open green land is taken up by buildings thereby increasing the overall absorption of solar radiation (Situma, 1988).

By virtue of its equatorial location, Nairobi experiences sunshine for a larger part of the day and in all months of the year (Figure 3-6). The mean annual sunshine duration is 6.9 hours and the mean daily maximum and minimum are 9.25 hours and 4.25 hours respectively.

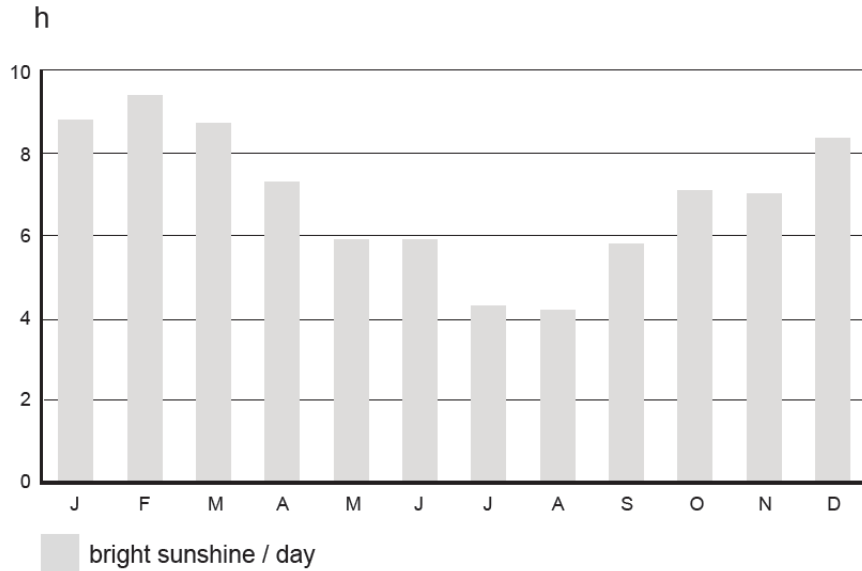


Figure 3-6: Mean Monthly Sunshine Duration for the City of Nairobi.

Source: Herzog et al, 2007.

The mean annual rainfall is 1080 millimetres falling in two distinct seasons: long rains from March to May and short rains from mid-October to December (Figure 3-7). Sometimes during the long rains the city experiences torrential floods with devastating effects to human as well as animal life. Relative humidity is highest in the month of May and lowest in the month of February with values of 75 percent and 60 percent respectively.

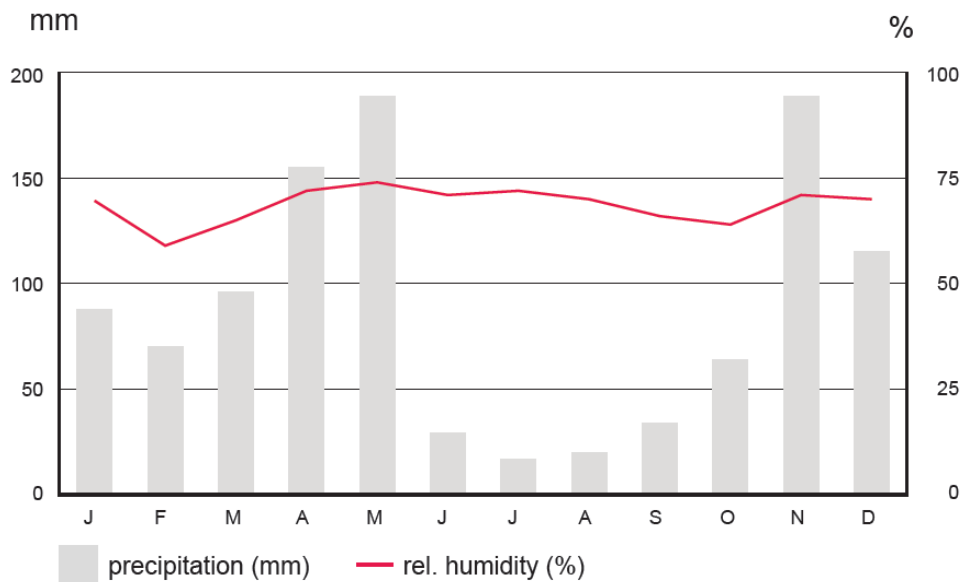


Figure 3-7: Mean monthly rainfall and relative humidity patterns for the City of Nairobi.

Source: Herzog et al, 2007.

### **3.2.5 Soils**

According to Kenya (1982), the soils of the City of Nairobi and its environs fall into two broad categories. The first category consists of soils developed on plateaus and high level structural plains, which are flat to gently undulating with slopes generally less than 8 percent. Some of these soils are developed on tertiary basic igneous rocks such as olivine basalts, nepheline, phonolites and older basic tuffs. More specifically, these soils are:

- Imperfectly drained, very deep, dark grey to black, firm to very firm, bouldery and stony, cracking clay. These are predominant in the flat landscape extending to the Athi plains.
- Moderately well-drained, shallow, yellowish red to dark yellowish brown, friable gravelly clay over rock –ironstone soils, with lithosols. These soils occur to the South and North-East of the city.
- Poorly drained, deep to very deep dark brown to very dark greying brown, mottled, firm to very firm, cracking clay – occurring to the south and North east of the city.

The second category of soils includes those developed on volcanic foot-ridges with dissected lower slopes of major older volcanoes and mountains, which are undulating to hilly. This area covers the entire western part of the city region.

### **3.2.6 Distribution of Residential Neighbourhoods**

The high-income group is accommodated in the north and western parts of Nairobi where land use intensities and population densities are low. These residential areas include, among others, Karen, Langata, Westlands, Muthaiga, Kitisuru, Lavington, Spring Valley, Kileleshwa, Kilimani, Hurlingham and Parklands. Housing comprises free-standing single houses on large lots (at least 0.2 ha) with a few scattered homes and low-rise flats. The density in this category is up to a maximum of 100 persons per hectare. Infrastructure services such as water supply, roads and street lighting in these neighbourhoods, just like in the lower income brackets, has been provided by the City Council of Nairobi (CCN). However, owing to the CCN's inadequate capacity to meet urban service demand, neighbourhood associations and private sector involvement in environmental management have come up to play a complementally role. This is particularly evident in maintenance of roads and drainage systems, and solid waste management.

The middle-income housing comprises modest semi-detached houses and walk-up flats predominantly with a few scattered detached single family houses. According to Mwaura (2002), these medium density areas have an average of 35 dwellings per hectare with population densities ranging between 100 and 250 persons per hectare. They include neighbourhoods such as Nairobi South, Buru Buru, Donholm, and Tena. Some residents of this group have however moved out to the suburb areas of Ngong, Ongata Rongai, Mavoko and Kitengela. Land in the suburb areas is cheaper thus enabling construction of bigger houses. However, the people have to contend with commuting using an inefficient public transport system. Save for the planned areas where the CCN has provided infrastructure services, the rest of the neighbourhoods are characterized by untarmacked roads, private sector participation in garbage collection and lack of street lighting.

The low-income housing comprises fairly inexpensive flats and attached houses mainly in inner city areas of Eastlands such as Kaloleni, Mbotela and Ofafa Maringo. It also includes self-help site and service schemes in Umoja, Dandora and Kariobangi. Mwaura (2002) points out that occupancies are often in form of rooms giving rise to 250 persons per hectare. However, the low-income living in informal settlements have housing comprising spontaneous development with very high densities of up to 750 to 1000 persons per hectare. These informal settlements are located in Kibera, Mukuru, Korogocho, Mathare Valley, Kawangware, Kangemi and Pumwani, just to name a few. The environmental situation in the informal low-income neighbourhoods is appalling. Majority of rural to urban migrants end up in these neighbourhoods thus leading to overcrowding. Open spaces in the settlements are always at the risk of being grabbed by speculative developers. Environmental quality in the public space system is generally poor.

### ***3.2.7 Housing Delivery Systems***

Housing in the City of Nairobi is delivered broadly by two systems, namely, private sector and public sector. The CCN and National Housing Corporation are mandated to supply public housing, with the latter being the only player at present. The majority of the public housing, especially that built in the 1960s, and early 1970s, caters for the medium and high-income categories. The private sector is another player in housing delivery in Nairobi and this includes staff and servant quarters provided by private sector employers. Private developers get mortgage finance from lending institutions, such as Housing Finance and Savings and Loan, to put up

housing units which are later on sold to individuals. In the private sector category also lies the self-funded, self-initiated house construction. In this system, owners participate intensively to produce housing units without government subsidies. This is evident in the peri-urban areas of the city and is characterized by a lack of provision of formal infrastructure services and a basis for payment of rates to the CCN.

The remaining proportion of housing in the city is shelter in informal settlements. According to Payne (1984), the informal or popular housing activities in the uncontrolled settlements are a response to failure of the public and private formal sectors to supply enough housing at affordable prices to meet the needs of the low-income households.

### ***3.2.8 Policy Issues on Urban Environmental Management***

Policies for urban environmental management in Kenya fall within an established legal and institutional framework. The legal framework comprises the Physical Planning Act, the Local Government Act, the Building Code and the Environmental Management and Co-ordination Act (EMCA). The institutional framework, established by the above items of legislation, includes the central government, local authorities and National Environmental Management Authority (NEMA). The focus of the policies is on physical planning issues and environmental control issues.

#### ***3.2.8.1 Physical Planning Issues***

Physical planning issues are dealt with in the Physical Planning Act, Chapter 286 Laws of Kenya. The Act provides for the preparation and implementation of physical development plans. Development in this context is the making of any material change in the use or density of any buildings or land or the subdivision of any land. The Act defines the orderly and organized manner in which the plan preparation and implementation processes are to be carried out so as to realize desirable spatial environments. In this regard, the Act focuses on the following issues:

- i. Provision of a basis for land administration, survey, allocation, registration, extension of user, change of user and land subdivision.
- ii. Provision of a basis for development control and for assisting in monitoring the general trends in land use and land development.
- iii. Ensuring environmental protection through participatory approach.

- iv. Provision of a network of communication between areas of activity so as to achieve an integrated social and economic system.
- v. Provision of a long term strategy for urbanization and the general pattern and direction of growth in a given spatial unit.
- vi. Identification of major issues that require special attention due to their overall impact on growth and development. Such include resource potentials, demographic factors, levels and standards of infrastructure and services.
- vii. Provision of a spatial framework to guide the implementation of social, economic and physical development in a co-ordinated manner.

### **3.2.8.2 Environmental Control Issues**

Policies on environmental control are hinged on the need to live and operate in a clean and healthy environment. This requires that policy provisions are implemented to ensure that urban land is used in accordance to stipulations in the physical development plan. Environmental control is realized through provisions in the Physical Planning Act and Local Government Act (Chapter 265 Laws of Kenya). In this respect, the Physical Planning Act empowers local authorities to do the following tasks with a view to manage the environment:

- prohibit or control the use and development of land and buildings in the interests of proper and orderly development of their areas;
- control or prohibit the subdivision of land or existing plots into smaller areas;
- consider and approve all development applications and grant all development permissions;
- ensure the proper execution and implementation of approved physical development plans;
- formulate by-laws to regulate zoning in respect of use and density of development; and
- reserve and maintain all the land planned for open spaces, parks, urban forests and green belts in accordance with the approved physical development plan.

The Local Government Act defines the various functions of local authorities and empowers them in the discharge of those functions. Fundamentally, local authorities are tasked with provision of a

wide range of services to ensure that urban areas are livable environments. In this respect, the Local Government Act empowers local authorities to:

- prohibit and control the development and use of land and buildings in the interest of the proper and orderly development of its area;
- control trades and occupations through issuance, renewal or cancellation of licenses;
- establish and maintain sewerage and drainage works within or without its area;
- lay out building plots or otherwise subdivide any land acquired or appropriated by it, whether within or without its area, for the purpose of housing schemes for the inhabitants of its area;
- undertake the supply of, and establish, acquire and maintain works for the supply of water within its area, and with the consent of any other local authority within the area of that local authority;
- control and care for all public streets which are situated within its area;
- subject to the Electric Power Act, ensure that its area is supplied with electricity, light, heat or power.

In order to achieve its numerous functions, the Local Government Act empowers local authorities to make by-laws from time to time. This is in respect to such matters as are necessary for the maintenance of the health, safety and well-being of the inhabitants of their respective areas.

Local Authorities also draw their mandate to manage the urban environment from the Local Government (Adoptive By-Laws) (Building) order 1968, otherwise known as the Building Code. This is a set of building by-laws which any local authority may adopt as a guide in environmental management. A bulk of the by-laws relate to buildings proper. However, the few that are of interest to this study in the sense of having a bearing on the outdoor public space environment are as follows:

- i. Building lines: The Code empowers a local authority to prescribe a building line for any street or part of a street. In this respect, a person who erects any building other than a boundary wall, fence, gate, portico, step or other like projection from the building, nearer to the street than such building line, is guilty of an offence.



- ii. Access to plots: The Code requires that every plot be provided with at least one access from a road.
- iii. Boundary walls: Unless a local authority otherwise agrees, the development of any plot shall include the provision of boundary walls, screen walls, fences or other means of enclosure of approved materials, construction and design.
- iv. Height of boundary walls: Where the ground of a boundary line is of normal slope, the Code provides that boundary walls, screen walls, fences or other means of enclosure of residential plots shall not be erected to a greater height than 4 feet 6 inches (1350 millimetres) where abutting on to a street or in front of the building line of the main building, or 6 feet (1800 millimetres) in any other case.

The EMCA of 1999, on the other hand, spells out the precise steps, inter-institutional linkages and various prescribed instruments to be used to protect the violation of a clean and healthy environment by proposed, on-going or existing projects. It sets out the environmental planning framework throughout Kenya aimed at organizing the use of land to achieve maximum practicable degrees of economy, convenience, beauty and sustainable use.

Generally, the City of Nairobi has the benefit of being in a country with well defined legal and institutional structures for spatial planning and environmental management. The unfortunate part of it however is that the structures have failed to ensure sustainable residential public space environments that guarantee quality living. Getting a solution to this problem calls for a design of an empirical approach which needs not to study each and every public space but a few whose findings can be generalized to the entire population of spaces. Sampling design is therefore central in this approach.

### **3.3 Sampling design**

This study is intended to obtain as much information as possible from the study of public spaces of residential neighbourhoods with a view to unfold the dilemma as to whether the spatial dimension of the spaces can be used to inform environmental management. In order to achieve this purpose, multi-stage sampling is carried out to pick representative samples for residential

neighbourhoods and public spaces. Neuman (2000) emphasizes the essence of sampling in the extract below:

*“We can’t study every case of whatever we are interested in, nor should we want to. Every scientific enterprise tries to find out something that will apply to everything of a certain kind by studying a few examples, the results of the study being as we say, ‘generalizable’.*

Initially, residential neighbourhoods are sampled and then followed by establishment of the population of public spaces in the neighbourhoods. Sample size is determined and then public spaces for detailed inquiry sampled out.

### **3.3.1 Sampling of Residential Neighbourhoods**

The population of residential neighbourhoods in this study includes the universe of planned residential neighbourhoods in the City of Nairobi. These fall into high-income, middle-income and low-income categories, a land use pattern resulting from the colonial masterplan which promoted segregation of residential areas on the basis of race and hence economic class (Nevanlinna, 1996). Long after Kenya attained her independence in 1963, segregation of residential neighbourhoods on economic class has remained a deep-rooted tradition in the planning of residential settlements in Nairobi. With respect to the present study, this classification presents stratified random sampling as the most appropriate method of selecting the segment of the population, neighbourhoods in this case, that are investigated (Mugenda and Mugenda, 1999; Bryman, 2004). Based on Survey of Kenya (1995), the sampling frame of planned residential neighbourhoods is as shown in Table 3-3 below. Categorization of the neighbourhoods into the respective income group is guided by the researcher’s experience of the study area.

**Table 3-3: Sampling frame of planned neighbourhoods in the City of Nairobi.**

<b>INCOME CATEGORY</b>	<b>01 HIGH INCOME</b>	<b>02 MIDDLE INCOME</b>	<b>03 LOW INCOME (PLANNED)</b>
NEIGHBOURHOODS	Westlands, Groganville, Muthaiga, Kitisuru, Lavington, Spring Valley, Kileleshwa, Kilimani, Kibarage, Barton, Mitini, Parklands, Bernard, Kyuna, Thomsom, Loresho, Milimani	Golf Course, Sunview, Magiwa, Southlands, Ngei, Otiende, Nairobi Dam, Pangani, Outerring Road, Buru Buru I-V, Nairobi South 'C', Nairobi South 'B', Woodley, Tena, Doonholm, Savannah, Nairobi West	Ofafa Maringo, Lumumba, Makadara, Ofafa Jericho, Kimathi, Kaloleni, Pumwani, Starehe, Ziwani, Kariokor, Shauri Moyo, Umoja II, Uhuru, Harambee, Umoja I, Madaraka, Mbotela, Huruma, New Mathare, Kariobangi North, Dandora, Kariobangi South, Makongeni, Bahati,

Source: Kenya, 1995.

Neighbourhoods in each income group exhibit unique characteristics with regard to internal street structure, arrangement of plan components, built-form and geographical location. Internal street structure for some neighbourhoods is grid-like with long and straight streets intersecting orthogonally. For others, the resulting pattern is irregular with an intersection of curved and straight streets. Arrangement of plan components in some neighbourhoods exhibits dwelling clusters defined by intersecting streets, courtyards, cul-de-sacs and rows of buildings. Builtform is that of bungalows, maisonettes, flats, single rooms forming dwelling blocks or a combination of these forms. Geographically, the neighbourhoods are distributed around but at varying distances from the CBD.

Primarily, internal street structure is used as the criterion for clustering the stratified samples of neighbourhoods to ensure that no neighbourhood with unique characteristics is left out. In a situation where all neighbourhoods in the same stratum have the same description of internal street structure, other characteristics, such as built-form and geographical location, are applied in clustering them. Neighbourhoods forming the study sample are arrived at as follows:

### 3.3.1.1 High Income

Stratification of the high income category based on their internal street structures results in two clusters illustrated in Table 3-4.

**Table 3-4: Clustering of High Income Neighbourhoods**

<b>Grid-like Structure</b>	<b>Irregular Structure</b>
i. Parklands	i. Milimani    ii. Thompson    iii. Mitini
ii. Groganville	iv. Kileleshwa    v. Lavington    vi. Muthaiga
iii. Westlands	vii. Spring Valley    viii. Loresho    ix. Kibarage
iv. Kilimani	x. Kitisuru    xi. Barton    xii. Kyuna

Source: Author, 2010.

A simple random sampling application to select a sample from each of the clusters resulted in the selection of Parklands, Mitini and Lavington neighbourhoods. In the category of neighbourhoods

with irregular internal street structure, two neighbourhoods are sampled given that they are thrice as many as in the other category. Parklands is located in the north of the CBD, has dwelling clusters defined by orthogonally intersecting streets, and a builtform of maisonettes and flats. Mitini is located in the west of the CBD and mainly has bungalows and cul-de-sacs in its spatial planning pattern. Lavington, just like Mitini, is located in the west of the CBD and is characterized by maisonettes, bungalows and flats.

### 3.3.1.2 Middle Income

All the middle income neighbourhoods have an irregular internal street structure. Builtform is that of maisonettes, bungalows, flats or a mix of these. The main distinguishing feature among the neighbourhoods is the arrangement of their spatial plan components – some have their internal streets intersecting to create dwelling clusters whereas others have dwelling clusters without intersecting streets (Table 3-5). The latter category has a characteristic pattern of cul-de-sacs and courtyards. Geographical location of the neighbourhoods in relation to the CBD is also different.

**Table 3-5: Clustering of Middle Income Neighbourhoods.**

<b>Clusters with intersecting streets</b>	<b>Clusters without intersecting streets</b>
Doonholm ( <b>E<sub>1</sub></b> ); Outerring Road ( <b>E<sub>1</sub></b> );Buru Buru I ( <b>E<sub>1</sub></b> ); Tena ( <b>E<sub>1</sub></b> ); Savannah ( <b>E<sub>1</sub></b> ); Umoja I ( <b>E<sub>1</sub></b> ); Pangani ( <b>N.E</b> ); Southlands ( <b>S</b> ); Ngei ( <b>S</b> ); Otiende ( <b>S</b> ); Sunview ( <b>S</b> ); Golf Course ( <b>S</b> ); Magiwa ( <b>S</b> ); Woodley ( <b>S</b> ); Nairobi South B ( <b>S</b> ); Nairobi South C ( <b>S</b> ) Nairobi Dam ( <b>S</b> ).	Buru Buru III ( <b>E<sub>2</sub></b> ); Buru Buru V ( <b>E<sub>2</sub></b> ); Buru Buru II ( <b>E<sub>2</sub></b> ); Buru Buru IV ( <b>E<sub>2</sub></b> ).

Source: Author, 2010.

Key:

- E<sub>1</sub> – Clusters with intersecting streets, located in the east of the CBD
- E<sub>2</sub> – Clusters without intersecting streets, located in the east of the CBD
- N.E– Clusters with intersecting streets, located to the north-east of the CBD
- S – Clusters with intersecting streets, located to the south of the CBD

Application of simple random sampling to the neighbourhoods after clustering them on the basis of street structure and geographical location (Table 3-5) resulted in selection of Tena, Pangani,

Otiende and Buru Buru V Neighbourhoods. Tena and Buru Buru V are located to the east of the CBD, Otiende to the south, and Pangani to the north-east of the CBD. On builtform, Tena has a mix of maisonettes, bungalows and flats; Pangani has a mix of maisonettes and flats; Otiende has a mix of maisonettes and bungalows whereas Buru Buru V is composed of maisonettes.

### 3.3.1.3 Low Income

The City's low income neighbourhoods have an irregular internal street structure. In view of this, builtform is used as the criterion for clustering them. Their builtforms are different with some being walk-up flats, single storey and double storey row housing, and others a mix of single storey housing and walk-up flats (Table 3-6).

Application of simple random sampling to each of the clusters results in the selection of Ofafa Maringo, Madaraka and Umoja II neighbourhoods. Ofafa Maringo and Madaraka are public rental housing neighbourhoods located to the east and south of the CBD respectively. Umoja II, on the other hand, is located to the east of the CBD and has privately owned housing units.

**Table 3-6: Clustering of Low Income Neighbourhoods.**

<b>A Mix of Single and Double Storey Row Housing</b>	<b>Walk-up flats</b>	<b>A Mix of Single Storey and Walk-up Flats</b>
Lumumba; Makadara; Ofafa Maringo; Ofafa Jericho; Kimathi; Harambee; Kaloleni; Starehe; Mbotela; Ziwani; Kariokor; Shauri Moyo; Kariobangi North; Makongeni; Bahati.	Kariobangi South; Madaraka; Huruma.	Dandora; Pumwani; Umoja II; Eastleigh.

Source: Author, 2010.

The ten neighbourhoods collectively make up a representative sample of the City's planned residential neighbourhoods. This is with regard to economic level, geographical location, building typology, and fundamentally, owing to the focus of this study, the structure of the street space system. The neighbourhoods exhibit diverse patterns of street space structure as shown in the respective linkage diagrams below (Figure 3-8).



(a) Parklands



(b) Mitini



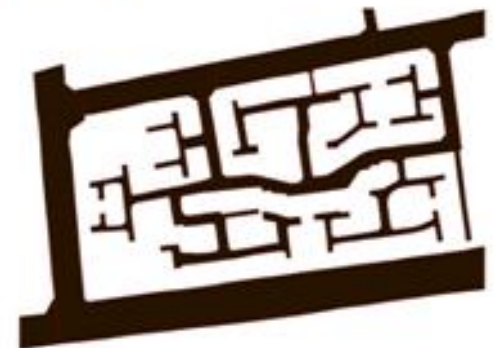
(c) Lavington



(d) Pangani



(e) Otiende



(f) Buru Buru V

Figure 3-8: Neighbourhood street space structures:  
Source: Author, based on Survey of Kenya maps, 2010.

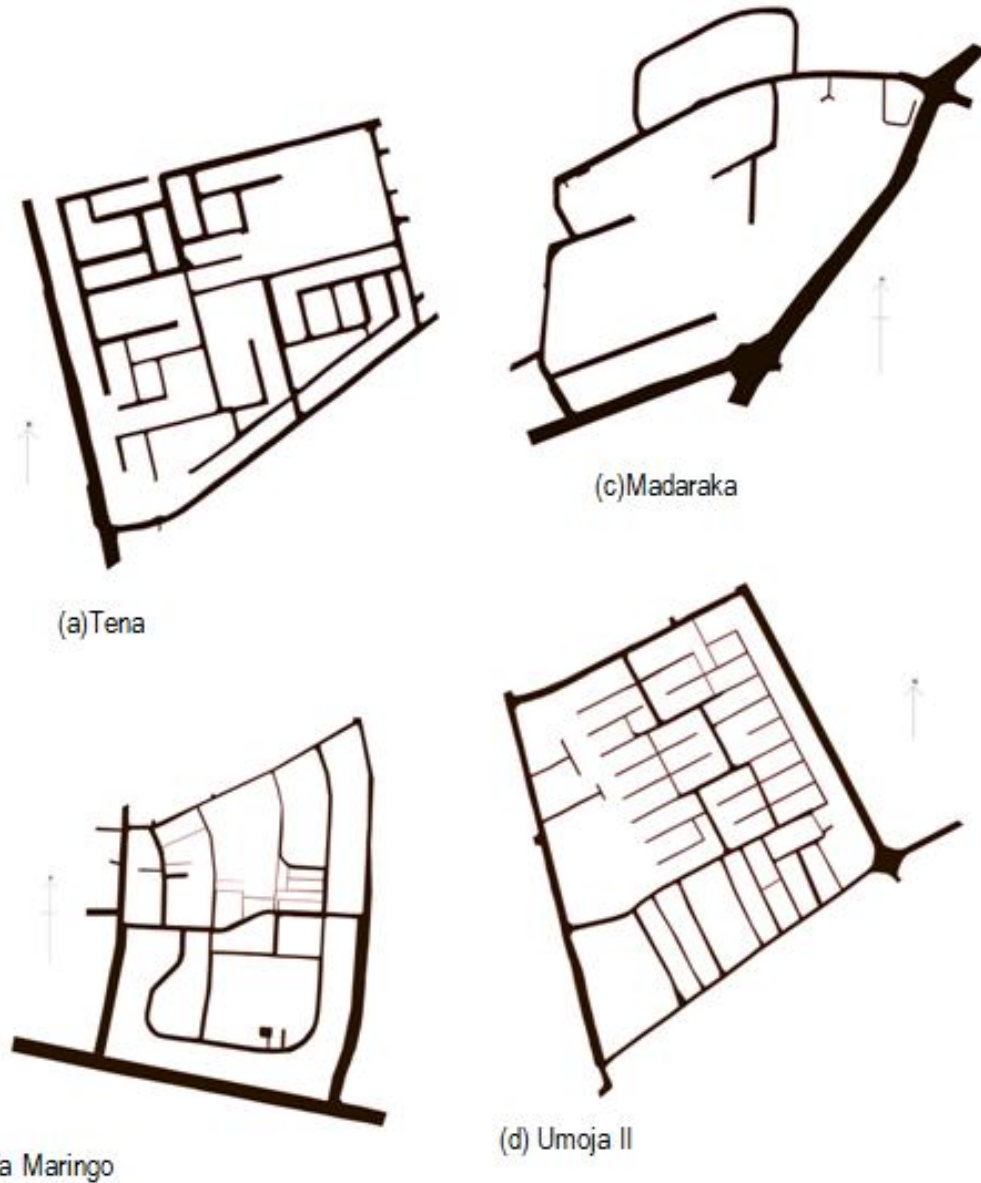


Figure 3-9: Neighbourhood street space structures:

Source: Author, based on Survey of Kenya maps, 2010.

### **3.3.2 Establishment of the Study Population**

Preparation of neighbourhood axial maps is a prerequisite to establishment of the parent population of axial spaces in the neighbourhoods. Initially, an accurate axial map of each neighbourhood is drawn at a scale of 1:1250. The axial maps are based on maps obtained from Survey of Kenya, which is a department of the Ministry of Lands and Settlements. Hillier and Hanson (1984) recommend this scale as the best although a range of up to 1:10,000 still works. This is followed by a reconnaissance survey of each neighbourhood to identify any omitted

spaces for the purpose of including them in the respective axial maps. At this stage of the survey, environmental problems in the public space system are also documented for use in the next level of environmental survey. The updated axial maps (Figures 3-10 to 3-19) present the universe of public spaces, hence the study population.

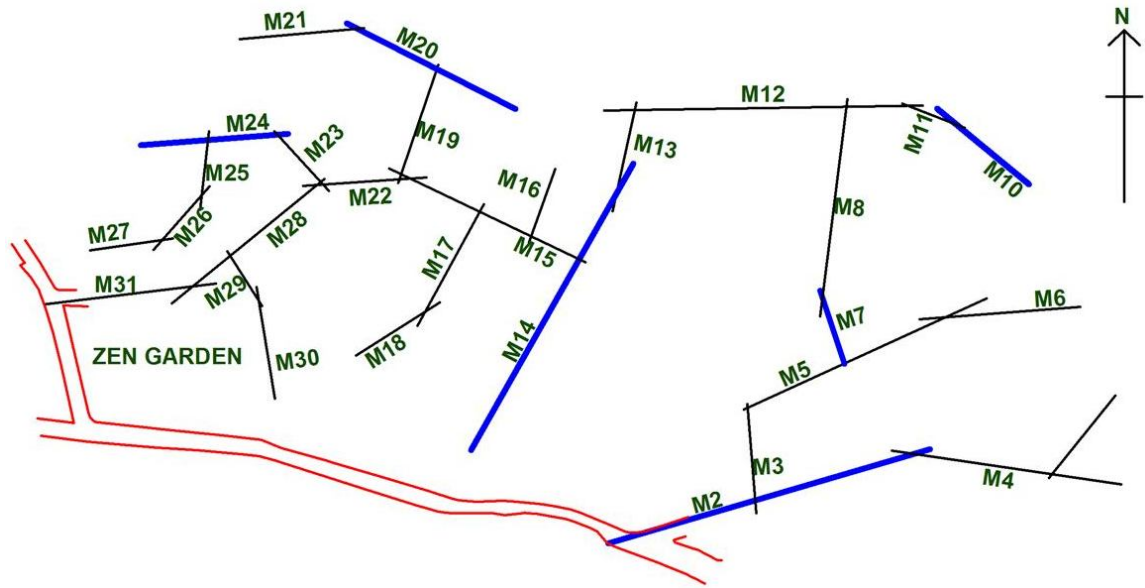


Figure 3-10: Axial map for Mitini residential neighbourhood.

Source: Author, 2010.



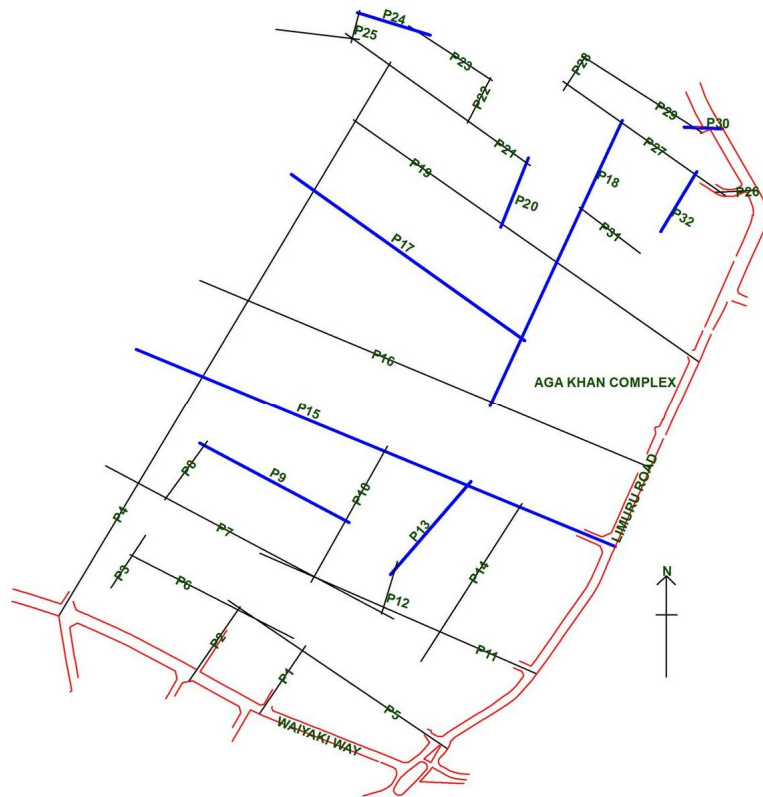


Figure 3-11: Axial map for Parklands residential neighbourhood.  
 Source: Author, 2010.

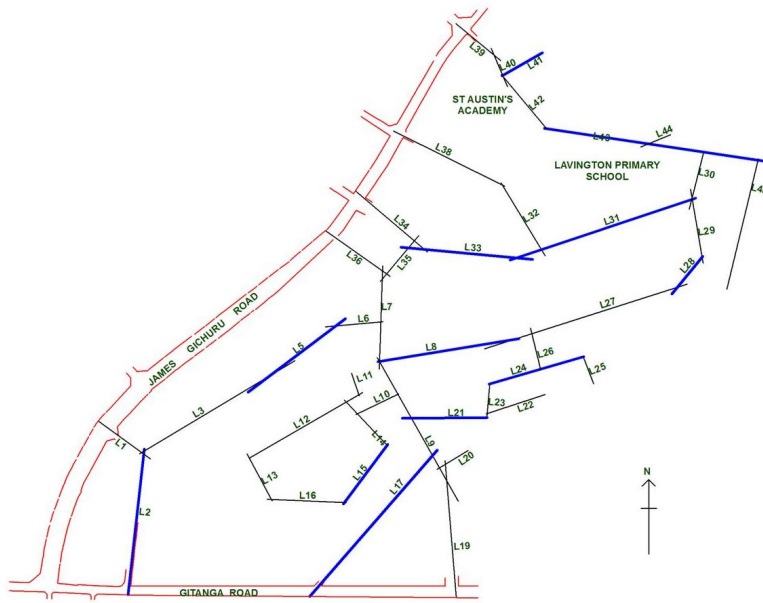


Figure 3-12: Axial map for Lavington residential neighbourhood.  
 Source: Author, 2010.

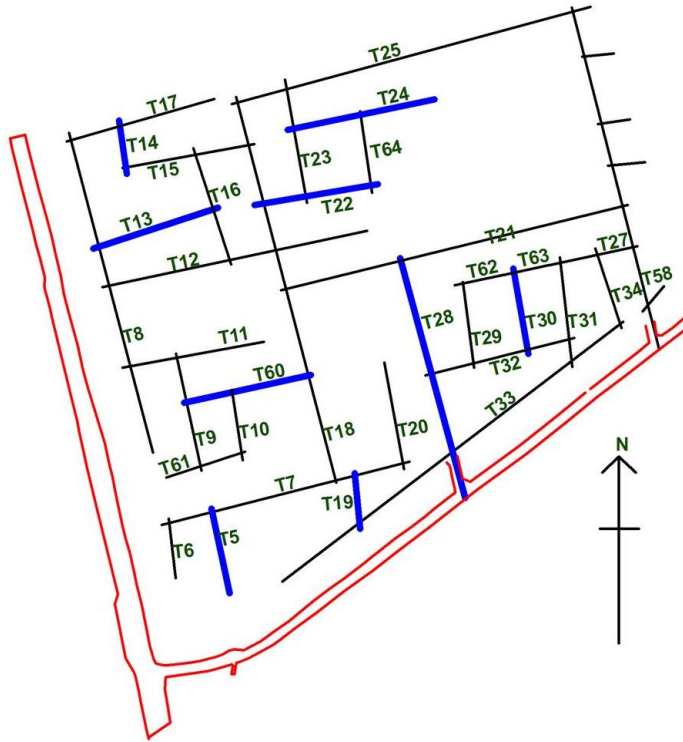


Figure 3-13: Axial map for Tena residential neighbourhood.

Source: Author, 2010.

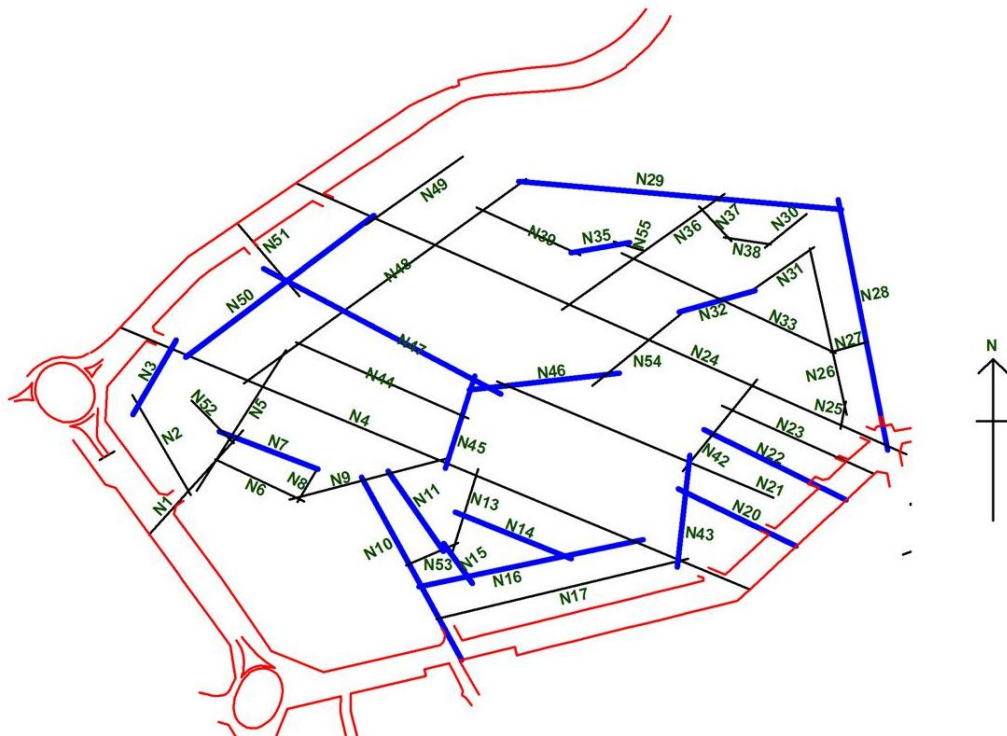


Figure 3-14: Axial map for Pangani residential neighbourhood.

Source: Author, 2010.

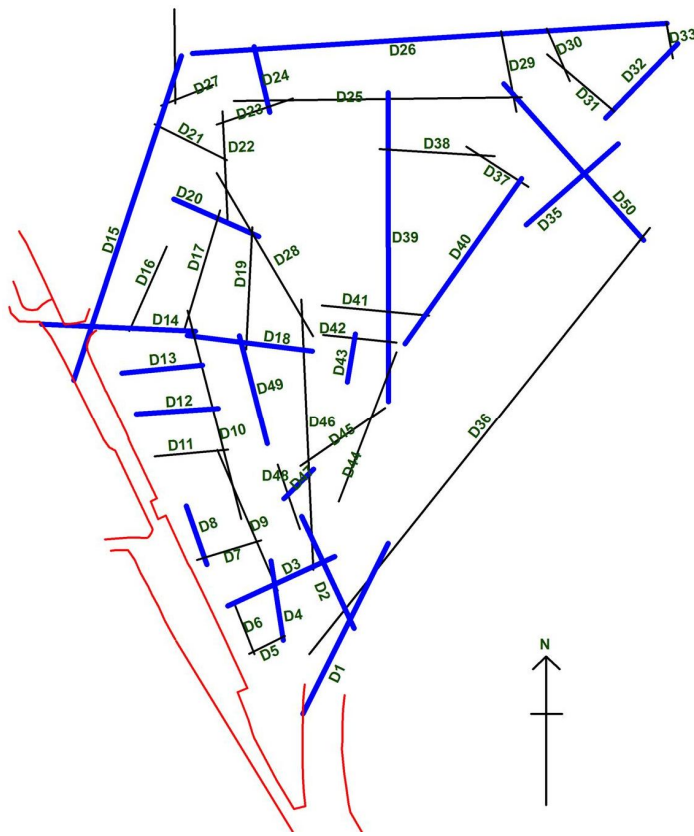


Figure 3-15: Axial map for Otiende residential neighbourhood.  
 Source: Author, 2010.

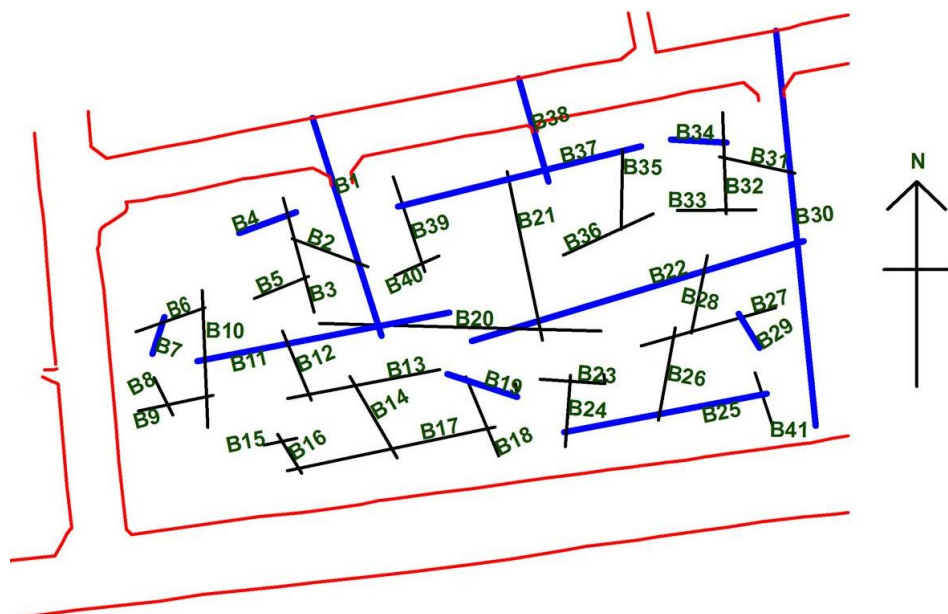


Figure 3-16: Axial map for Buru Buru V residential neighbourhood.  
 Source: Author, 2010.

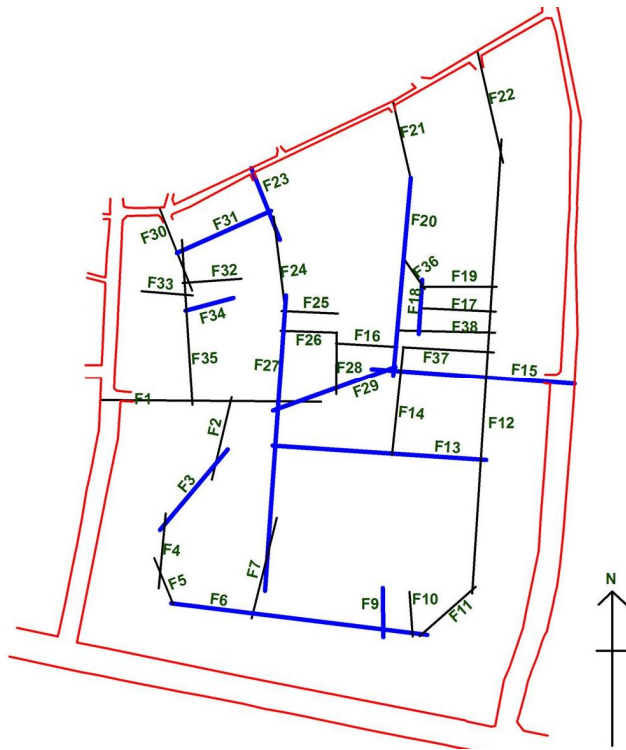


Figure 3-17: Axial map for Ofafa Maringo residential neighbourhood.  
Source: Author, 2010.

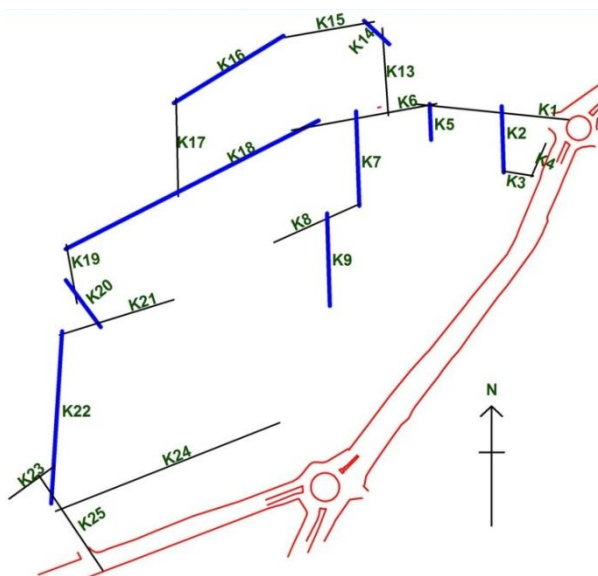


Figure 3-18: Axial map for Madaraka residential neighbourhood.  
Source: Author, 2010.

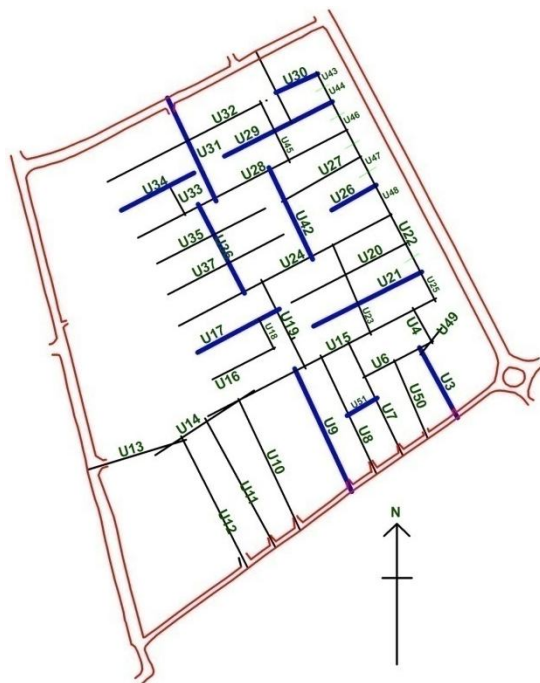


Figure 3-19: Axial map for Umoja II residential neighbourhood.

Source: Author, 2010.

The study population is summarized in table 3-7 below which illustrates its distribution across the ten neighbourhoods.

**Table 3-7: Distribution of the study population across the ten neighbourhoods**

S/No.	Neighbourhood	Study Population
1.	Parklands	27
2.	Mitini	29
3.	Lavington	43
4.	Tena	35
5.	Pangani	45
6.	Otiende	49
7.	Buru Buru V	41
8.	Ofafa Maringo	37
9.	Madaraka	22
10.	Umoja II	41
<b>TOTAL</b>		<b>369</b>

Source: Author, 2010.

### **3.3.3 Determination of Population Sample Size**

This study focuses on 120 of the 369 public spaces defining the population of the sample residential neighbourhoods. This figure is guided by the body of literature on establishment of sample size. A review of the literature reveals that different authors have different criteria for calculation of sample size thus giving different results for the same population. They however all underscore the principal consideration in setting a sample size, that is, be able to yield results that can accurately be generalized to the parent population. This requires the sample to have a degree of representativeness of the population (Bryman, 2004).

Kerlinger (1973) underscores the essence of a large sample for purposes of minimizing sampling error. He however indicates that a sample size of 10% of the target population is large enough so long as it allows for reliable data analysis, provides desired level of accuracy in estimates of the large population and allows for testing for significance of differences between estimates. Going per Kerlinger's approach, it means that a sample size of 37 public spaces suffices for this study.

Patton (1990), on the other hand, argues that the sample size, when purposeful sampling is applied, depends on what one wants to know, the purpose of the inquiry, what is at stake, what will be useful, what will have credibility and what can be done within available time and resource. He points out that the intent of purposeful sampling is to select information-rich cases for in-depth study, size and specific cases being dependent on study purpose. In this regard then, the researcher has to make judgment as to what size of sample meets the purpose of the study and allows for generalization of findings.

Lincoln and Guba (1985) in Patton (1990:185) recommend sample selection to the point of redundancy;

*"... In purposeful sampling, the size of the sample is determined by informational considerations. If the purpose is to maximize information, the sampling is terminated when no new information is forthcoming from the new sampled units. Thus redundancy is the primary criterion."*

Lincoln and Guba therefore have no indication as to what specific size of sample; the researcher has to sample individual units to the level of being convinced that the sampled units are representative of the parent population.

According to Krejcie (1970), in Ng'ang'a et al. (2009), sample size is determined by the following formula:

$$n = \frac{X^2 N p q}{d^2 (N-1) + X^2 p q}$$

where n = desired sample size

N = target population

p = proportion of the target population estimated to have a particular characteristic. Where there is no estimate 50% (or 0.5) is used.

q = 1-p for a binomial distribution

d = degree of accuracy desired given by the significance level (take 0.05 for 95% confidence level)

X<sup>2</sup> = the table chi square value for one degree of freedom relative to the desired level of confidence (X<sup>2</sup> = 3.841 at 95% confidence level).

In applying Krejcie's formula to this study, the obtained value for the sample size (n) is 189 spaces.

Naasiuma (2000) provides the following formula for determining sample size:

$$n = \frac{N c_v^2}{c_v^2 + (N-1) e^2}$$

where n = sample size

N = target population

c<sub>v</sub> = coefficient of variation (take 0.5)

e = tolerance at desired level of confidence (take 0.05 at 95% confidence interval)

In using Naasiuma's formula for the population of 369, a sample size of 79 is obtained.

From the foregoing, it is worthy appreciating that there are different approaches to sample size determination. In this study, after consideration of the above approaches, the criterion which has been used employs magnitude of environmental problems in public space as a fundamental factor in picking a space for detailed inquiry. This criterion is described in detail in the next section to bring out how a sample size of 120 is arrived at.

### 3.3.4 Sampling of Public Spaces

To facilitate sampling of public spaces for inclusion in the study, each of the public spaces, presented in the axial maps, is identified by a unique code for purposes of systematic study and analysis. The spaces are then sampled in a two-stage process.

In the first stage, a public space environmental survey is conducted in which all the spaces in each neighbourhood are included. The spaces are each systematically observed by the principal investigator and then scored against each of the following environmental variables using a five-point scale:

- solid waste
- parking problem
- dust pollution
- odour pollution
- quality of greenery
- storm water drainage problem
- vehicular-pedestrian conflict and
- destruction of road network.

For any given environmental problem, the best condition is given a score of five (5) whereas the worst condition is given a score of one (1). Table 3-8 illustrates the scoring scale for the environmental problems whereas the score sheet is presented as Appendix 1.

**Table 3-8: Scoring scale for public space environmental problems.**

Environmental Problem	Description	Measuring Scale					Description
Solid waste	Dirty	1	2	3	4	5	Clean
Parking problem	High	1	2	3	4	5	Low
Dust pollution	Smelly	1	2	3	4	5	Fresh
Odour pollution	Smelly	1	2	3	4	5	Fresh
Quality of greenery	Bushy	1	2	3	4	5	Mown
Storm water drainage problem	High	1	2	3	4	5	Low
Vehicular-pedestrian conflict	High	1	2	3	4	5	Low
Destruction of road network	High	1	2	3	4	5	Low

Source: Author, 2010.



Using odour pollution as an example, a description of the scores is illustrated in Table 3-9 below:

**Table 3-9: A description of scores used in the measuring scale**

Description	1	2	3	4	5	Description
Smelly	Very smelly	Somewhat more smelly than fresh	Equally smelly and fresh	Somewhat more fresh than smelly	Very fresh	Fresh

Source: Author, 2010.

This preliminary assessment is carried out on neighbourhood basis in order to make possible selection of public spaces. It is at this stage that the figure of 120 public spaces is arrived at. Considering that the environmental problems are different and no study has demonstrated that scores across variables can be summed up to give a consolidated score to aid easy selection of spaces over the five-point scale, spaces are judged by considering their scores under each environmental problem in order to identify worst and best spaces (spaces scoring 1 and 5 respectively) with regard to their environmental status. This requires that the best and worst public spaces under each environmental problem are identified and then comparison carried out across all the environmental problems in order to single out which spaces are indeed worst and best in overall. All the spaces falling in these extreme conditions are included in the study sample. For the spaces that fall in between the extreme conditions, the same judgment is applied and selection of spaces carried out to the point that the next space being selected has no new information being added to the sampled spaces. In using this sampling approach, which is advocated by Patton (1990), a sample size of 120 public spaces is established. Distribution of these sample public spaces per neighbourhood is shown in table 3-10. These sample spaces are bolded in Figures 3-10 to 3-19.

**Table 3-10: Sample size for public spaces in the ten residential neighbourhoods**

S/N o.	Neighbourhood	Study Population	Sample Size	Sampled Spaces
1.	Pangani	45	18	N7,N50,N10,N15,N11,N14,N16,N43,N20,N22,N28,N3,N32,N35,N29,N47,N46,N45
2.	Buru Buru V	41	12	B1,B34,B29,B4,B7,B30,B22,B25,B11,B19,B37,B38
3.	Otiende	49	21	D32,D40,D15,D50,D26,D35,D14,D20,D47,D21,D12,D4,D13,D18,D24,D3,D39,D8,D43,D49
4.	Tena	35	9	T22,T24,T30,T28,T14,T13,T60,T19,T5
5.	Umoja II	41	12	U31,U42,U3,U9,U29,U21,U17,U36,U34,U30,U26,U51
6.	Madaraka	22	9	K2,K5,K14,K18,K22,K7,K20,K16,K9
7.	Ofafa Maringo	37	12	F31,F15,F3,F34,F6,F9,F20,F23,F13,F29,F27,F18
8.	Lavington	43	12	L8,L5,L43,L33,L41,L28,L2,L24,L21,L34,L17,L15
9.	Parklands	27	9	P30,P20,P18,P15,P13,P9,P24,P17,P32
10	Mitini	29	6	M2,M7,M24,M20,M14,M10
<b>TOTAL</b>		<b>369</b>	<b>120</b>	

Source: Author, 2010

The sampling criterion is informed by three considerations – one, the quantity of spaces has to be at least thirty for findings to be generalized to the parent population which is the universe of public spaces in the ten neighbourhoods (Kazmier, 1976). Two, the spaces have to reflect the distribution of each environmental problem with regard to its magnitude. Three, the geographical spread of the sampled spaces has to be representative of all the spaces in each neighbourhood. A key consideration on this criterion is to keep sampling error as low as possible. This suggests that a larger sample is necessary for a decrease in sampling error (Bryman, 2004). This further concurs with the central limit theorem to the effect that as the sample size is increased, the sampling distribution of the mean approaches the normal distribution (that is, the bell-shaped curve) in form regardless of the population distribution. According to Kazmier (1976), the sampling distribution of the mean is assumed to be approximately normal whenever the sample size is at least thirty.

### ***3.3.5 Sampling of Respondents***

Purposive sampling is employed in selection of public space users for interview on the status of environmental variables. Public space users that have the required information are selected and interviewed. There is no specific number of respondents is pegged to this but interviewing is carried out to the level that no new information is coming forth. Interviewing is applied in collection of data on provision of public space services and in circumstances where an environmental problem, say solid waste, does not manifest itself in a clear way. The latter scenario is informed by the possibility that maintenance routines would have been applied to a space prior to the data collection day. The users in this case are residents or operators of business or such other activities constituting a public space.

## **3.4 Data Collection Methods and Techniques**

Data needs for the study include secondary and primary data. Primary data comprises space syntax data, spatial data, and public space environmental data. The following methods and techniques are used in data collection:

### ***3.4.1 Primary Data***

This is data which is collected afresh and for the first time, and therefore is original in character. For survey research, just like this study, primary data is collected in the individual public spaces either through observation or through direct communication with respondents by use of personal interviews. Some type of primary data is obtained by making reference to residential neighbourhood layout plans. Depending on the nature of primary data being collected, this study thus makes use of the following methods: axial alpha-analysis, observation and interview.

#### ***3.4.1.1 Axial Alpha-analysis***

Space syntax theory and method (Hillier and Hanson, 1984), whose focus is on how space works in its relation to other spaces of the plan system, forms a core component of this study. Alpha-analysis, a space syntax method of assessing exterior space (as opposed to interiors of buildings), is used to generate data from the axial space system of the residential neighbourhoods under inquiry.

As mentioned earlier in this chapter, preparation of neighbourhood axial maps is a pre-requisite to applying this method of data collection. An accurate axial map of each neighbourhood is defined by drawing it on the respective layout plan at a scale of 1:1250. Hillier and Hanson (1984) recommend this scale as the best for alpha-analysis although the procedure works successfully even on maps up to the scale of 1:10,000. An axial map primarily defines units of analysis from the continuous public space system of a settlement.

An axial map of a neighbourhood is made by first finding the longest straight line that can be drawn within a street space and drawing it on an overlaid tracing paper, then the second longest, and so on until the entire street space is covered and all axial lines that can be linked to other axial lines without repetition are so linked. An axial line defines the axial or public space. An axial space is therefore a unit of a continuous street space which extends in one dimension and is linked to one or more other units in the street space system of the settlement.

Application of alpha-analysis on the axial or public space system requires that streets surrounding or leading to a residential neighbourhood are defined. These constitute the carrier space. Figures 3-20 and 3-21 illustrate an axial map for Mitini neighbourhood in two versions – in the first case, the axial space structure superimposed on the continuous public system and in the second case, the axial space structure on its own but with the carrier space. For meaningful statistical analysis to be possible, each public space is identified with a unique code.

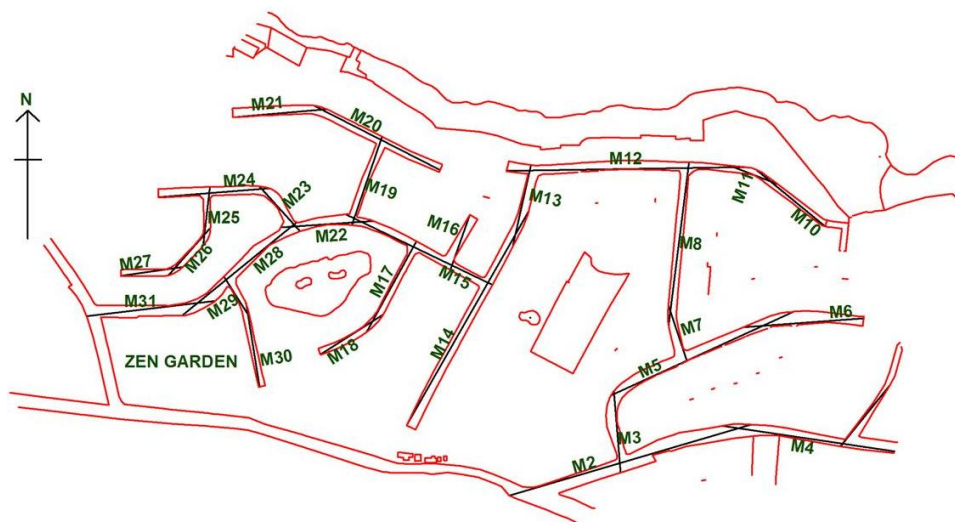


Figure 3-20: Axial map superimposed on public space system. Source: Author, 2010.

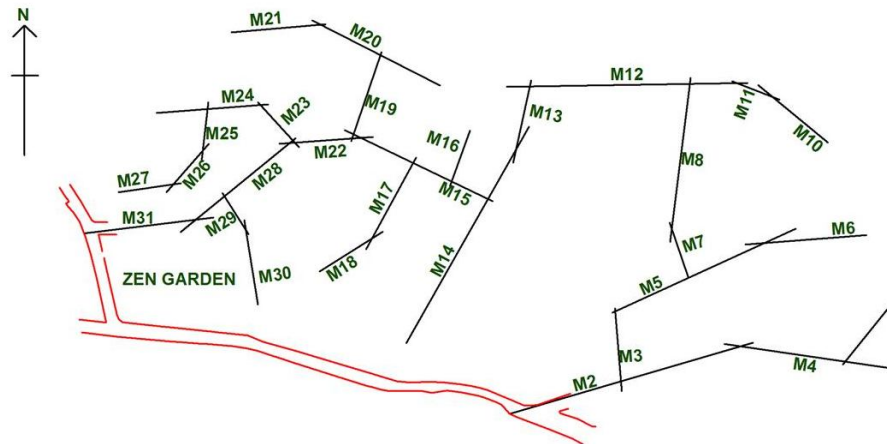


Figure 3-21: Axial map with only the carrier space.

Source: Author, 2010.

Syntactic variables whose data is generated through axial alpha-analysis fall under the broad dimensions of constitutedness-unconstitutedness, distributedness-nondistributedness, and symmetry-asymmetry. The variables, alongside the procedure for generating respective data, are presented in chapter one. In collecting syntactic data for the present study, just like for the other variables, focus is limited to the sampled public spaces.

### 3.4.1.2 Observation method

The observation method entails the investigator seeking information by way of his own direct observation without asking from a respondent. According to Kothari (1996), the method becomes a scientific tool of data collection when it is systematically planned and recorded and is subjected to checks and controls on validity and reliability. While using this method, the researcher keeps in mind things like:

- What should be observed?
- How should the observations be recorded?
- How can the accuracy of the observation be ensured?

In view of this, observation presents itself in three dimensions which also underlie the present study. These are:

- a. Structured and unstructured observation
- b. Participant and non-participant observation
- c. Controlled and uncontrolled observation.

According to Bryman (2004), structured observation, also called systematic observation, is a method in which the researcher employs explicitly formulated rules for the observation and recording of behaviour or some other condition. The rules inform observers about what they should look for and how they should record it. Kothari (1996) presents the following issues as characterizing structured observation:

- A careful definition of the units to be observed;
- The style of recording the observed information;
- Standardized conditions for observation; and
- Selection of pertinent data for observation.

When observation is to take place without these characteristics being thought of in advance, the same is termed as unstructured observation.

The distinction between participant and non-participant observation depends upon the observer's sharing or not sharing the life of the group or environment he is observing. Kothari (1996) points out that when the observer observes by making himself, more or less, a member of the group he is observing so that he can experience what the members of the group are experiencing, this is referred to as participant observation. But when the observer observes as a detached emissary without an attempt on his part to experience through participation what others feel, the observation is termed as non-participant observation. On the other hand, observation is said to be controlled when it takes place according to pre-arranged plans on what to observe and what method to use in recording the observation. Uncontrolled observation takes place in a natural setting and no attempt is made to use precision instruments. The idea underlying uncontrolled observation is to get a spontaneous picture of a situation. However, in controlled observation, mechanical or precision instruments are used as aids to accuracy and standardization (Ibid.).

The present study is structured and controlled. It employs participant observation to collect primary data. This is made possible by the following factors:

- The street space system of residential neighbourhoods is structured into a series of axial spaces. An axial space is the unit of analysis.

- Variables to be observed and the style of recording the observations are defined in an observation-cum-interview schedule. This data collection technique is presented in Appendix 2.
- Tools and procedures for measuring and recording the observations are specified in the observation-cum-interview schedule. These include:
  - i. Measuring wheel, for measuring horizontal and long distances.
  - ii. 5-metre long measuring tapes, for measuring short distances, both horizontal and vertical, for instance width of a sidewalk and starting height of windows respectively.
  - iii. Cameras, for still photography.
  - iv. Counting machines, for tallying variables such as number of people, vehicles and trees in space.
  - v. Electronic calculator, for standardization of measures
- Observation time for the human use system of public space. This is carried out on week days between 9.00 in the morning and 4.00 in the evening, a time frame that is outside the peak hours when people are going to or coming from duty. This time limit is necessary for consistency in the nature of data that is observed. This is particularly critical in observing the environmental status of distribution of people in public space.

Data collected through structured observation is measured either qualitatively using a Likert-like scale or with the aid of precision instruments. In the environmental survey stage, in which sampling of public spaces for detailed investigation is carried out, the observed magnitude of environmental problems in all the public spaces is measured qualitatively. In the stage for detailed investigation of public spaces, qualitative measurement is used to collect data on the following variables:

- Intensity of mix of activities in the space, measured on a scale of 1 to 4;
- Intensity of taking care of planting, measured qualitatively on a scale of 1 to 7;
- Dust pollution, measured on a scale of 1 to 5;
- Odour pollution, measured on a scale of 1 to 5;
- Quality of solid waste, measured on a scale of 1 to 5; and
- Quality of greenery, measured on a scale of 1 to 5.

The rest of the variables in the list presented in chapter one are measured with the aid of precision instruments. Considering that the axial spaces are of different sizes, both in length (expressed in metres) and area (expressed in square metres), measurements made with the aid of precision instruments are mostly standardized so that comparison across the spaces can be possible. This entails presenting the measurement either per metre or per square metre of the space. For instance, variable F11 (number of chemists fronting a public space) is expressed as a ratio of the number of chemists to the length of the axial space. For space F29 in Ofafa Maringo neighbourhood, the value for F11 is  $1/147$  which is equal to 0.007. For space N22 in Pangani neighbourhood, the value for F11 is  $2/180$  which is equal to 0.011. It is important to note that despite the two spaces (F29 and N22) being of different lengths (147 and 180 metres respectively), the standardized measures are of the same scale and can therefore be used in statistical analyses where generalization of results is of interest. Where it is required in the observation schedule that a variable be standardized on the basis of square metre, for instance the proportion of area of public space covered with grass (variable B5 in Appendix 2), the same approach of standardization is followed. Some variables however do not require to be standardized and are meaningful for statistical analyses the way they are measured. Some of these include: width of space (variable B1), length of space (variable B2), area of space (variable B3) and total width of sidewalks (variable C2). Table 3-11 below shows an example of data collected through observation.



**Table 3-11: An example of data collected through observation.**

SPACE CODE	VARIABLE								
	A2	B1	B2	B3	B4	B5	B6	B7	B8
D40	3	12	282	3384	39.982	25.118	7.388	2.394	25.118
D26	3	12	665	7980	33.835	31.328	11.905	7.895	15.038
D50	3	18	286	5148	5.031	27.778	2.972	58.275	5.944
D24	3	15	91	1365	31.941	54.799	3.297	7.766	2.198
D32	3	12	142	1704	41.667	38.028	12.676	0.587	7.042
D8	3	9	84	756	0.661	11.508	5.952	59.392	22.487
D18	3	15.6	175	2730	35.897	1.722	12.821	49.56	0
D4	3	11	99	1089	27.273	30.67	4.132	22.681	15.243
D3	3	11	162	1782	50.898	25.253	11.223	4.209	8.418
M14	3	14	406	5684	43.772	32.442	7.213	0.352	16.221
M10	3	12	142	1704	47.242	15.827	0	5.276	31.655
M24	3	12.7	175	2223	44.669	18.893	9.447	0	26.991
U9	3	9	204	1836	3.431	1.144	0.98	94.444	0
U29	2	4.5	174	783	0	4.215	10.243	83.244	2.299
U36	3	10.5	149	1564.5	0	0.32	1.278	98.402	0
U17	3	4	145	580	0	2.759	10.517	86.724	0
U21	2	5	184	920	0	10.717	9.957	79	0.326
U34	2	4.5	119	536	0	11.007	14.366	74.44	0.187
U30	2	4.5	60.5	272.25	0	13.3333	11.093	75.574	0
L43	3	33	630	20790	11.717	70.892	0.519	14.947	1.924

Source: Author, 2011.

### **3.4.1.3 Interview method**

The interview method of data collection involves presentation of oral-verbal stimuli and reply in terms of oral-verbal responses (Kothari, 1996). The method is used through personal interviews and where possible, through telephone interviews. The present study uses personal interview in collecting data on some of its variables. This method entails an interviewer asking questions generally in a face-to-face contact to the other person or persons giving information.

Collecting information through the method of personal interviews can be either structured or unstructured. It is in this perspective that we talk of structured and unstructured interviews respectively. Structured interviews involve the use of a set of predetermined questions and of highly standardized techniques of recording. In a structured interview therefore, the interviewer follows a rigid procedure laid down, asking questions in a form and order prescribed. On the other

hand, unstructured interviews are flexible as they do not follow a system of predetermined questions and standardized techniques of recording information.

The present study makes use of a structured personal interview. Variables whose data is collected through this method are:

- Intensity of taking care of planting (variable D59), measured qualitatively on a scale of 1 to 7;
- Intensity of private security patrols (variable D58), measured qualitatively on a scale of 1 to 7;
- Intensity of garbage collection (variable D55), measured qualitatively on a scale of 1 to 7; and
- Intensity of Kenya Police patrols (variable D56), measured qualitatively on a scale of 1 to 7;

These variables are presented in the observation-cum-interview schedule in Appendix 2.

### **3.4.2 Secondary Data**

Secondary data refers to that type of data which has already been collected and analyzed by someone else. The data is already documented and available. In this regard, this study obtains its secondary data from (a) various government publications; (b) research journals; (c) books and newspapers (d) reports and publications of various institutions (e) research theses and (f) public records and statistics. Literature review is used as the method of collecting secondary data.

#### **3.4.2.1 Literature review**

A review of books, newspapers, and published articles in refereed research journals and theses written in the areas of spatial planning and environmental management aided in establishing information about the research problem. This preliminary search was crucial as it helped refine the research problem and objectives. Initially, general reading in the subject area is carried out to identify specific areas of interest. This is then followed by a focused review of relevant literature.

A review of documents in the City Council of Nairobi's department of City Planning and Architecture yielded information on Ground Coverage and Plot Ratio for the various residential

neighbourhoods being investigated in the study. Information on census data for the City of Nairobi is obtained from the Kenya National Bureau of Statistics. Individual residential neighbourhood maps are extracted from maps at Survey of Kenya which is a department of the Ministry of Lands and Settlements in the Government of Kenya. Various national policy documents are reviewed and these reveal the government's mandate and intentions on spatial planning and urban environmental management.

### **3.5 Data Analysis and Interpretation**

This study uses the SPSS, Version 16.0, to aid in analysis of data and generation of outputs for interpretation. Initially, all the observation-cum-interview schedules containing field data are coded by assigning them identification numbers. A data file is then created in the SPSS program and all the variables defined. Data for both continuous and categorical variables is then entered. The successive steps in data analysis and interpretation after data entry into the SPSS are as follows:

- Screening and cleaning the data;
- Multicollinearity assessment;
- Running multiple regression;
- Evaluating regression models; and
- Evaluating each of the independent variables.

Prior to starting data analysis, the data set is first checked for errors. This is the data screening process in which each of the variables is checked for scores that are out of range, that is, not within the range of possible scores. The case with such an error is identified and the error corrected in the data file.

All independent variables in the study are assessed for multicollinearity. This is realized by running a bivariate correlation of all the independent variables. Multicollinearity exists when any two independent variables are highly correlated with a coefficient of at least 0.7. Tabachnick and Fidell (2001) point out that multicollinearity is not good for multiple regression analysis considering that the variables measure the same thing. They recommend omitting one of the variables or forming a composite variable from the scores of the two highly correlated variables. In this study, one of such variables is omitted and is common with variables in which one is the

opposite of the other. An example of this is seen in variables B21 (percent of space that is gentle) and B22 (percent of space that is steep).

Once variables contributing to multicollinearity are omitted, multiple regressions are run using the stepwise method. A selected set of independent variables is regressed against an environmental variable to establish the extent to which the latter is explained by the former. A regression analysis generates a number of outputs, among them being a model summary (Table 3-12). Values in these outputs are useful in interpreting the general linear relationship already discussed in chapter one.

**Table 3-12: Model Summary output for Model 2 – an output from SPSS.**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate (S <sub>e</sub> )
1	.581 <sup>a</sup>	.338	.329	.011308
2	.662 <sup>b</sup>	.439	.423	.010483
3	.699 <sup>c</sup>	.489	.467	.010077
4	.727 <sup>d</sup>	.529	.502	.009738
5	.747 <sup>e</sup>	.559	.527	.009495
a. Predictors: (Constant), C3				
b. Predictors: (Constant), C3, N1				
c. Predictors: (Constant), C3, N1, D18				
d. Predictors: (Constant), C3, N1, D18, F17				
e. Predictors: (Constant), C3, N1, D18, F17, D17				

Source: Author, 2011.

In the table above, R= Multiple correlation coefficient; R<sup>2</sup>= Coefficient of determination; and Adjusted R<sup>2</sup>= Adjusted Coefficient of determination; C<sub>3</sub>= Frequency of intersections within the space; N<sub>1</sub>= Building space index; D<sub>18</sub>= Average no. of storeys per square metre of space; F<sub>17</sub>= Frequency of informal business activities in the space; D<sub>17</sub>= Average no. of storeys per length of space; S<sub>e</sub>= Standard error of the estimate.

In the model summary table, R Square is the coefficient of determination and indicates how much of the variance in the dependent variable (Frequency of Interruption of pedestrian flow by

vehicular traffic) is explained by the model. Expressed as a percentage, this means that the model explains 55.9 percent of the variance in the dependent variable. Adjusted R Square is applied when a small sample is involved. In the present study, Adjusted R Square is not used given that the sample size, which also works for the ANOVA, is greater than 100 and therefore large.

A coefficients table is another output from a multiple regression (Table 3-13). In constructing a regression equation, the unstandardized coefficients listed as B are used. In comparing different variables, standardized coefficients listed as Beta are used. 'Standardized' means that these values for each of the different variables have been converted to the same scale to allow for comparison. In this case, interest is in comparing the contribution of each independent variable. In this model therefore (Table 3.11), variable C3 contributes 42.9 percent whereas variable N1 contributes 29.2 percent to the model.

**Table 3-13: Coefficients for Model 2 – an output from SPSS.**

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-.002	.003		-.670	.505
C3	.518	.121	.429	4.267	.000
N1	.000	.000	.292	3.067	.003
D18	.627	.235	.235	2.665	.010
F17	.094	.034	.250	2.744	.008
D17	.230	.107	.224	2.151	.035

a. Dependent Variable: Frequency of interruption of pedestrian flow by vehicular traffic

Source: Author, 2011.

To assess the statistical significance of the model, it is necessary to look at the output labelled ANOVA. For Model 2, the p-value (Table 3-14) is 0.000. Since this is less than 0.01, then the prediction is significant at 99 percent confidence level.

**Table 3-14: ANOVA for Model 2 – an output from SPSS.**

ANOVA <sup>f</sup>						
Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	.008	5	.002	17.470	.000 <sup>e</sup>
	Residual	.006	69	.000		
	Total	.014	74			
e. Predictors: (Constant), C3, N1, D18, F17, D17						
f. Dependent Variable: Frequency of interruption of pedestrian flow by vehicular traffic						

Source: Author, 2011.

The predictive models illustrate that environmental problems in a public space can be expressed as a function of spatial variables. This implies that the problems can be minimized to negligible levels through manipulation of spatial variables through planning.

### **3.6 Ethical Considerations**

Before undertaking the study, approval was sought from the School of Architecture and Building Sciences and the Board of Post-graduate Studies, Jomo Kenyatta University of Agriculture and Technology. Permission to conduct the research was granted by the National Council of Science and Technology, City Council of Nairobi and the Provincial Administration.

In conducting interviews in the public space system of residential neighbourhoods, an explanation is initially made to the respondents on the purpose of the research and its significance. They were assured that their responses would be treated with utmost confidence and that their identification was not required in the research. They were informed that their participation in the interview was voluntary. Those willing to participate were accorded the necessary privacy by ensuring that only the respondent and the researcher were present at the time of conducting the interview.

### **3.7 Conclusion**

This chapter has established that Nairobi, which is the area in which this study is based, has a rich history of planning which dates back to the colonial period. Plan implementation, especially after independence, stands out as an overwhelming challenge for both the central government

and CCN. However, the city is well served by elaborate legal and institutional frameworks for environmental management. Despite this, it is an issue of concern that environmental problems in the public space system of residential neighbourhoods remain pervasive. In this light, the chapter has advanced an empirical methodology which is applied in the study of this dilemma with a view to evolve spatial planning guidelines whose application can result in environmentally sustainable public spaces. Results of application of this methodology are presented in the next chapter of this study.

## CHAPTER FOUR

### 4.0 NEIGHBOURHOOD PUBLIC SPACE ENVIRONMENTAL PROBLEMS

#### 4.1 Introduction

This chapter presents public space environmental problems in the City of Nairobi's residential neighbourhoods as a result of application of the empirical methodology advanced in Chapter Three of the study. Central in the present chapter is establishment of which spatial planning characteristics and to what extent they explain each of the environmental problems in public space. The chapter identifies spatial patterns that have a bearing on environmental problems. Inferences on how these patterns can be utilized in environmental management are elaborately discussed in the next chapter.

Public space environmental problems discussed in this chapter are related to vehicular-pedestrian conflict, parking in undesignated areas, public space pollution, solid waste accumulation in public space, defective storm water drainage system, neglect of greenery, destroyed road network, and human distribution in public space. Different dimensions of each of these problems are looked at and each of them presented as a prediction of spatial variables.

#### 4.2 Vehicular – Pedestrian Conflict

Protection of people and interruption of their activities in public space from the threat of vehicles is of pertinent concern in the spatial planning of residential neighbourhoods. Oglesby and Hicks (1982) point out that vehicles rolling over highways and streets are an important parcel of life as they are the principal means of transporting persons and goods. In essence then, motor vehicles cannot be done away with, more so in urban areas where they are heavily relied on as a means of transportation. Some urban streets, in fulfilling their transportation function, serve primarily as arteries for local traffic and others mainly provide access to property. Oglesby and Hicks add that the volume of vehicular traffic on urban streets varies widely depending on whether the setting is a highway serving a town or a local road serving a residential neighbourhood. In making reference to the United States of America, which is a developed country and has a car as a mainstay in its economy, they write that traffic volume on a highway averages about 800 vehicles per day and that traffic volume on purely residential streets would be much lower. Comparatively, the volume of vehicles on highways and residential streets of developing countries is much lower.



According to Alexander (1977), a major road passing through a residential neighbourhood is not good for the pedestrian and destroys the neighbourhood. He points out that the heavier the traffic in an area, the less people think of it as home territory. This underlines the fact that people always want to identify with a neighbourhood as place to dwell in and this identity can only be strong if a neighbourhood is protected from heavy traffic. Alexander cites 200 vehicles per peak hour as the threshold for a livable neighbourhood. Anything higher than this deteriorates the quality of the neighbourhood and highly compromises pedestrian safety from vehicles.

Through traffic in a neighbourhood exacerbates vehicular-pedestrian conflict. Such traffic is fast, noisy and dangerous to the pedestrian due to the increased risk of accident. Empirical studies, as documented in Alexander (1977), demonstrate that the spatial planning for vehicular circulation systems in a neighbourhood, and in particular the kind of junctions that are provided, affects the level of safety and accidents therein. T-junctions have many fewer accidents than four-way intersections. A T-junction is safest if it is a right-angled junction. Any deviation from a right angle compromises a driver's clarity of vision and accidents are bound to be higher.

Even though cars are dangerous to pedestrians, it is important to underscore that in a neighbourhood's public space system, activities occur just where cars and pedestrians meet. This is evident for example in parking lots where children play, in car wash areas where conversations and discussions grow naturally as cars are being worked on, and in homes where a car is quite often used as an extension of the house whereby people sit in parked cars, next to their houses, eating or drinking and talking. It emerges then that a car is an important object for one's personal comfort and in the social life of a neighbourhood, and therefore its accommodation in a neighbourhood ought to be planned for such that the peace and safety of the pedestrian is guaranteed. The common spatial planning practice of solving vehicular – pedestrian conflict in public space, as Alexander (1977) documents, is to segregate pedestrians and cars. This practice however fails to recognize the fact that cars and pedestrians also need each other, and that a great deal of urban life occurs at just the point where these two systems meet. In places where there is total separation between the two, seldom does one have the same sort of liveliness. Despite this, it is essential to keep pedestrians separate from vehicles for purposes of avoiding accidents and preserving the tranquility of pedestrian life.

To resolve vehicular-pedestrian conflict in an urban settlement, according to Alexander (1977), it is necessary to find an arrangement of pedestrian paths and roads, so that the two are separate, but meet frequently, with the points where they meet recognized as focal points. At these nodes, there should be small parking lots and space for kiosks and shops. He however underscores that this kind of segregation of cars from pedestrians is only appropriate where traffic densities are medium or medium high. Under this category of traffic densities, he suggests that pedestrian paths should be laid out at right angles to roads, not along them, so that the paths gradually begin to form a second network, distinct from the road system, and orthogonal to it. The paths should be put in the middle of the cluster block so that they run across the roads. At low densities, as in the case of a cul-de-sac gravel road serving half-a-dozen houses, the paths and roads can obviously be combined. There is no reason even to have sidewalks. On the other hand, at very high traffic densities, pedestrian paths are laid out to run along the roads. In this case, according to Alexander (1977), the conflict is solved by extra wide sidewalks (about 4.5 m) that are about 450mm above the road surface. The specified height makes the pedestrian world higher than the vehicular world and this makes the pedestrian to feel psychologically secure. The height also makes it impossible for a runaway car to mount the kerb and run the pedestrian down. However, the sidewalk should be marked at its edge with a low wall or railing or balustrade. In regard to the width, at least 4.5m is comfortable to a pedestrian along a shopping street with traffic. He notes that in a conventional sidewalk, measuring 1.8m wide, a pedestrian feels cramped and threatened by the presence of cars. In order to afford the extra width which people need in order to be comfortable, Alexander suggests that a double width sidewalk be put on one side of the road only with road crossings at intervals of 60 to 90 metres. The demerit though of this spatial layout is that there can only be shops along one side of the road.

At the points where pedestrian paths cross roads, the cars have power to frighten and subdue the people walking across the road at the same grade. Even in points where there are provisions for a pedestrian right-of-way, this has in no way translated to a right to life. It is important to note that no amount of white lines, crosswalks, traffic lights and button operated signals ever quite manage to change the fact that a car is of such a weight that it will run over any pedestrian unless the driver brakes. In many occasions the driver brakes, but in some instances this has not happened due to failure of the brakes or of the driver to be alert. The concern then which comes to the fore

is how such a crossing should be articulated in its layout so that it renders safety to pedestrians. Alexander (1977) points out that the pedestrians who cross the road must be extremely visible from the road. Cars should be forced to slow down when they approach the crossing. Accordingly, if the pedestrian crosses 12 inches above the roadway, and the roadway slopes up to it, this satisfies both requirements. A slope of 1 in 6, or less, is safe for cars and solid enough to slow them down. To make the crossing even easier to see from a distance and give thrust to the pedestrian's right to be there, the pedestrian path could be marked by a canopy at the edge of the road. Alexander summarizes articulation of a road crossing as follows:

*'At any point where a pedestrian path crosses a road that has enough traffic to create more than a two second delay to people crossing, make a "knuckle" at the crossing: narrow the road to the width of the through lanes only; continue the pedestrian path through the crossing about a foot above the roadway; put in islands between lanes; slope the road up toward the crossing (1 in 6 maximum); mark the path with a canopy or shelter to make it visible'.*

However, Alexander raises caution with regard to application of this measure. It should not be used on every road, but only on those roads where there is critical need for it as informed by the criterion of two seconds delay time. Traffic engineers may be opposed to the measure but, nevertheless, the functional issue is vital and worthy not ignoring.

In the present study, it is established that some roadways in the public space system have sidewalks on one or two sides while others do not. In low vehicular density neighbourhoods, sidewalks have not been planned for just as suggested by Alexander. People have either defined them as footpaths at the roadside or simply walk on the road surface that also serves vehicles. In the high vehicular density neighbourhoods, sidewalks are planned for on one or both sides of the road. In all the neighbourhoods, heavy traffic flow is limited to the peripheral road system. Given that the local roads largely handle traffic destined for specific points therein, a raft of measures as advanced by Alexander, such as knuckling of the road at crossing points, are not applicable. This however in no way decimates Alexander's measures as indeed they are a big contribution to the philosophy of resolving vehicular-pedestrian conflict in areas of high vehicular densities such as town centres. In this study then, vehicular-pedestrian conflict is looked at as locations where vehicles have encroached into zones of pedestrian activity. Plates 4-1 'a' and 'b' below illustrate this.



a.



b.

Plate 4-1: Vehicular-Pedestrian Conflict.

Source: Author, 2011.

#### **4.2.1 Modelling Frequency of Interruption of Pedestrian Flow by Vehicular Traffic**

Multiple regression analysis between frequency of interruption of pedestrian flow by vehicular traffic and axial alpha variables shows that 26.3 percent of the variance in the dependent variable is significantly explained by adjacency and permeability per metre of space and adjacency and impermeability per square metre of space (Model 1 in Table 4-1). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Frequency of Interruption of pedestrian flow by vehicular traffic} = 0.006 + 0.113N_3 + 1.774N_5 \pm 0.012S_e \dots\dots\dots (1)$$

The variable of adjacency and permeability refers to the number of buildings that are both adjacent and permeable to the public space, that is, the constitutedness property of that space (Hillier and Hanson, 1984). To allow for comparison among axial spaces of different lengths, this variable is standardized per metre of space. On the other hand, adjacency and impermeability refers to the number of buildings that are both adjacent and impermeable to the public space, which is the unconstitutedness property of the space. The measure is standardized per square metre of space to allow for comparison of spaces of different two-dimensional extents. The two predictor variables have a positive relationship with the dependent variable, implying that an

increase in either of the variables, while holding all the other independent variables constant, results in an increase in the dependent variable, that is, a higher frequency of interruption of pedestrian flow. It is evident from the model that both constitutedness and unconstitutedness properties contribute to presence of pedestrians in space. However, from the beta-values of the two variables, (Model 1 in Table 4-1), constitutedness has a higher contribution to the regression model, implying that it results in a higher number of pedestrians in space. Further, there lies a difference on the kind of pedestrians that predominate each of the two spatial domains. A public space defined by permeable buildings or plots allows residents to access their properties. On the other hand, a public space defined by impermeable buildings or plots allows only non-residents or strangers to dominate it and therefore is a risky place for residents to pass. This concurs with Oscar Newman's assertion that blank walls and lack of surveillance promote crime (Newman, 1972). Moirongo (2011) points out that spaces characterized with non-constitutedness, besides being a safe haven for criminals, are receptacles of solid waste. He further identifies the variable of depth from the carrier space as being inversely related to the problem of interruption of pedestrian flow by vehicular traffic. Similarly in this study, the correlation is negative save for the fact that it is weak ( $r = -0.074$ ). This means that the deeper a public space is in the axial layout of a settlement, the less the vehicular activity and therefore the fewer the points of interruption of pedestrian flow. Alexander (1977) and Towers (2005) point out that this kind of interruption may not be an issue in neighbourhoods where vehicular density is low. They write that in such neighbourhoods, paths and roads can be combined without bothering to provide sidewalks.

Multiple regression analysis between frequency of interruption of pedestrian flow by vehicular traffic and all independent variables as predictors realizes that five independent variables significantly explain 55.9 percent of the variance in the dependent variable (Model 2 in Table 4-1). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Frequency of Interruption of pedestrian flow by vehicular traffic} = -0.002 + 0.518C_3 + 0.000N_1 + 0.627D_{18} + 0.094F_{17} + 0.230D_{17} \pm 0.009S_e \dots \dots \dots (2)$$

All these variables have a direct relationship with the frequency of interruption of pedestrian flow by vehicular traffic. This means that increasing any of the variables while holding all the other independent variables constant results in a corresponding increase in the frequency of interruption of pedestrian traffic. These variables include frequency of intersections within the

space, building space index, average number of storeys per square metre of space, frequency of informal business activities in the space and the average number of storeys per metre of space. When the number of roads and pathways making a junction with the space increases, it implies that the number of vehicles in the space goes up just as the number of pedestrians. Consequently, the number of locations with interruption of pedestrian flow by motor vehicles goes up. This agrees with findings by Baran et al (2008) that residential streets with higher connectivity attract more walking behaviour than in streets with lower connectivity. Similarly, the number of pedestrians in public space rises with an increase in building space index, that is, the number of buildings that are both adjacent and permeable to it (Hillier and Hanson, 1984). An increase in the frequency of pedestrian activities in public space implies an increase in walking behaviour just as is the case with an increase in storey height of residential buildings. An increase in residential units, vertically in this case, means an increase in the number of neighbourhood residents and strangers who visit them. The people who come into public space due to the spatial plan characteristics are not entirely pedestrian; some come in driving. In effect then, the frequency of vehicular-pedestrian conflict increases. Since the presence of people in public space has the attendant benefit of curbing crime (Moirongo, 2011; Alexander, 1977; Jacobs, 1961), what spatial planning ought to do is to provide sidewalks that are protected from the effect of the car in public spaces where these characteristics are evident.

These findings suggest that constitutedness and unconstitutedness of public space, frequency of intersections, building space index, storey height and distribution of business activities are some of the public space characteristics that do significantly explain the frequency of interruption of pedestrian flow by vehicular traffic in the public spaces of the City of Nairobi's residential neighbourhoods. These characteristics fall into the following spatial patterns: constitutedness, connectivity and land use. Through manipulation of these patterns, spatial planning can manage the problem of vehicular-pedestrian conflict. An explanation of these patterns is presented in the next chapter of this study.

#### ***4.2.2 Modelling Density of Parking on Pedestrian Walkways***

Multiple regressions between density of parking on pedestrian walkways and axial alpha variables shows that adjacency and permeability per metre of space and building space index

explain 22.4 percent of the variance in the dependent variable (Model 3 in Table 4-1). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Density of parking on paved areas (pedestrian walkways)} = 0.000 + 0.008N_3 - 0.00002N_1 \pm 0.001S_e \dots\dots\dots (3)$$

In this prediction, adjacency and permeability per metre of space has a positive relationship with the density of parking on pedestrian walkways whereas building space index has a negative relationship. This means that an increase in the adjacency and permeability of public space, while holding other variables constant, correspondingly leads to an increase in the density of parking on pedestrian walkways. To the contrary, an increase in building space index results in a decrease in the density of parking on pedestrian walkways. Intuitively, when a public space has adjacent buildings opening to it, pedestrians flow through it. Cars also flow through it if a road is provided. It is expected that an increase in the number of buildings that are adjacent and opening into the same length of space results in an increase in the number of people and motorists in the space. Fundamentally, the empirical investigation resulting in this model confirms the intuition. Motorists, who come into the space, residents and strangers alike, end up parking on pedestrian walkways thus robbing pedestrians of their comfort of movement. In the sample neighbourhoods surveyed in this study, it emerges that this pattern is characteristic of public spaces with high density of settlement. Such spaces have a high number of retail shops and informal business activities. Whereas constitutedness of space results in increased presence of people in the space and therefore improved sense of security (Hillier, 1988), it has a weakness of promoting vehicular encroachment on pedestrian walkways and therefore compromising on pedestrian safety (Plate 4-1). Most of these motorists are attracted by the commercial land use activities in the space. According to Alexander (1977), residents of neighbourhoods with low vehicular densities can make do with this problem without feeling that their safety is compromised. Pedestrian safety becomes highly compromised in neighbourhoods with high vehicular densities. In a low density neighbourhood, residential properties are gated and the frequency of commercial activities is much lower, if any. Pedestrian encounter in public space is also lower. An increase in building space index therefore does not result in increased activity in public space. The more this pattern increases for a given public space, the lower the density of parking on sidewalks. As illustrated by Beta-values in Model 3 of Table 4-1, the overall contribution of building space index to

understanding the variance in the dependent variable is lower than the contribution made by the variable of adjacency and permeability per metre of space.

Multiple regression analysis between density of parking on pedestrian walkways and all independent variables as predictors shows that just one independent variable significantly explains 17 percent of the variance in the dependent variable (Model 4 in Table 4-1). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Density of parking on paved areas (pedestrian walkways)} = - 0.00004 + 0.00003B_6 \pm 0.001S_e \dots \dots \dots (4)$$

This variable, which is the percentage of space area that is paved, has a direct relationship with the density of parking on pedestrian walkways. This means that an increase in the amount of public space that is paved, while holding all other variables constant, results in a corresponding increase in the density of parking on pedestrian walkways. One is left to wonder whether paved pedestrian walkways in a residential neighbourhood are a necessary evil; good for pedestrians to walk on and at the same time a magnet to cars on the look-out for parking space. It is imperative that a spatial planning solution is obtained so that the conflict between vehicles and pedestrians is kept at bay.

These results suggest that constitutedness of public space, building space index and percentage of space area that is paved are some of the public space characteristics that do significantly explain the density of parking on pedestrian walkways in the public space system of residential neighbourhoods in the City of Nairobi. These characteristics fall into the following patterns: constitutedness, land use and ecological balance. If spatial planning is to consider these patterns in the evolution of settlement layouts, the problem of vehicular-pedestrian conflict can be significantly and sustainably addressed. The patterns are elaborately discussed in the next chapter of this study.



**Table 4-1: Regression Results for Vehicular-Pedestrian Conflict in Public Space.****Model 1: Frequency of Interruption of pedestrian flow by vehicular traffic using alpha variables as predictors**

Var	Uns. B	SE B	$\beta$
N3	.113	.019	.506
N5	1.774	.507	.295

Constant= 0.006; R= 0.513; R<sup>2</sup>= 0.263; Adjusted R<sup>2</sup>= 0.250; S<sub>e</sub> = 0.012; df= 2,112; F= 19.967; Sig. =0.000

**Model 2: Frequency of Interruption of pedestrian flow by vehicular traffic using all independent variables as predictors**

C3	.518	.121	.429
N1	.000	.000	.292
D18	.627	.235	.235
F17	.094	.034	.250
D17	.230	.107	.224

Constant=- 0.002; R= 0.747; R<sup>2</sup>= 0.559; Adjusted R<sup>2</sup>= 0.527; S<sub>e</sub> = 0.009; df= 5, 69; F= 17.470; Sig. =0.000

**Model 3: Density of parking on paved areas (pedestrian walkways) using alpha variables as predictors**

N3	.008	.001	.537
N1	-2.216E-5	.000	-.309

Constant=- 0.000; R= 0.473; R<sup>2</sup>= 0.224; Adjusted R<sup>2</sup>= 0.210; S<sub>e</sub> = 0.001; df= 2, 114; F= 16.452; Sig. =0.000

**Model 4: Density of parking on paved areas (pedestrian walkways) using all independent variables as predictors**

B6	2.975E-5	.000	.413
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Constant= - 0.00004; R= 0.413; R<sup>2</sup>= 0.170; Adjusted R<sup>2</sup>= 0.138; S<sub>e</sub> = 0.001; df= 1, 26; F= 5.331; Sig. =0.029

Where:

R= Multiple correlation coefficient; R<sup>2</sup>= Coefficient of determination; S<sub>e</sub>= Standard error of the estimate; Uns. B= Unstandardised coefficient; SE B= Standard error of B;  $\beta$ = Standardized coefficient; df= degrees of freedom of the model; F= Analysis of Variance coefficient; Sig. = Significance (p) value of the model.

N<sub>3</sub>= Adjacency and permeability per metre length of space; N<sub>5</sub>= Adjacency and impermeability per square metre of space; C<sub>3</sub>= Frequency of intersections within the space; N<sub>1</sub>= Building space index; D<sub>18</sub>= Average no. of storeys per square metre of space; F<sub>17</sub>= Frequency of informal business activities in the space; D<sub>17</sub>= Average no. of storeys per length of space; B<sub>6</sub>= Percentage of space area that is paved.

Source: Author, 2011.

### **4.3 Undesignated Parking**

Cars are a part and parcel of urban living and are an economic mainstay, ranging from local to national and to regional scales. In residential settlements, cars cannot be divorced from pedestrian life as indeed a great deal of pedestrian activity takes place where cars are. However, Alexander (1977) does recommend that in spatial planning, cars be segregated from pedestrians for purposes of safety of the latter. Closely related to resolving vehicular-pedestrian conflict is the need to evolve spatial environments that are fit for use by both pedestrians and motorists with regard to the function of parking. Spatial planning guidelines stipulate that cars in the public space system should be parked in designated parking lots (Plate 4-2).

Further to the need to park in designated lots, there exists a guideline on how much of the land area should be budgeted for parking. Alexander (1977) writes that when more than 9 percent of a land parcel being developed into a settlement is given to parking, it is not possible to make an environment fit for human use. He underscores that the physical environment is for people's social intercourse and that when the density of cars passes a certain limit, people subconsciously feel that the environment is overwhelmed and is no longer a people place. He adds that environments that have less than 9 percent of the ground area devoted to parking lots stand the benefit of being humane and not destroyed socially or ecologically by the presence of cars. Parking lots can be either huge or tiny. According to Alexander, tiny parking lots are far better for the environment than for the large ones, even when their total areas are the same. Large parking lots dominate the landscape, create unpleasant places and have a depressing effect on the open space around them. If they are large enough to attract unpredictable traffic, they pose danger to children who prefer to play in parking lots. Generally then, he advises that parking lots should be small, serving no more than five to seven cars. The parking lots should be spaced so that they are at least 30 metres apart.

Despite the provisions on the parking function in the public space system of residential neighbourhoods, it is unfortunate to note that motorists have a tendency to park their cars in undesignated areas. In view of this, the question which comes to the fore in this study concerns whether there could be any spatial plan features that motivate this behaviour. The study identifies

these features and establishes the extent to which they explain the problem of parking in undesignated areas in residential neighbourhoods.



Plate 4-2: Undesignated and designated parking in public space.

Source: Author, 2011

#### **4.3.1 Modelling Density of Parking on Grass**

Multiple regressions between density of parking on grass and axial alpha variables indicate that 14.7 percent of the variance in the dependent variable is significantly explained by depth from “Y” space and adjacency and permeability per metre of space (Model 5 in Table 4-2). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Density of parking on grass} = 0.000 + 0.00009N_9 + 0.001N_3 \pm 0.0004S_e \dots \dots \dots (5)$$

Depth from Y refers to the number of steps a public space is from Y in the axial map (Hillier and Hanson, 1984). Y is the carrier space and is given the value 0. In the neighbourhoods, roads leading to them are used as the carrier space. Adjacency and permeability, on the other hand, refers to the number of buildings that are both adjacent and permeable to the public space, that is, the “constitutedness” property of space (Ibid). In this case, the index of adjacency and permeability is standardized per metre of space to allow for comparison among public spaces of different lengths. The two variables have a direct relationship with the dependent variable,

implying that an increase in each of the variables, while holding all the other variables constant, results in a corresponding increase in the density of parking on grass. The deeper or more segregated a space is in a residential settlement layout, the fewer the pedestrians (Hillier, 1988). This inverse relationship is also confirmed by Moirongo (2011) who, in his study of the Nairobi CBD, points out that the deeper one goes into an urban settlement the less the dominance of vehicular activities and road infrastructure become. This concurs with this study's findings that longer lengths of roads neglected by responsible authorities are found in deeper and segregated areas of settlements (Model 30). It is not surprising then to find that parking lots are not provided in such zones of the settlement. With this scenario, residents of and visitors to these areas are inclined to park on grass, probably due to lack of parking lots and its surface quality being better than that of the road surface. Plate 4-3 illustrates the case of parking on grass.



Plate 4-3: Undesignated parking on grass.

Source: Author, 2011.

Constitutedness has a direct relationship with the number of pedestrians and motorists in a public space (Alexander, 1977; Hillier, 1988; Moirongo, 2011). If a parking lot is provided in such a space (Plate 4-4) and then it is used to capacity, any additional motorist ends up parking on an undesignated area such as grassed surface.



Plate 4-4: Communal parking lot.

Source: Author, 2011.

Since constitutedness has power to promote a sense of security in public space, we cannot afford to get rid of it so as to save grass areas from destructive effects of undesignated parking. The challenge to spatial planning lies therefore in balancing between promoting constitutedness and protecting the quality of grassed areas.

Multiple regressions between density of parking on grass and all independent variables as predictors show that eight independent variables significantly explain 98.5 percent of the variance in the dependent variable (Model 6 in Table 4-2). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Density of parking on grass} = 0.000 + 0.191D_{44} + 0.00009N_9 - 0.002D_{24} + 0.008E_{22} - 0.009D_{43} - 0.00008D_{30} + 0.038C_{13} + 0.00004C_2 - 0.07C_3 + 0.065F_{11} + /- 0.00008S_e \dots\dots\dots(6)$$

Six out of the eight independent variables have a direct relationship with the dependent variable, implying that an increase in each of the variables while holding all the other variables constant results in a corresponding increase in the density of parking on grass. The six variables include density of buildings with setbacks, depth from Y space, frequency of outdoor lighting fixtures, frequency of alleyways making a junction with the space, total width of sidewalks, and frequency of chemists in the space. An increase in building setback, in particular where the plot line is not defined by a perimeter wall or hedge simply passes a message that motorists are invited to park their cars. A substantial portion of this space fronting a building is covered with grass and when it is used for parking, greenery ends up being destroyed. This means that if nature is to be

protected from the damaging effect of undesignated parking, then as much as possible building setback should be discouraged. Moirongo (2011) has similarly established that building setbacks have negative environmental effects in Nairobi's central business district. He points out that the farther buildings are removed from the building line, the more vehicles dominate the space. The increase in traffic volume in the space, besides posing a security risk to pedestrians, is visually disturbing and therefore robbing residents of the much needed livable environment. As discussed above under prediction of density of parking on grass using alpha variables, depth from Y once again emerges as a pattern that has a direct relationship with the dependent variable. Outdoor lighting fixtures, alleyways making a junction with the space sidewalks and chemists are features that act as magnets to motorists looking for parking space. From this finding, it emerges that motorists want to park their cars in areas that are safe, areas that are benefitting from public surveillance. Unfortunately, when parking lots in these magnet areas are full, motorists park on the adjacent grassed areas even when parking lots in the vicinity are vacant. Whereas these public space features are important in residential settlement layout, spatial planning has a role of ensuring that they do not promote undesignated parking and lead to destruction of greenery.

The public space features which have an inverse relationship with density of parking on grass include ratio of average height of space boundary to space width, frequency of buildings with setbacks, spread of windows along length of space on ground floor, and frequency of vehicular road intersections in the space. This means that an increase in each of these variables while holding the other variables constant results in a corresponding decrease in the density of parking on grass. The findings reinforce the fact that motorists want to park their cars where they are sure of car safety which is a function of the intensity of pedestrians and motorists in space. For any public space, the ratio of boundary height to space width goes up with an increase in boundary height. This implies that as boundary height increases, surveillance of public from the building or plot goes down and the density of parking in such an area decreases. It is important to mention here that most of these neighbourhood boundaries are screens that do not allow for visual connection between the public space and the private property behind the screen. The case of a higher frequency of buildings with setbacks resulting in a lower density of parking on grass is that of gated buildings. True as this variable expresses, these buildings have been removed from the edge of the public space by some distance. However, because of the boundary edge, motorists cannot access this space for parking which otherwise is private property. These motorists are

therefore left with the option of parking along the carriageway as Model 8 illustrates. An increase in the spread of windows along the length of the space does not result in an increase in the presence of people and motorists in space. What the variable produces, while holding the other variables constant, are longer block lengths characterized with low permeability and connectivity. The resulting sense of safety in the public space is lower and in effect any undesignated parking on any surface, grass inclusive, definitely goes down. When there is an increase in the frequency of road intersections in the space, the space's level of control increases just as does the number of motorists and pedestrians. This is in agreement with findings by Baran et al (2008) which show that residential streets with higher connectivity and control exhibit more walking behaviour. With this provision, there is increased surveillance along the carriageway and motorists therefore see no need to park on grass which is a distance off the road. When there is an increase in road intersections in a public space, it means that the number of blocks increases and in effect this reduces the length of the block. With cars and pedestrians suffusing among cluster blocks and the resulting increase in surveillance, motorists prefer parking just at the edge of the carriageway rather than on grass which is a distance away. A motorist's need to park in areas that benefit from surveillance also explains why there is a high tendency to park on sidewalks, alleyways and outside chemists.

From the above findings, it emerges that depth from Y space, constitutedness, building setbacks, ratio of boundary height to width of space, presence of lighting fixtures, alleyways, sidewalks and chemists, and frequency of road intersections with the space are some of the public space characteristics that can be used to explain the problem of parking on grass. These characteristics fall into the following spatial patterns: integration, constitutedness, land use, provision of public space services, scale of space, and connectivity. The influence of these patterns is discussed in the next chapter of this study.

#### ***4.3.2 Modelling Density of Parking on Carriageway***

Multiple regression analysis between density of parking on carriageway and alpha variables indicates that 20.8 percent of the variance in the dependent variable is significantly explained by adjacency and permeability per metre of space and relative depth of axial space (Model 7 in Table 4-2). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Density of parking on carriageway} = -0.001 + 0.010N_3 + 0.004N_{10} \pm 0.001S_e \dots\dots\dots (7)$$

It has already been explained in the preceding sections that adjacency and permeability refers to the constitutedness property of public space. Relative depth of axial space is an index that indicates the level of integration or segregation of a space in relation to all other axial spaces in the settlement system. Relative depth values range between 0 and 1, with low values indicating a space from which the system is shallow, that is, a space which tends to integrate the system, and high values a space which tends to be segregated from the system (Hillier and Hanson, 1984). Spaces that are shallow in the settlement layout are of a higher measure of integration whereas deeper spaces with their high relative depth values are more segregating in the settlement layout system (Hillier, 1988). The two independent variables have a direct relationship with the dependent variable, meaning that an increase in any one of them while holding all the other constant results in a corresponding increase in the density of parking on the carriageway. Constitutedness of public space has an effect of promoting presence of people and motorists in the space (Alexander, 1977; Hillier, 1988; Moirongo, 2011). Increased surveillance in space improves the sense of security (Jacobs, 1961) and this motivates motorists to park next to their destinations, though unfortunately along undesignated areas of the carriageway. It is important to mention here that very few of the public spaces surveyed in this study have parking lots, for instance Plate 4-4, but this is not the reason prompting motorists to park on undesignated areas of the carriageway. As this finding aptly illustrates, constitutedness of space is among the patterns that contribute to this environmental problem. Public spaces that are more integrating exhibit more walking behaviour (Baran et al, 2008). Similarly, Hillier (1988) and Min (1993) point out that spaces with low relative depth values, that is, spaces which are more integrating, have a high encounter rate of people and low burglary rates. However, findings by Baran et al (2008) suggest that spaces with high relative depth values, that is, spaces which are segregated in the settlement layout system, have less walking behaviour. The level of vehicular activity in segregated spaces is also much lower. There are no activity magnets or parking lots in such spaces. As Moirongo (2011) points out, segregated spaces are not accorded priority in infrastructure upgrading programmes. The few motorists who find themselves in segregated spaces do not mind parking on the carriageway as it poses no danger to other motorists. In this regard then, the more segregated a space is, the higher the density of parking on carriageway.



Multiple regressions between density of parking on carriageway and all independent variables as predictors realize that three independent variables significantly explain 63.6 percent of the variance in the dependent variable (Model 8 in Table 4-2). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Density of parking on carriageway} = 0.000 + 0.143D_{44} + 0.030C_3 - 0.030D_{17} \pm 0.0004S_e \dots\dots\dots (8)$$

Two of these variables have a direct relationship with the dependent variable and include density of buildings with setbacks and frequency of vehicular road intersections in the space. This implies that an increase in any of the variables while holding other variables constant leads to a corresponding increase in the density of parking on carriageway. For a residential property that is defined with a screen of some kind as boundary, parking in the space from which the building has been set back is not available to any motorist in the public space since it is private space. Also the space between the edge of the carriageway and the plot boundary is perceived as semi-private and is usually maintained by the owner of the plot that fronts it. In this regard then, the space is not available to motorists for parking. It therefore means that the higher the number of such boundarised buildings, the higher the density of parking on the carriageway. It is important to mention here that this variable, as captured in Model 6, represents buildings whose property edge is not defined by some screen as boundary. When a building is removed from the plot boundary line at the frontage of the public space, particularly where this boundary is not a wall or a hedge of some kind, there is a tendency for motorists to be attracted to park on the grass area at the front of the building. What is emerging in this finding is that motorists are also attracted to park along a carriageway in a public space where this pattern is evident. It is worthy mentioning that this pattern is also characterized with constitutedness, a spatial property that promotes a sense of safety in public space (Moirongo, 2011). This explains why public spaces with adjacent buildings or plots opening into them are magnets for the parking function, and if lots to accommodate the function are not provided, cars end up being parked on undesignated areas. This pattern promotes conflict between vehicles and pedestrians as the latter's flow is interrupted. Building setbacks are among the established building by laws that spatial planning of a settlement has to respond to. Its viability as an environmental management tool, in so far as this finding suggests, is in no doubt retrogressive. An increase in the frequency of vehicular road

intersections in the space has the impact of creating more permeability and higher control in the space and therefore more walking behaviour (Baran et al, 2008). Vehicular flow also becomes higher while block lengths reduce. The resulting effect of this pattern is a high sense of safety in space and a higher density of parking along the carriageway.

The ratio of average storey height to length of space has an inverse relationship with the dependent variable. This means that an increase in average storey height for the same length of space while holding all the other variables constant results in a decrease in the density of parking along the carriageway. The reason for this pattern can be given varied interpretations. Normally, when the population density in a given public space is increased through provision of more storey heights, there is emphasis on providing adequate parking lots to serve occupants of and visitors to the multi-storey blocks. This implies that the density of parking in undesignated areas goes down. The reason is also psychological; motorists do not want to park in an area where they greatly inconvenience other users. For instance, a motorist is attracted to park along a carriageway fronted by a single storey block than one fronted by a multi storey block. It emerges then that the multi storey dimension of spatial planning is not bad as it helps control the menace of undesignated parking along carriageways.

From the above discourse, the following public space characteristics aid in understanding the problem of undesignated parking along carriageways of residential neighbourhoods in the city of Nairobi: constitutedness, integration of space, density of buildings with setbacks, frequency of vehicular road intersections, and ratio of average storey height to length of the space. Patterns that emerge from these characteristics include constitutedness, integration, land use, scale of space and connectivity. These spatial patterns are discussed in the next chapter of this study.

**Table 4-2: Regression Results for Undesignated Parking on Grass and Carriageway of Public Space.**

**Model 5: Density of parking on grass using alpha variables as predictors**

Var	Uns. B	SE B	B
N9	8.840E-5	.000	.322
N3	.001	.001	.193

Constant= 0.000; R= 0.384; R<sup>2</sup>= 0.147; Adjusted R<sup>2</sup>= 0.132; S<sub>e</sub> = 0.0004; df= 2, 114; F= 9.855; Sig. =0.000

**Model 6: Density of parking on grass using all independent variables as predictors**

D44	.191	.023	1.273
N9	8.771E-5	.000	.265
D24	-.002	.000	-.307
E22	.008	.001	.209
D43	-.009	.002	-.555
D30	-7.734E-5	.000	-.186
C13	.038	.008	.212
C2	5.542E-5	.000	.113
C3	-.007	.003	-.114
F11	.065	.028	.070

Constant= 0.000; R= 0.992; R<sup>2</sup>= 0.985; Adjusted R<sup>2</sup>= 0.976; S<sub>e</sub> = 0.00008; df= 10, 17; F= 110.140; Sig. =0.000

**Model 7: Density of parking on carriageway using alpha variables as predictors**

N3	.010	.002	.407
N10	.004	.001	.233

Constant= - 0.001; R= 0.456; R<sup>2</sup>= 0.208; Adjusted R<sup>2</sup>= 0.194; S<sub>e</sub> = 0.001; df= 2, 114; F= 14.939; Sig. =0.000

**Model 8: Density of parking on carriageway using all independent variables as predictors**

D44	.143	.026	.796
C3	.030	.009	.420
D17	-.030	.010	-.422

Constant= 0.000; R= 0.797; R<sup>2</sup>= 0.636; Adjusted R<sup>2</sup>= 0.590; S<sub>e</sub> = 0.0004; df= 3, 24; F= 13.963; Sig. =0.000

Where:

R= Multiple correlation coefficient; R<sup>2</sup>= Coefficient of determination; S<sub>e</sub>= Standard error of the estimate; Uns. B= Unstandardised coefficient; SE B= Standard error of B; β= Standardized coefficient; df= degrees of freedom of the model; F= Analysis of Variance coefficient; Sig. = Significance (p) value of the model.

N<sub>9</sub> = Depth from "Y", the carrier space; N<sub>3</sub>= Adjacency and permeability per metre of space; D<sub>44</sub>= Density of buildings with setbacks; D<sub>24</sub>= Ratio of average height of space boundary to average width of space; E<sub>22</sub>= Frequency of outdoor lighting fixtures (post and luminaries); D<sub>43</sub>= Frequency of buildings with setbacks; D<sub>30</sub>= Spread of windows along length of space on ground floor; C<sub>13</sub>= Frequency of alleyways making a junction with the space; C<sub>2</sub>= Total width of sidewalks in metres; C<sub>3</sub>= Frequency of vehicular road intersections in the space; F<sub>11</sub>= Frequency of chemists in the space; N<sub>10</sub>= Relative depth of axial space; D<sub>17</sub>= Ratio of average storey height to length of space.

Source: Author, 2011.

**4.3.3 Modelling Density of Parking on Bare Soil**

Multiple regression analysis between density of parking on bare soil and alpha variables realizes that 10.9 percent of the variance in the dependent variable is significantly explained by measure of control of axial space and adjacency and impermeability per metre of space (Model 9 in Table 4-3). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

*Density of parking on bare soil = 0.001 + 0.000N<sub>a</sub> + 0.024N<sub>6</sub> +/- 0.002S<sub>e</sub> ..... (9)*

The two independent variables have a direct relationship with the dependent variable. This means that an increase in each of the dependent variables while holding all the other variables constant results in a proportional increase in the density of parking on bare soil. The measure of control of axial space indicates the total share contribution a space receives from its immediate neighbours. In explaining this variable, Hillier and Hanson (1984) writes that each space has a certain number n of immediate neighbours. Each space therefore gives to each of its immediate neighbours 1/n, and these are then summed for each receiving space to give the control value of that space. This means that the higher the number of immediate neighbours an axial space has, the higher the number of cars it receives due to its higher control value. High control spaces attract more walking behaviour (Baran et al, 2008) and therefore enjoy a high sense of safety. Motorists are therefore motivated to park in both designated and undesignated spots in the space, bare soil areas being inclusive. On the other hand, adjacency and impermeability refers to the unconstitutedness property of a public space (Hillier and Hanson, 1984). Despite the fact that such spaces are characterized with high incidents of crime (Newman, 1972; Hillier, 1988; Moirongo, 2011), it is interesting to note that an increase of this pattern in public space, holding all other variables constant, attracts parking (Plate 4-5).



Plate 4-5: An unconstituted section of public space that attracts parking.

Source: Author, 2011.

As seen in section 4.2.1, unconstitutedness encourages dominance of a space with strangers (Newman, 1972). As this study finds out, there exists an informal arrangement whereby motorists who park in public spaces fronted with blank walls engage the strangers, who are regular parking boys in the area, to keep an eye over their cars or clean them up at a small fee. In this arrangement, motorists are assured of safety of their cars and therefore do not mind parking in such spaces. With time however, the surface quality of this space becomes bare soil due to overuse.

Multiple regressions between density of parking on bare soil and all independent variables as predictors show that eleven independent variables significantly explain 98.8 percent of the variance in the dependent variable (Model 10 in Table 4-3). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Density of parking on bare soil} = 0.000 + 0.627F_{11} + 0.090D_{47} + 0.481E_{24} + 0.246N_5 - 0.033C_{14} - 0.004D_{43} - 0.000005D_2 - 0.021F_{15} + 0.000C_{15} - 0.020N_2 + 0.000009B_{20} \pm 0.00007S_e \dots\dots\dots (10)$$

Six of these variables have a direct relationship with density of parking on bare soil whereas five have an inverse relationship. The variables which have a direct relationship with density of parking on bare soil include frequency of chemists fronting the space, frequency of outdoor seating, frequency of advertisement/display lighting, adjacency and impermeability per square metre of space, frequency of pedestrian roads making a junction with the space and percentage of space area that is flat. It implies that an increase in each of the variables while keeping all the other variables constant results in an increase in the density of parking on bare soil. As pointed out in the preceding discourses, motorists want to park their cars in public spaces that are characterized with a high sense of safety from criminal activity. This sense of safety is promoted by surveillance from people in space (Jacobs, 1961; Hillier, 1988). In this regard then, provision of chemists, other commercial activities with advertisement or display lighting, and outdoor seating areas all attract people into public space. In this case, a higher connectivity accorded to a space by roads results in a higher presence of people in public space as indeed established by Baran et al (2008). The higher surveillance results in parking along the carriageway (Model 8) which overflows to adjacent bare soil surfaces. The contribution of adjacency and impermeability of a space to parking has been extensively discussed above under Model 9. Sections of public space that are flat attract the function parking. Flat areas of space tend to be devoid of residents but dominated by parking boys and scavengers of valuable products from solid waste that has been dumped in such areas. Moirongo (2006) has established a direct link between flat sections of public space and solid waste accumulation by pointing out that terrains which do not support washing away of waste by rain water lead to solid waste build-up. Motorists are attracted to park in such areas because of two reasons; one, the space is not used by residents because of its association with solid waste and a higher possibility of crime and is therefore negative space (Trancik, 1986), and two, the engagement of parking boys to wash the motorists' cars or just guard them at some fee as already discussed above. In all these cases, overuse of undesignated parking areas makes their surface quality degenerate to bare soil.

The variables which have an inverse relationship with the dependent variable include frequency of pedestrian roads making a junction with the space, frequency of buildings with setbacks, percentage of space length fronted with backs of buildings/inhabited plots, frequency of institutions fronting the space, and adjacency and permeability per square metre of space. In these cases, it implies that an increase in each of the predictor variables while holding all the

other variables constant leads to a corresponding decrease in the density of parking on bare soil. A higher frequency of pedestrian roads making a junction with the space means that there is a higher level of surveillance in the space. Just as in Models 6 and 8 above, motorists prefer parking along the carriageway to other undesignated areas because of the improved surveillance. In this model, buildings and institutions do not have provision for motorists to park in the space in which the building has been removed from the edge of the public space. This case falls in the category of gated communities whose density of settlement is lower than those that are not gated. Public spaces of such low density settlements have little or no business activities and therefore there is no magnet to attract motorists, who are strangers, to that space. Motorists who dominate the space are either residents or their visitors who park in the private residential compounds. This suggests that the more we have this spatial pattern, the less the parking in the public space, and on bare soil and grass areas in particular as brought out in Model 6. The property of adjacency and permeability captured in this model also relates to the low density settlements that have clearly defined and gated plots. For this kind of settlements, an increase in adjacency and permeability results in less parking on bare soil and grass areas. In this case, the only locations where undesignated parking is evident are along carriageways and sidewalks. When a public space is fronted with backs of buildings or plots, it points to unconstitutedness of the space. When this property increases, presence of people in public space goes down whereas crime rate increases (Hillier, 1988; Jacobs, 1961). The number of motorists parking their cars in such a space in effect drops and the density of parking on bare soil therefore declines.

From this discourse, it emerges that some of the variables which aid understanding the problem of undesignated parking on bare soil include the following: measure of control of axial space, constitutedness and unconstitutedness of space, frequency of chemists, outdoor seating and lighting infrastructure, pedestrian and vehicular roads making a junction with the space and percentage of space area that is flat. These variables fall into the following spatial patterns: control of space, constitutedness, land use, provision of public space services and connectivity. These patterns, which have a bearing on environmental management, are discussed in the next chapter of this study.

**4.3.4 Modelling Overall Density of Parking on Undesignated Areas**

Multiple regression analysis between overall density of parking on undesignated areas and alpha variables realizes that just 10 percent of the variance in the dependent variable is significantly explained by adjacency and permeability per metre of space (Model 11 in Table 4-3). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

*Overall density of parking on undesignated areas = 0.000 + 0.018N<sub>3</sub> +/- 0.003S<sub>e</sub> ..... (11)*

Adjacency and permeability refers to the constitutedness property of public space and in this case has a direct association with the dependent variable. This means that an increase in adjacency and permeability results in a corresponding increase in the overall density of parking in undesignated areas. The property of constitutedness has a direct correlation with movement density in a public space (Hillier, 1988; Moirongo, 2011). When movement density in a public space is high, surveillance and a sense of security in the space also tend to be high (Jacobs, 1961; Alexander, 1977; Hillier, 1988). As pointed out in section 4.3.2, increased surveillance ensuing from this spatial pattern motivates motorists to park their vehicles in the space because of the higher sense of safety. It is only unfortunate that parking in these spaces ends up being in undesignated areas.

Multiple regressions between overall density of parking on undesignated areas and all independent variables show that 54.8 percent of the variance in the dependent variable is explained by adjacency and permeability per square metre of space, adjacency and permeability per metre of space, and the frequency of chemists in the space (Model 12 in Table 4-3). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

*Overall density of parking in undesignated areas = 0.000 + 0.379N<sub>2</sub> - 0.023N<sub>3</sub> + 0.595F<sub>11</sub> +/- 0.001S<sub>e</sub> ..... (12)*

In this model, two variants of constitutedness emerge with one having a direct and the other an inverse relationship with the dependent variable. In the scenario of direct relationship, an increase in constitutedness, while holding all the other variables constant, results in a proportional increase in the overall density of parking in undesignated areas of the public space. The dynamics of this association has been extensively discussed in Model 11 above. In the other



scenario, as brought out in this model, an increase in constitutedness, while holding all other variables constant, results in a decrease in parking on undesignated areas. As discussed in Models 6, 8 and 10, motorists prefer parking in undesignated areas of a public space that has improved surveillance and therefore a high sense of security. Further, in model 10, the case of low density or gated residential settlements is discussed whereby an increase in their frequency results in a drop in the density of undesignated parking on grass and bare soil surfaces. It is this pattern of constitutedness that re-emerges in the present model whereby an increase in the frequency of gated compounds drastically reduces the available options and magnitude of the area for undesignated parking. It is necessary to point out again that gated compounds in the sample neighbourhoods investigated in this study have their buildings set back from the edge of the plot and the public space and the boundary has a screen fence delineating the compound as a private space in relation to the public space it fronts. In effect, this means that the space between the screen fence and the building line is not available for parking by any motorist in the public space. Conversely, in the case of buildings that do not have boundaries defining them as for example seen in Ofafa Maringo residential neighbourhood, the space between the building line and the edge of the road is available for encroachment by any motorist in the public space in need of parking space.

Frequency of chemists fronting the public space has a direct relationship with the overall density of parking on undesignated areas. This means that an increase in the number of chemists in the space, while holding all other variables constant, results in an increase in the dependent variable. Chemists are magnets that attract a high movement density of both pedestrians and motorists. A chemist is adjacent and permeable to the public space and a section of the space it fronts is well policed by passers-by, residents and strangers alike. Any parking lot serving a chemist therefore gets filled up quickly and motorists, whether or not going to the chemist, end up parking in the adjacent but undesignated areas.

From the above discussion, it emerges that constitutedness of space and land use are some of the spatial planning patterns that do explain the environmental problem of overall density of parking on undesignated areas of residential neighbourhoods. These patterns are discussed in the next chapter of this study.

**Table 4-3: Regression Results for Undesignated Parking on Bare Soil and as Overall Density in Public Space.**

**Model 9: Density of parking on bare soil using alpha variables as predictors**

Var	Uns. B	SE B	B
N8	.000	.000	-.267
N6	.024	.010	.206

Constant= 0.001; R= 0.330; R<sup>2</sup>= 0.109; Adjusted R<sup>2</sup>= 0.094; S<sub>e</sub> = 0.002; df= 2, 114; F= 6.984; Sig. =0.001

**Model 10: Density of parking on bare soil using all independent variables as predictors**

F11	.627	.025	.713
D47	.090	.005	.592
E24	.481	.038	.364
N5	.246	.016	.713
C14	-.033	.003	-.510
D43	-.004	.001	-.262
D2	-4.825E-6	.000	-.180
F15	-.021	.003	-.261
C15	.000	.000	-.119
N2	-.020	.005	-.192
B20	8.789E-6	.000	.101

Constant= 0.000; R= 0.994; R<sup>2</sup>= 0.988; Adjusted R<sup>2</sup>= 0.980; S<sub>e</sub> = 0.00007; df= 11, 16; F= 118.973; Sig. =0.000

**Model 11: Overall density of parking on undesignated areas using alpha variables as predictors**

N3	.018	.005	.315
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Constant= 0.000; R= 0.315; R<sup>2</sup>= 0.100; Adjusted R<sup>2</sup>= 0.092; S<sub>e</sub> = 0.003; df= 1, 114; F= 12.600; Sig. =0.001

**Model 12: Overall density of parking on undesignated areas using all independent variables as predictors**

N2	.379	.102	1.795
N3	-.023	.009	-1.257
F11	.595	.248	.330

Constant= 0.000; R= 0.740; R<sup>2</sup>= 0.548; Adjusted R<sup>2</sup>= 0.491; S<sub>e</sub> = 0.001; df= 3, 24; F= 9.693; Sig. =0.000

Where:

R= Multiple correlation coefficient; R<sup>2</sup>= Coefficient of determination; S<sub>e</sub>= Standard error of the estimate; Uns. B= Unstandardised coefficient; SE B= Standard error of B; β= Standardized coefficient; df= degrees of freedom of the model; F= Analysis of Variance coefficient; Sig. = Significance (p) value of the model.

N<sub>8</sub>= Measure of control of axial space; N<sub>6</sub> = Adjacency and impermeability per metre of space; F<sub>11</sub>= Frequency of chemists fronting the space; D<sub>47</sub>= Frequency of outdoor seating; E<sub>24</sub>= Frequency of advertisement/display lighting; N<sub>5</sub>= Adjacency and impermeability per square metre of space; C<sub>14</sub>= Frequency of pedestrian roads making a junction with the space; D<sub>43</sub>= Frequency of buildings with setbacks; D<sub>2</sub>= Percentage of space length fronted with backs of buildings/inhabited plots; F<sub>15</sub>= Frequency of institutions fronting the space; C<sub>15</sub>= Frequency of vehicular-cum-pedestrian roads making a junction with the space; N<sub>2</sub>= Adjacency and permeability per square metre of space; B<sub>20</sub>= Percentage of space area that is flat; N<sub>3</sub>= Adjacency and permeability per metre of space.

Source: Author, 2011.

#### **4.4 Public Space Air Pollution**

Pollution has generally been described as the introduction by man into the environment of substances or energy liable to cause hazards to human health, harm to living resources and ecological systems, damage to structures or amenity, and interference with legitimate uses of the environment (Holdgate, 1979). These harmful substances are referred to as pollutants and they cause harm to air, land and water bodies.

Environmental pollution is worst in urban areas throughout the world due to their concentrated population, high consumption of energy and industrial activities. Holdgate points out that the disposal of the urban population's sewage, municipal and industrial wastes cause environmental degradation of land and water systems. He adds that urban heat-island effects tend to confine much of the dust particles and other atmospheric pollutants within the urban area and this exacerbates the effects of pollution on the population.

Air pollution in urban areas presents itself in the form of dust and odours. Rao (1991) defines air pollution as any atmospheric condition in which certain substances are present in such concentrations that they can produce undesirable effects on man and his environment. These substances are either particulate or gaseous. Particulates are those atmospheric substances that are not gases and can be either suspended droplets or solid particles or a mix of the two. Particulates can be composed of inert or extremely reactive materials. Inert materials do not react readily with the environment nor do they exhibit any morphological changes as a result of combustion or any other such process, whereas reactive materials can be further oxidized or may react chemically with the environment. Various particulate pollutants are categorized as follows: dust, smoke, fumes, mist, fog and aerosols. Dust, which is the particulate pollutant focused on by this study, is formed by natural disintegration of rock and soil or by the mechanical processes of grinding and spraying. Dust particles have large settling velocities and are removed from the air by gravity and other inertial processes. Dust lowers the quality of air and thus poses risk to human health. Fine dust particles also act as centres of catalysis for many of the chemical reactions taking place in the atmosphere.

Odour pollution, on the other hand, is a result of the presence of noxious gases in the atmosphere. Rao (1991) singles out sulphur dioxide and nitrogen dioxide as some of the gaseous matter that contributes to odour pollution. Sulphur dioxide is a colourless gas with a characteristic sharp, pungent odour. The main source of this gas in residential settlements is combustion from motor vehicles, diesel generators, municipal incineration, refuse burning, and adjacent industrial processes. Nitrogen dioxide, on the other hand, is a brown pungent gas with an irritating odour. It is emitted by fuel combustion and nitric acid industrial plants. Alloway and Ayres (1997) write that waste water, such as sewage, can be a source of noxious odours, degrade river water quality and contribute to the spread of infectious diseases. In the residential neighbourhoods investigated in this study, some of the sources of odour pollution in the public space system include rotting garbage resulting from inefficient systems of solid waste collection, blocked storm water drains, poor surface drainage, broken-down sewerage system, unmaintained public toilets and poor use of negative space. According to Trancik (1986), negative or lost space in a settlement is that part of public space that nobody cares about maintaining. These spaces are ill-defined and fail to connect to other elements of the public space system in a coherent way. In other words, lost spaces are disintegrated and are characterized with higher levels of odours than integrated spaces. These spaces end up being used in the wrong way; as spots for dumping solid waste, defecating and urinating.

To avert the impacts of pollution, environmental monitoring has become recognized and embraced as being vitally important in detecting where insidious pollution is occurring, the pollutants involved and the sources from which they come. This approach to environmental management has not been successful in putting public space air pollution under control. It is a postulate of this study that the nature of pollution problems in residential settlements is exacerbated by spatial planning patterns that are in place. It follows then that if spatial planning is cognizant of features that contribute to pollution, it is possible to realize pollution-free environments. This study identifies residential public space features that are associated with dust and odour pollution and establishes the extent to which they explain the air pollution problems.

#### **4.4.1 Modelling Dust Pollution**

Multiple regression analysis between dust pollution and axial alpha variables demonstrates that 4.6 percent of the variance in the dependent variable is explained by depth from Y, which is the

carrier space of a residential settlement (Model 13 in Table 4-4). The model, whose prediction is significant at 95 percent confidence level, is illustrated below.

$$\text{Dust pollution} = 2.047 + 0.164N_9 \pm 1.27S_e \dots\dots\dots (13)$$

Depth from Y refers to the number of axial steps a public space is from Y in the axial map (Hillier and Hanson, 1984). Y is the carrier space and is given the value 0. Roads at the periphery of the neighbourhood are used as the carrier space. In this prediction, depth from Y has a direct relationship with dust pollution in residential public space. This suggests that an increase in depth from Y, while holding all other variables constant, results in a corresponding increase in dust pollution. This finding concurs with that of Moirongo (2011) who, in his study of Nairobi CBD, realizes that spaces that are deep or segregated in a settlement layout tend to be neglected by agencies responsible for upgrading road infrastructure. Spaces that are shallow from the Y space are characterized with higher movement activity than in the deeper spaces and therefore tend to receive priority consideration when we have an infrastructure upgrading programme (Plate 4-6).



Plate 4-6: A dusty deep public space.

Source: Author, 2011.

On the other hand, multiple regressions between dust pollution and all independent variables illustrate that six variables explain 69.6 percent of the variance in the dependent variable (Model 14 in Table 4-4). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Dust pollution} = 1.227 + 0.035B_4 + 0.264D_{59} + 0.014C_5 - 0.302F_{22} - 0.19.722D_{17} + 0.172D_{23} +/ - 0.713S_e \dots \dots \dots 14$$

Four of these variables have a direct relationship with the dependent variable whereas two have an inverse relationship. Those that have a direct relationship include percentage of the area with tarmac, taking care of planting, percentage of road surface that is curved, and average height of space boundary. This association is such that an increase in any one of these variables, while holding all the others constant, results in an increase in dust pollution. Public spaces in the neighbourhoods that have tarmacked roads attract more pedestrian and vehicular activity owing to their high level of constitutedness. This means that there is high intensity of use of the space resulting in degradation as for instance seen in undesignated parking on grass areas, along sidewalks and the carriageway. The vehicles and pedestrians, on a rainy season, also carry mud with them some of which is left in the public space. The consequence of this intensity of use of the space is high dust pollution during the dry and windy periods of the day. Taking care of planting, of course in a wrong way, leads to an increase in dust pollution in two ways. One instance is when ground cover is deliberately removed and thus leaving the ground surface bare (Plate 4-7). The other way is when tree branches are haphazardly cut and consequently creating wind thoroughfares. The more the role of trees as windbreaks is compromised, the higher the dust pollution in public space.



Plate 4-7: Taking care of planting that leads to exposure of soil surface.

Source: Author, 2011.

In addressing the subject of air pollution in urban areas, Hough (1995) underscores that the only satisfactory controls for solid particles, gases and other airborne contaminants carried in the city's

air are institutional and technical. However, when pollution is dilute, the plant is an important control device. It is a known fact that plants filter dust and therefore contribute to improved air quality in public space.

Curved road surfaces do not allow for total flow of particulate matter carried in storm water as evidenced in Plate 4-8. A curved section of a road, in this case, creates an environment where solid waste is trapped. A higher percentage of such road surfaces definitely leads to increased dust pollution in public space when the weather is dry and windy.



Plate 4-8: Public space with a curved and tarmacked road surface.

Source: Author, 2011.

An increase in average height of space boundary has an effect of decreasing surveillance in a public space from residents of the property immediately behind the boundary. Such sections of a public space attract dumping of solid waste (Moirongo, 2011) and have a higher crime rate owing to their unconstitutedness (Hillier, 1988). Ground cover adjacent to these dumping areas gets destroyed thus exposing bare soil. Once it rains, storm water is retained at such spots and the process of decomposition, besides generating odours, also contributes to dust pollution since the

broken-down particles are readily blown up by wind. In cases where the public space boundary is a building (Plate 4-9), increasing average height of the boundary implies increasing the density of occupancy and therefore intensity of use of the space. This increases erosion of the road surface and the quantity of particulate waste matter in the space. Consequently, dust levels in the air go up whenever it is windy.



Plate 4-9: Buildings as space boundary.

Source: Author, 2011.

Independent variables that have an inverse association with dust pollution in public space include mix of activities in the space and ratio of average storey height to length of space. This suggests that an increase in either of the variables, while holding all other variables constant, results in a corresponding decrease in dust pollution in public space. Intuitively, spaces characterized with a high mix of activities should have high levels of dust pollution. However, as this study finds out, spaces with this feature are the commercial hubs of residential neighbourhoods. Such spaces are shallow from the carrier space and their road infrastructure is not neglected and therefore experience lower levels of dust pollution. This is in tandem with findings in Model 13 and those of Moirongo (2011) which point out that deep spaces tend to be left out in upgrading programmes of a neighbourhood's public space infrastructure. In addition to this, a space with a high mix of



activities does not have adjacent grass and flower areas that can be parked on by motorists looking out for parking space. Motorists are therefore left with the option of parking either along the sidewalk or carriageway when the parking lot serving the commercial hub is full. Similarly, an increase in average storey height implies an increase in plot ratio and hence surveillance of a space. Misuse of space such as dumping of solid waste and other particulate material does not occur. On a windy day, dust pollution is therefore much lower in the space. Besides this, because of the resulting higher density of settlement, such a space receives priority consideration when it comes to infrastructure upgrading programmes such as tarmacking of roads or sealing of potholes. Such programmes are a boost to the reduced levels of dust pollution in the space.

The above findings suggest that depth of a public space from Y space, percentage of space with tarmac, taking care of planting, percentage of road surface that is curved, activity mix, buildings with boundary walls and height of the boundary are some of the public space characteristics that can be used to explain the problem of dust pollution in public space. These characteristics fall into the following spatial patterns: integration, constitutedness, land use, provision of public space services, ecological balance and transportation planning. These patterns are discussed in the next chapter of the study.

#### **4.4.2 Modelling Odour Pollution**

Multiple regression analysis between intensity of odour pollution and axial alpha variables demonstrates that 24.5 percent of the variance in the dependent variable is explained by relative depth of axial space and adjacency and permeability per square metre of space (Model 15 in Table 4-4). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Odour pollution} = 2.595 + 5.905N_{10} - 31.136N_2 \pm 1.124S_e \dots\dots\dots (15)$$

Relative depth of axial space refers to the level of integration or segregation of a space in relation to all other spaces in the settlement plan system (Hillier and Hanson, 1984). Spaces that are shallow in the settlement layout have low relative depth values whereas deeper spaces have high relative depth values and therefore more segregating in the settlement layout system (Hillier, 1988). On the other hand, adjacency and permeability index of a space refers to its

constitutedness (Ibid.). Whereas the variable of relative depth of axial space has a direct relationship with odour pollution, the measure of adjacency and permeability per square metre of space has an indirect relationship. This means that an increase in the relative depth value of a space, while holding the other variable constant, leads to a corresponding increase in the amount of odour pollution. It also means that an increase in the index of constitutedness of a public space, while holding the other variable constant, results in a decrease in the amount of odour pollution.

Spaces that are more integrating in a settlement plan system, that is, spaces that are shallow and therefore have low relative depth values, are characterized with a high intensity of use. Hillier (1988) points out that the more integrating a space is, the higher the number of people or encounter rate in the space. The density of motor vehicles in such spaces, both moving and parked, is also high. Shallow spaces also have better road and lighting infrastructure. Generally, agencies responsible for management of the public space system of a settlement give priority to spaces that are shallow in relation to the carrier space. Because of the higher level of activity in such integrating spaces and the higher frequency of attention it receives insofar as provision of public space services is concerned, the level of odour pollution is lower. Conversely, segregated spaces, with their high relative depth values, are less busy with activity and are usually left out when it comes to maintenance of infrastructure and provision of public space services. Because of this, segregated spaces have higher levels of odour pollution. On the other hand, a public space that is constituted by adjacent buildings has fewer odours. Constitutedness of public space promotes presence of people and motorists in the space (Alexander, 1977; Hillier, 1988; Moirongo, 2011). Increased presence of people and motorists in space minimizes existence of negative or lost spots that attract wrongful use such as dumping solid waste or urinating (Plate 4-10). In effect then, the spatial pattern of constitutedness contributes to lowering of odour pollution.



Plate 4-10: A space with adjacent but impermeable buildings.

Source: Author, 2011.

Multiple regression analysis between intensity of odour pollution and all independent variables realizes that five independent variables significantly explain 61.6 percent of the variance in the dependent variable (Model 16 in Table 4-4). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Odour pollution} = 3.937 + 1.219D_{42} + 0.018B_4 - 0.771F_{28} - 8.841F_{17} - 0.184B_{15} \pm 0.823S_e \dots\dots\dots (16)$$

Two of the independent variables have a direct relationship with the intensity of odour pollution and include the proportion of buildings with setbacks and the percentage of space that is tarmacked. This means that an increase in any of these variables while holding all other variables constant results in an increase in the intensity of odour pollution. In the neighbourhoods surveyed in this study, public spaces that have a higher percentage of tarmac and proportion of buildings with setbacks have a lower density of pedestrians. This is characteristic of neighbourhoods with well defined residential plots with single family occupancy. For instance, Lavington has a comparatively much lower density of pedestrians in public space (Plot Ratio = 25 percent) than

Pangani whose Plot Ratio is 200 percent. A minimal number or lack of pedestrians in public space leads to some sections of the space being negative and therefore attracting wrong usage. Unlike in the CBD of Nairobi where Moirongo (2011) points out that the higher the number of motorists or pedestrians in public space the lower the odour, it emerges in this study that it is only the number of pedestrians in a residential public space that has a significant bearing on the intensity of odour pollution.

Three of the five independent variables that have an inverse relationship with the intensity of odour pollution include plot ratio, frequency of informal businesses, and average tree canopy clearance from the ground. This implies that an increase in any of the variables while holding all the other variables constant results in a corresponding decrease in the intensity of odour pollution. Higher plot ratios and frequency of informal businesses characterizing a public space have the effect of increasing density of people in the space. Similarly, a section of a public space that has trees with a higher canopy clearance from the ground attracts more people to relax or socialize under shade. Conversely, people tend to keep off from shrubs or planting of canopy clearance from the ground that does not permit social activity under its shade. In the latter case, the space attracts wrongful use and, according to Trancik (1986), such is lost or negative space. It therefore follows that a public space with a pattern that promotes density and suffusion of people in the space is integrated and therefore free of elements that lead to production of odours. This is in line with the finding by Moirongo (2011) that spaces frequented by pedestrians, and more so residents, tend to experience less disintegration and hence the lower the odour.

These findings suggest that integration, constitutedness of public space, land use and ecological balance are some of the spatial patterns that significantly explain the intensity of odour pollution in public space. These patterns are discussed in the next chapter of this study.

**Table 4-4: Regression Results for Public Space Air Pollution.**

**Model 13: Dust pollution using alpha variables as predictors**

Var	Uns. B	SE B	$\beta$
N9	.164	.069	.213

Constant= 2.047; R= 0.213; R<sup>2</sup>= 0.046; Adjusted R<sup>2</sup>= 0.037; S<sub>e</sub> = 1.270; df= 1, 118; F= 5.628; Sig. =0.019

**Model 14: Dust pollution using all independent variables as predictors**

B4	.035	.004	.578
D59	.264	.073	.260
C5	.014	.004	.244
F22	-.302	.080	-.268
D17	-19.722	6.510	-.205
D23	.172	.074	.157

Constant= 1.227; R= 0.849; R<sup>2</sup>= 0.721; Adjusted R<sup>2</sup>= 0.696; S<sub>e</sub> = 0.713; df= 6, 68; F= 29.297; Sig. =0.000

**Model 15: Odour pollution using alpha variables as predictors**

N10	5.905	1.188	.399
N2	-31.136	8.662	-.289

Constant= 2.595; R= 0.495; R<sup>2</sup>= 0.245; Adjusted R<sup>2</sup>= 0.232; S<sub>e</sub> = 1.124; df= 2,117; F= 18.962; Sig. =0.000

**Model 16: Odour pollution using all independent variables as predictors**

D42	1.219	.317	.353
B4	.018	.005	.293
F28	-.771	.211	-.314
F17	-8.841	2.986	-.252
B15	-.184	.086	-.179

Constant= 3.937; R= 0.785; R<sup>2</sup>= 0.616; Adjusted R<sup>2</sup>= 0.588; S<sub>e</sub> = 0.823; df= 5, 69; F= 22.110; Sig. =0.000

Where:

R= Multiple correlation coefficient; R<sup>2</sup>= Coefficient of determination; S<sub>e</sub>= Standard error of the estimate; Uns. B= Unstandardised coefficient; SE B= Standard error of B;  $\beta$ = Standardized coefficient; df= degrees of freedom of the model; F= Analysis of Variance coefficient; Sig. = Significance (p) value of the model.

N<sub>9</sub>= Depth from "Y", the carrier space; B<sub>4</sub>= Percentage of the area with tarmac; D<sub>59</sub>=Taking care of planting; C<sub>5</sub>= Percentage of road surface that is curved; F<sub>22</sub>= Mix of activities in the space; D<sub>17</sub>= Ratio of average storey height to length of space; D<sub>23</sub>= Average height (in metres) of space boundary; N<sub>10</sub>=Relative depth of axial space; N<sub>2</sub>= Adjacency and permeability per square metre of space; D<sub>42</sub>= Proportion of buildings with setbacks; F<sub>28</sub>= Plot ratio for the space; F<sub>17</sub>= Frequency of informal businesses; B<sub>15</sub>= Average tree canopy clearance from ground in metres.

Source: Author, 2011.

#### 4.5 Solid Waste Accumulation in Public Space

According to Rao (1991), solid waste is that material which arises from various human activities and which is normally discarded as useless or unwanted. It consists of the highly heterogeneous mass of discarded materials from the urban community as well as the more homogeneous accumulation of agricultural, industrial and mining wastes.

Solid wastes are classified based partly on content and partly on moisture and heating value. Rao (1991) documents a typical classification as follows:

(i) Garbage: This refers to the putrescible solid waste constituents produced during the preparation or storage of items such as meat, fruit and vegetables. Garbage wastes have a moisture content of about 70 percent and a heating value of around  $6 \times 10^6$  J/kg.

(ii) Rubbish: This refers to non-putrescible solid waste constituents, either combustible or non-combustible. Combustible wastes include such materials as paper, wood, rubber and leather. Examples of non-combustible wastes include metals, glass and ceramics. Wastes falling in this category contain a moisture content of about 25 percent and a heating value of around  $15 \times 10^6$  J/kg.

(iii) Pathological wastes: These comprise dead animals and human waste among others. They have a moisture content of about 85 percent and there are 5 percent non-combustible solids. Heating value is around  $2.5 \times 10^6$  J/kg.

(iv) Industrial wastes: These include wastes such as chemicals, paints, sand, metal ore and sewage treatment sludge.

(v) Agricultural wastes: These originate from agricultural activity and include wastes such as animal manure and crop residues.

Rao writes that the principal sources of solid wastes are domestic, commercial, industrial and agricultural activities. He points out that domestic and commercial wastes are many times referred to as urban wastes. He adds that the main constituents of urban wastes are similar throughout the world, but the weight generated, the density and proportion of constituents vary widely from country to country, and from town to town within a country according to the level of economic development, weather and social conditions.

Unless solid waste is handled properly, it presents negative effects on human health and causes damage to the environment. It is for these reasons that presence of solid waste in public space should be avoided and any waste generated properly handled at the point of origin. Solid waste presents health risks to human health which arise from the breeding of disease vectors, fundamentally consisting of flies and rats. Rao outlines the negative impacts as follows:

(i) Refuse dumps serve as a source of food for rats and small rodents which quickly proliferate and spread to neighbouring areas. Rats destroy property, infect by direct bite and spread various diseases like plague, endemic typhus, salmonellosis and trichinosis. Apart from this mode of disease transmission, the handling and transfer of biological wastes poses a threat to the worker and those he contacts. This is through direct contact with the waste or through infection by vectors.

(ii) Hazardous wastes (that is, toxic and radioactive wastes) are injurious to human health. Some have acute effects while others have their effects felt after a prolonged period of exposure. Improper disposal of hazardous wastes has resulted in the death of humans and animals through contamination of food and water supplies.

(iii) Environmental damage caused by solid waste is mostly aesthetic in nature. This is seen in the uncontrolled dumping of urban wastes which destroys nature and creates views that are eyesores. Uncontrolled dumping of waste contributes to water pollution when its leachate enters the surface water and ground water systems. Uncontrolled burning of open solid waste dumps causes air pollution.

In view of the dangers posed by improperly handled solid waste, it is imperative that proper methods of disposal are put in place. According to Neal and Schubel (1987) and Rao (1991), disposal of solid waste is at present limited to land and ocean. They underscore that some of the wastes can be recovered and reprocessed, a procedure referred to as recycling. Rao (1991) highlights methods of solid waste disposal used in various parts of the world as including open dumping, sanitary landfilling, incineration and composting. Whereas sanitary landfilling is the main method used in the developed world, open dumping is common in the developing countries (Kharbanda and Stallworthy, 1990; Rao, 1991).

The subject of solid waste can be wide and on its own constitute an area of inquiry. However, the present study is not intended to examine its various dimensions, such as composition and

distribution in space, but focuses on quantifying solid waste collectively as a problem in the public space system of residential neighbourhoods. It seeks to establish public space characteristics that are related with the solid waste problem and the extent to which they explain it. The solid waste problem in public space is measured in terms of the proportion of space area it occupies, its maximum height in space, and overall quality, that is, the measure of how fresh or rotten the solid waste is. The index of solid waste quality serves to indicate how long the solid waste has stayed in the public space since it was dumped.

#### **4.5.1 Modelling Solid Waste Area**

Multiple regressions between proportion of space area occupied with solid waste and alpha variables show that 15.9 percent of the variance in the dependent variable is significantly explained by adjacency and impermeability per metre of space and relative depth of axial space (Model 17 in Table 4-5). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Area of space occupied with solid waste} = 0.198 + 3.881N_6 - 0.639N_{10} \pm 0.189S_e \dots\dots\dots (17)$$

Adjacency and impermeability refers to the non-constitutedness property of public space whereas relative depth is a measure of how integrating or segregating a space is in relation to all other spaces in the settlement plan system (Hillier and Hanson, 1984). Spaces that are shallow in the settlement layout have higher relative depth values and therefore more integrating in the settlement plan system. On the other hand, deeper spaces have low integration values and therefore more segregating in the settlement layout system (Hillier, 1988). Adjacency and impermeability per metre of space is directly proportional to area of space occupied with solid waste. This implies that an increase in adjacency and impermeability, while holding all the other variables constant, results in a corresponding increase in the area of space occupied with solid waste. An increase in non-constitutedness lowers the encounter rate of pedestrians and increases portions of the public space that are neglected or lost. As Moirongo (2011) also finds out, such lost spaces attract wrongful usage. Non-constituted spaces thus not only have odours as Model 15 illustrates but also have large areas occupied with solid waste (Plate 4-11). This finding further agrees with that of Moirongo (2006) to the effect that non-constitutedness of space leads to solid waste build-up.





Plate 4-11: An impermeable section of axial space with a large solid waste area.

Source: Author, 2011.

Relative depth of axial space, on the other hand, has an inverse relationship with the dependent variable. This means that an increase in the relative depth value of a space, while holding the other variable constant, results in a decrease in the area occupied with solid waste. Spaces that are shallow in a settlement layout system are more integrating than the deep spaces. Shallow spaces also have a higher encounter rate of pedestrians and lower burglary rates (Hillier, 1988), an environment that stimulates investment in both informal and formal activities. This high level of activity generates solid waste and is no wonder then that it covers a large area in shallow spaces. On the contrary, spaces of high relative depth values are not as busy with activity as shallow spaces and therefore solid waste generated is minimal. Because of this, the area of public space covered with solid waste is minimal.

Multiple regression analysis between area of space occupied with solid waste and all independent variables realizes that five independent variables significantly explain 47.1 percent of the variance in the dependent variable (Model 18 in Table 4-5). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Area of space occupied with solid waste} = 0.663 - 0.014D_{58} - 0.072D_{55} - 0.025D_{56} + 2.280F_{33} - 2.482E_{22} \pm 0.154S_e \dots\dots\dots (18)$$

Four of the five variables that have an inverse relationship with the area of space occupied with solid waste include provision of private security patrols, provision of the service of garbage collection, provision of Kenya police patrols, and frequency of outdoor lighting fixtures. The relationship implies that an increase in any of the variables while holding all other variables constant results in a corresponding decrease in the area of space occupied with solid waste. Provision of security patrol services, just like provision of outdoor lighting fixtures, has the effect of promoting a sense of safety in a public space. This in turn motivates presence of larger numbers of people in the space thus making the space to function in its wholeness. This means that there is little or no disintegrated space that will attract wrongful usage such as dumping of solid waste. Just as it can be inferred from intuition, this model confirms that the higher the frequency of garbage collection, the lower the area occupied with solid waste. Conversely, the frequency of people seated or lying down in public space has a direct relationship with the area of space occupied with solid waste. This means that the higher the number of people seated or lying down in public space, while holding all other variables constant, the larger the area of space occupied with solid waste. Normally, seating or lying down as an activity in public space takes place on areas planted with grass. This activity is quite often accompanied with eating or such activity that generates garbage or litter.

These findings suggest that constitutedness, integration and provision of public space services are some of the patterns that explain the area of space occupied with solid waste. These patterns are discussed in the next chapter of this study.

#### **4.5.2 Modelling Solid Waste Height**

Multiple regressions between solid waste height and axial alpha variables shows that 9.9 percent of the variance in the dependent variable is significantly explained by relative depth of axial space and adjacency and impermeability per metre of space (Model 19 in Table 4-5). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Maximum height of solid waste} = 0.425 - 0.776N_{10} + 3.625N_6 \pm 0.268S_e \dots\dots\dots (19)$$

The nature of the relationship the predictor variables have with the maximum height of solid waste is the same as the one they have with the area of space occupied with solid waste. Without discussing the same relationship in this section, it suffices to say that the axial alpha variables that predict maximum height of solid waste are the same as those that predict the area of space occupied with solid waste. Plate 4-12 illustrates a non-constituted public space that has a large solid waste height.



Plate 4-12: An impermeable public space with a big pile of solid waste.

Source: Author, 2011.

Multiple regression analysis between maximum height of solid waste and all independent variables realizes that 26.2 percent of the variance in the dependent variable is significantly explained by three independent variables (Model 20 in Table 4-5). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Maximum height of solid waste} = 1.078 - 0.142D_{55} + 2.016F_{17} + 4.531B_{17} \pm 0.246S_e \dots\dots\dots (20)$$

Out of the three predictor variables, frequency of garbage collection has an inverse relationship with the dependent variable. This means that an increase in the frequency of garbage collection, while holding all the other variables constant, results in a corresponding decrease in maximum height of solid waste in public space. When the frequency of garbage collection is higher, it

definitely means that piling up of solid waste in public space is lower. On the other hand, frequency of informal business activities and density of trees in space have a direct relationship with the dependent variable. This implies that an increase in any of the two variables, while holding all the other variables constant, results in a corresponding increase in the maximum height of solid waste in public space. Informal business activities are magnets that attract people into public space and, as discussed under Model 18, this has an effect of reducing the overall area covered with solid waste. However, informal businesses are point sources of solid waste and usually the operators take the responsibility of collecting and dumping it at some location in the space. This relationship confirms what can be inferred from intuition that the higher the number of such business activities, the greater the maximum height of solid waste in public space. A higher density of trees is observed in the high income neighbourhoods (Plate 4-13). Residents of these neighbourhoods invest in a good quality environment in their public spaces through provision of litter bins for use by pedestrians (Plate 4-13) and routine mowing of grass and clean-up programmes (Plate 4-14). However, it is unfortunate to observe that the litter collected from cleaning of the road is dumped at the periphery of the space (Plate 4-15) where we have grass cover and flowers.



Plate 4-13: A high density of trees in public space. Provision of litter bins.

Source: Author, 2011.

This litter, once it decomposes, is good as plant food, but if it is not managed well, the piles of litter destroy ground covering plants, are eyesores and a source of odour pollution. It therefore

emerges that the higher the density of trees, the greater the littering and hence the higher the height of solid waste.



Plate 4-14: A high density of trees in public space and routine cleaning programmes.

Source: Author, 2011.



Plate 4-15: A high density of trees in public space and solid waste build-up.

Source: Author, 2011.

The above findings suggest that integration of a space, constitutedness, provision of public space services, land use and ecological balance in space are some of the public space patterns that explain the maximum height of solid waste in space. These patterns are discussed next chapter of this study.

**4.5.3 Modelling Quality of Solid Waste in Public Space**

Quality of solid waste refers to the freshness or rottenness of the solid waste in public space. This measure is an indicator of the amount of time solid waste has stayed in the space ever since it was dumped there. Solid waste that has just been dumped in an area is usually fresh and in whole masses. Conversely, waste that has stayed for long in an area of public space is normally rotten and disintegrated. Quality of solid waste in this regard is measured using a five-point scale whereby one (1) stands for most rotten and five (5) stands for most fresh.

Multiple regression analysis between quality of solid waste in space and axial alpha variables shows that 5.6 percent of the variance in the dependent variable is significantly explained by depth from "Y", the carrier space (Model 21 in Table 4-5). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Quality of solid waste in space} = 2.556 + 0.185N_9 \pm 1.279S_e \dots\dots\dots (21)$$

In this regression, depth from Y has a direct relationship with the quality of solid waste in public space. This suggests that an increase in depth from Y results in a corresponding increase in the quality of solid waste in space. Public spaces with low depths from Y have more people and a higher density of informal businesses or such other activities that generate solid waste. Solid waste from individual business activities is dumped at a common point, usually at neglected sections of the public space. Since none bothers to care about such spaces, the waste overstays and by the time it is collected for disposal at designated locations, it is rotten and even infested with rodents and other disease causing vectors. Spaces that are deeper from the carrier space have higher values of depth from Y and consequently higher scores in the scale of solid waste quality. This means that the solid waste in spaces of higher depth from Y is fresh and not disintegrated. This is because there is little, if any, business activity that generates waste. Any waste generated from households is frequently communicated to the undesignated and negative

locations of the public spaces of the settlement plan system. It is common practice in the public space system that once a pile of solid waste has been defined, more and people take it as a receptacle and over time you find that the waste pile has become much bigger (Plate 4-16). The consequence of this is that spaces closer to the carrier space have bigger heights of solid waste that is more rotten than in spaces farther from the carrier space.



Plate 4-16: A shallow public space characterized with impermeability.  
Source: Author, 2011.

Multiple regressions between quality of solid waste and all independent variables illustrate that 46.3 percent of the variance in the dependent variable is significantly explained by four independent variables (Model 22 in Table 4-5). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Quality of solid waste in space} = 2.141 + 0.130D_{58} + 0.073B_6 + 0.019B_5 - 0.022D_{35} \pm 0.988S_e \dots\dots\dots (22)$$

Three of the predictor variables have a direct relationship with the dependent variable and include private security patrols, percentage of space area that is paved and percentage of space area that is covered with grass. This relationship is such that an increase in any of the variables, while holding all other variables constant, results in an increase in the quality of solid waste in space, that is, the more the fresh the solid waste. The more there is security patrols, the higher the perceived sense of safety and therefore the higher the number of people in a public space. Both

the security officers and people in public space police the space and therefore collectively deter wrongful use. Similarly, paved areas or sidewalks and areas covered with grass benefit from surveillance of users and this hinders wrong activities such as crime (Jacobs, 1961) and dumping of solid waste (Moirongo, 2011). Presence of many people in space also minimizes existence of negative or portions of space that are neglected (Trancik, 1986). Spaces benefiting from such surveillance therefore have minimal solid waste and which mostly is fresh. On the contrary, where there is no surveillance, there is motivation for solid waste build-up (Plate 4-16) that ends up overstaying in the same spot prior to collection for appropriate disposal.

Transparency of buildings, as used in this study, refers to the buildings' glazed and see-through openings. Largely, this variable is limited to window openings. For this model, the variable has an inverse relationship with the dependent variable. This implies that an increase in the percentage of building wall length that is transparent, while holding all other variables constant, results in a decrease in solid waste quality, that is, solid waste in the space is more rotten. This scenario is characteristic of high density residential settlements whereby we have up to five floor levels for a given length of dwelling block. This suggests that as density of settlement for any public space increases, the percentage of wall length that is transparent also goes up. The level of informal and small scale formal business activities in such a space is high and these generate waste which is disposed in common but undesignated locations in the public space. The locations are the neglected areas of public space that nobody bothers to care for. Because of the long duration it takes to have the City Council of Nairobi to remove the solid waste from the space for disposal at designated sites, it is bound to extensively decompose, disintegrate and become a health hazard. It is important to mention that the variable of transparency contributes to constitutedness and hence improved surveillance of a public space. This has an effect of reducing the area of space covered with solid waste (Model 18) but contributes to increasing solid waste height due to the organized way of handling solid waste generated from the informal business activities (Model 20).

The above findings suggest that integration of space, provision of public space services, ecological balance and land use are some of the spatial patterns that explain quality of solid waste in public space. These patterns are discussed in the next chapter of this study.



**Table 4-5: Regression Results for Solid Waste Accumulation in Public Space.**


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**Model 17: Area of space occupied with solid waste using alpha variables as predictors**

Var	Uns. B	SE B	$\beta$
N6	3.881	1.163	.283
N10	-.639	.200	-.270

Constant= 0.198; R= 0.399; R<sup>2</sup>= 0.159; Adjusted R<sup>2</sup>= 0.145; S<sub>e</sub> = 0.189; df= 2,117; F= 11.069; Sig. =0.000

**Model 18: Area of space occupied with solid waste using all independent variables as predictors**

D58	-.014	.007	-.201
D55	-.072	.023	-.289
D56	-.025	.008	-.288
F33	2.280	.749	.297
E22	-2.482	1.131	-.214

Constant= 0.663; R= 0.687; R<sup>2</sup>= 0.471; Adjusted R<sup>2</sup>= 0.433; S<sub>e</sub> = 0.154; df= 5, 69; F= 12.304; Sig. =0.000

**Model 19: Maximum height of solid waste using alpha variables as predictors**

N10	-.776	.284	-.240
N6	3.625	1.648	.193

Constant= 0.425; R= 0.314; R<sup>2</sup>= 0.099; Adjusted R<sup>2</sup>= 0.083; S<sub>e</sub> = 0.268; df= 2,117; F= 6.402; Sig. =0.002

**Model 20: Maximum height of solid waste using all independent variables as predictors**

D55	-.142	.035	-.418
F17	2.016	.787	.263
B17	4.531	2.060	.225

Constant= 1.078; R= 0.512; R<sup>2</sup>= 0.262; Adjusted R<sup>2</sup>= 0.231;  
S<sub>e</sub> = 0.246; df= 3, 71; F= 8.415; Sig. =0.000

**Model 21: Quality of solid waste in space using alpha variables as predictors**

N9	.185	.070	.238
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Constant= 2.556; R= 0.238; R<sup>2</sup>= 0.056; Adjusted R<sup>2</sup>= 0.048; S<sub>e</sub> = 1.279; df= 1, 118; F= 7.063; Sig. =0.009

**Model 22: Quality of solid waste in space using all independent variables as predictors**

D58	.130	.044	.288
B6	.073	.018	.403
B5	.019	.006	.312
D35	-.022	.007	-.287

Constant= 2.141; R= 0.681; R<sup>2</sup>= 0.463; Adjusted R<sup>2</sup>= 0.432; S<sub>e</sub> = 0.988; df= 4, 70; F= 15.097; Sig. =0.000

Where:

R= Multiple correlation coefficient; R<sup>2</sup>= Coefficient of determination; S<sub>e</sub>= Standard error of the estimate; Uns. B= Unstandardised coefficient; SE B= Standard error of B;  $\beta$ = Standardized coefficient; df= degrees of freedom of the model; F= Analysis of Variance coefficient; Sig. = Significance (p) value of the model.

N<sub>6</sub>= Adjacency and impermeability per metre length of space; N<sub>10</sub>= Relative depth of axial space; D<sub>58</sub>= Private security patrols; D<sub>55</sub>= Garbage collection; D<sub>56</sub>= Kenya police patrols; F<sub>33</sub>= Frequency of people seated/lying down; E<sub>22</sub>= Frequency of outdoor lighting fixtures (posts and luminaries); F<sub>17</sub>= Frequency of informal business activities; B<sub>17</sub>= Density of trees in space; N<sub>9</sub> = Depth from "Y", the carrier space; B<sub>6</sub>=Percentage of space area that is paved; B<sub>5</sub>= Percentage of space area that is covered with grass; D<sub>35</sub>= Percentage of building wall length that is transparent.

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Source: Author, 2011.

#### **4.6 Defective Storm Water Drainage System**

Storm water refers to rain water that flows over land as runoff. According to Garg (1979), a part of it is intercepted by the soil, a part of it evaporated and the remaining part constitutes storm water runoff. The storm runoff is removed from a settlement using either of the following methods: a combined sewerage system which is designed to carry maximum flow of both sewage and rain runoff, or a separate system whereby sewers and drains are each designed to carry maximum sewage discharge and maximum rain runoff respectively. Bartlett (1981) adds that storm water drains are designed according to the extent and type of area to be drained, and must be based on a specific figure of rainfall intensity. For this to be properly designed, it is absolutely necessary to estimate the urban storm drainage discharge likely to enter the drains. This information is necessary for storm drainage and design as it will guide on the capacity of the channel to be provided. Some caution however is to choose a proper and economical value of rain intensity for which the drains must be designed. The intensity of rainfall to be adopted in the design should be neither too large as to cause too heavy investments, nor should it be too small to cause frequent overflowing of the drains. Garg (1981) adds that if a drainage system carries only storm water, then it can discharge, without treatment, to convenient water courses. If a combined system of drainage is used, discharge is normally to a sewage treatment works, with provision often being made en route for storm water overflows. These overflows can be sources of pollution and the modern tendency is therefore towards 'separate' rather than 'combined' systems.

According to Stephenson (1981), storm water drainage problems in urban settlements have been exacerbated by construction of pavements and buildings which reduce the average permeability of the ground. He adds that storm water can be a cause of flooding and environmental pollution and that drains are constructed in settlements to avert these problems. He points out that at the level of settlement planning, where design alternatives exist which have similar costs, it is sensible to opt for the least-risk system. In this regard, he writes that an open channel has a higher margin of safety against flooding than a closed conduit. Other than clogging of drainage channels and impervious ground surfaces, this study establishes that slope of the space and the kind of activities taking place in the space do account for the problem of stagnant storm water in public space.

The construction of a storm water drainage system in a settlement does not necessarily mean the problem of flooding or pollution due to storm water is totally eliminated. This has been the assumption and as this study finds out, drainage channels in Nairobi's residential settlements, though with the higher margin of safety in being open, are clogged with loose soil and solid waste matter most of which is rotten. During a heavy downpour, the channels can hardly be seen as they are overflowed with storm water. The malfunctional state of these channels, coupled with the resulting odour pollution due to the accumulated and rotten solid waste, presents a health risk to the humans residing in the settlements. Other than the provision of drainage channels, Stephenson (1981) suggests a number of other practices that have been embraced or advanced to manage storm water drainage problems. These include:

- (i) The day-to-day operation or management of the catchment – this has an important bearing on runoff quantity and quality and the obvious benefit is pollution control. Residential settlement activities in this regard include street cleaning, efficient refuse disposal, discharge monitoring and treatment of runoff.
- (ii) Runoff control: On-site detention and retention of storm water, ground water recharge, provision of rough surfaces to retard flow and regular cleaning of drains to relieve them of considerable load are measures that control runoff. Control measures are either structural (for example diversion, storage and channel improvements) or policy (for example insurance, flood warning systems and building control regulations). These runoff control measures are practised in the United States of America and Europe but are not in the developing world.
- (iii) Storm water management policy: A reasonable management policy is normally assumed at the time of design. Failure to adhere to a management programme often results in exceedance of the capacity of the system. Adherence, on the other hand, alleviates load even on an under-designed system or allows more intensive development to take place in the catchment.

To deal with the storm water problem in settlements, it is imperative that an adequate and steady supply of requisite resources must be guaranteed. In developing countries such as Kenya, this is a challenge and consequently problems associated with storm water drainage continue to persist. It is in this light that the study seeks to come up with an alternative approach to spatial planning

which, if employed in the layout of residential settlements in Nairobi, results in minimizing the associated problems such as defective storm water drainage systems.

#### **4.6.1 Modelling Area of Space Commonly Occupied with Stagnant Water**

Multiple regression analysis between area of space commonly occupied with stagnant storm water and axial alpha variables reveals that 4.7 percent of the variance in the dependent variable is explained by adjacency and impermeability per metre of space (Model 23 in Table 4-6). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Area of space commonly occupied with stagnant water} = 0.078 + 2.476N_6 \pm 0.168S_e \dots\dots\dots (23)$$

Adjacency and impermeability refers to the unconstitutedness property of a space (Hillier and Hanson, 1984). This variable has a direct relationship with the area of space commonly occupied with stagnant storm water. This means that an increase in unconstitutedness results in a corresponding increase in the dependent variable. Public spaces that are not accessed from the adjacent buildings suffer neglect as nobody bothers to care for them (Trancik, 1986). Due to the poor surveillance that characterizes them, such spaces do not have a perceived sense of safety and are prone to crime (Jacobs, 1961). Impermeable spaces, because of their neglect, attract wrong usage such as dumping of solid waste (Plate 4-16). In view of this, it is then not surprising that such spaces have a high degree of storm water drainage problems. Any drainage channel in the space is overgrown with grass and clogged with solid waste. In the event of a heavy downpour, such spaces pose a health risk to people in the neighbourhood as they are flooded and dirty with rotten solid waste and disease causing pathogens. This finding concurs with that of Moirongo (2011) who, in his investigation of the Nairobi CBD, establishes that the more impermeable a space is from adjacent buildings, the more likely it is to find stagnant storm water in the space. He also finds out that relative depth of axial space has a direct relationship with area of space with stagnant water. In this study however, relative depth has a significant inverse relationship at 95 percent confidence level with storm water area ( $\rho = -0.158$ ). This means that in the residential neighbourhoods, the higher the relative depth of a space, that is, the more segregated the space is, the lower the volume of storm water flow. This can be appreciated from the consideration that storm water channels are designed to carry water out of the settlement. Stagnant storm water is therefore bound to be minimal in the deeper spaces and more

pronounced in the shallower spaces because of the effect of combination of flows from the inner channels of the settlement. A likelihood of blockage of storm water channels is therefore higher as relative depth of a space decreases.

Multiple regressions between area of space commonly occupied with stagnant storm water and all independent variables show that 66.9 percent of the variance in the dependent variable is explained by four independent variables (Model 24 in Table 4-6). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Area of space commonly occupied with stagnant water} = 0.11 + 0.007B_{20} + 2.09F_4 - 0.001B_5 - 0.001B_4 \pm 0.101S_e$$

..... (24)

Two of the four variables have a direct relationship with the dependent variable and include percentage of space that is flat and frequency of retail shops. This implies that an increase in any of the variables, while holding all other variables constant, results in an increase in the area commonly occupied with stagnant storm water. An area that is flat means that any storm water on it will not flow away. Over time, the flat space develops depressions especially if motor vehicles pass over it when wet. This means that the larger the flat area becomes, the more the stagnant storm water it holds. The portion of public space outside retail shops, both vehicular and pedestrian ways, is more eroded than the rest of the areas of the space due to overuse. There is a high density of pedestrians and motorists who pass through or use the space as they visit the retail shops. Over time, potholes develop which retain storm water when it rains. Therefore, the more retail shops there are for any given public space, the more the degradation of public space due to overuse and the higher the area commonly occupied with stagnant storm water. This revelation on the influence of retail shops on area commonly occupied with stagnant storm water in residential neighbourhoods contradicts the findings by Moirongo (2011) in the study of Nairobi CBD. Whereas in the present study the relationship between the variables is direct, the variables relate inversely in the case of the Nairobi CBD. Morongo's argument is to the effect that the more we have human or pedestrian activities encouraged in a public space by shops, the more is the attention that is accorded to the well being of the space. He underscores that such activities are an engine to a better environment. However, as this study finds out, the nature of a settlement has a bearing on the thrust of environmental management interventions accorded to it.

The other two of the predictor variables have an inverse relationship with the area commonly occupied with stagnant storm water. These include percentage of space area that is covered with grass and percentage of space area that is tarmacked. This implies that an increase in any of the variables, while holding all the other variables constant, results in a decrease in the area commonly occupied with stagnant storm water. Unlike a tarmacked surface, a grassed surface reduces the speed of flow of storm water thus allowing the water to percolate into the ground. Grass in this regard protects the ground from erosion by storm water. Besides this, grassed areas of a public space are mostly used by pedestrians who, comparatively, are of a lower load than motor vehicles. This means that there is little likelihood of depressions occurring on a grass surface and therefore chances of getting stagnant storm water whenever it rains are minimal. Tarmacked surfaces of a public space are relatively smooth and are usually graded to allow for storm water flow to an adjacent drainage channel. This means that the less a public space is tarmacked, the more the likelihood of stagnant storm water occurring in the space (Plate 4-17). Hough (1995) argues against having large areas of space that are impervious as this impedes natural infiltration of storm water into the ground. This influence of a tarmacked surface on storm water flow is consistent with that of Moirongo (2011) in his study of the CBD of the City of Nairobi.



Plate 4-17: A less tarmacked public space with stagnant storm water.

Source: Author, 2011.

These findings suggest that the degree of adjacency and impermeability, percentage of space area that is flat, frequency of retail shops, percentage of space area that is covered with grass and percentage of space area that is tarmacked are some of the variables that explain the problem of storm water stagnation in public space. These variables fall into the following patterns: constitutedness, land use and ecological balance. The patterns are discussed in the next chapter of this study.

**Table 4-6: Regression Results for Defective Storm Water Drainage System in Public Space.**

**Model 23: Area of space commonly occupied with stagnant water using alpha variables as predictors**

Var	Uns. B	SE B	$\beta$
N6	2.476	1.029	.216

Constant=0.078; R= 0.216; R<sup>2</sup>= 0.047; Adjusted R<sup>2</sup>= 0.039; S<sub>e</sub> = 0.168; df= 1,118; F= 5.784; Sig. =0.018

**Model 24: Area of space commonly occupied with stagnant water using all independent variables as predictors**

B20	.007	.001	.693
F4	2.090	.796	.188
B5	-.001	.001	-.170
B4	-.001	.001	-.147

Constant=0.110; R= 0.818; R<sup>2</sup>= 0.669; Adjusted R<sup>2</sup>= 0.650; S<sub>e</sub> = 0.101; df= 4, 70; F= 35.295; Sig. =0.000

Where:

R= Multiple correlation coefficient; R<sup>2</sup>= Coefficient of determination; S<sub>e</sub>= Standard error of the estimate; Uns. B= Unstandardised coefficient; SE B= Standard error of B;  $\beta$ = Standardized coefficient; df= degrees of freedom of the model; F= Analysis of Variance coefficient; Sig. = Significance (p) value of the model.

B<sub>5</sub>= Percentage of space area that is covered with grass; N<sub>6</sub>= Adjacency and impermeability per metre length of space; B<sub>20</sub>=Percentage of the space that is flat; F<sub>4</sub>= Frequency of retail shops; B<sub>4</sub>= Percentage of space area that is tarmacked.

Source: Author, 2011.

#### 4.7 Neglect of Greenery

Greenery, encompassing ground covers, shrubs and trees, is a fundamental element of life and not just one of the many objects that fill a residential neighbourhood. Greenery influences microclimate and is useful in many other ways, for instance in air pollution control and where erosion by wind and water are an issue of concern. It is a part of the broad concept of nature which Ian McHarg says we as much need in the city as in the countryside (McHarg, 1969). He

underlines the fact that we must maintain the bounty of this great cornucopia which is our inheritance.

According to Dupriez and Leener (1998), man and plant-life have cohabited quite peacefully for thousands of years despite man having actualized his ability to conquer the living space. They however note that in the last four or five centuries and particularly in recent decades, man has become a conquering predator in his relationship with plant-life. The old checks and balances between man and nature have been broken and man no longer grasps the vital need for plants and trees in specific. They have attributed this behaviour to man's failure to understand the importance of plants.

Umenne and Rutto (1998) write that maintaining new plants and introducing new ones is an integral part of settlement planning and architecture. While underscoring the important role played by plants in the urban environment, they point out that industrialized societies are busy advancing stronger and more cogent arguments for a renaissance of the spirit of nature-sensitive human settlements such as: nature conservation, environmental sustainability, harmonious co-existence of man and nature and the built form. Unfortunately though, they note that the industrializing Third World appears indifferent to the current debate, the consequence being the depletion, mutilation and neglect of nature. Ian McHarg, as quoted in Swaffield (2002), appeals for the unity of our eyes with the world, the aim being to get back to the lost relationship. He writes thus:

*"Let us then abandon the simplicity of separation and give unity its due. Let us abandon the self-mutilation which has been our way and give expression to the potential harmony of man-nature. The world is abundant; we require only a defense born of understanding to fulfill man's promise. Man is that uniquely conscious creature who can perceive and express. He must become a steward of the biosphere" – p. 173.*

For man to achieve this noble appeal in the planning and design of residential settlements, he must do so with nature at the back of his mind. It is unfortunate however that he is behaving abnormally to greenery in urban settlements and thus putting it at the brink of depletion. Dupriez and Leener (1998) allude this behaviour to man's ignorance of the vital role played by greenery. However, this study posits that the behavioural pattern is a consequence of spatial plan characteristics of the public spaces of settlements. This study therefore sets out to test this



conjecture with anticipation that any relationship established can be a useful guide in formulating measures that sustainably mitigate the problem.

**4.7.1 Modelling Area of Neglected Greenery**

Multiple regressions between area of neglected greenery and axial alpha variables show that 15.2 percent of the variance in the dependent variable is significantly explained by the measure of control of axial space and building space index (Model 25 in Table 4-7). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Area of neglected greenery} = 0.105 + 0.103N_8 - 0.003N_1 \pm 0.165S_e \dots\dots\dots (25)$$

The measure of control of axial space has a direct relationship with the dependent variable. This implies that an increase in the measure of control, while holding all other independent variables constant, results in a corresponding increase in the area of neglected greenery and therefore a worse public space environment with regard to the area of space with neglected greenery. The measure of control of axial space has a positive correlation with the frequency of people in space. Such a space therefore benefits from better surveillance resulting from its higher control value. According to Jacobs (1961), a street as public space should have frequent crossings (which in effect make it a high control space) that provide a variety of routes for walkers, thus favouring proliferation of small specialty shops or such like businesses. As this study finds out, higher control of a space is associated with smaller solid waste areas ( $r = -0.06$ ) and this is attributed to the better surveillance. However, it correlates directly with solid waste height ( $r = 0.159$ ) and this is attributed to the isolated point disposals of solid waste that the space receives from small scale businesses therein (Model 20) and also from its neighbouring spaces.

This study observes that surveillance of a space deters wrongful use but taking care of greenery, such as mowing grass, is never an issue to be attended to by public space users. It takes the effort of residents of the property adjacent to the space to take care of greenery in that locality. However, where there are no defined plots as for instance is the case in public rental housing, all the users should take responsibility of taking care of greenery. Unfortunately, this is never the case and instead attention is on movement and other activities in the space. It is because of this that public spaces with high control, which are predominant in high density residential

neighbourhoods, are characterized with a high level of neglect of greenery (Plate 4-18). There is general complacency in this perspective as the residents keep in wait for the City Council of Nairobi (CCN), which owns the neighbourhoods, to come and take care of greenery in public space.



Plate 4-18: Neglect of greenery in public space.

Source: Author, 2011.

Conversely, public spaces with low control values have fewer people in public space and this is a characteristic of neighbourhoods with gated residential properties. In this case, there is an implicit territory of public space, one constituted by the residential property. Greenery in this territory is taken care of by residents of the constituting property (Plate 4-14). Umenne and Rutto (1998), as they point out above, the culture of taking care of planting has not been accorded serious consideration in Third World countries, such as Kenya, with the consequence being the depletion, mutilation and neglect of nature. As this study finds out, delineating a residential settlement into plots may inculcate in the residents a sense of responsibility over greenery in public space immediately outside their respective plots. One may be cautious not to subdue the measure of control of a space in neighbourhood spatial planning considering that it has its attendant benefits of minimizing solid waste area and burglary rates (Hillier, 1988). Building space index, as already pointed out, indexes the constitutedness property of a public space. It is inversely related with the area of space covered with neglected greenery, implying that as the number of buildings

permeable to space increases, while holding all other variables constant, it results in a corresponding decrease in the area of neglected greenery. As already pointed out, residents of a property that is permeable to a public space have a tendency to take care of greenery immediately outside the property.

Multiple regressions between area of neglected greenery and all independent variables show that 48.2 percent of the variance in the dependent variable is significantly explained by percentage of space area with grass, percentage of space length fronted with fronts of buildings and measure of control of axial space (Model 26 in Table 4-7). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Area of neglected greenery} = 0.079 + 0.005B_5 - 0.001D_1 + 0.054N_8 \pm 0.131S_e \dots\dots\dots (26)$$

The percentage of space length fronted with fronts of buildings is a measure of constitutedness of a public space. This has an inverse relationship with the area of space covered with neglected greenery whereas the measure of control has a direct relationship. The nature of influence of these spatial patterns on neglected greenery area has already been discussed under Model 25. On the other hand, percentage of space with grass has a direct relationship with the area of neglected greenery. This means that an increase in the area of space with grass, while holding all other variables constant, results in an increase in the area of neglected greenery. Unlike flowers or trees, grass requires minimal effort, if any, to grow in some sections of public space. This thesis however does not apply to a scenario where one is keen on a particular species of grass. It therefore follows that in any public space of Nairobi's residential neighbourhoods, there is grass of whichever species growing on it with little or no human intervention. In other words, among the greenery that requires attention, grass is the dominant. This in effect then means that neglect of greenery in public space, to a large extent, is centred on the care accorded to grass cover. It implies that the more we have a public space with large areas of grass cover, the higher the area of neglected greenery. It is important to mention that grass as ground cover, alongside other plants, is vital in preventing soil erosion and in promoting infiltration of storm water into the ground (Hough, 1995). One therefore will be keen not to clear grass from public space as the adverse effects are enormous, just to mention, soil erosion and dust pollution.

These findings suggest that measure of control of axial space, constitutedness and ecological balance are some of the spatial patterns that explain the problem of neglected greenery in public space. These are explained in the next chapter of this study.

**4.7.2 Modelling Quality of Greenery**

Quality of greenery refers to how bushy or well taken care of greenery is. A public space with shrubs that are well sheared and grass that is kept trim in this case scores five (5) on a five-point scale. If the greenery is bushy, the space scores one (1) in the five-point scale. A multiple regression analysis between quality of greenery and alpha variables illustrates that 12.4 percent of the variance in the dependent variable is significantly explained by adjacency and impermeability per metre of space and the measure of control of axial space (Model 27 in Table 4-7). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Quality of greenery} = 3.138 - 20.734 N_6 - 0.441N_8 +/- 1.15S_e \dots\dots\dots (27)$$

The variable of adjacency and impermeability, or unconstitutedness, has an inverse relationship with the quality of greenery and this implies that an increase in unconstitutedness while holding the other predictor variables constant, results in a corresponding decrease in the quality of greenery. Unconstituted spaces are neglected spaces of a settlement. They are insecure and attract all manner of wrong use (Moirongo, 2006). Because of the nature of such a space, as for instance illustrated on Plate 4-16), there are no pedestrians to accord it surveillance thus making it prone to crime (Jacobs, 1961, Hillier, 1988). Adjacent properties do not open into it and therefore residents do not feel bound to take care of it. Any greenery in such a space therefore suffers neglect and over time its quality deteriorates. The measure of control of axial space, just like adjacency and impermeability, has an inverse relationship with the dependent variable. This means that an increase in the control value of a space, while holding all other variables constant, results in a decrease in the quality of greenery. If the space has grass, it means that it gets bushier as control value increases. The dynamics of this relationship has been discussed under Model 25.

Multiple regressions between quality of greenery and all independent variables reveal that 23.2 percent of the variance in the dependent variable is significantly explained by percentage of space length fronted with fronts of buildings and private security patrols (Model 28 in Table 4-7). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Quality of greenery} = 1.253 + 0.013D1 + 0.116D_{58} \pm 1.082S_e \dots\dots\dots (28)$$

Each of the variables has positive relationship with the dependent variable. This suggests that an increase in either of them, while holding all other variable constant, results in an increase in the quality of greenery and therefore a better environment. A public space fronted with fronts of buildings implies that the buildings are permeable to it. In other words, the space is constituted by the buildings. In advocating for this property of spatial plan structure, Hillier (1988) empirically establishes a positive correlation between constitutedness and encounter rate of pedestrians but an inverse relationship with burglary rate. He thus confirms Jane Jacobs' assertion that having more people in public space is associated with lower crime risk (Jacobs, 1961). Alexander (1977) comes out in support of buildings having entrances into a street as a way increasing movement and in effect improving safety in the street. This sense of safety in public space is also promoted by security patrols. The frequency of people in a public space is high if they are certain that there are security patrols. When there is surveillance in a public space, residents develop a sense of belonging to it and give care to greenery. As this study finds out, even in public rental housing, residents at some point in time engage in improving the quality of greenery (Plate 4-19).



Plate 4-19: Trimming of grass in public space.

Source: Author, 2011.

From the above findings, it emerges that constitutedness of public space, measure of control and provision of public space services are some of the patterns that explain the problem of quality of greenery in public space. These are discussed in the next chapter of this study.

**Table 4-7: Regression Results for Neglect of Greenery in Public Space.**

**Model 25: Area of neglected greenery using alpha variables as predictors**

Var	Uns. B	SE B	$\beta$
N8	.103	.024	.373
N1	-.003	.001	-.205

Constant=0.105; R= 0.390; R<sup>2</sup>= 0.152; Adjusted R<sup>2</sup>= 0.138; S<sub>e</sub> = 0.165; df= 2, 117; F= 10.504; Sig. =0.000

**Model 26: Area of neglected greenery using all independent variables as predictors**

B5	.005	.001	.545
D1	-.001	.000	-.227
N8	.054	.024	.194

Constant=0.079; R= 0.694; R<sup>2</sup>= 0.482; Adjusted R<sup>2</sup>= 0.460; S<sub>e</sub> = 0.131; df= 3, 71; F= 21.984; Sig. =0.000

**Model 27: Quality of greenery using alpha variables as predictors**

N6	-20.734	7.120	-.254
N8	-.441	.165	-.233

Constant=3.138; R= 0.352; R<sup>2</sup>= 0.124; Adjusted R<sup>2</sup>= 0.109; S<sub>e</sub> = 1.150; df= 2, 115; F= 8.141; Sig. =0.000

**Model 28: Quality of greenery using all independent variables as predictors**

D1	.013	.004	.345
D58	.116	.044	.278

Constant=1.253; R= 0.482; R<sup>2</sup>= 0.232; Adjusted R<sup>2</sup>= 0.211; S<sub>e</sub> = 1.082; df= 2, 72; F= 10.879; Sig. =0.000

Where:

R= Multiple correlation coefficient; R<sup>2</sup>= Coefficient of determination; S<sub>e</sub>= Standard error of the estimate; Uns. B= Unstandardised coefficient; SE B= Standard error of B;  $\beta$ = Standardized coefficient; df= degrees of freedom of the model; F= Analysis of Variance coefficient; Sig. = Significance (p) value of the model.

N<sub>8</sub>= Measure of control of axial space; N<sub>1</sub>= Building space index; B<sub>5</sub>= Percentage of space area with grass; D<sub>1</sub>= Percentage of space length fronted with fronts of buildings; N<sub>6</sub>= Adjacency and impermeability per metre length of space; D<sub>58</sub>= Private security patrols.

Source: Author, 2011.

#### **4.8 Destroyed Road Network**

A hierarchical pattern of road system is a characteristic feature of residential neighbourhoods. Towers (2005) writes that this road system comprises a network of primary, secondary and local distributor roads. In the layout of residential neighbourhoods, this road network gives priority to cars and public transport vehicles. In layout of the roads, attention is given to road widths and junctions that ease and speed up vehicular movements. In regard to public transport, the routes and destinations of buses need to be identified and bus stops established.

Besides vehicular roads, layout of residential neighbourhoods considers provision of a network of pedestrian and cyclist routes which are positive, safe, direct, accessible and free from barriers. Towers (2005) and Alexander (1977) point out that streets which are designed for low traffic speeds are safe for walking and cycling (ideally 20 mph or less), especially when detailed layout and design (of junctions, crossings and surfacing) has their needs in mind. People feel safer on streets where there is activity, where they can be seen by drivers, residents and other users. However, Towers (2005) adds that if the infrastructure needs of pedestrians are to be supported, the needs of drivers must be secondary. They must be forced to travel more slowly and take the more circuitous routes. Given this new priority in settlement planning, people are encouraged to walk more. Towers observes that in low density neighbourhoods, the most frequent journeys – taking young children to school, going to the local shops – are frequently made by car. Conversely, in denser urban housing with pedestrian priority, these journeys are more easily made on foot.

Despite the crucial role played by the transport infrastructure, it is unfortunate to note that in Nairobi's residential neighbourhoods, large sections of the road infrastructure are in a degraded state. Whereas the CCN has a responsibility of upgrading all roads in residential neighbourhoods, the role that spatial planning plays, in the context of spatial relations, is an area that research has not explored. On this basis, this study seeks to find out the spatial plan patterns associated with the problem of destroyed road network and the extent to which they explain it. Application of these patterns in layout of residential neighbourhoods has the capacity to minimize the environmental problem.

**4.8.1 Modelling Length of Destroyed Road**

Multiple regression analysis between length of destroyed road and alpha variables shows that 9.6 percent of the variance in the dependent variable is significantly explained by building space index and adjacency and permeability per metre of space (Model 29 in Table 4-8). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

*Length of destroyed road = 0.672 - 0.011N<sub>1</sub> + 1.661N<sub>3</sub> +/- 0.381S<sub>e</sub> ..... (29)*

Building space index refers to the number of buildings that are both adjacent and permeable to the public space (Hillier and Hanson, 1984). In fully developed residential streets with same building typology, a longer axial space will have a higher building space index than a shorter one. Adjacency and permeability per metre of space refers to building space index that is standardized to allow for comparison among spaces of different lengths. Both variables are indexes of constitutedness of public space.

Building space index has an inverse relationship with the dependent variable. This means that an increase in the variable, while holding all other independent variables constant, results in a decrease in the length of destroyed road. Jacobs (1961) and Hillier (1988) point out that the number of people is greater in a public space characterized with a higher index of constitutedness. Jacobs (1961) writes that the ensuing sense of safety in such a space favours proliferation of small specialty shops that further enliven the public space. The space, which is busy with residents and strangers involved in different activities, benefits from a consolidated effort to protect it from environmental decline. The authority responsible for maintenance of the neighbourhood road infrastructure is left with little choice but to give priority to such a space. Besides the level of use of the space, the priority of infrastructure upgrading is informed by the comparatively higher revenue base of the space that the authority partly relies on for its operations (Plate 4-1a). On the other hand, constitutedness has a positive relationship with the length of destroyed road. This is in the sense that as constitutedness increases, while holding all other predictor variables constant, the length of destroyed road also increases. Sometimes the authority responsible for upgrading of the roads is overwhelmed to do so and the high intensity of use of a constituted space ends up in overuse and increased length of destroyed road.



Multiple regressions between length of destroyed road and all independent variables illustrate that 53.5 percent of the variance in the dependent variable is significantly explained by four predictor variables (Model 30 in Table 4-8). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Length of destroyed road} = 0.922 - 0.013B_4 - 0.014B_1 + 0.046N_9 + 2.641C_{12} \pm 0.279S_e \dots\dots\dots (30)$$

Two of the four variables have an inverse relationship with the dependent variable and include percentage of space area with tarmac and width of the space. This implies that an increase in either of them, while holding all other variables constant, results in a decrease in the length of destroyed road. Tarmac, as a road surfacing material, has a higher resistance to erosion, be it by wind or storm water, than a murramed surface. Because of this property, the larger the percentage of public space area that is tarmacked, the lower the length of destroyed road. However, as Hough (1995) points out, large impervious surfaces in a settlement are not desirable as they hinder percolation of water into the ground and instead promote storm water runoffs. Width of public space, on the other hand, has a bearing on the intensity of use of a space. If all other variables are held constant, increasing width of public space has the effect of lowering the intensity of use and therefore the length of destroyed road. Towers (2005) and Alexander (1977) write that in residential settlement plan layouts where streets are intended to accommodate only low traffic speeds, there is no need of segregating vehicular and pedestrian lines of movement; in fact, there is no need of creating sidewalks. In such a scenario, both pedestrians and vehicles compete for the road space for their respective activities (Plate 4-18). An increase in width of the space, with or without increasing the width of the vehicular carriageway, has an effect of creating additional space to accommodate pedestrian activity. In this regard, the intensity of use of the road is relieved and consequently the length of destroyed road is smaller.

The other two variables have a direct relationship with the dependent variable and include depth from Y and the frequency of vehicles using the space. The relationship suggests that an increase in any of the variables, while holding all other predictor variables constant, leads to a corresponding increase in the length of destroyed road. Public spaces that are of greater depth from Y in a settlement layout tend to be left out when it comes to programmes for upgrading of road infrastructure (Moirongo, 2011). This finding, which is in tandem with Moirongo's, illustrates

that public spaces that are shallow from Y have more movement and business activities and therefore receive priority when it comes to making a strategic choice as to which space to upgrade. Public spaces that are shallower from Y therefore have shorter sections of the road in bad condition whereas spaces deeper from Y have longer roads in bad condition. On the other hand, when the frequency of vehicles using a public space gets higher, it means that the intensity of use of the road in the space increases. The consequence of this is a bigger length of destroyed road.

The above findings suggest that constitutedness, transportation planning, ecological balance and integration are some of the patterns that explain the problem of length of destroyed road in public space. These patterns are discussed in the next chapter of this study.

#### **4.8.2 Modelling Area of Destroyed Road**

Multiple regression analysis between area of destroyed road and axial alpha variables shows that 8.0 percent of the variance in the dependent variable is significantly explained by adjacency and impermeability per square metre of space (Model 31 in Table 4-8). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Area of destroyed road} = 0.304 + 35.014N_5 \pm 0.273S_e \dots\dots\dots (31)$$

Adjacency and impermeability of space has a direct relationship with the dependent variable, implying that when it is increased, it results in a corresponding increase in the area of destroyed road. Unconstitutedness of a public space is associated with lower encounter rates of people and consequently higher burglary rates (Hillier, 1988). In order to enliven public spaces of settlements and in effect improve surveillance and a sense of safety, Alexander (1977) asserts that buildings should have entrances onto the street. Moirongo (2011) establishes that unconstitutedness of public space leads to solid waste build-up. Such spaces therefore suffer neglect as nobody bothers to care about them. Roger Trancik refers to such spaces as negative or lost (Trancik, 1986). Considering that such a pattern does not support social intercourse in public space, it is therefore not surprising that larger areas of destroyed road are evident due to neglect.

Multiple regressions between area of destroyed road and all independent variables illustrate that 75.1 percent of the variance in the dependent variable is significantly explained by eight predictor variables (Model 32 in Table 4-8). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Area of destroyed road} = 0.149 - 0.007B_4 - 0.017B_1 + 0.474C_9 + 0.092C_{11} + 1.987C_{12} - 0.081C_7 - 4.839C_{14} + 0.002B_{20} \pm 0.15S_e \dots\dots\dots (32)$$

One half of the independent variables has a direct relationship with the area of destroyed road and includes total number of vehicular movement lanes, density of vehicles using the space, frequency of vehicles using the space, and percentage of space that is flat. This relationship implies that an increase in any of the independent variables, while holding all other independent variables constant, leads to an increase in the area of destroyed road in the public space. The first three variables in this category have a bearing on the intensity of use of the road space by motor vehicles. In scenarios where the volume of vehicular traffic using a road is high, it can be inferred, just as from intuition, that the area of destroyed road is higher. An area of public space that is flat has storm water drainage problems associated with it (Model 24) considering that it does not support natural surface flow of storm water. The retained water weakens road structure and over time, it develops potholes especially if motor vehicles pass over it. Flat areas of public space also promote solid waste build-up as this degree of slope does not support washing away by storm water (Moirongo, 2011). In this respect, flat areas of a public space work against road quality and therefore lead to a poor public space environment.

The other half of predictor variables has an inverse relationship with the area of destroyed road and includes percentage of space area covered with tarmac, width of the space, width of the road, and frequency of pedestrian roads making a junction with the space. This means that an increase in any of the variables, while holding all other independent variables constant, results in a decrease in the area of destroyed road. Tarmac has a higher resistance to the wearing effect of erosion and intensity of use than bear soil. This suggests that the more a public space is tarmacked, the lower the area of destroyed road. However, as Hough (1995) argues, surfacing a large area of space with such an impervious material is not desirable as it goes against the ecological principle of supporting infiltration of storm water into the ground. An increase in width

of public space and an increase in width of road, just like the percentage of space area that is tarmacked, have an effect of lowering the area of road that is destroyed. The discussion under Model 30, illustrating how an increase in public space width contributes to lowering the length of destroyed road, applies in this model though the effect in this model is on lowering the area of destroyed road. The frequency of pedestrian roads making a junction with the space, on the other hand, makes the space people-dominated. This suggests that when connectivity of a space is higher, the resulting number of people in the space is also higher (Min, 1993). Because of people-dominance in public space, the volume of vehicular traffic is reduced and therefore the extent of destruction of the carriageway is much lower. This indicates that motor vehicles are one single-most cause of road destruction in the residential public space system.

The above findings suggest that the degree of adjacency and impermeability, percentage of space area covered with tarmac, width of space, intensity of use of a road carriageway, frequency of pedestrian roads making a junction with the space, and percentage of space area that is flat are some the variables that explain the problem of area of destroyed road in a residential neighbourhood public space system. The variables fall into the following patterns: constitutedness, ecological balance, transportation planning and connectivity. These patterns are discussed in the next chapter of this study.

**Table 4-8: Regression Results for Destroyed Road Network in Public Space.**

**Model 29: Length of destroyed road using alpha variables as predictors**

Var	Uns. B	SE B	B
N1	-.011	.003	-.337
N3	1.661	.648	.257

Constant=0.672; R= 0.310; R<sup>2</sup>= 0.096; Adjusted R<sup>2</sup>= 0.081; S<sub>e</sub> = 0.381; df= 2, 117; F= 6.231; Sig. =0.003

**Model 30: Length of destroyed road using all independent variables as predictors**

B4	-.013	.002	-.681
B1	-.014	.005	-.237
N9	.046	.020	.195
C12	2.641	1.300	.173

Constant=0.922; R= 0.731; R<sup>2</sup>= 0.535; Adjusted R<sup>2</sup>= 0.508; S<sub>e</sub> = 0.279; df= 4, 70; F= 20.118; Sig. =0.000

**Model 31: Area of destroyed road using alpha variables as predictors**

N5	35.014	10.914	.283
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Constant=0.304; R= 0.283; R<sup>2</sup>= 0.080; Adjusted R<sup>2</sup>= 0.072; S<sub>e</sub> = 0.273; df= 1, 118; F= 10.292; Sig. =0.002

**Model 32: Area of destroyed road using all independent variables as predictors**

B4	-.007	.001	-.518
B1	-.017	.003	-.392
C9	.474	.089	.511
C11	.092	.039	.150
C12	1.987	.735	.183
C7	-.081	.023	-.383
C14	-4.839	2.118	-.153
B20	.002	.001	.138

Constant=0.149; R= 0.867; R<sup>2</sup>= 0.751; Adjusted R<sup>2</sup>= 0.721; S<sub>e</sub> = 0.150; df= 8, 66; F= 24.903; Sig. =0.000

Where:

R= Multiple correlation coefficient; R<sup>2</sup>= Coefficient of determination; S<sub>e</sub>= Standard error of the estimate; Uns. B= Unstandardised coefficient; SE B= Standard error of B; β= Standardized coefficient; df= degrees of freedom of the model; F= Analysis of Variance coefficient; Sig. = Significance (p) value of the model.

N<sub>1</sub>= Building space index; N<sub>3</sub>=Adjacency and permeability per metre length of space; B<sub>4</sub>= Percentage of space area with tarmac; B<sub>1</sub>= Width of the space in metres; N<sub>9</sub>= Depth from "Y", the carrier space; C<sub>12</sub>= Frequency of vehicles using the space; N<sub>5</sub>= Adjacency and impermeability per square metre of space; C<sub>9</sub>= Total no. of vehicular movement lanes; C<sub>11</sub>= Density of vehicles using the space; C<sub>7</sub>= Width of road (carriageway); C<sub>14</sub>= Frequency of pedestrian roads making a junction with the space; B<sub>20</sub>= Percentage of space that is flat.

Source: Author, 2011.

#### **4.9 Human Distribution in Public Space.**

The simple social intercourse created when people rub shoulders in public space is one of the most essential kinds of social glue in society (Alexander, 1977). In the City of Nairobi's residential public space system, this glue is largely missing and as this study establishes, is a consequence of the properties of the public space itself and of the structure of the spatial plan fabric of the neighbourhood. The issue which comes to the fore in this regard concerns the properties a public space should have so that the encounter rate of humans is increased.

According to Jacobs (1961), higher encounter rates in public space have the associated benefit of lower crime risk. In her assertion, both the stranger and the resident police public space thus promoting a sense of safety. Alexander (1977) adds that a public space devoid of human movement is dangerous. In his argument, he roots for buildings opening into the street as a way of ensuring that streets are live with human movement. Moirongo (2011), on the other hand, writes that people in outdoor space are involved in varied activities and that the physical environment is one of the factors that influence activity mix. The physical environment, for instance, can assemble or disperse, integrate or segregate and invite or repel.

In view of the need to humanize public space in residential neighbourhoods so that it is safe to operate in, this study finds it necessary to unearth public space characteristics that have an association with human distribution. Through regression analysis, the study establishes the characteristics and the extent to which they explain human distribution in public space.

##### **4.9.1 Modelling Frequency of People in Public Space**

Multiple regression analysis between axial alpha variables and frequency of people in public space reveals that 21.5 percent of the variance in the dependent variable is significantly explained by depth from  $Y$  and adjacency and permeability per metre of space (Model 33 in Table 4-9). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Frequency of people in space} = 0.114 - 0.018N_9 + 0.426N_3 \pm 0.075S_e \dots\dots\dots (33)$$

In this prediction, depth from  $Y$  has an inverse relationship with the dependent variable. This suggests that an increase in depth from  $Y$ , while holding all other predictor variables constant,

results in a decrease in the frequency of people in public space. Unlike in shallower spaces where there are more people and a higher level of investment in small scale retail shops and informal activities, deeper spaces are marked with lower levels of activity. This public space environment is not desirable because of its characteristic lower surveillance from public space users and therefore a lower sense of safety (Jacobs, 1961). Hillier (1988) adds that public spaces with fewer people have higher burglary rates. Adjacency and permeability per metre of space, on the other hand, indexes the constitutedness property of public space which, in this model, relates directly with the dependent variable. This implies that an increase in constitutedness, while holding all other independent variables constant, leads to a corresponding increase in the frequency of people in public space. The spatial environment characterized with this pattern is desirable because of its associated benefit of crime prevention (Jacobs, 1961; Alexander, 1977). Hillier (1988) empirically establishes a positive correlation between constitutedness and encounter rate of pedestrians, a scenario that concurs with the findings of the present study. In effect, these findings add to the doubt already cast on the concept of defensible space as advocated for by Newman (1972) and Coleman (1985), at least in so far as one of its main conjectures behind it is that the elimination of natural movement and encounter within housing estates increases safety. In disagreeing with this view, Hillier (1988) points out that advocates of defensible space seem to believe that criminals are part of the passing crowd, and that strangers are therefore in principle dangerous.

Multiple regressions between frequency of people in space and all independent variables show that 79.1 percent of the variance in the dependent variable is significantly explained by eight independent variables (Model 34 ion Table 4-9). The model, whose prediction is significant at 99 percent confidence level, is illustrated below.

$$\text{Frequency of people in space} = 0.086 - 0.058D_{42} + 1.546F_4 + 0.517F_{17} + 34.638F_9 + 0.182D_{46} + 1.552C_3 - 0.008N_9 + 0.000D_1 + 0.041S_e \dots\dots\dots (34)$$

Two of these predictor variables have an inverse relationship and include proportion of number of buildings with setbacks and depth from Y space. This suggests that an increase in any of the variables, while holding all other variables constant, results in a decrease in the frequency of people in space. Building setback refers to the distance by which the building is removed from the

edge of the public space. For the sample public spaces examined in this study, building setback ranges from zero (0) to six (6) metres. When a building setback is greater than zero, the building wall ceases being the property boundary and instead a fence of some kind serves this role. This is a feature of low density settlements in which there is a clear definition of public and private environments within the outdoor space system. Inasmuch as there is constitutedness in this spatial layout, removal of a building off the edge of a public space has the effect of reducing pedestrian flow due to reduced social intercourse between the residents and stranger in the public space. In regard to the variable of depth of a public space from  $Y$ , the manner in which it leads to a decrease in the frequency of people in public space has already been discussed under Model 33.

The remaining six independent variables have a direct relationship with the dependent variable and include frequency of retail shops, frequency of informal business activities, frequency of bookshops, proportion of buildings with social places, frequency of intersections within the space, and percentage of space length fronted with fronts of buildings. This suggests that an increase in any one of them, while holding all other independent variables constant, results in an increase in the frequency of people in public space. The first four in this category of variables are activity magnets that pull people into the public space fabric of the residential settlement and the more there are in a public space, the higher the frequency of people. A public space with a high frequency of intersections is a high connectivity space and according to Min (1993), is associated with a high encounter rate of people. Such a public space is also of high control (Hillier and Hanson, 1984) and positively correlates with encounter rate (Hillier, 1984). Fronts of buildings defining a public space are permeable to it and thus are an index of the property of constitutedness. The influence of constitutedness on frequency of people in public space has been elaborately discussed under Model 33.

These findings suggest that integration, constitutedness, land use and connectivity are some of the public space patterns that explain human distribution in public space. These patterns are discussed in the next chapter of this study.



**Table 4-9: Regression Results for Human Distribution in Public Space.**

**Model 33: Frequency of people in space using alpha variables as predictors**

Var	Uns. B	SE B	B
N9	-.018	.004	-.365
N3	.426	.112	.313

Constant=0.114; R= 0.463; R<sup>2</sup>= 0.215; Adjusted R<sup>2</sup>= 0.201; S<sub>e</sub> = 0.075; df= 2,117; F= 15.978; Sig. =0.000

**Model 34: Frequency of people in space using all independent variables as predictors**

D42	-.058	.016	-.259
F4	1.546	.357	.283
F17	.517	.165	.225
F9	34.638	7.610	.264
D46	.182	.059	.189
C3	1.552	.470	.212
N9	-.008	.003	-.164
D1	.000	.000	.131

Constant=0.086; R= 0.889; R<sup>2</sup>= 0.791; Adjusted R<sup>2</sup>= 0.765; S<sub>e</sub> = 0.041; df= 8, 66; F= 31.175; Sig. =0.000

Where:

R= Multiple correlation coefficient; R<sup>2</sup>= Coefficient of determination; S<sub>e</sub>= Standard error of the estimate; Uns. B= Unstandardised coefficient; SE B= Standard error of B; β= Standardized coefficient; df= degrees of freedom of the model; F= Analysis of Variance coefficient; Sig. = Significance (p) value of the model.

N<sub>9</sub>= Depth from "Y", the carrier space; N<sub>3</sub>= Adjacency and permeability per metre length of space; D<sub>42</sub>= Proportion of no. of buildings with setbacks; F<sub>4</sub>= Frequency of retail shops; F<sub>17</sub>= Frequency of informal business activities; F<sub>9</sub>= Frequency of bookshops; D<sub>46</sub>= Proportion of buildings with social places; C<sub>3</sub>= Frequency of intersections within the space; D<sub>1</sub>= Percentage of space length fronted with fronts of buildings.

Source: Author, 2011.

#### **4.10 Emerging spatial planning Patterns**

This chapter has looked at environmental problems as a function of public space variables that significantly predict them. An elaborate discussion of the influence of predictor variables on each environmental problem reveals emerging spatial planning patterns which are a result of the action of a number of related independent variables. Each pattern is made up of a number of independent variables that point to it. Table 4-10 presents the established spatial planning patterns and the respective environmental problems they influence.

**Table 4-10: Established Spatial Planning Patterns.**

Public Space Environmental Problem	Different dimensions of the Environmental Problem	Spatial Planning Patterns Influencing the Environmental Problem								
		a	b	C	d	E	F	g	h	j
<b>Vehicular-Pedestrian Conflict</b>	Frequency of interruption of pedestrian flow by vehicular traffic	•			•			•		
	Density of parking on pedestrian walkways	•					•	•		
<b>Undesignated Parking</b>	Density of parking on grass	•		•	•	•		•		•
	Density of parking on carriageway	•		•	•	•		•		
	Density of parking on bare soil	•	•		•			•		•
	Overall density of parking on undesignated areas	•						•		
<b>Public Space Pollution</b>	Dust pollution	•				•	•	•	•	•
	Odour pollution	•				•	•	•		
<b>Solid Waste Accumulation in Space</b>	Solid waste area	•				•				•
	Solid waste height	•				•	•	•		•
	Solid waste quality					•	•	•		•
<b>Defective Storm Water Drainage System</b>	Area of space commonly occupied with stagnant storm water	•					•	•		
<b>Neglect of Greenery</b>	Area of neglected greenery	•	•				•			
	Quality of greenery	•	•							•
<b>Destroyed Road Network</b>	Length of destroyed road	•				•	•		•	
	Area of destroyed road	•			•		•		•	
<b>Humanization of Public Space</b>	Frequency of people in public space	•			•	•		•		

Source: Author, 2011.

**KEY:**

- a. Constitutedness of public space
- b. Control of public space
- c. Scale of public space
- d. Connectivity of public space
- e. Integration of public space
- f. Ecological balance of public space
- g. Land use planning in public space
- h. Transportation planning in public space
- j. Public space services

#### **4.11 Conclusion**

The chapter has realized nine spatial planning patterns which co-interact to influence public space environmental problems. The dynamics of interaction among the spatial planning patterns are discussed in the next chapter of the study.

## CHAPTER FIVE

### 5.0 NEIGHBOURHOOD PUBLIC SPACE PATTERNS

#### 5.1 Introduction

This chapter discusses nine spatial planning patterns established in the preceding chapter of this study. The patterns are discussed with regard to how they inform environmental management. The chapter looks at each pattern, and in association with other patterns, in regard to the environmental problems they solve. A discussion on the interaction among various spatial patterns is essential as it informs how spatial planning can evolve a balanced and environmentally sustainable urban residential ecosystem. The following framework is used as a guide in the discussion of the patterns:

- What is the meaning of the spatial planning pattern and what variables make it up?
- Why has the established pattern led into the public space environmental problems?
- How does the pattern interact with other patterns?
- What interventions ought to be put in place to revitalize the public space environment in the City of Nairobi's residential neighbourhoods to make it a desirable place to operate in?

The spatial patterns include constitutedness, control, scale, connectivity, integration, ecological balance, land use, transportation planning and provision of public space services.

#### 5.2 Constitutedness of Public Space

According to Hillier and Hanson (1984), constitutedness of a space is said to exist when adjacent buildings and other bounded areas, such as inhabited plots, gardens and parks, are directly or indirectly permeable to it. Permeability in this regard refers to access between the enclosed and public space environments which can be either physical access through doors or gates, or visual access through windows or transparent perimeter wall openings. When buildings or such bounded areas are directly accessible to an axial or public space, we say that the space is constituted by the buildings, but if the space is adjacent to buildings or bounded areas to which it is not directly permeable, we say it is unconstituted. In this study, constitutedness of a public space is measured by, among other variables, the degree of adjacency and permeability, which refers to the number of buildings or inhabited plots that are both adjacent and permeable to the space. The measure is standardized on the basis of either area or length of space in order to

allow for comparison of measures among axial spaces of different sizes. Where standardization is not carried out, constitutedness is measured merely as building space index which, according to Hillier and Hanson (1984), refers to the number of buildings or bounded areas that are both adjacent and permeable to the space. Conversely, unconstitutedness is measured in terms of the degree of adjacency and impermeability which is the standardized measure of the number of buildings and other bounded areas that are adjacent and impermeable to the space. Other variables which this study establishes as pointing up to constitutedness include percentage of space length fronted with fronts of buildings/inhabited plots, average height of space boundary, ratio of average height of space boundary to width of space, and percentage of building wall length that is transparent. Broadly then, constitutedness is defined by the degree of permeability or accessibility, the degree of enclosure and the degree of transparency. This implies that constitutedness deals with the quality of the boundaries that define public space. Jacobs (1995) writes that these boundaries, besides being the edge of a street, play the role of setting the street apart, keeping eyes on and in the street and making it a place. This suggests that if the boundaries were blank, the interaction between the solids and voids would be negative. On the other hand, Gehl (1996) points out that houses or buildings laid out such that their entrances face a public space, a pedestrian path or outdoor area contribute to assembly of people and events. Otherwise, inaccessible buildings constituting a public space promote dispersal of people and events. Fundamentally then, the pattern of constitutedness has a bearing on the presence of people and surveillance in a public space, the manner of use of the space, and the resulting quality of the public space environment. In this respect, a constituted space is a better quality environment to operate in whereas an unconstituted one is dangerous owing to the wrong use it is put to.

Surveillance of public space promotes a sense of safety among public space users (Jacobs, 1961). A direct correlation between unconstitutedness and burglary rate in public spaces of residential neighbourhoods has also been empirically established by Hillier (1988). Since safety in public space is an aspect that every user of the space desires, it then goes without saying that constitutedness of public space is a pattern that spatial planning of any settlement should endeavour to achieve. It is however unfortunate to note that in the City of Nairobi's residential neighbourhoods, spatial planning has failed to substantially characterize the public space

environment with this spatial pattern as seen in the insufficient articulation of boundaries to maximize on public space surveillance.

When the degree of permeability of a public space is higher, the encounter rate of pedestrians increases (Min, 1993; Baran et al; 2008). Variables that significantly account for the degree of permeability of a public space include building space index, adjacency and permeability per metre of space, adjacency and permeability per square metre of space, and percentage of space length fronted with fronts of buildings. A higher degree of permeability has a minimizing effect on density of parking on pedestrian walkways, density of parking on bare soil and overall density of parking on undesignated areas. Further, it contributes to lower levels of odour pollution, a higher quality of greenery, a lower area of space with destroyed greenery, a lower length and area of destroyed road, and a higher frequency of people in public space. In the layout of residential settlements, residents of buildings constituting a public space have a higher sense of community reminiscent of what Clarence Perry yearned for (Perry 1929). At the local scale of the public space system, there are courts, crescents and circuits which define communities united by a common purpose, say provision of public space services such as security patrols and garbage collection. Despite these positive aspects of permeability, it should be applied with limits bearing in mind that there are negative environmental effects associated with its higher degree. In this respect, a higher degree of permeability of space leads to a higher frequency of interruption of pedestrian flow by vehicular traffic, increased density of parking on grass and road carriageway, larger solid waste area and height, and bigger area of space commonly occupied with stagnant storm water. To some extent also, as discussed in the preceding chapter, a higher degree of permeability promotes density of parking on pedestrian walkways, bare soil, and overall density of parking on undesignated areas of public space, and a bigger length of destroyed road. Further, whereas permeability creates clusters of cohesive communities at local scales of a residential settlement layout, it has in some cases resulted in neglect of public spaces that serve as links between these clusters. In Pangani estate, for example, the spaces linking these clusters are back streets that are wayleaves for sewer but because they are unconstituted, they are dump sites for solid waste. Plate 5-1 illustrates this problem whereas Figure 5-1 shows some of the impermeable public spaces in the same neighbourhood.

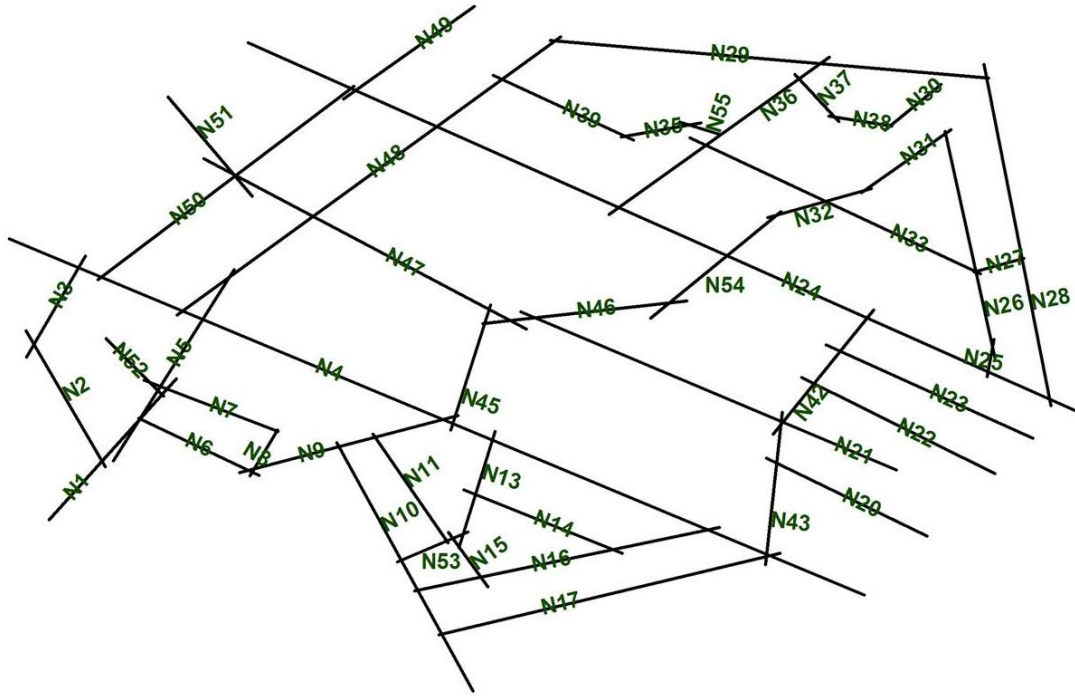


Figure 5-1: Solid waste build-up in unconstituted spaces N11, N7 and N14.  
 Source: Author, 2011.



Plate 5-1: A large deposit of solid waste in axial space N14.  
 Source: Author, 2011.

Moirongo (2011) points out that the environmental problems in public space, which are a result of accessibility, are either stationary or vehicular-related. Vehicular problems are a result of the need for parking space in public space in which the demand by far outstrips supply. This sees motorists park in undesignated areas which ends up conflicting with pedestrian activity. The other set of problems is a result of use of the space, with the environmental status getting worse as the intensity of use increases. This brings into focus other spatial patterns that interact with this dimension of constitutedness to produce either a better or worse public space environment. These include control of space, public space services, ecological balance, transportation planning and land use. These are discussed later in the chapter but just briefly, a higher degree of permeability results in greater control of space. The more we have residents accessing a public space, the more they have control of it. They can make decisions with regard to activities taking place in the space for purposes of improving the environment. In this regard, residents with a higher degree of control of a public space are able to successfully lobby for the flow of public space services such as tarmacking of roads, provision of amenities and garbage collection. In the negative sense though, when permeability of a public space gets higher, the traffic circulation pattern changes due to the increase in the density of vehicular use. This in turn affects ecological balance of the space as for instance seen in the destruction of greenery and displacement of people from space by the ubiquitous car. A higher degree of permeability of a public space influences change of land use in the space. For instance, it motivates investment in small scale business activities, such as retail shops and chemists, which add to the already existing residential land use.

The degree of enclosure of a space determines the extent to which the space is policed. In the present study, this dimension of constitutedness is significantly indicated by the average height of space boundary. Scale of public space, measured as a ratio of boundary height to width of space, is also an indicator of the degree of enclosure. As this study finds out, a higher ratio of boundary height to width of space is associated with a higher density of parking on grass areas of public space. On the other hand, a higher height of space boundary contributes to increased levels of dust pollution. When a public space boundary is of such a height that residents of the building behind the boundary cannot have an eye on the public space, then control of the space goes down and its use becomes negative. Similarly, a higher ratio of boundary height to width of the space means poor surveillance of public space by residents of the building located behind the



boundary line. This explains why such spaces are inhabited by parking boys, neglected with regard to provision of amenities and infrastructure, have large solid waste areas and high levels of both dust and odour pollution. Poor surveillance of space in this regard gets more pronounced when the width of space is narrow, say 2.5 metres, and building walls defining public space boundary are as high as five storeys. Whereas vehicles are excluded from a space of such a scale, the resulting high intensity of pedestrian activity and weak control lead to the static environmental problems. However, when scale is appropriate, surveillance and control are adequate and this results in a better quality environment for public space users.

The degree of transparency refers to the intensity of glazed and see-through building openings constituting a space. In this study, the degree of transparency is indicated by the percentage of building wall length that is transparent. This is found to correlate inversely with the quality of solid waste in public space in the sense that as transparency increases, solid waste in the space gets more rotten. This is a case of buildings with opaque boundary walls in which windows visible from the public space are those from the second storey and above. It is also a case of a public space whose land use pattern is characterized with high density of settlement in the vertical dimension. In this case, land use allows for bigger plot ratios against fixed widths of the constituted public spaces. Irrespective of land use density, the degree of control of space by residents of a building whose windows on ground floor are not visible from the public space is weak considering that there is no visual connection between this building level and the space. In public spaces with higher plot ratios, this measure of transparency is higher but unfortunately does not contribute to improved surveillance and control of space. This is because of the higher ratio of building height to width of space. The angle of vision brought out by the line of sight from the building window in relation to the ground area of the public space does not allow for visual surveillance over the entire section of the constituted space. Surveillance of public space is better when this angle is smaller and for the same space, this is achieved with lower building heights. Areas not benefiting from this line of sight are negative zones that end up in wrongful use as for instance seen in the dumping of solid waste, undesignated parking and habitation by potential criminals. Such wrongful use negatively affects public space ecological balance as seen in the destruction of greenery and distribution of people and their outdoor activities. A desirable public space environment in this regard is one where the constituting buildings have visual connection with the

public space at ground level. This way then, a higher degree of transparency promotes surveillance and control of space and hence a better public space environment.

From the above discourse, it emerges that constituted public spaces are desirable environments to operate in. In view of the environmental problems resulting from the failure in spatial planning, the issue that comes to the fore is on what needs to be done to public space in order to restore the desirable environmental quality. Prior to advancing revitalization measures, it is necessary to concretize specific areas where spatial planning has failed with regard to constitutedness of public space in the layout of residential neighbourhoods. These include:

- i. Creation of public spaces constituted by adjacent but impermeable buildings.
- ii. Use of opaque boundary walling that deprives public space of surveillance from residents at ground floor level of the constituting buildings. In such a scenario, transparency of buildings that is relied on in surveillance of public space is that of the second and higher storeys of the constituting building. As this study shows, this is not effective. Due to the resulting poor control of space, the public space is left vulnerable to wrong environmental use.
- iii. Allowing for car-domination in the public space by “blindly” creating permeable environments. The cars have consequently become a threat to pedestrian safety and comfort and contributed to ecological imbalance through encroachment of zones for greenery and pedestrians.
- iv. Creation of clusters of constituted buildings with the spaces in between the clusters suffering neglect. The spaces attract stationary environmental problems as for instance seen in Pangani residential neighbourhood (Figure 5-1).
- v. Laxity in enforcement of building controls or blindly permitting high plot ratios without regard to the impact on scale of the space. In Umoja II residential neighbourhood, for example, a three-metre wide pedestrian space environment is constituted by a five-storey, and very soon to be, six-storey building (Plate 5-2). This kills the sense of a desirable scale in the public space since it subjects the user to the experience of being at the bottom of a narrow ditch.



Plate 5-2: A public space in Umoja II neighbourhood with incorrect scale.

Source: Author, 2011.

In order to revitalize the public spaces of Nairobi's residential neighbourhoods, spatial planning has to employ a raft of measures. One, it has to ensure that public spaces that are impermeable to the constituting buildings are made permeable. This is informed by empirical evidence that a higher frequency of people in a public space promotes a sense of safety and motivates investment in small scale non-residential activities such as businesses. The characteristic high control in such a space makes it stand a better chance of being prioritized for infrastructure upgrading and provision of public space services by the local authority. Two, use of solid perimeter walls for buildings constituting a public space should be minimized. Whereas this study does not decimate the importance of a resident's privacy, spatial planning should ensure that a public space has activities that pull people into and through the space. In this regard, a mix of use in the same building block can achieve this end by, for instance, creating shops on ground floor and residential units on subsequent floor levels. Three, spatial planning should ensure that cars are brought under control in the layout of settlements. Whereas a car is important in the urban economy, reliance on it should be discouraged though establishment of a reliable city-wide motor transport system. For a residential settlement, public transport termini and high speed vehicles should be limited to the periphery. Emphasis should be on pedestrian circulation in the inner part of the settlement, in which case there can be free interaction with cars (Towers, 2005). Activity hubs in the space, such as chemists and retail shops, should be served adequately with parking for cars. In up-market neighbourhoods where residents must do with cars, spatial planning should

provide sidewalks that offer adequate safety to pedestrians. Whatever the cadre of residential settlement, spatial planning should ensure that cars are localized to the motor carriageway by ensuring that the adjacent areas are raised by at least 450 millimetres (Alexander, 1977). Four, creation of clusters of constituted buildings is good as it promotes a sense of community. Quite often, there are passages which link different clusters. As this study establishes, these passages are not constituted and end up being used wrongly (Plate 5-1). Spatial planning should avoid layout concepts that result in such negative spaces. Where existent, the local authority should accord limited control of the passages to residents of the buildings constituting it. The local authority should however reserve the right to access the space whenever need arises, say for instance, to attend to a utility line. Alternatively, spatial planning should make the adjacent buildings permeable to the space and create businesses and such other activity magnets at the ground level. This will drastically improve the encounter rate of people in the space, its control and therefore the quality of the environment. Five, the City Council of Nairobi should have its capacity strengthened to enable it adequately guide any spatial planning changes in the built environment. In doing this, the local authority should consider quality of the space with regard to its scale and capacity of infrastructure. Building structures that undermine the quality of the environment should be either demolished or restored to the desirable level.

### **5.3 Control, Scale and Connectivity of Public Space**

Control of a public space by other spaces is an aggregation of the shared contribution it receives from the neighbouring spaces. This shared contribution that a space receives could be people, vehicles or solid waste, just to mention a few. In this regard, a space which receives more people from neighbouring spaces has a higher control value than one which receives fewer people. Each public space has a certain number  $n$  of immediate neighbours. Each space therefore gives to each of its immediate neighbours  $1/n$ , and these are then summed for each receiving space to give the control value of that space. In effect, each space is partitioning one unit of value among its neighbours and getting back a certain amount from its neighbours. Hillier and Hanson (1984) point out that spaces which have a control value greater than 1 are strong control spaces whereas those below 1 are weak control spaces. Considering that control takes into account relations between a space and its immediate neighbours, it is a local measure.

Control of space is one pattern that finds ground in Oscar Newman's theory of defensible space (Newman, 1972). Newman points out that the degree of control of space, embodied in the manner in which the space is defined, has power to prevent crime. He advocates for differentiation of outdoor space into a series of socio-spatial domains with different degrees of accessibility, namely the public, semi-public and semi-private, and private continuum. The fundamental philosophy of the theory is that people have a natural impulse to exercise control over their local territory. This implies that a stranger to a territorial domain experiences its control from those who identify with it and if the intention was to commit crime, this spatial arrangement is deterrent. Otherwise, a counter response is raised from those who hold claim to the territory. The effectiveness of this theory has been challenged in chapter two of this study but the intention here is to bring out control of public space as a desirable spatial planning pattern. As Jacobs (1961) argues out, in a public space environment, both residents and strangers play the role of policing the space and this deters environmental ills such as crime. This means that both have control of the manner in which a public space is put to use and when this control is higher, the environment is safer and therefore a better environment to operate in.

Unlike in the theory of defensible space where better control of space is associated with limited accessibility, this study establishes that control of space is better with a higher degree of accessibility. In this respect, a public space with a higher degree of constitutedness is characterized with a higher measure of control. Residents of buildings constituting such a space have better control of the space and can therefore make decisions that work for a better public space environment. A high control space therefore has a better sense of community as residents are able to come together and organize for services such as private security patrols. This also puts them in a better position to lobby for local authority services such as garbage collection, and upgrading of road and lighting infrastructure, storm water drainage and water reticulation.

Closely related with the pattern of control is the scale of space. As already mentioned in section 5-2 above, a public space that is 3.0 metres wide and has a six storey building constituting it does not benefit from surveillance through the windows of residential units in the upper floors. Control of public space by residents from such a block is therefore weak and this leaves the space subject to environmental abuse. Moirongo (2011) points out that wider public spaces in relation to multi-storey buildings are desirable as this results in many buildings overlooking the space and

therefore better control of the space. He however cautions against having overly wide public spaces and neither should they also be too small. In Nairobi's residential settlements, some multi-storey building blocks have come up in total disregard of the scale of the constituted space, thus creating agoraphobic or claustrophobic spaces. In addressing the subject of scale, Greenbie (1981) writes that when the height of the enclosing walls is more than twice the width we get an unpleasant feeling of being at the bottom of a ditch. If the width exceeds the height of vertical elements by more than four times, we begin to lose a sense of enclosure. Large spaces are said to be agoraphobic whereas narrow spaces are claustrophobic. With regard to the scale of the residential public space environment, what is needed is an appropriate plot ratio that does not compromise the quality of the public space environment.

Connectivity of public space has a direct relationship with the measure of control of the space. Hillier and Hanson (1984) have related connectivity of a space with its degree of distributedness. A spatial system is said to be distributed if there is more than one route from one space to another and routes always form rings. Otherwise, in a nondistributed system, there will never be more than one route between two locations in the space. A distributed system has diffusion of spatial control whereas a nondistributed system, in regard to the relation between a building in the settlement and the carrier space, is unitary and with superordinate control. Variables that explain the pattern of connectivity in its relation with control of space include frequency of intersections within the space, frequency of vehicular road intersections in the space, and frequency of pedestrian roads making a junction with the space. In this regard, this study establishes that a higher frequency of intersections within a public space leads to a higher encounter rate of people in the space. This relationship has similarly been established by Min (1993) and Baran et al (2008), with the latter further establishing that high control spaces exhibit more walking behaviour. A higher presence of people in public space implies that the people have a better control of the space and this has been associated with an improved sense of safety (Jacobs, 1961; Hillier, 1988; Moirongo, 2011). It is important to note that a public space with long cluster blocks has fewer road intersections and therefore lower connectivity and weaker control. On the other hand, a space with shorter cluster blocks has higher connectivity and better control of the public space environment.

A public space with a high degree of control spurs change in land use for the space. The higher encounter rate of people in such a space motivates investment in small scale business activities such as retail shops, chemists, clothing shops and grocery outlets. Such activities are magnets that pull strangers into the space who, alongside residents, contribute to surveillance of the space. The resulting improved sense of safety is a consequence of a mix in land use activities which ensure that a space is live with activity even into the middle hours of the night. This does not suggest that business activities end up dominating the residential use. What is required is a balanced mix and distribution of land use activities to ensure that there is a sustained flow of people into and through the space.

Despite the already underscored benefits of creating high control public spaces in the layout of residential settlements, it is important to mention that there are negative impacts associated with it. High control spaces exhibit problems in the patterns of transportation planning and ecological balance. This study shows that high control spaces are associated with a high density of parking in undesignated areas, particularly on bare soil. It is also associated with larger areas of neglected greenery and a decrease in the quality of greenery. Increased business activity in high control spaces sees more motorists flow into the space and because of the few parking areas in the space, if at all any are provided, they end up parking on the adjacent grass and bare soil areas. This destabilizes the space's ecological balance by destroying greenery and displacing pedestrians from their amenity spaces. Besides this, when the number of people in a public space is high, greenery in the space suffers from the tragedy of the commons. This consequently leads to larger areas of neglected greenery and a decline in the quality of greenery.

In view of the above, the issue that comes to the fore is on what ought to be done to revitalize the public space environment of residential neighbourhoods in the City of Nairobi. Prior to addressing this issue, it is necessary to point out that in layout of residential settlements, spatial planning has failed to create public spaces characterized with a high degree of control and connectivity, and the correct scale. Where it has been able to achieve this pattern, it has failed to contain the resulting high intensity of vehicles and ecological imbalance in the space. In this respect, if the public space environment is to be restored to make it a better environment with regard to its control, spatial planning ought to do the following:

- i. Ensure that public spaces constituted by impermeable buildings or plots are made accessible from the buildings or plots. By engaging residents in a consultative forum, a balanced mix of activities at the ground floor of the constituting buildings should be agreed upon.
- ii. Ensure that multi-storey structures are not proposed in areas where they destroy the appropriate scale of a public space. For the existing scale-less and high rise residential blocks, ground floor should be allocated small scale businesses and opened up to the public space so as to improve on its control.
- iii. Maximize on pedestrian paths while minimizing on vehicular roads making a junction with the space. This entails improving the citywide public transport system with a view to reduce the city residents' reliance on personal cars. As this study finds out, a higher frequency of pedestrian roads making a junction with the space correspondingly reduces the intensity of parking in undesignated areas whereas it increases the measure of control of a space.
- iv. Long cluster blocks should be split to create pedestrian streets in between. These streets should be permeable from the adjacent buildings. The resulting increase in the number of streets making a junction with the space leads to an increase in the control value of the space.
- v. All motor vehicles should be confined to the carriageway. This can be achieved by raising the adjacent pedestrian zones by at least 450 millimetres so that the vehicles can be deterred from mounting over the edge of the road. Adequate parking spaces should be provided in lots next to activity magnets.
- vi. Residents of buildings constituting a public space should be sensitized on the need to take care of greenery in the space.

#### **5.4 Integration of Public Space**

Public or axial space in a settlement, when described and quantified in terms of its degree of symmetry–asymmetry, presents the character of the space insofar as its degree of integration with respect to the whole system is concerned. Two axial spaces are said to relate symmetrically when there is no intermediate space in between them. On the other hand, the relationship is asymmetric if one has to pass through an intermediate space to move from one space to another (Hillier and Hanson, 1984). It is succinct then to put that in a residential settlement with a series of



axial spaces, unless one is considering the relationship between two adjacent axial spaces, the relationship that is of central focus is that of asymmetry. The degree of asymmetry of an axial space can be looked at in terms of how deep the settlement system is from the space, or how deep it is from the carrier space. In this respect, variables respectively addressing the subject of symmetry-asymmetry of axial or public space are relative depth and depth from the carrier space. In a settlement layout, the more descriptions are symmetric, then the more there will be a tendency to the integration of social categories, such as the categories of inhabitant and stranger. Conversely, the more they are asymmetric then the more there will be a tendency to the segregation of social categories. Prior to getting to understand how relative depth and depth from the carrier space contribute to integration and segregation of public space, it is important to first shed light on the concepts of integration and segregation.

Segregation, as Moirongo (2011) points out, is to a greater extent associated with homogeneity or specialization. It implies a separation of functions and groups that differ from one another. In this regard, residential settlements in the City of Nairobi are segregated on the basis of income level into low-income, middle-income and high-income. On the other hand, integration is associated more with generalization and diversity or heterogeneity. According to Gehl (1996), integration implies that various activities and categories of people are permitted to function together or side by side. This implies that integration of space in a settlement is enhanced by diversity, mixing of activities and emphasis on pedestrian dominance in space. Conversely, mono-functionalism promotes segregation.

In spatial planning of cities, zoning of land use is one major factor that brings out segregation of functions. In Nairobi, for instance, we have the Central Business District (CBD) whose land use is primarily commercial. At its outskirts, land use is delineated into zones of industrial, educational, recreational, public purpose, commercial and public utility uses. These diverse and mono-functional zones are interconnected by pattern of transportation. Within each land use, zoning further causes segregation. For instance, in industrial use, we have distinct zones for light and heavy manufacturing industries. As already mentioned, residential land use is segregated into low-income, middle-income and high-income neighbourhoods. Whereas this homogeneous distribution of functions is a consequence of zoning, it is possible to have integration of land uses, for instance, residential and commercial. As this study establishes, a higher degree of integration

in public space is desirable as is associated with a higher encounter rate of people and therefore an improved sense of safety. What this suggests is that within the settlement of a neighbourhood, we can have both integration and segregation characterizing the public space environment. In effect, this brings to the fore the bi-polar character of the public space system of a residential settlement whereby on one end we have spaces that are most integrating and on the other end spaces that are least integrating or segregating. Integrating spaces are naturally inviting. They are easily accessible and by virtue of their higher degree of activity mix, motivate people to move into and through the spaces. On the other hand, segregating spaces, with their mono-functional nature, are repulsive. Their location in the layout does not encourage people to move into them.

In a settlement layout, spaces that are segregating are a consequence of principles of space that are advocated by modern theories of space. According to Hillier and Hanson (1984), these theories in almost all cases stress three related principles: that space should be hierarchically arranged through a well-marked series of zones from public to private (Newman, 1972); that the object of spatial organization must be to encourage specific groups of people to identify with particular spaces by excluding others from access (Newman, 1980); and that those spaces identified with particular groups should be segregated from each other (Alexander, 1977). These ideas, as Hillier and Hanson (1984) point out, are pervasively present when space is discussed, often appearing to act as taken-for-granted model of 'good' spatial order rather than an explicitly stated theory. These principles have been assumed and even recommended as guidelines in the layout of settlements (Newman, 1972). However, as this study establishes, embracing these principles results in over-hierarchised axial spaces that are weak as integrating spaces. This kind of structure is asymmetric (in the sense that you must pass through an intermediate space to go from one space to another) and non-distributed or more simply a 'tree', everywhere branching and becoming deeper, with primary cells at the deepest end of the tree. Primary cells are buildings. A relation between two spaces 'a' and 'b' is said to be distributed if there is more than one non-intersecting route from 'a' to 'b' and non-distributed if there is only one (Hillier and Hanson, 1984). If at all segregating spaces in a residential settlement are to be avoided, spatial planning is duty-bound to appreciate that, just like a city, the settlement is not a tree (Alexander, 1965).

Asymmetric nondistributed structures in a settlement layout exclude accidental contact with neighbours as neighbours, that is, in the vicinity of their own dwellings. In other words, such a structure promotes segregation. Whatever contacts may occur accidentally will be as little as possible, a scenario that in any case is guaranteed by the axial breakup of space. Contact is minimized if lines are short – they are, as it were, projected away from the primary cell, the dwelling itself. Conversely, for space that is integrating, accidental contacts will inevitably occur in the vicinity of dwellings. In such a space, longer sight lines minimize the reductive effect of local breakup of space on numbers of such contacts.

An axial or public space that is shallow in relation to the carrier (Y) space has a higher degree of symmetry whereas a remarkably deep one is asymmetric. In the latter case, we talk of the structure being tree-like, or nondistributed as movement occurs from the carrier space to the primary cell. This suggests that a space closer to the carrier space is more integrating whereas a remarkably deep space is segregating.

Variables in this study that mainly explain the pattern of segregation and integration of public space are depth from the carrier space and relative depth. Depth from the carrier space (Y) is the number of axial steps a public space is from Y (Hillier and Hanson, 1984). Y is given the value 0. In the neighbourhoods, roads leading into them are used as the carrier space. On the other hand, relative depth of an axial space indicates how deep or shallow the settlement system is from the space. The least relative depth exists when all the spaces are directly connected to the original space, and the most when all the spaces are arranged in a unilinear sequence away from the original space. This implies that every additional space in the system adds one more level of depth. It is important to reiterate that relations of depth in a settlement system necessarily involve the notion of asymmetry. This is because spaces can only be deep from other spaces if it is necessary to pass through intervening spaces to arrive at them. Relative depth values range between 0 and 1, with low values indicating a space from which the system is shallow, that is a space which tends to integrate the system, and high values a space which tends to be segregated from the system (Hillier and Hanson. 1984).

This study establishes that a higher value of depth from Y is associated with a higher density of parking on grass, a higher level of dust pollution and a larger length of destroyed road. It also is

associated with a lower encounter rate of people in space and lower degree of solid waste accumulation. In this regard, a higher degree of breakup of public space destabilizes ecological balance in its impact on greenery and distribution of people in space. It also affects the pattern of transportation with more vehicles being evident in shallow spaces and fewer in the segregated spaces. Its impact on land use pattern, seen in the higher mix of activities in integrating spaces, polarizes the direction of public space services by the responsible agencies, in this case the CCN. This sees spaces with a higher degree of integration accorded priority in provision of public space services whereas segregated spaces are neglected. On the other hand, the measure of relative depth indicates that shallow spaces have larger solid waste areas and bigger solid waste heights, basically due to the higher level and mix of activity. It further shows that segregated spaces are characterized with a higher density of parking on the vehicular carriageway and higher level of odour pollution.

In view of the above, what then can be done to revitalize the public space environment of Nairobi's residential neighbourhoods with regard to the pattern of integration and segregation? One fact to underscore is that there is failure of spatial planning in layout of settlements in creation of remarkable breakup in the public space system. Minimum breakup resulting in shallow spaces in relation to the settlement's carrier space is desirable. The problem of breakup gets more pronounced when there is only one road leading into and out of a settlement. In this regard, spatial planning should embrace the tenet of Perry's neighbourhood unit planning concept (Perry, 1929) whereby a neighbourhood is fully surrounded by a peripheral road system. The interior of the settlement should then be accessed from the surrounding roads such that its entire public space system is shallow. According to Moirongo (2011), a shallow space, and therefore most integrating, has depth values of 1, 2 and 3. Spatial planning should establish a major commercial hub sited more or less centrally in the neighbourhood such that axial accesses from the peripheral road system are linked to it. This ensures a sustained flow of people in the public spaces of the neighbourhood as they go to and from the activity magnet at the centre. In overall, spatial planning should endeavour not to create public spaces of depth greater than 3. To strengthen integration, all public spaces should be constituted by buildings with a balanced mix of activities on their ground floors.

### **5.5. Ecological Balance of Public Space**

According to Reekie (1975), ecology is the scientific study of living organisms in relation to their surroundings or environment. Ecology is an aspect of spatial planning given that in the planning of settlements, ecological considerations are often referred to. In this respect, in the layout of urban residential settlements, failure to respond to ecological considerations results in an environment that is not fit for human habitation. An ecological approach to evolution of urban settlements is therefore deterministic given that it influences the resultant form and quality of public space environment (Hough, 1995). Ian McHarg refers this approach as design with nature (McHarg, 1995).

An ecological system, or 'ecosystem' as it is sometimes called, is a one of a self-sustaining community of plants and animals existing in its own particular environment (Reekie, 1975). There are many ecosystems in the world, but the world is one great unique and complex ecosystem in which man in relation to his environment is the dominant subject. Man, in contrast to other living organisms, has the ability to not only adapt to many different natural conditions, but can also change his environment and has enormous technological powers to do so. Indeed, this is what he has done and continues to do on an ever increasing and sometimes irresponsible scale in the layout and construction of habitations and settlements.

Life in an ecosystem depends upon what are described as fundamental processes by which carbon, nitrogen, oxygen, phosphorous and sulphur continually pass through the bodies of living things and back into environment (Ibid.). These processes require the action of, for instance, bacteria which are essential for decomposition. Hydrological cycle is one such bio-physical process that is critical to the stability and therefore life, of an ecosystem. Hough (1995) writes that the bio-physical processes respond to natural laws and are form-giving to natural adaptations. This way, the processes shape the physical landscape. Reekie (1975) points out that these processes in the biosphere should never be interfered with. Otherwise, there occurs a risk of repercussions of the greatest consequence on the physical well-being of human existence on this planet.

Urban settlements and their inhabitants are ecological systems. In shedding light on this fact, Reekie writes that the settlements exhibit in their organization, patterns of arrangement and development and growth, decay and renewal, similar to those observed in some natural ecological systems. It would follow therefore that by an understanding of the basic causes of expansion, limitation and change, and by the way change generates further change, lessons valuable to the planning process can be learned. However, whereas the analogy of an urban settlement to a natural ecosystem is valid, it is unfortunate to note that urban settlements have been subjected to influences beyond the range of natural system. This is despite man's technological deterministic ability exhibited in his use of sophisticated forecasting techniques and the conditioning of human behaviour by its interaction with the environment.

In order for spatial planning to ensure that urban settlements are ecologically balanced and therefore better living environments, it is important to have understanding of what urban ecology is. According to Hough (1995) urban ecology comprises the total urban landscape and the people who live there, including unstructured spatial and social environments. In this, nature is a fundamental force that determines the morphology of space and human endeavours therein. Lozano (1993), in advancing urban ecology to a higher level, writes that it involves affluent groups shifting their residential bases towards the suburban periphery while being succeeded in the deteriorating housing stock by the less affluent groups. This is a manifestation of urban sprawl whereby a city grows spatially with establishment of residential zones by the affluent class at the city's outskirts. The reverse of sprawl, that is, gentrification, may also occur. In this, the affluent groups return to an area to renovate it, in effect displacing the existing low-income and minority populations. Residential settlements in the city of Nairobi have not been spared of this dynamics of urban ecology. With sprawl and gentrification taking effect, land use is changing in the older residential settlements as for instance seen in conversion of residential use to public purpose (such as offices) or commercial use (such as supermarkets). The affluent are able to successfully negotiate for higher plot ratios in low-income settlements whereby they put up apartments that are beyond the capacity of the existing residents to afford. It is however unfortunate to note that the motivation of the affluent in the process of gentrification is driven by economic rather than social goals. Because of this, high rise buildings have come up, for instance in Umoja II neighbourhood, that totally disregard scale of public space and capacity of infrastructure for sewer and storm water drainage. An increase in land use density has brought

with it more cars and their related problems, increased consumption patterns and associated generation of waste. Whereas it is desirable to have a mix of activities and increased encounter rate of pedestrians in a residential settlement and public space in particular, this perspective of urban ecology has and still is contributing to environmental decline in space. Higher levels of air pollution and solid waste accumulation are some of the resultant adverse effects in public space.

These processes of sprawl and gentrification, in their respective characteristics of colonization of unoccupied territories, succession and displacement of populations, have contributed to homogeneous urban localities. There lacks inter-social intercourse among the localities which are segregated on the basis of social and economic status. As this study finds out, Asian populations have almost been fully displaced from Pangani residential neighbourhood by African populations. In this neighbourhood, multi-storey mixed use buildings are coming up with the CCN permitting a plot ratio of 200 percent. Asians have relocated to Parklands and Lavington, neighbourhoods which are similarly experiencing the impact of urban ecology. Besides the changing composition of residents in these neighbourhoods on the basis of race, the density of settlement in each neighbourhood is on the increase. By and large, this study points out that urban ecology has promoted segregation rather than integration of societies. It is difficult to achieve environmental sustainability when society is segregated along social and economic lines. Moirongo (2011) points out that the major cause of this scenario is the affluent who are ever in demand for homogeneity and segregation. In underscoring the unacceptability of this behaviour, he equates it to seeking to establish dominance in the community. Dominance in this case is the appropriation of potential habitats (niches in the ecosystem) of subordinate groups by the dominant one. In this regard, the segregated pattern of homogeneous habitats is based on the most desirable urban niches being occupied by the dominant group. In the process of allocation of space and uses, the dominant group not only takes the most desirable niches but also manages to force the subordinate groups to specialize.

From the foregoing discourse, it is clear that a community characterized with segregation is not sustainable. On the other hand, when a community or ecosystem is heterogeneous – characterized with diversity and balanced mix of activities – it is sustainable; it is a healthy environment to live in. Conversely, homogeneous settlements are faced with all manner of environmental ills. For instance, in the public space system, the sense of safety is low due to

absence of or inadequate number and distribution of people in the space. Solid waste build-up, destroyed road infrastructure and damage to greenery are some of the other environmental problems evident in specialized environments. This danger to the environment, as Reekie (1975) puts it, lies in the exploitation of physical resources in settlements without proper planning and control. In other words, the environmental problems are due to failure in planning to exercise its due role of ensuring that critical ecological capacity is not exceeded. Critical ecological capacity is the level of use of a natural resource beyond which the environment is adversely affected (Ibid.). Pressures on the critical ecological capacity have arisen from the explosive growth of urban populations. This is followed with an increase in spending power and leisure, thus causing ever-bigger demands for raw materials, water, food, energy, consumer goods, buildings, roads, and recreational facilities and at the same time producing more and more waste and pollution. A higher number of vehicles on roads makes the quality of air worse whereas large areas of tarmac interfere with the infiltration of storm water into the ground.

In this study, variables established as significantly explaining ecological balance in public space include percentage of space area that is paved, percentage of space area with tarmac, density of trees in space and percentage of space area that is covered with grass. Paved areas are sidewalks and the more there are, the higher the density of parking on them. A large area of tarmac is associated with higher levels of dust and odour pollution but with a lower magnitude of destroyed road and area of space commonly occupied with stagnant storm water. Whereas a higher density of trees in space contributes to higher solid waste height, a larger percentage of space area covered with grass minimizes on rotten solid waste and area of space commonly occupied with stagnant storm water.

Paved or tarmacked areas of space, in interfering with infiltration of storm water to the ground, promote storm water flow which, for Nairobi's settlements, ends up in rivers. No deliberate effort has been made by spatial planning to have this water collected and stored as is the case in the developed world (Stephenson, 1981). On-site detention and retention of storm water to facilitate ground water recharge is desirable. However, this requires that pavements and tarmac are kept to a minimum. In underscoring the terrible effect of concrete and asphalt or tarmac on the environment, (Alexander (1977) writes that they destroy the microclimate; they do nothing with the solar energy that falls on them; they are unpleasant to walk on; there is nowhere to sit;



nowhere for children to play; the natural drainage of the ground is devastated; and animals and plants can hardly survive. In this regard then, the use of asphalt and concrete in public space should be as minimal as possible. In keeping with this, Alexander recommends that on local roads, closed to through traffic, grass should be planted all over the road and paving stones set occasionally into the grass to form the surface for the wheels of those cars that need access to the street. This not only allows the movement function of the car but also allows the percolation of water into the ground. Recharge of ground water is necessary for maintenance of hydrological balance. Hough (1995), in underscoring the ecological basis for urban form, suggests that when the city water is recycled back into the system, there are reduced costs and increased benefits. Urban development becomes a participant in the workings of natural systems.

Plants play a very important role in the ecological balance of space. In their relationship with animals in an ecosystem, they aid in the balancing of oxygen and carbon dioxide in the atmosphere. This suggests that in a settlement devoid of or with inadequate trees, the concentration of carbon dioxide exhaled by animals is higher than in a settlement with more trees. Whereas trees utilize carbon dioxide in photosynthesis, Moirongo (2011) points out excess availability of the gas due to vehicular emissions limits health of plants. This is the more the reason why spatial planning ought to limit intensity of vehicular activity in residential settlements while addressing traffic circulation patterns. As advanced in the preceding chapter, citywide public transport system needs to be upgraded to make it reliable so that residents do not over-rely on personal cars. The vehicular carriageway should be two-way with a maximum of two lanes. Either side of the carriageway should not have any hard-compacted grounds as these limit thriving of greenery and trees in particular. Hough (1995) asserts that compacted soils and paved surfaces, besides limiting the spread of plant root system, reduce water penetration and supply of nutrients, lower ground water levels and interfere with the transfer of air and gases.

It is unfortunate that Nairobi's residential settlements are continually becoming unsustainable, almost hitting the critical ecological limit. In his discussion of the subject of sustainability, Walter (1992) points out that it is rooted in the ecology of natural systems. Sustainability implies that the needs of a population and the flow of resources needed to support them are in dynamic balance. If they are not, stress and exhaustion sets in. The resulting environmental crisis is thus due to over-population, over-consumption and obsolete values and political structures (Moirongo, 2011).

It is due to failure of planning, as an instrument of government policy, to ensure good management of natural resources; that is, to organize and successfully use them, but with full regard to ecological factors.

To revitalize Nairobi's residential settlements within the confines of ecology, spatial planning needs to ensure that there is a balance between ecology and transportation planning; ecology and land use; and ecology and integration or heterogeneity. These relationships have already been discussed above. Further, spatial planning must ensure a balance between ecology and conservation in settlements. In this regard, for diversity and thus integration to prevail, spatial planning must be in keeping with Jane Jacobs' assertion that age and condition of buildings must vary (Jacobs, 1961). Any new planting should co-exist with the old stock. An eco-sensitive settlement must be well-balanced in its inter-relatedness of landscape elements. Indeed, as Richard Register points out, this inter-relationship has a bearing on quality of life in a public space (Register, 2006). He adds that the more heterogeneous or diverse an urban settlement is, the less dependent it is on motorized transport; the fewer the resources it requires and the less impact it has on nature.

## **5.6 Land use in Residential Settlements**

Andrews (1972) points out that the manner in which urban land is put to use is enabled by a group of formal control devices which include zoning, building and housing codes, subdivision regulations and property taxation. He adds that the modern city is densely built-up and spread out such that extension of the traditional formal control devices to the dispersed city has been only moderately successful. Despite this, it is the control systems and development ideas that must deal directly with the arduous details of land use relationships, for which comprehensive planning usually provides merely the broadest sketch, and the city government only the vehicle. In the present study, aspects of land use that are examined are those relating to zoning and subdivision regulations.

Urban land use policy is such that a city's uses are contemplated on one at a time, by categories. Indeed, as Jacobs (1961) puts it, the approach to analyzing cities on the basis of use by use has become a customary spatial planning tactic. Planners then put together findings on various categories of use into broad overall 'pictures'. Jacobs dismisses this approach to spatial planning

and understanding cities as solemn nonsense. In her argument, to understand cities, we have to deal outright with combinations or mixture of uses, not separate uses, as the essential phenomena. This segregation of land uses is the product of zoning which, as already mentioned, is a land use control device. Reps (1964) describes zoning as a police power measure enacted by units of local government and permissive state legislation. Zoning regulations establish, in advance of applications for development, groups of permitted homogeneous uses that vary from district to district. Some of the uses included residential, industrial and educational. Zoning, as it stands in the local authority system, is a method for controlling bulk, use, intensity, location and density of development. It is however unfortunate to note that problems of urban land use have been met with mixed degrees of success with zoning as a control device. Reps highlights some of its weaknesses, after propositions on what zoning is, as follows:

- i. Zoning is a police power measure: It follows that the impact of zoning regulations must be reasonable and that their effect must not be so burdensome that they amount to taking of property instead of a mere restriction in the interests of protecting or promoting the public health, safety, morals or general welfare. Regulations found to be unreasonably burdensome are invalidated by court action. In this regard, constitutional rights are protected but the community is stripped of this power to guide land development, and the public at large may suffer unfortunate consequences from the assertion of private rights in land. It may seem desirable to introduce a system of compensation to supplement the police power where severe limitations on land use are deemed essential or desirable to shape and guide community development.
- ii. Zoning is permissive: While much state legislation requires local governments to carry out specified services or to provide certain facilities, the choice of regulating or not regulating land use is optional. It would be desirable for state legislation to require all communities or those having certain characteristics to enact such regulations.
- iii. Zoning is enacted by units of local government: Zoning regulations are extremely parochial. Standards required in any single local authority area may vary enormously depending on the whims of local legislators. Spatial planning makes much of the

principle that land similarly located must be similarly zoned within a given local authority area. Unfortunately this concept is cruelly violated when a homogeneous area is zoned for industry on one side of a local authority boundary line and for high-class, low-density residential uses on the other side. Standards of enforcement vary equally widely. The possibility of achieving co-ordinated and balanced urban development under such a situation, insofar as land use regulation is effective at all, can be written off as a mere fiction. In this regard, it would be desirable to deny zoning powers to the smaller units of government and place this responsibility at county level or as a function of state government.

- iv. Zoning establishes regulations in advance of applications for development permission: This suggests that the use to which a district of an urban area is to be put to is pre-decided in relation to making of development proposals. It would be desirable for any issue of legal validity to be raised when dealing with each application to develop land or to change its use.
- v. Zoning establishes groups of permitted uses that vary from district to district: In an understandable attempt to simplify in a complex and bewildering world, spatial planning has done three things. It has attempted to prepare detailed standards for development which are supposed to cover all inconceivable situations. It has Balkanized cities into districts with precise and rigid zone boundary lines. It has established categories of uses that have segregated rather than integrated functional portions of cities and which have often disregarded the interrelationships between rather widely separated categories of uses. In this respect, it would be desirable to do away with, or at least place far less emphasis on, the creation of districts and lists of supposedly compatible land uses.
- vi. Zoning is not necessarily related to other regulatory devices: There is a multitude of regulatory measures – zoning, subdivision regulations, building codes, sanitary restrictions, and others – enacted at different times, often by different bodies, enforced by different sets of officials and reviewable by different administrative organs. Zoning ordinances do conflict with these regulations, for instance community

subdivision regulations. It would be desirable to consolidate all or most regulations dealing with control of urban growth into a single development ordinance that provides a sensible and efficient system of administration and enforcement, which is purged of ambiguities, conflicting provisions and redundancies.

- vii. Zoning is not necessarily related to any community plan: There are few communities that can claim with much justification that their regulations stem directly from any comprehensive, long-range plan. It would be desirable for statutes to require any local development regulations or discretionary administrative decisions reached on development proposals to be clearly based on a community plan, expressed graphically and/or as meaningful statements of development policy.

Spatially, as already mentioned, zoning segregates rather than integrates urban function. The spatial planning of the City of Nairobi is characterized with this segregation right from the Central Business District (CBD) to its periphery. This implies that it has homogeneous residential neighbourhoods, industrial area and CBD. This planning pattern necessitates an elaborate traffic circulation system to link the various districts. Whereas this is at the city-wide scale, it is important to mention that segregation can also take place within a land use. In this regard, residential land use in the City of Nairobi is segregated on the basis of economic and hence social lines into low-income, middle-income and high-income categories. Segregation of land uses and residential areas into distinct neighbourhoods reflects a fragmented as opposed to a holistic approach to environmental management (Ravetz, 1980). This in turn suggests a deeper fragmentation or a tendency in society towards compartmentalization in thought and behaviour.

Aspects of land use addressed in this study include mix of activities, connectivity or distribution of public space and density of settlement. It emerges that land use mix, a higher degree of distribution of public space, higher density of pedestrians and a higher density of settlement are desirable for a better public space environment.

A mixture of uses, if it is to be sufficiently complex to sustain settlement safety, public contact and cross-use, needs an enormous diversity of ingredients. At the level of public space, this has a bearing on distribution of activities in the buildings constituting the space. Spatial planning has often failed to create heterogeneous settings in public space in Nairobi's residential

neighbourhoods. The existing situation is mostly that of homogeneous residential use, a scenario that deprives the public space of people for a larger part of the day during working hours. As Jacobs (1961) aptly puts it, inconvenience and lack of public street life are two of the by-products of residential monotony in such a case. Danger is another – which is fear of the public space in the absence of people. A residentially monotonous space lacks commercial choices as well as cultural interest, implying that there are no activity magnets to pull people into the space to enliven it. This dilemma gets worse with most residential houses enclosed in compounds defined by opaque boundaries. This means that even from the early hours of the evening, once residents have accessed their houses and closed gates of their compounds, the danger in the street becomes more real. These plot boundaries defeat the social purpose that Clarence Perry envisioned in his neighbourhood unit concept (Perry, 1929). The boundaries deter eye to eye contact between and among residents of adjacent houses and in street surveillance. However, Perry's neighbourhood unit achieves a mix of activities as a whole but not along its public space or street system. The neighbourhood has an evident centre in which he provides a civic space and neighbourhood institutions and schools around it (Figure 2-4). At traffic junctions along main streets at the periphery, he proposes shops. Regional institutions are sited at the edge of the neighbourhood next to the high capacity thoroughfares. Playgrounds are monotonously distributed in the neighbourhood whereas part of the space could have been used for other activities. A residential street has only playgrounds as the other activity save for those in contact with traffic junctions where there are shops. Generally, a residential street in Perry's neighbourhood model lacks diversity insofar as mix of uses is concerned. This implies that for a larger part of the day, the street will be lacking public life and therefore unsafe to operate in. The same scenario of segregation of uses is reflected in Ebenezer Howard's Garden City (Hall, 1996). In both cases, residents have to bear with the inconvenience of moving longer distances when in need of a service not in proximity to their locations.

Spatial planning, in providing for a mix of uses in a residential public space system, must do so with caution or else it creates a repulsive rather than an inviting environment. Norton (1972) points out that an admitted cause of residential and commercial slums, traffic congestion and other indicia of urban obsolescence is the haphazard mixing of incompatible land uses. The biggest challenge in city spatial planning then is not how to design and build a perfect urban machine but rather how to take out the misfits of the existing machine. In existing residential

settlements whose public spaces are characterized with homogeneous use, the challenge is how to introduce a balanced mix of compatible land uses. In such developments, incompatible uses are physically separated from each other. Norton (1972) writes that in the earliest days of zoning, it was thought that all uses could be classified very simply by a "hierarchy of uses" into three districts – residential, commercial and manufacturing. Residential districts included nothing but "parlors," other than a few essential accessory uses such as churches, public schools, and suburban railroad depots. Everything allowed in residential districts was permitted in commercial districts. The manufacturing or big-city district was a catch-all for every kind of use including manufacturing, commerce and housing (for people who could not afford to live elsewhere). Norton qualifies this classification as primitive and instead advocates for spatial planning which creates zoning districts in which are permitted different use groups (combinations of compatible uses). The use groups include residential uses; community facilities which are properly associated with some or all residential districts; retail and commercial uses; wholesale and commercial amusement uses, including a group of heavy commercial and automotive service uses; and manufacturing uses. One of the manufacturing use groups includes office, laboratory and manufacturing uses which, when subjected to adequate controls over bulk and landscaping, are appropriate in certain locations in low density residential areas if they comply with certain performance standards. In other words, as Norton adds, it is in order to let a pig into the parlor provided it is a housebroken pig with a pleasing face. The philosophy behind this attempt at classification according to standards of compatibility and incompatibility is based on the fact that what counts in spatial planning is not what functions but how you bring functions together. In this regard, houses and apartments, stores and even factories, can be mixed harmoniously and advantageously, provided the design is right. Right design in this respect must be responsive to a set of factors that are an indicator of incompatibility.

From the standpoint of residential areas, Norton (1972) writes that incompatibility of uses and buildings has generally been measured by the following factors (most of which justify the separation of industry and high density apartments from a single-family district):

- a. danger to persons or property (such as fire, explosion, hazard, corrosive fumes, and auto, truck, railroad, airplane traffic);

- b. danger to health, convenience, and comfort (such as excessive smoke, dust, odour, noise (including traffic noise), vibration, glare at night, industrial waste, garbage, obstruction to light and air and overcrowding of people on the land);
- c. danger to morals (such as commercial gathering places for drinking, gambling, amusement);
- d. miscellaneous other factors (such as aesthetic, psychological and physical deterioration of neighbourhood desirability due to factors including appearance of grounds and buildings, commercial signs, uses with unpleasant association, decline of neighbourhood homogeneity, encroachment of commercial-visitor parking on residential streets, increased vehicular street traffic induced by commercial and industrial establishments, and parental fear of physical and moral danger to children).

From the standpoint of commercial areas, incompatibility of uses and buildings may be measured by "economic incompatibility factors" such as land uses and buildings which interrupt pedestrian traffic flow in retail areas. Such interruptions are created by: 1) "dead spots" where shoppers lose interest in going further; 2) driveways and such other physical breaks in the sidewalks; 3) cross traffic, either vehicular or pedestrian; and 4) areas characterized by hazards, noises, odour, unsightliness, or other unpleasant features. Similarly, industry today recognizes new design standards of modern factories and planned industrial districts and in general, that residences should be excluded from manufacturing districts. The reason for this is on the principle, no doubt, that if people live in the pig-sty long enough, they eventually send the pigs elsewhere.

In the present study, a number of variables significantly contribute to the mix of activities in public space. These include frequency of informal businesses, frequency of chemists, frequency of retail shops and proportion of buildings with social places. A higher frequency of retail shops, informal business activities, bookshops and proportions of buildings with social places are associated with a higher encounter rate of people in public space which, according to Jacobs (1961), is a desirable environmental quality. A higher intensity of mix of activities in space and a higher frequency of informal businesses in space are associated with a higher level of provision of public space services such as garbage collection and upgrading of roads. In consequence, the levels of dust and odour pollution in space are lower. A higher frequency of informal business activities in space enhances frequency of interruption of pedestrian flow by vehicular traffic. Similarly, a



higher frequency of activities in a public space contributes to increased density of parking in undesignated areas such as grass and bare soil sections. In view of this, in introducing activity mix in the residential public space, spatial planning ought to be wary of its negative contribution to the environment. Given that combination of diverse and compatible activities with residential use is desirable for better quality and sustainable public space environment, spatial planning should incorporate, in layout of residential settlements, measures for minimizing vehicular-pedestrian conflict and undesignated parking. These measures have been extensively discussed in the preceding chapter and they entail making elaborate interventions on the pattern of transportation planning.

Closely related to land use is the pattern of connectivity or distributedness in a settlement. According to Hillier and Hanson (1984), distributedness of space in a settlement is said to exist when there is more than one route of movement from one point to another. Distribution of space is greater with a higher frequency of intersections. This has a bearing on the scale of convenience in space use with regard to block length. Shorter block lengths have the benefit of increasing pedestrian encounter rate in public space and thus enhance its control. Jacobs (1961) writes that long block lengths with homogeneous use deny users of the constituted space the ability to access other uses conveniently. A user has to walk the entire length of the block to get to a junction leading him to a street where the desired service can be accessed. She advocates for shorter block lengths to allow for convenient access to one street from another. The streets created by breaking up the long block must however be permeable from the adjacent buildings which also should accommodate diversity of uses. She argues that such a layout complemented by the diverse mix of activities enhances the scale of convenience which is about the distance an activity is from users. A settlement with a higher degree of distribution of public space is opened up to users and presents with it a wider economic opportunity. Diverse and compatible land uses come up which, in residential neighbourhood, include places for buying, eating, seeing things or getting a drink.

Density of people in a settlement is another aspect of land use that can either promote or minimize environmental problems in a residential public space. This study establishes that plot ratio of a space, average number of storeys of buildings fronting the space and intensity (frequency, density and proportion) of buildings with setbacks as variables that significantly

contribute to density of use of space. A higher plot ratio and average number storeys implies a higher density of people in a given space. Such a space is associated with a higher intensity of provision of public space services resulting in lower levels of odour pollution. However, vehicular pedestrian conflict increases as seen in the higher frequency of interruption of pedestrian flow by vehicular traffic. Low density settlements, which are characterized with a higher proportion of buildings with setbacks, have a lower encounter rate of people in public space and higher levels of odour pollution. Low density settlements are however associated with lower levels of undesignated parking on grass and bare soil areas.

A sufficiently dense concentration of people in a settlement is a desirable quality that supports environmental sustainability. Jacobs (1961), in supporting this assertion, points out that the purpose for which people are in a settlement space does not matter and includes people there because of residence. She adds that it is concentration of people in a settlement that produces convenience. This concentration is not about numbers loosely added up indefinitely from thinly spread populations; it is about density of settlement. In this regard, Moirongo (2011) points out that high density does not necessarily imply pedestrian congestion. Rather, pedestrian congestion in high density districts is not a result of high density as such but a consequence of inadequate allocation of space at and near the surface level of pedestrian use.

This suggests that in layout of high density neighbourhoods, spatial planning should lay a lot more emphasis on space for the pedestrian than space for the car. Jacobs (1961) adds that dwellings of a district (like any other use of the land) need to be supplemented by other primary uses so that people on the streets can be spread through the hours of the day. Without help from concentration of people who live there, there can be little convenience or diversity where people live, and where they require it. In regard to dwellings in the CBD, she writes that they have to be intensive in their use of land too, for reasons that go much deeper than cost of land. For instance, this ensures a higher presence of people in the public space of the CBD at night once businesses have closed. It is important to underscore at this point that diversity of use is critical if spatial planning is to realize a desirable concentration of residents. In regard to this, Jacobs asserts that no concentration of residents, however high it may be, is sufficient if diversity is suppressed or thwarted by other insufficiencies. However, it still remains a fact that dense

concentrations of people are one of the necessary conditions for flourishing diversity in a settlement.

There are a number of advantages of high residential density settlements as opposed to low density settlements. Journey distances, including the all-important journeys to work and school, are kept to the minimum. The concentration of people makes it economical for local authorities to provide public space services such as street lighting, garbage collection, piped water and sewerage system. In such a settlement, diverse businesses and other services start and flourish given that there is a ready clientele. From the ecological perspective, such people-concentrated settlements characterized with mixed use, emphasis on pedestrian spaces and not the car, and harmonious balance of buildings with nature are environmentally sustainable.

From the foregoing discourse, revitalization of the public space system of Nairobi's residential neighbourhoods with regard to land use entails four areas of focus by spatial planning:

- (i) diverse mix of activities – the activities should be compatible with residential use;
- (ii) density of settlement – this should be increased both horizontally and vertically with keenness to achieve diversity in builtform;
- (iii) ecological considerations – both old and new structures should co-exist. Emphasis should be on pedestrian convenience but not the car. Builtform should be well balanced with planting;
- (iv) scale – Avoid long blocks. Public space should be so distributed and provided with diverse uses that it enhances user convenience.

## **5.7 Transportation Planning**

Transportation planning, according to Ross (1988), is a process that has as its goal the determination of needed improvements or new facilities in order to meet the transportation needs of a specific region or area. It is a comprehensive process encompassing travel demand, facility construction and comprehensive needs assessment. The primary objective is to facilitate movement of people and goods between activities separated in space. Cycling, freight movement, walking and other travel modes are all appropriately the subjects with which the broad term 'transportation' is concerned. Residential patterns, daily activities, social interaction, geography, economics, and consumption are all shaped by transportation.

The transportation system in Nairobi's residential settlements, which this study focuses on, is limited to vehicular roads, associated sidewalks and exclusively planned pedestrian routes. These are developed and maintained by the state and local governments or private sector. A major factor in transportation planning has always been the interplay between travel modes and urban development (Ibid.). This means that as travel responds to the spatial arrangements of urban and rural areas, so do these spatial arrangements respond to the modes of travel.

In early periods, as Ross points out, towns and cities were small and concentrated enough that travel could appropriately be accomplished by walking or by horse. In turn, these travel modes made a small, concentrated arrangement an appropriate form for towns and cities. Subsequently however, changes in transportation technology caused corresponding changes in distribution of land use. For instance, there exists extensive urban development along transit routes. The automobile has changed the spatial configurations of urban areas tremendously. It has made possible a great separation between one's work place and residence, and this has resulted in lower urban densities, suburban sprawl, and corresponding changes in urban development.

The urban transportation pattern can be looked at in two levels – citywide and local. At the citywide scale, transportation pattern is a link between various land use districts. At the local scale, transportation pattern is a link between different sub-regions or clusters or blocks that make up a district. It is the latter scale of transportation, with reference to residential neighbourhoods as land use districts, that is the subject of this study. Variables this study establishes as significantly describing the pattern of transportation in public spaces of residential neighbourhoods include frequency and density of vehicles in the space, total number of vehicular movement lanes, width of road and total width of sidewalks. A higher frequency of vehicles using the space is associated with a bigger length of destroyed road. On the other hand, a larger area of destroyed road is a result of a higher number of vehicular movement lanes, and a greater density and frequency of vehicles using the space. The scenario of a bigger number of vehicular lanes contributing to a higher area of road destruction is more pronounced in high density settlements. Conversely, in low density residential neighbourhoods, wider roads are associated with a smaller area of destroyed road. Sidewalks in a residential public space are for the convenience of pedestrians especially where the intensity of use of the carriageway by vehicles is

high. However, as this study finds out, a bigger width of sidewalks leads to the problem of undesignated parking both on the sidewalk and the grass areas next to it. As pointed out in the preceding chapter, it is the role of spatial planning to ensure that vehicles are restricted to the carriageway and that they do not encroach into zones designated for pedestrian activity. However, in low vehicular density spaces, vehicles and pedestrians can use the road for movement thus eliminating the need for sidewalks (Alexander, 1977; Towers, 2005). In this interaction though, it is the person who needs to go to the car and not the other way round. At all times, the vehicles should be limited to the carriageway. Spatial planning should emphasize on pedestrian in layout of residential settlements so as to minimize the ecological and pollution problems that come with the car. This however requires formulation and implementation of a city-wide transportation plan that will put in place an effective and reliable public transportation system. This minimizes over-reliance on personal cars, cuts down on resource use and work towards environmental sustainability of residential settlements.

Besides the impact the pattern of transportation in a residential settlement has on the ecological well being of public space, it also affects the following spatial planning patterns: distribution or connectivity of space, land use, scale, integration, control of and provision of public space services. With regard to distribution and scale of public space, transportation pattern can create either long or short cluster blocks. Jacobs (1961) writes that shorter blocks brought about by a higher degree of connectivity and distribution of public space in a settlement improve the scale of convenience of users. This kind of circulation pattern, supported by a balanced mix of compatible uses, works towards sustainability of the public space environment.

Transportation and land use patterns are inextricably linked. Ross (1988) points out that differences in patterns of land use result in varying demands for transportation. Conversely, the type of transportation system configuration influences the pattern of land development. In this regard, the urban environment, transportation systems and land use patterns all interact, with changes in one of these parts producing changes in other parts. In a residential settlement, the pattern of transportation often creates cluster blocks that are long and homogeneous. This is one area where spatial planning has failed thus resulting in poor quality public space environments. Residents in such a space have to bear with the inconvenience of walking long distances to move from one public space to another. In regard to this, the desirability of short blocks and land use

mix has already been underscored. Other aspects of land use that are a consequence of the pattern of transportation include density of use and zoning. A transportation pattern that results in shorter blocks and conveniently distributed routes motivates residents to invest in diverse business activities. Diversity is a key ingredient to increasing density of people in a residential public space environment (Jacobs, 1961). A higher density of people in public space in a pedestrian dominated environment is desirable. This not only promotes a sense of public safety but also enhances ecological sustainability. It has been discussed elsewhere in this chapter that zoning of activities is not desirable given that it promotes segregation rather than integration of functions. The bottom-line of successful mix of activities in a residential public space, as opposed to creation of functional zones, is compatibility of use. How a spatial planner does this mixing, as opposed to what he mixes, is critical if at all a better public space environment is to be realized.

A desirable transportation pattern in a residential settlement, that is, one which creates short blocks, higher degree of distribution of public space, and motivates investment in diverse activities, results in improved control of public space. Residents and owners of businesses and visitors to the space aid in policing the space. The public space users are able to readily identify any deviant behaviour and appropriately deal with it. The residents and business operators have a say on what quality of space they want. It is no worry then to find that the local authority prioritizes such a space in provision of public space services such as solid waste collection, cleaning of storm water drains and provision and maintenance of street lighting infrastructure.

It is however unfortunate that public spaces of residential neighbourhoods in Nairobi have continued to suffer environmental decline due to weaknesses in the transportation pattern. In particular, the pattern has resulted in poor distribution of public space, homogeneity of functions and ecological imbalance in space. In this regard, any spatial planning endeavour to revitalize the settlements, insofar as transportation planning is concerned, has to focus on the following areas:

- I. break-up of long blocks into short ones. Additional streets realized out of this improve distribution of public space.
- II. creation of balanced mix of land uses. To achieve this, residents of a given space need to be involved to decide on what they consider to be good for them. A better distribution of public space is a motivation for residents to invest in a

diverse mix of activities. Diversity of use and the associated constitutedness of space enhance safety and control of the space.

- III. restoration of ecological balance by evolving transportation patterns which ensure that:
  - (a) area of space covered with tarmac and concrete is minimized.
  - (b) dominance of the car in space is minimized.
  - (c) pedestrian dominance in space is enhanced.
  - (d) the car is limited to the carriageway to stop it from destroying greenery and displacing people from pedestrian environments.

### **5.8 Public Space Services**

Local authorities are the agencies chiefly concerned with provision of public space services at the level at which they affect real development and therefore the everyday environment in which residents operate. According to the Local Government Act – Chapter 265 Laws of Kenya (Kenya, 1998), local authorities in the country are empowered to provide a range of public space services.

Some of these include:

- (i) Provision and maintenance of amenities – such include bus stands, seating, and telephone services.
- (ii) Removal of trees and dilapidated boundaries –the local authority has power to require the owner of any premises to do any of the following acts: (i) to remove, lower or trim to the satisfaction of the local authority any tree, shrub or hedge overhanging or interfering in any way with the traffic on any road or street; (ii) to remove any dilapidated fence or structure abutting upon any public place.
- (iii) Preservation of trees – this entails the control of the cutting of timber and the destruction of trees and shrubs, to prohibit the wasteful destruction of trees and shrubs, and to require and regulate the planting of trees, flowers and shrubs on any public place.
- (iv) Public transport – the local authority is obligated to either establish and maintain a service of public transport or enter into an agreement with any person for the establishment and maintenance by him of any such service.
- (v) Sanitary services – this entails establishment and maintenance of public lavatories, closets and urinals in public space.

- (vi) Lighting of streets – the local authority is to arrange for the lighting of, or itself to light, streets and other public places. This entails erection and maintenance of lamps for that purpose.
- (vii) Footways – the legislation requires local authorities to construct footways along the side of any road or street, and to pave or surface any such footway with concrete blocks or stones or in any other way. The local authority is to recover from the owners of land abutting upon such footways the whole or part of the expenses incurred in the project. Recovery of such expenses is normally the case if the project was requested by owners of land abutting such footways. Alternatively, such works can be carried out by such owners but the local authority has to be in control of the manner in which it is carried out.
- (viii) Advertisements – the local authority is empowered to prohibit or control the display of advertisements or advertising devices which in its opinion is likely to affect injuriously the amenities of or to disfigure any neighbourhood.
- (ix) Street decorations – a local authority is empowered to control street decorations and to prohibit or control the erection and removal of temporary platforms, seats and other structures for the use of the public at any meeting or entertainment or function of any kind.
- (x) Sewerage and drainage – A local authority is empowered to establish and maintain sewerage and drainage works within or without its area. Such sewers, drains and pipes can be carried through, across or under any public road, street or square. Such acts may also be performed in respect of private land but upon issuance of a thirty days notice in writing to the owner or occupier of the intention to do so.
- (xi) Roads – Every local authority is empowered to have the general control and care of all public streets which are situated within its area. The streets are vested in such local authority in trust to keep and maintain the same for the use and benefit of the public.

Despite there being a legal framework for provision of public space services, as this study finds out, the CCN has failed to live to its mandate. According to Makworo and Mireri (2011), public spaces in the city continue to suffer environmental degradation due to weaknesses in the political governance system of the city. Whereas this study underscores that increasing density of a settlement is desirable as long as it does not contribute to overcrowding, low density residential



areas such as Parklands and Lavington have had their density of settlement increased ( through CCN authorization of high plot ratio developments) without a corresponding upgrade of the capacity of public space infrastructure. This has resulted in an increase in vehicular densities and strain in sewerage and storm water drainage systems. Largely, CCN has failed to allocate adequate resources for public space environmental management. To get out of this problem, Makworo and Mireri suggest, among other measures, strengthening of the capacity of CCN towards public space environmental management.

Variables which this study establishes as adequately describing the pattern of public space services include intensities of taking care of planting, private security patrols, garbage collection and Kenya Police patrols; frequency of outdoor seating; frequency of people seated/lying down; frequency of outdoor lighting fixtures (posts and luminaries); and frequency of advertisement/display lighting. This study establishes that a higher intensity of taking care of planting promotes dust pollution in public space. On the other hand, a higher intensity of private security patrols or garbage collection or Kenya Police patrols, in one way or another, leads to a decrease in the solid waste problem in public space. On the same note, a better quality of greenery is attained in public spaces where there is a higher intensity of private security patrols.

Just like a higher intensity of taking care of planting leads to public space environmental decline, a higher frequency of provision of outdoor seating leads to an increase in density of parking on bare soil. A higher frequency of people seated/lying down (which is use of space) and outdoor lighting contributes to a larger area of space occupied with solid waste. On a positive note though, a higher frequency of outdoor lighting fixtures and advertisement/display lighting leads to a decline in density of parking on grass and bare soil areas of public space respectively. In view of this, it is the responsibility of spatial planning to know the extent to which public space services should be provided. It should note that whereas there are benefits associated with it, it also has adverse effects of its own kind on the public space environment. Where benefits of providing a public space service outweigh pitfalls, it is prudent to provide the service but then apply the applicable spatial interventions to counter the associated pitfalls. The dynamics of doing this in management of environmental problems has been discussed in the preceding chapter.

Provision of public space services in residential settlements has influence on or is influenced by various other public space patterns. These include land use, constitutedness, distribution of space, ecological balance, integration and scale of space. Variables of land use that have a bearing on provision of public space services include density of settlement and diversity or mix of activities. Neighbourhoods whose public spaces are characterized with a high density of settlement and diversity of activities fronting the space have high encounter rates of people in space, both residents and strangers. These people play the role of policing the space thus deterring any intention to commit crime (Jacobs, 1988). The diverse activities in buildings constituting the space contribute to assembly of people and events in the space (Gehl, 1996). The resulting space, besides being a safe environment to operate in, is a high control space. The people associated with such a space have a say on what they want in it. They are able to successfully lobby for provision of public space services from the CCN, and in circumstances where CCN is unable to deliver, as quite often is the case, the people mobilize themselves into other options such as engaging the private sector in delivery of the required service. This study establishes that in a number of high control public spaces in the sample neighbourhoods, security patrols and garbage collection are carried out under private arrangements.

Ecological balance in public space is enhanced if there is a higher degree of provision of public space services. Better practices of taking care of planting result in better quality plants that are efficient in maintenance of hydrological balance. Urban ecological imbalance results if provision of public space services is poor. A higher intensity of garbage collection is desirable not only in this respect but also because its accumulation on grass areas interferes with the percolation of storm water into the ground. In other words, solid waste accumulation promotes storm water runoff. This is because it destroys grass which is useful in retaining storm water thus allowing it to infiltrate the ground.

Public spaces which are shallow in relation to the carrier space of a settlement, that is, spaces which are more integrating, are associated with higher encounter rates of people walking (Baran et al, 2008; Hillier, 1988). This scenario is similar in a public space environment with shorter blocks and therefore higher connectivity (Min, 1993). The better distribution of public space resulting from shorter blocks in a settlement and a higher degree of integration of space motivate investment in diverse activities. Such a layout results in better control spaces and accords

convenience to users. Residents of any of the spaces in this pattern know one another and can therefore distinguish themselves from strangers – a quality that is desirable in crime control. With such a level of integration in the community constituting the space, it is much easier to influence the nature and direction of flow of public space services than in a space characterized with homogeneity and segregation. Heterogeneous public space environments are of particular interest to local authorities when it comes to service provision because of the revenue it derives from business activities established in it.

This study has already alluded the problem of public space environmental decline to weaknesses in the capacity of the CCN as the lead agency in spatial planning and political governance of the city. In particular, CCN has been unable to deliver the required public space services. In order to revitalize the residential public space environment, it is imperative that three areas of focus are attended to. One, CCN needs to be strengthened towards provision of public space services. Makworo and Mireri (2011) single out adequate resource allocation (personnel and facilities) by CCN as one major area that requires strengthening in order to improve the city's public space environment. Two, in view of this institutional weakness and also borrowing from the observed trend of private sector participation in environmental management, there is need for CCN and the private sector, based on each neighbourhood, to forge partnerships for provision of public space services. In this approach, CCN should not abdicate its responsibility as lead agency but co-ordinate the private sector to ensure that the two parties raise adequate requisite resources to meet each neighbourhood's environmental management needs. Three, as observed earlier in this section, provision of public space services leads to some environmental problems. Despite this shortcoming, it is the position of this study that service provision in public space should be intensified as it largely minimizes environmental problems. To ameliorate the problems that emerge out of provision of public space services, spatial planning should ensure that adequate and relevant spatial interventions, as discussed in chapter four, are put in place.

## **5.9 Conclusion**

This chapter has demonstrated that sustainable public space environmental management can be achieved by considering the interaction among the various spatial patterns to minimize environmental problems. No single pattern can be considered in isolation of others that it

interacts with. Conclusions on the study's hypotheses and how spatial planning influences public space environmental status, and recommendations on how spatial planning can be effectively applied so as to play its rightful role in minimizing environmental problems in public spaces of the City of Nairobi's residential neighbourhoods are presented in the next chapter of the study.

## CHAPTER SIX

### 6.0 CONCLUSIONS AND RECOMMENDATIONS

#### 6.1 Introduction

This chapter presents the conclusion and recommendations emanating from the study. Central to it is hypothesis testing which aids drawing an inference on the relationship between spatial planning and public space environmental management in residential neighbourhoods of the City of Nairobi. The chapter underscores how spatial planning has failed in creation of desirable public space environments and advances recommendations on how spatial planning can be improved so that the public spaces it creates can be environmentally sustainable. Ultimately, it gives direction on areas for further research, and implication of the study's findings for theory, practice and methodology.

#### 6.2 Objective One

The first objective of the study required establishment of the extent of relationship between spatial planning and public space environmental status. This is realized through hypothesis testing. The General Linear Model (GLM) underlying regression analysis, pointed out in Chapter One, makes it possible to undertake powerful statistical analyses to aid inference on the relationship. Of interest in this study is establishing the statistical significance of the variation in the dependent variable due to the contribution of two or more independent variables in the multiple regression model. In this respect, analysis of variance (ANOVA) becomes necessary (Pallant, 2005). ANOVA allows investigation of the variation in the scores of a dependent variable produced by the independent variables (Ibid.). Just like regression analysis, ANOVA brings out how much of the variation in the dependent variable can be attributed to error (Hinton et al, 2004). Besides this, ANOVA aids in determining the statistical significance of the results in the model.

In the GLM, scores in data vary and this variability is measured by calculating sums of squares or sums of the squared deviations from the mean. The total variability in the data is calculated by working out the variability of all the scores in the model, such as variability due to the independent variables or to sources of error. Alternatively, a sum of squares for each source of variability is

worked out and then all these added up to get the total sums of squares arising from each source of variation.

Once the above calculation has been carried out, the next step is to work out an average amount of variability due to each source. This is because amount of variation may differ with different cases or conditions. An average variability or mean square is worked out by dividing the sums of squares attributed to one source of variation by the degrees of freedom for the same source of variation. Mean square is also called variance and is the square of the standard deviation. By comparing the variance due to a particular source, such as independent variables, with an appropriate error variance, the resulting variance ratio (F value) will be large if there is a large systematic variation in the data due to the independent variables. If it is small (around 1) then the variability due to the independent variables is no different from the variability arising by random error. The calculated value of F (variance ratio) is used to decide if the prediction in the regression model is statistically significant or not.

In the present study, each model is a functional representation of spatial planning against environmental status and this creates a basis for drawing inferences on how spatial planning influences environmental management. Establishing whether there exists a significant relationship between spatial planning and environmental status is carried out by assessing the statistical significance of each prediction (model). As Pallant (2005) points out, this tests the null hypothesis that the multiple correlation coefficient,  $R$ , in a prediction model equals zero (0). Table 6-1 below illustrates that, for each of the 34 models, there exists a significant relationship between spatial planning variables and the respective environmental variable. This implies that the null hypothesis is rejected. In this regard, the study concludes that there is a significant relationship between spatial planning and the environment. This suggests that spatial planning, depending on how it is applied, can either minimize or maximize environmental problems in the public spaces of residential neighbourhoods, hence its link to environmental management.

**Table 6-1: Results of hypothesis testing**

<b>Model</b>	<b>R</b>	<b>R<sup>2</sup></b>	<b>Degrees of freedom (df)</b>	<b>Variance Ratio - F</b>	<b>Sig. (p-value)</b>	<b>Testing of null hypothesis at 95% confidence level</b>
1	0.513	0.263	2,112	19.967	0.000	Rejected
2	0.747	0.559	5,69	17.470	0.000	Rejected
3	0.473	0.224	2,114	16.452	0.000	Rejected
4	0.413	0.170	1,26	5.331	0.029	Rejected
5	0.384	0.147	2,114	9.855	0.000	Rejected
6	0.992	0.985	10,17	110.140	0.000	Rejected
7	0.456	0.208	2,114	14.939	0.000	Rejected
8	0.797	0.636	3,24	13.963	0.000	Rejected
9	0.330	0.109	2,114	6.984	0.001	Rejected
10	0.994	0.988	11,16	118.973	0.000	Rejected
11	0.315	0.100	1,114	12.600	0.001	Rejected
12	0.740	0.548	3,24	9.693	0.000	Rejected
13	0.213	0.046	1,118	5.628	0.019	Rejected
14	0.849	0.721	6,68	29.297	0.000	Rejected
15	0.495	0.245	2,117	18.962	0.000	Rejected
16	0.785	0.616	5,69	22.110	0.000	Rejected
17	0.399	0.159	2,117	11.069	0.000	Rejected
18	0.687	0.471	5,69	12.304	0.000	Rejected
19	0.314	0.099	2,117	6.402	0.002	Rejected
20	0.512	0.262	3,71	8.415	0.000	Rejected
21	0.238	0.056	1,118	7.063	0.009	Rejected
22	0.681	0.463	4,70	15.097	0.000	Rejected
23	0.216	0.047	1,118	5.784	0.018	Rejected
24	0.818	0.669	4,70	35.295	0.000	Rejected
25	0.390	0.152	2,117	10.504	0.000	Rejected
26	0.694	0.482	3,71	21.984	0.000	Rejected
27	0.352	0.124	2,115	8.141	0.000	Rejected
28	0.482	0.232	2,72	10.879	0.000	Rejected
29	0.310	0.096	2,117	6.231	0.003	Rejected
30	0.731	0.535	4,70	20.118	0.000	Rejected
31	0.283	0.080	1,118	10.292	0.002	Rejected
32	0.867	0.751	8,66	24.903	0.000	Rejected
33	0.463	0.215	2,117	15.978	0.000	Rejected
34	0.889	0.791	8,66	31.175	0.000	Rejected

Source: Author, 2011.

### **6.3 Objective Two**

The second objective of the study entailed establishing how spatial planning influences public space environmental status in the City of Nairobi's residential neighbourhoods. The study realizes that various public space characteristics either minimize or promote various public space environmental problems. Various related public space characteristics constitute nine spatial planning patterns which co-interact to influence public space environmental status. These patterns include: relationship of public space with boundaries that define it; control of public space; scale of space; connectivity of public space; integration of public space; ecological balance; land use planning; transportation planning and provision of public space services.

Axial alpha variables, in explaining public space environmental status, are narrow in scope. This is exhibited in their low percentages of explanation of variances in the dependent variables whereby they range between 4.6 percent for Model 13 and 26.3 percent for Model 1. On the other hand, when all public space variables are considered in prediction of public space environmental problems, the study realizes larger percentages in explanation of variances in the dependent measures. The variance range is between 98.8 percent for Model 10 and 17 percent for Model 4.

### **6.4 Objective Three**

The third objective of this study entailed inferring how spatial planning can be effectively applied so as to play its rightful role in minimizing environmental problems in public spaces of the City of Nairobi's residential neighbourhoods. The study realizes nine spatial planning patterns that are interrelated and whose application to public space planning has a minimizing effect on environmental problems in public space. In applying stipulations of these patterns to evolution of spatial layouts, spatial planners should consider how each pattern interacts with other patterns in order to realize environmentally sustainable public space environments.

Boundaries (buildings or fencing) constituting a public space should be permeable to it. This calls for minimization of enclosure of public space and enhancement of transparency of boundaries to allow for surveillance of the space by residents. Where the residents feel that their privacy is compromised by transparent fencing, surveillance of space can be reinforced by introducing diverse activities in space. The mix of activities should be such that people are attracted to flow into and through the space. For a high-rise building block, this effect can be achieved by creating



shops on ground floor and residential units on the upper floors. In all cases, activities constituting a public space need to be accessible from the space.

There is need to create high control public spaces in the layout of residential settlements. This is achieved by ensuring that a public space is constituted by the adjacent boundaries; distribution of public space is enhanced by use of short cluster blocks; density of settlement is increased; and that there is a diverse mix of activities in the space. High control spaces are associated with a high frequency of pedestrians and motorists in public space and a higher level of provision of public space services by the CCN.

Public spaces, in their relation with the constituting buildings, should be of the right scale. In this regard, the height of the enclosing walls should not be more than twice the width of the constituted public space. Similarly, the width of public space should not exceed the height of constituting boundaries by more than four times.

In the layout of residential neighbourhoods, remarkable breakup in the public space system should be avoided. Shallow spaces in relation to the carrier space have minimal breakup and are desirable for a better quality environment. The problem of excessive breakup arises when a residential neighbourhood is planned like 'tree', that is, yielding a structure which is asymmetric and nondistributed. The layout should endeavour to achieve a shallow public space system whose highest depth from Y value is 3. A spatial system with this quality is more integrating than it is segregating. It has a higher encounter rate of pedestrians, motivates investments in diverse activities, has a sense of community and gets prioritized by the local authority in provision of public space services.

Residential public space layout should be cognizant of ecological considerations. This requires that in urban renewal schemes, the age and condition of buildings should be varied. New planting should co-exist with the old stock. Landscape elements must be well balanced in their inter-relationship with the settlement if at all eco-sensitivity is to be achieved.

Layout of residential public spaces should be characterized with a high density of settlement. A sufficiently dense concentration of people in a settlement is a desirable quality that supports

environmental sustainability. In this regard, emphasis should be laid on the vertical dimension of building development as a way of increasing density of settlement. This approach allows for more open space for the residents thus avoiding overcrowding. In doing this, there should be no loss of focus on diversity in builtform and mix of activities.

Layout of transportation networks in a public space should be such that pedestrian movement is enhanced whereas car movement is minimized. Continuous pavements should be avoided and any vehicular carriageway, where provided, should be limited to two lanes. The layout of the carriageway should be such that the car cannot mount the kerb to displace people from pedestrian zones and destroy greenery. Creating pedestrian-dominant residential neighbourhoods in which residents do not rely on personal cars however calls for an efficient and reliable public transport system at the city-wide scale.

There is need to strengthen the capacity of the CCN to deliver public space services. This is in regard to resource allocation, personnel and equipment. In view of this and the observed trend of private sector participation in public space environmental management, there is need for CCN to forge partnerships with the private sector, at the level of each residential neighbourhood, for purposes of co-delivery of public space services.

## **6.5 Theoretical Implications**

This study has exploited mainly two streams of literature; firstly, the literature related to spatial planning and secondly, literature on public space environmental management. In relation to both of these, different variables and patterns have been discussed. The main area of research to which this study has aimed at contributing is the research on spatial planning. Literature on PSEM has been used as a point of departure into the discussion on spatial planning. In this section, a summary of the most important theoretical contributions to research on spatial planning is presented.

### ***6.5.1. Contributions to Theories on Spatial Planning***

In conducting scientific research, the credibility and novelty of the results of a study can be considered the most important signs of the quality of the study (Ulkuniemi, 2003). Thus, the theoretical contributions of a study need to be carefully formulated and presented. The main field

of study that this research has aimed at contributing to is the field of spatial planning which, as this study establishes, has not been effective in minimizing environmental problems in residential neighbourhoods. In terms of the knowledge and new insights that this research has generated to the field of spatial planning and also to PSEM, one of the most important contributions concerns the entire purpose of this study; to develop an alternative approach to spatial planning whose utilization results in sustainable PSEM in residential neighbourhoods.

By studying spatial planning in residential neighbourhoods, this study provides quite valuable insights into the scope of interest that spatial planning addresses. Most importantly, the study has added to our knowledge of the importance of understanding the PSEM from the spatial planning perspective. As argued in the theoretical discussions presented in Chapters One and Two, theories and concepts on spatial planning are not able to functionally explain environmental problems in the residential public space system. The theories have not paid enough attention to the essence of the concept of PSEM. Although PSEM constitutes the very foundation underlying the issues studied in spatial planning, the meaning of the concept has not been elaborated. Instead, PSEM has erroneously been conceived as limited to the actions of a local authority to translate blueprints, as produced by spatial planning, into footprints. This study establishes the link between spatial planning and PSEM by identifying nine spatial planning patterns that have a bearing on the quality of the public space environment. This gives spatial planning a more organized view of the use of the PSEM concept. This study has provided an understanding of PSEM as a process involving intercourse between the various spatial planning patterns which have been elaborated in chapter five.

The focus on PSEM in this study has resulted in identifying specific environmental problems in the residential public space system. These environmental problems also provide an important contribution to spatial planning research by extending the scope of focus of spatial planning. This study has concluded that each of the environmental problems has a significant relationship with the spatial characteristics of a public space. These problems are elaborated in Chapter Four by discussing how they are minimized or promoted by spatial planning.

One could also think that if a spatial planner wants to evolve a layout of a residential neighbourhood, he could simply return to the theories and concepts discussed in chapter two, and the legislative framework on spatial planning in order to gain understanding of the task at

hand. However, the theories and concepts have focused on addressing spatial organization without a systematic account of the inherent environmental problems. The empirical setting which forms the basis of this study, however, formulates spatial planning functionally as an object of intervention in PSEM. It can thus be argued that this study has provided important insights into evolving sustainable public space environments.

### ***6.5.2. New Insights for Residential Neighbourhood Planning Research***

The empirical context of this study has been residential neighbourhoods, or more specifically, the residential neighbourhoods in the City of Nairobi. In addition to the existing literature on residential neighbourhood planning, empirical patterns generated in this research, which are rooted in various models, provide useful insights on how to mitigate public space environmental problems through residential settlement layout. The patterns present a pragmatic approach to solving environmental problems in the residential public space system. In these patterns, the specific role played by spatial planning in minimizing or promoting environmental problems is singled out. The study has demonstrated that the patterns are interrelated and that consideration of intercourse among the patterns is fundamental to realization of sustainable public space environments. In this regard then, this study can be seen as contributing to the existing body of knowledge on residential neighbourhood planning research.

## **6.6 Practical Implications**

In addition to the theoretical contributions described, this study has provided new insights for practical PSEM. As this study is conducted from the perspective of environmental problems in public space, the most important practical area it has contributed to is PSEM in residential neighbourhoods. Nine spatial planning patterns are advanced whose core focus is minimizing public space environmental problems. What ought to be done under each spatial pattern in order to realize a better public space environment is elaborated in section 6.4. Table 6-2 presents a summary of practical implications of this study.

**Table 6-2: Environmental management implications of various spatial planning patterns**

Spatial Planning Pattern	Interventions	Environmental management implications	
		Positive Results	Negative Results
1. Constitutedness	<ul style="list-style-type: none"> <li>-enhance permeability</li> <li>-minimize enclosure</li> <li>-enhance transparency</li> </ul>	<ul style="list-style-type: none"> <li>-high frequency of people</li> <li>-improved sense of safety</li> <li>-diversity in activities</li> <li>-better provision of public space services</li> </ul>	<ul style="list-style-type: none"> <li>-increased vehicular-pedestrian conflict</li> <li>-undesigned parking</li> <li>-bigger length of destroyed road</li> </ul>
2. Control of space	<ul style="list-style-type: none"> <li>-ensure constitutedness</li> <li>-enhance distributedness by use of short blocks</li> <li>-increase density of settlement</li> <li>-diverse mix of activities</li> </ul>	<ul style="list-style-type: none"> <li>-high frequency of pedestrians and motorists</li> <li>-better provision of public space services</li> </ul>	<ul style="list-style-type: none"> <li>-undesigned parking</li> <li>-neglect of greenery</li> </ul>
3. Scale	<ul style="list-style-type: none"> <li>-appropriate relation of height of boundary to width of space</li> </ul>	<ul style="list-style-type: none"> <li>-correct human scale</li> </ul>	<ul style="list-style-type: none"> <li>-Agoraphobic environment</li> <li>-Claustrophobic environment</li> </ul>
4. Connectivity	<ul style="list-style-type: none"> <li>-enhance distributedness by use of short blocks</li> </ul>	<ul style="list-style-type: none"> <li>-high frequency of pedestrians</li> <li>-better control of space</li> <li>-diverse mix of activities</li> <li>-improved scale of convenience</li> </ul>	<ul style="list-style-type: none"> <li>-Undesignated parking along carriageway</li> </ul>
5. Integration	<ul style="list-style-type: none"> <li>-avoid remarkable break-up in public space system</li> <li>-Limit depth from Y value to a maximum depth of 3</li> <li>-avoid tree-like layouts</li> </ul>	<ul style="list-style-type: none"> <li>-higher frequency of pedestrians</li> <li>-diverse mix of activities</li> <li>-better sense of community</li> <li>-better provision of public space services</li> </ul>	

<p>6. Ecological balance</p>	<ul style="list-style-type: none"> <li>-minimize provision of vehicular spaces</li> <li>-emphasize on provision of pedestrian spaces</li> <li>-vary age and condition of buildings</li> <li>-new planting to co-exist with old stock</li> </ul>	<ul style="list-style-type: none"> <li>-reduced undesignated parking</li> <li>-higher frequency of people in space</li> <li>-reduced air pollution</li> <li>-better quality of greenery</li> </ul>	
<p>7. Land use planning</p>	<ul style="list-style-type: none"> <li>-ensure diverse mix of activities</li> <li>-ensure high density of settlement</li> <li>-provide more pedestrian spaces and less vehicular spaces</li> <li>-create short cluster blocks</li> </ul>	<ul style="list-style-type: none"> <li>-higher frequency of people in space</li> <li>-better provision of public space services</li> <li>-higher level of control</li> </ul>	
<p>8. Transportation planning</p>	<ul style="list-style-type: none"> <li>-create short cluster blocks</li> <li>-minimize area covered with tarmac</li> <li>-enhance reliance on pedestrian lines of movement</li> <li>-minimize car dominance in space</li> <li>-avoid continuous pavements</li> <li>-protect greenery from damaging effect of the car</li> <li>-provide reliable citywide public transport system</li> </ul>	<ul style="list-style-type: none"> <li>-pedestrian-dominated environments</li> <li>-improved ecological balance</li> <li>-reduced public space pollution</li> <li>-better quality of greenery</li> <li>-better control of space</li> </ul>	

9.Public space services	<ul style="list-style-type: none"> <li>-strengthen capacity of CCN</li> <li>-Enhance better practices of taking care of greenery</li> <li>-CCN to forge partnerships with private sector</li> </ul>	<ul style="list-style-type: none"> <li>- better quality of roads</li> <li>-clean public space environment</li> <li>-well lit public space</li> <li>-reduced public space air pollution</li> </ul>	-higher frequency of undesignated parking
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Source: Author, 2012.

## **6.7 Methodological Implications**

The present study has certain limitations that need to be taken into account when considering the study and its contributions. However, some of these limitations can be seen as fruitful avenues for future research under the same theme.

### ***6.7.1 Limitations of the survey design***

This study has focused on a phenomenon that is a very extensive, that is, residential neighbourhoods at the citywide scale. Clearly, this represents a challenging task for research regardless of the more specific interests that the study may have. The present study has been carried out from a wide empirical perspective that has generalization of results as its primary goal. The study is designed as a survey using the space syntax method as a guide to the overall approach. Because of the need to generalize results, the study does not delve into much detail insofar as the spatial characteristics of each neighbourhood are concerned. However, the empirical setting represents the whole idea of a survey research. This empirical setting which presents an opportunity to learn something about the general phenomenon also aids in making inferences about a single case that may need to be studied in depth.

### ***6.7.2 Difficulties in sampling***

Characteristics of residential neighbourhoods and their public spaces vary widely and therefore no single sampling technique can be applied in selection of units of observation. Different methods and stages of sampling have to be employed in order to overcome difficulties in sampling.

### **6.7.3 Data Collection Methods**

A study of this nature works with the use of structured observation as a method of data collection. Such data is measured either qualitatively using a Likert-like scale or with the use of precision instruments. Use of interviewing is limited to circumstances when a variable is not manifest in public space. Generally, quantitative method of data collection is advisable.

### **6.7.4 Preparation of Axial Maps**

Accuracy in preparation of neighbourhood axial maps is an important aspect sampling and collection of data. A scale of 1:1250 is desirable although axial maps of a scale of up to 1:10,000 have worked with the space syntax method.

### **6.7.5 Measurement and Standardization of Data**

Just like in preparation of axial maps, accuracy in measurement and standardization of data is an important aspect of data collection. This implies that research assistants have to be trained if at all the data collected is to be reliable.

### **6.7.6 Collecting Data on Human Use of Space**

There has to be consistency in choice of time for collecting environmental status data with regard to human use of space. There are peak and off-peak periods when space is used. Consistency in observation time throughout the entire duration of data collection is necessary so as to avoid distortion of results.

## **6.8 Future Directions**

1. This study establishes that provision of public space services in Nairobi's residential neighbourhoods is so much a task that the CCN has been unable to cope. From field observation, there is a lot of potential in CCN going into partnerships with private organizations at neighbourhood level for co-delivery of public space services. There is need for further research on how this can be actualized in a residential public space system that has diverse spatial characteristics and patterns.



2. This study focuses on residential neighbourhoods in the City of Nairobi from the perspective of spatial planning. There is need for similar studies in other urban areas of Kenya, sampled in a manner that can allow for generalization of findings to enable development of a theory on residential public space environmental management in Kenya.

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**APPENDICES**

**Appendix 1: Environmental Status Data Score Sheet**

**NEIGHBOURHOOD:** \_\_\_\_\_

**DATE:** \_\_\_\_\_

**SHEET NO.** \_\_\_\_\_

Public Space Code	Scores							
	Vehicular-pedestrian conflict	Parking problem	Dust pollution	Odour pollution	Solid waste	Storm water drainage problems	Quality of greenery	Destruction of road network

## Appendix 2: Public Space Questionnaire/Observation Guide

### PUBLIC SPACE QUESTIONNAIRE/OBSERVATION GUIDE

Researcher: \_\_\_\_\_ Neighbourhood \_\_\_\_\_ Date: \_\_\_\_\_

Equipment required: measuring wheel, 5m measuring tapes, cameras, counting machines, calculator, drawing tools, etc.

#### I. GENERAL INFORMATION ABOUT THE PUBLIC SPACE

A1: Space code: \_\_\_\_\_

A2: Type of space: Tick appropriate description.

Score	Space
1	Alleyway
2	Pedestrian street
3	Vehicular and pedestrian street

#### NOTE:

-An alleyway is a narrow passage between buildings or plots

-A pedestrian street is a public road (hard surface) that has houses and buildings on one or both sides and is exclusively for use by pedestrians

-A vehicular and pedestrian street is like a pedestrian street save for the use by both vehicles and pedestrians

#### II. SPATIAL PLANNING VARIABLES OF THE PUBLIC SPACE

##### B) Physical Factors

##### Dimensions of Space:

B1: Width of the space in metres \_\_\_\_\_

B2: Length of the space in metres \_\_\_\_\_

B3: Area of the space in M<sup>2</sup> \_\_\_\_\_

##### Landscaping:

Indicate in percentage the area of the space with:

Surface	Area in M <sup>2</sup>	Percentage
Tarmac		B4=
Grass		B5=
Paving slabs		B6=
Bare soil		B7=
Flowers		B8=
Others (specify)		B9=
Total area		100%

## Trees

B10: Tree location in the space: Tick appropriately.

Score	Tree location
0	No tree
1	At the periphery – one side
2	At the periphery – both sides
3	Between edge of the road and periphery – one side
4	Between edge of the road and periphery – two sides

B11: No. of trees shading human activities (e.g. movement) per length of space \_\_\_\_\_

B12: No. of trees screening buildings from environmental factors per length of space \_\_\_\_\_

B13: Average tree height in metres \_\_\_\_\_

B14: Average tree canopy diameter in metres \_\_\_\_\_

B15: Average tree canopy clearance from ground in metres \_\_\_\_\_

B16: Ratio of total canopy area to area of space \_\_\_\_\_

B17: Ratio of total no. of trees to area of space \_\_\_\_\_

B18: Average tree spacing in metres along length of space \_\_\_\_\_

B19: Spread of trees along length of space

1. Trees are spread along entire length of space
2. More than half the length of the space is spread with trees
3. Half the length of the space is spread with trees
4. Less than half the length of the space is spread with trees
5. There is no tree over the entire length of the space

## Topographic character

B20: Percent of space that is flat (<0.5 %): \_\_\_\_\_

B21: Percent of space that is gentle (0.5-5 %): \_\_\_\_\_

B22: Percent of space that is steep (5-9 %): \_\_\_\_\_

B23: Percent of space that is very steep (≥9 %): \_\_\_\_\_

## **C) Movement Patterns**

Sidewalks (Planned or unplanned pedestrian walkways)

C1: Distribution of sidewalks: Tick appropriate description

0. No sidewalk
1. sidewalk on one side of the road
2. sidewalk on two sides of the road

C2: Total width of sidewalk(s) in metres \_\_\_\_\_

Vehicular use system (Road carriageway)

C3: Frequency of intersections within the space (i.e. no. of intersections per metre length of space) \_\_\_\_\_

C4: Percent of road surface that is straight \_\_\_\_\_

C5: Percent of road surface that is curved \_\_\_\_\_

C6: How can vehicular traffic movement in the space be described? Tick appropriately.

1. No vehicular movement
2. Cul-de-sac road
3. One way movement
4. Two way movement

C7: Width of road (carriageway) \_\_\_\_\_

C8: Width of traffic moving lane \_\_\_\_\_

C9: Total no. of vehicular movement lanes \_\_\_\_\_

C10: Type of traffic junctions in the space. Tick appropriately.

1. No junction
2. T-junction or Y-junction
3. 4-way intersections
4. Combination of T- and 4-way junctions
5. Other (specify) \_\_\_\_\_

C11: Total number of vehicles using the space (parked and moving) per unit area of the space \_\_\_\_\_

(Note: to measure this variable, have two research assistants walk through the space along its length in opposite directions. Get the average of the counted vehicles)

C12: Total number of vehicles using the space (parked and moving) per metre length of the space \_\_\_\_\_

C13: No. of alleyways making a junction with the space per metre length of space \_\_\_\_\_

C14: No. of pedestrian roads making a junction with the space per metre length of space \_\_\_\_\_

C15: No. of vehicular-cum pedestrian roads making a junction with the space per metre length of space \_\_\_\_\_

#### Parking (Designated and Undesignated)

Percentage of parking on different surfaces in the space

Surface	No. of Autos	Percentage
Tarmac		C16=
Grass		C17=
Paved area		C18=
Bare soil		C19=
Others		C20=
TOTAL		100%

#### **D) Built Environment**

##### Buildings

D1: Percent of space length fronted with fronts of buildings/ inhabited plots: \_\_\_\_\_

(Note: Front of a building/inhabited plot refers to the side where the principal access is).

D2: Percent of space length fronted with backs of buildings / inhabited plots: \_\_\_\_\_

(Note: Back of a building/inhabited plot refers to the side directly opposite the front and with minor or no access).

D3: Percent of space length fronted with sides of buildings/inhabited plots: \_\_\_\_\_

D4: Total no. of buildings/plots per metre length of space \_\_\_\_\_

D5: Total no. of buildings per M<sup>2</sup> of space \_\_\_\_\_

### Permeability

D6: Length of adjacent and permeable buildings (or plots where applicable) fronting the space  
\_\_\_\_\_

D7: Ratio of length of adjacent and permeable buildings (or plots where applicable) fronting the space to the length of the space \_\_\_\_\_

D8: Ratio of length of adjacent and permeable buildings (or plots where applicable) fronting the space to the area of the space \_\_\_\_\_

D9: Ratio of the no. of doors (and/or gates where applicable) fronting the space to the area of the space \_\_\_\_\_

D10: Ratio of the no. of doors (and/or gates where applicable) fronting the space to the length of the space \_\_\_\_\_

D11: Average centre to centre of doors/gates fronting the space in metres  
\_\_\_\_\_

### Height

Percent of buildings that are:

D12: Single storey \_\_\_\_\_

D13: Double storey \_\_\_\_\_

D14: Three storey \_\_\_\_\_

D15: More than three storey \_\_\_\_\_

D16: Average no. of storeys of buildings fronting the space \_\_\_\_\_

D17: Ratio of average no. of storeys to the length of space (D16/length) \_\_\_\_\_

D18: Ratio of average no. of storeys to area of space (D16/area) \_\_\_\_\_

D19: Ratio of average no. of storeys to average width of space (D16/width)  
\_\_\_\_\_

### Space Boundaries

D20: Total no. of plots/building blocks with permeable boundaries fronting the space \_\_\_\_\_

D21: Ratio of total no. of plots/building blocks with permeable boundaries to length of the space  
\_\_\_\_\_

D22: Ratio of total no. of plots/building blocks with permeable boundaries to area of the space  
\_\_\_\_\_



D23: Average height (in metres) of space boundary \_\_\_\_\_

D24: Ratio of average height of space boundary to average width of the space  
\_\_\_\_\_

D25: Ratio of length of space with transparent boundary (allowing visual connection to public space) to total length of space \_\_\_\_\_

D26: Ratio of length of space with transparent boundary to area of space \_\_\_\_\_

#### Transparency of Buildings – Ground Floor only

D27: Ratio of total length of windows (at ground floor) with visual connection to the space to length of space \_\_\_\_\_

D28: Ratio of total length of windows (at ground floor) with visual connection to the space to area of space \_\_\_\_\_

D29: Ratio of total area of windows (at ground floor) to area of space \_\_\_\_\_

D30: Spread of windows along length of space on ground floor

1. Windows are spread along entire length of space
2. Windows are spread over more than half the length of the space
3. Half the length of the space is spread with windows
4. Less than half the length of the space is spread with windows
5. There is no window over the entire length of the space

#### Transparency of Buildings – First Floor and above

D31: Ratio of total length of windows (first floor and above) with visual connection to the space to length of space \_\_\_\_\_

D32: Ratio of total length of windows (first floor and above) with visual connection to the space to area of space \_\_\_\_\_

D33: Spread of windows along length of space on first floor and above:

1. Windows are spread along entire length of space
2. Windows are spread over more than half the length of the space
3. Half the length of the space is spread with windows
4. Less than half the length of the space is spread with windows
5. There is no window over the entire length of the space

Transparency - generally

D34: Average centre to centre of windows \_\_\_\_\_

D35: Percent of building wall length that is transparent \_\_\_\_\_

D36: Percent of building wall area that is transparent \_\_\_\_\_

D37: Average starting height of windows in metres (from building floor level) \_\_\_\_\_

Setbacks

(Note: Setback refers to the distance a building is from the edge of the public space)

Indicate percent of buildings with the following setbacks in space?

Setback	No. of buildings	Percentage
D38: 0 metres		D38=
D39: 3 metres		D39=
D40: 4.5 metres		D40=
D41: 6 metres		D41=
Total		100

D42: Ratio of no. of buildings with setbacks to total no. of buildings \_\_\_\_\_

D43: No. of buildings with setbacks per metre length of space \_\_\_\_\_

D44: No. of buildings with setbacks per M<sup>2</sup> of space \_\_\_\_\_

D45: No. of buildings without setback per metre length of space \_\_\_\_\_

Activities

D46: Ratio of no. of buildings with social spaces or places to total no. of buildings fronting the space \_\_\_\_\_

Outdoor Amenities:

Indicate no. of items of the following amenities in the space?

Amenities	No.	No. per metre
D47: Outdoor seating		D47=
D48: Telephone booths		D48=
D49: Play equipment		D49=
D50: Fast food vendors		D50=
D51: Bus stop shelters		D51=
D52: Display and exhibition structures		D52=
D53: Newspaper selling points		D53=
D54: Others (specify)		D54=

Outdoor services: How can provision of the following services be described? 1. Daily 2. Weekly 3. Forth-nightly 4. Monthly 5. Yearly 6. Rarely 7. Never. Indicate appropriately.

Service	Score						
	1	2	3	4	5	6	7
D55: Garbage collection							
D56: Kenya Police patrols							
D57: CCN Askari patrols							
D58: Private security patrols							
D59: Taking care of planting							
D60: Maintaining street surface							

Garbage and its composition

D61: Type of garbage found in space. Indicate (0) for no and (1) for yes. Augment this recording with photography.

Waste	0=no, 1=yes	Waste	0=no, 1=yes
a).Paper		g). Medical wastes	
b). Organic wastes		h). Household furniture	
c). Construction and demolition debris		j). Glass	
d). Plastic		k). Metals	
e). Textiles		m). Used oil containers	
f). Tyres		n).Others	

D62: Proportion of adjacent axial spaces with worse garbage problem than this \_\_\_\_\_

E) Infrastructure Systems or Utility Network

Are the following utilities provided/available in the space? Assign (1) for yes and (0) for no.

E1: Security/street lights \_\_\_\_\_

E2: Sewerage drainage \_\_\_\_\_

E3: Storm water drainage \_\_\_\_\_

E4: Telecommunication cables and/or posts \_\_\_\_\_

E5: Bollards \_\_\_\_\_

E6: Kerbs \_\_\_\_\_

E7: Other (specify) \_\_\_\_\_

Storm water drainage

How is storm water disposed? 0=no, 1=yes

E8: Direct into the storm water channels \_\_\_\_\_

E9: Onto the space surface \_\_\_\_\_

E10: Into catchbasins \_\_\_\_\_

E11: Into underground storage \_\_\_\_\_

E12: Other (specify) \_\_\_\_\_

If storm water channels exist in the space, of what form are they? 0=no, 1=yes

E13: Open channels \_\_\_\_\_

E14: Closed channels \_\_\_\_\_

What form does the drainage channel take? 0=no, 1=yes

E15: Passes centrally through the space \_\_\_\_\_

E16: Passes at the periphery on one side of the space \_\_\_\_\_

E17: Passes at the periphery on both sides of the space \_\_\_\_\_

E18: No. of storm water catchbasins per metre length of space \_\_\_\_\_

Artificial Lighting

Which of the following provide artificial lighting in the space? 0=no, 1=yes

E19: Outdoor lighting fixture (post and luminaries) \_\_\_\_\_

E20: Building security lighting \_\_\_\_\_

E21: Advertisement/display lighting \_\_\_\_\_

Frequency of the artificial lighting fixtures in no. per metre length of space

E22: Outdoor lighting fixture (post and luminaries) \_\_\_\_\_

E23: Building security lighting \_\_\_\_\_

E24: Advertisement/display lighting \_\_\_\_\_

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### III. ECONOMIC AND LAND USE VARIABLES

Activities fronting the space at ground level from the adjacent buildings. Count the activities and indicate their intensity per metre length of space.

Activity	Number	No. per metre length of space
Clothing shops		F1=
Stores/supermarket, etc		F2=
Cafes/restaurants/bars		F3=
General retail shops		F4=
Hardware shops		F5=
Offices		F6=
Residential houses		F7=
Kiosks /small-scale roadside commerce		F8=
Bookshops		F9=
Photo studios		F10=
Chemist/pharmacy/clinic		F11=
Barber shop/ salon		F12=
Garages		F13=
Electrical appliances		F14=
Institutions (i.e. schools, hospitals, etc.)		F15=
Others (specify)		F16=

#### Scale of business activities fronting the space

Scale of business	Number	No. per metre length of space
Informal (without trading license)		F17=
SMEs, e.g. MPESA (with trading license)		F18=
Large businesses (with trading license)		F19=

F20: Distribution of business activities along length of space

1. Businesses are spread along entire length of space
2. Businesses are spread over more than half the length of the space
3. Businesses cover half the length of the space
4. Businesses cover less than half the length of the space
5. There is no business activity over the entire length of the space

F21: Number of different activities (resulting from variables F1 to F16) \_\_\_\_\_

F22: Description of mix of activities in the space. Tick appropriately.

1. Single activity (say, residential only)
2. A mix of two activities, e.g. residential and commercial
3. A mix of three activities
4. A mix of more than three activities

Ownership of different commercial activities in racial proportions

Race	No. of Activities	Percentage
European		F23=
Asian		F24=
African		F25=
TOTAL		100%

Density of development for the space

F26: Recommended ground coverage (G.C.) of the space \_\_\_\_

F28: Recommended plot ratio (P.R.) of the space \_\_\_\_\_

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### III. SOCIAL VARIABLES (HUMAN USE SYSTEM OF THE SPACE)

The following section looks at the human use system of the space. Let two research assistants walk through the entire length of the space in opposite directions and record the number of people moving through, standing, or seated. This should be done between 9.00 a.m. and 4.00 p.m., a time frame that is outside the peak hours when people are going to or coming from duty.

Activity/Description	No. of people	Frequency (no. of people per metre length of space)	Density (no. of people per square metre of space)
Walking		F29:	F30:
Standing		F31:	F32:
Seated/lying down		F33:	F34:
Total		F35:	F36:

Where do these human activities take place? Assign (1) to the description that fits the location of the place and (0) to that which does not.

Walking		Sitting /Lying down		Standing	
F37: On the sidewalk		F43: In shade under shop verandah/canopy		F49: Next to physical supports (columns, trees, lamps, etc.)	
F38: Along the road (carriageway)		F44: In shade under the tree		F50: In front of shops	
F39: Across the road		F45: On steps		F51: Along the space at the periphery	
F40: On grass		F46: On grass		F52: Under verandahs	
F41: Under tree shade		F47: On landscaping seats/short walls		F53: Other (specify)	
F42: Other (specify)		F48: Other (specify)			

### N: PUBLIC SPACE PLANNING STUDY

Insert values for variables N1 – N6 for each space being studied.

ASPECTS OR PROPERTIES OF THE SPACE	SPATIAL PLANNING VARIABLES	VALUE
Constitutedness of public space	N1: Building space index (i.e. adjacency and permeability)	N1=
	N2: Adjacency and permeability per unit area	N2=
	N3: Adjacency and permeability per unit length	N3=
Unconstitutedness of public space	N4: Degree of adjacency and impermeability	N4=
	N5: Adjacency and impermeability per unit area	N5=
	N6: Adjacency and impermeability per unit length	N6=

NOTE: 1. Building space index refers to the number of buildings that are both adjacent and permeable to the public space.

2. Degree of adjacency and impermeability refers to the number of buildings that are adjacent and impermeable to the public space

Insert values for variables N7 – N10 from the axial maps of the residential neighbourhoods.

ASPECTS OR PROPERTIES OF THE SPACE	SPATIAL PLANNING VARIABLES	VALUE
Distributedness – nondistributedness	N7: Axial connectivity	N7=
	N8: Measure of control of axial space	N8=
Symmetry – Asymmetry	N9: Depth from “Y”, the carrier space	N9=
	N10: Relative depth of axial space (RA)	N10=

### ENVIRONMENTAL PROBLEMS IN SPACE

Measure the intensity of each environmental problem as indicated.

Environmental Problem	Different ways of measuring the problem	Intensity of the problem							
		Description							Variable
Vehicular-pedestrian conflict	Frequency of vehicular-pedestrian conflict	Number of locations with conflict in the space per metre length of space							H1=
	Density of vehicular-pedestrian conflict	Number of locations with conflict in the space per M <sup>2</sup> of space							H2=
Parking problem	Frequency of parking problem	Total number of vehicles per metre length of space parked on undesignated areas (e.g. on grass, along the road, double parking)							H3=
	Density of parking problem	Total number of vehicles per M <sup>2</sup> of space parked on undesignated areas (e.g. on grass, along the road, double parking)							H4=
Public Space pollution	Dust pollution	Clean	1	2	3	4	5	Dusty	H5=
	Odour pollution	Fragrant	1	2	3	4	5	Foul	H6=
Solid waste	Solid waste area	Ratio of area occupied by solid waste to total area of the space							H7=
	Solid waste height	Maximum height of garbage in metres							H8=



	Solid waste quality	Fresh	1	2	3	4	5	Rotten	H9=
Storm water drainage problems	Storm water area	Ratio of the area of space commonly occupied by stagnant storm water (evidenced from existing depressions/potholes and blocked drains) to total area of space							H10=
Neglect of greenery	Neglected greenery area	Ratio of area of space with neglected greenery to total area of space							H11=
	Quality of neglected greenery	Mown	1	2	3	4	5	Brushy	H12=
Destruction of road network	Length of destroyed road	Ratio of length of destroyed road to total length of space							H13=
	Area of destroyed road	Ratio of area of destroyed road to total area of the space							H14=

Note: Quantitative measurement of dust would require specialized conditions which are not possible with this study. This variable is therefore measured qualitatively by aid of a five-point rating scale shown below. A similar scale is applied to the qualitative measurement of odour, solid waste quality, and quality of neglected greenery.

Rating scale for qualitative measurement of dust

Description	1	2	3	4	5	Description
Clean	Very clean	More Clean than dusty	Equally clean and dusty	More dusty than clean	Very dusty	Dusty

Each environmental problem will first be regressed against all the space variables that are of interval measure in order to determine the variables that significantly influence it. Secondly, it will also be correlated with all other variables whose measures are non-parametric in order to infer more information about the relationship.