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Public Space Characteristics Underpinning Undesignated On-Street Parking in Residential Neighbourhoods of Nairobi City, Kenya

Micah Makworo*

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Abstract

Planned residential neighbourhoods in Nairobi are provided with designated on-street parking lots but motorists still prefer parking in undesignated areas. Could there be public space characteristics motivating this behaviour? Space syntax and structured observation were used in data collection. Descriptive statistics were used to analyze data on the status of undesignated on-street parking and revealed that the problem is most pronounced in middle income neighbourhoods. Multiple regression analysis established various spatial characteristics, such as depth from the carrier space; adjacency and permeability; building setbacks; outdoor lighting fixtures; relative depth of axial space and building storey height that significantly explain undesignated on-street parking. These characteristics should be considered in residential neighbourhood planning to counter the problem of undesignated on-street parking and promote public space environmental sustainability.

Keywords: Nairobi, On-street parking, Public space, Residential neighbourhoods, Space syntax.

INTRODUCTION

Vehicular streets in residential neighbourhoods, besides accommodating cars, are a setting where people socialize, move and engage in business and recreational activities. The streets accommodate sidewalks, storm water drainage channels, sewer lines and street lighting, which are fundamental to livability of a neighbourhood. Despite these benefits, the car therein is a threat to pedestrian safety and well-being of nature which, according to Hough (1995), influences the resultant form and quality of a public space environment. Public space in the City is under threat (Makworo and Mireri, 2011) and, in residential neighbourhoods, needs to be protected through appropriate planning to secure livability and environmental sustainability.

Residential neighbourhood layout is concerned with space creation and function. This entails definition of networks of public spaces, in relation to buildings and other activities, which in turn contribute to the settlement's spatial form. A settlement's spatial structure presents patterns which carry social information and content (Hillier and Hanson, 1984) and plays a crucial role in influencing human activities and social interaction (Cutini et al., 2020). The layout of residential neighbourhood streets thus presents spatial characteristics that determine the way they are used.

Many studies on settlement layout reveal a link between spatial plan structure and space use. Jacobs (1961) and Makworo et al. (2013) establish that distribution of people in public space, alongside their associated behaviour, is a consequence of spatial plan structures. Moirongo (2011), empirically links parking in undesignated areas of the central business district of Nairobi to spatial plan structures.

The theory of new urbanism advocates for an alternative to the typical car-dominated neighbourhoods (Stubbs, 2002). Principles underlying new urbanist developments include mixed use, high density regeneration-led projects, walkability and interconnected streets that are

*Corresponding author:
Micah Makworo, Senior Lecturer at the Department of Landscape Architecture, Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya. Email: micahmakworo@sabs.jkuat.ac.ke

pedestrian friendly (Morris & Kaufman, 1998; Stubbs, 2002).

The location of car parking in residential neighbourhoods can be either off-street or on-street. Off-street parking usually comprises a garage and a driveway space (Stubbs, 2002). Car-restrained residential areas have concentrated parking facilities, implying that cars do not get parked near residents' homes (Borgers et al., 2008). Availability of parking spaces, both on- and off-street, influences car ownership (Guo, 2013) and potentially reduces housing supply and increases minimum housing costs (Taylor, 2014). Car-free neighbourhoods epitomise sustainable mobility (Borges and Goldner, 2015).

The setting of this study is in the planned residential neighbourhoods of the City of Nairobi which is characterized by a rapid increase in the number of cars. Generally, this increase in car population is widespread in many cities of the world (Lansley, 2016; Taylor, 2014). Whereas pedestrian safety considerations in public space use require cars to be parked in designated lots (Alexander et al., 1977), motorists in Nairobi's residential neighbourhoods have persisted in parking in undesignated on-street areas. This study establishes public space characteristics motivating this behaviour and the extent of the relationship.

THEORY

This study is anchored in the space syntax theory conceived by Bill Hillier and Julienne Hanson at the University College London (Hillier and Hanson, 1984). It defines a method of structuring a settlement plan system in a manner that permits quantitative measurement of its spatial relations. Understanding spatial relationships informs the approach to evolution of desirable spatial forms in the physical environment (Wang et al., 2007). Once the relational quantities have been obtained, an explanation of the status of environmental occurrences in space is explained through correlation and regression studies.

Various studies have employed the theory to demonstrate how environmental behaviour is a function of spatial plan structures. For example, a positive correlation has been established between street integration and the volume of pedestrians in space (Hajrasouliha and Yin, 2015; Hillier and Iida, 2005; Ozbil et al., 2011; Baran et al., 2008; Min, 1993); intersection density and walking for transport (Badland et al., 2008; Christiansen et al., 2016; Koohsari et al., 2014; Baran et al., 2008); and between the measure of control and walking behaviour (Baran et al., 2008). The positive correlation between walking behaviour and connectivity has been alluded to shorter distances between intersections along a street (Frank, 2000).

Besides syntactic properties of space, Alfonzo et al. (2008), documented features of the neighbourhood built environment that have an association with walking and non-motorized transportation among adults. These include high population density; mixed land uses; sidewalk continuity; good pedestrian infrastructure and overall neighbourhood walkability.

RESEARCH METHODS

This paper generalizes its findings to the entire frame of public spaces of planned residential neighbourhoods in the City of Nairobi. Public space is the residential street. To permit systematic inquiry, the street is broken down into units referred to as axial spaces. An axial space thus forms the specimen of inquiry. In order to arrive at a representative sample of axial spaces, multi-stage sampling from the level of residential neighbourhoods to axial spaces was necessary.

The planning of residential neighbourhoods in the city of Nairobi stratifies them into high-income, middle-income and low-income categories. Based on this, a population frame of the neighbourhoods was defined and then subjected to further stratification using public space structure as a criterion. Application of simple random sampling to each stratum resulted in selection of a representative sample of ten neighbourhoods distributed as follows: three in the high income stratum (Parklands, Mitini and Lavington), four in the middle income stratum (Tena, Pangani, Otiende and Buru Buru V) and three from the low income stratum (Ofafa Maringo, Madaraka and Umoja II).

Preparation of neighbourhood axial maps was a pre-requisite to establishment of the parent population of axial spaces in the neighbourhoods. This is done by first finding the longest straight line that can be drawn within a street space of a neighbourhood map 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 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. Initially, an accurate axial map of each neighbourhood was drawn based on maps obtained from Survey of Kenya and Nairobi City County Government. This was followed by a reconnaissance survey of each neighbourhood to identify any omitted spaces for the purpose of including them in the respective axial maps. The updated axial maps presented the universe of public spaces, hence the study population. **Figure 1**, showing the axial map of Buru Buru V, illustrates how this study operationalized public space.

The same process was applied to all the sample neighbourhoods to determine the parent population of public spaces. In total, the study realized 369 public spaces in the sampled neighbourhoods.

To facilitate sampling of public spaces for inclusion in the study, each public space in the respective neighbourhood axial map was coded uniquely, as for example illustrated in **Figure 1**. The spaces were then sampled in a two-stage process. In the first stage, a public space survey was conducted in which all the public spaces in each neighbourhood were systematically observed to establish the status of undesignated on-street parking in each axial space. The status was measured as intensity using a five-point scale whereby the least intensity was given a score of one (1) and the highest intensity a score of five (5). This preliminary assessment was done on a neighbourhood basis in order to make possible selection of a sample that is representative of the parent population of public spaces. Simple random sampling was then applied in selection of spaces from each category of scores on neighbourhood basis. In total, 120 axial spaces were sampled for detailed inquiry in stage two of the study.

Axial alpha-analysis and structured observation were used as the main methods of primary data collection. Axial alpha-analysis, a space syntax

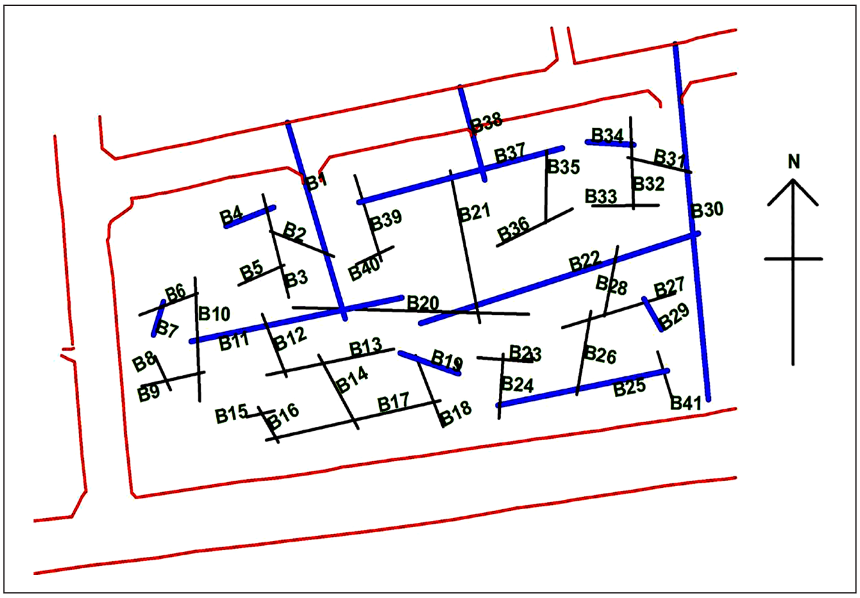

FIGURE 1
Axial map of Buru Buru V residential neighbourhood
Source: Author 2019

method of assessing exterior space of a settlement plan, was used to generate data from the axial maps of the residential neighbourhoods under inquiry. Syntactic variables whose data is generated through axial alpha-analysis were assessed in regard to their predictive strength of undesignated on-street parking.

Data collected through structured observation was both for non-syntactic variables (public space variables whose data is not collected through axial alpha-analysis) and distribution of undesignated on-street parking. Non-syntactic variables relate to the physical, social and economic characteristics of space. In stage one of the study, undesignated parking was measured as intensity using a five-point scale whereas in stage two, it was measured as density, which is the number of recorded counts per square metre of space. Observation of undesignated on-street parking was carried out on week days 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 back from work. Delimitation of observation time was necessary for consistency purposes.

Variables to be observed and the style of recording the observations were defined in an observation schedule. Data collected through structured observation was measured quantitatively using either a five-point scale or with the aid of precision instruments which included a measuring wheel, tape and tally counter. A measuring wheel was used for measuring horizontal and long distances whereas a 5-metre long tape was used for measuring short distances, both horizontal and vertical. A hand-operated tally counter was used to count vehicles parked in undesignated areas. Standardization of data, where necessary, was done so as to allow for comparison among spaces of different sizes.

Statistical Package for Social Sciences (SPSS) was used to aid analysis of data and generation of outputs for interpretation. Descriptive statistics (frequencies and percentages) were used to analyse data on the status of undesignated on-street parking in public spaces of the sampled neighbourhoods. This is the data that was collected in stage one of the study. Multiple regression using the stepwise method was applied in the analysis of data in the second stage of the study. The method was used to establish independent variables that significantly predict undesignated on-street parking in public space. Independent variables are the syntactic variables and those linked to the physical, social and economic characteristics of space. Undesignated on-street parking in public space comprised the dependent variable. Analysis of variance at 99 percent confidence level was used to test the significance of the relationship. Data for the study was presented in tables and an analysis report.

RESULTS

Stage One of the Study

This stage sought to establish the status undesignated on-street parking in public spaces of the sampled residential neighbourhoods. The status was measured as intensity using the following five-point scale: 1 – Very low; 2 – Low; 3 – Moderate; 4 – High; 5 – Very high. The public space survey established that the intensity of undesignated on-street parking varied across and within the neighbourhoods (**Table 1**).

TABLE 1: Intensity of undesignated on-street parking in the sample residential neighbourhoods

S/No	Neighbourhood	Total number of neighbourhood public spaces (N = frequency; % = percentage)	Number of public spaces under each score for undesignated parking				
			Score 1 (very low)	Score 2 (low)	Score 3 (moderate)	Score 4 (high)	Score 5 (very high)
1	Tena	N = 35	7	17	9	2	0
		% = 100	20	48	26	6	0
2	Pangani	N = 45	18	16	7	4	0

		% = 100	40	35	16	9	0
3	Buru Buru V	N = 41	20	19	2	0	0
		% = 100	49	46	5	0	0
4	Otiende	N = 49	17	27	4	1	0
		% = 100	35	55	8	2	0
5	Umoja II	N = 41	27	12	2	0	0
		% = 100	66	26	5	0	0
6	Madaraka	N = 22	14	8	0	0	0
		% = 100	64	36	0	0	0
7	Ofafa Maringo	N = 37	27	9	0	0	0
		% = 100	76	24	0	0	0
8	Lavington	N = 43	35	8	0	0	0
		% = 100	81	19	0	0	0
9	Parklands	N = 27	15	12	0	0	0
		% = 100	56	44	0	0	0
10	Mitini	N = 29	24	5	0	0	0
		% = 100	83	17	0	0	0

Source: Author 2019

The survey revealed that the intensity of undesignated on-street parking in the residential neighbourhoods ranged between 'very low' and 'high' (**Table 1**). Three neighbourhoods (Tena, Pangani, and Otiende) fell within this category whereas five (Madaraka, Ofafa Maringo, Lavington, Parklands and Mitini) had the intensity falling within 'very low' and 'low'. For Umoja II neighbourhood, the intensity was within 'very low', 'low' and 'moderate'. Neighbourhoods scoring above 50 percent in the scale of 'very low' intensity of undesignated on-street parking included Mitini (83%), Lavington (81%), Ofafa Maringo (76%), Umoja II (66%), Madaraka (64%) and Parklands (56%). Traces of high intensity of undesignated on-street parking were observed in Pangani (9%), Tena (6%) and Otiende (2%) neighbourhoods.

Stage Two of the Study

Stage two of the study, that sought to establish independent variables that significantly predict distribution of undesignated on-street parking (on grassed areas and road carriageway), was carried out at two levels. Firstly, axial alpha-variables were regressed against the dependent variable to establish the extent to which they explain the distribution. Secondly, all independent variables (that is, syntactic and non-syntactic) were regressed against the dependent variable in order to present a comprehensive picture of the prediction. The two-tier analysis demonstrates that syntactic variables alone account for a relatively smaller percentage of the variance in undesignated on-street parking, whereas a combination of syntactic and non-syntactic variables significantly explain a relatively larger percentage. The SPSS outputs for the two scenarios are illustrated in **Table 2**.

Modelling density of parking on grassed areas

Prediction using axial alpha variables

Multiple regression between density of parking on grassed areas and axial alpha variables indicated that 14.7 percent of the variance in the dependent variable is significantly explained by depth from Y space and adjacency and permeability (**Model 1** in **Table 2**). 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 grassed areas. The prediction is significant at 99 percent confidence level.

TABLE 2: Regression results for undesignated on-street parking on grassed areas and carriageway

Model 1: Density of parking on grassed areas 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^2 = 0.147; Adjusted R^2 = 0.132; S_e = 0.0004; df = 2, 114; F = 9.855; Sig. = 0.000

Model 2: Density of parking on grassed areas 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^2 = 0.985; Adjusted R^2 = 0.976; S_e = 0.00008; df = 10, 17; F = 110.140; Sig. = 0.000

Model 3: 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^2 = 0.208; Adjusted R^2 = 0.194; S^e = 0.001; df = 2, 114; F = 14.939; Sig. = 0.000

Model 4: 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^2 = 0.636; Adjusted R^2 = 0.590; S_e = 0.0004; df = 3, 24; F = 13.963; Sig. = 0.000

Where:
R= Multiple correlation coefficient; R^2= Coefficient of determination; S_e= 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_9 = Depth from "Y", the carrier space; N_3= Adjacency and permeability per metre of space; D_{44}= Density of buildings with setbacks; D_{24}= Ratio of average height of space boundary to average width of space; E_{22}= Frequency of outdoor lighting fixtures (post and luminaries); D_{43}= Frequency of buildings with setbacks; D_{30}= Spread of windows along length of space on ground floor; C_{13}= Frequency of alleyways making a junction with the space; C_2= Total width of sidewalks in metres; C_3= Frequency of vehicular road intersections in the space; F_{11}= Frequency of chemists in the space; N_{10}= Relative depth of axial space; D_{17}= Ratio of average storey height to length of space

Source: Author 2019

Prediction using all independent variables

Multiple regression between density of parking on grassed areas and all independent variables as predictors showed that eight independent variables significantly explained 98.5 percent of the variance in the dependent variable (**Model 2** in **Table 2**). The relationship is significant at 99 percent confidence level.

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 grassed areas. The six variables are 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.

The public space features which have an inverse relationship with density of parking on grass include average height of space boundary (expressed as a ratio to the width of the adjacent public space), frequency of buildings with setbacks, spread of windows along length of space on ground floor, and frequency of vehicular road intersections in the space. An inverse relationship implies 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.

Modelling density of parking on carriageway

Prediction using axial alpha variables

Multiple regression analysis between density of parking on road carriageway and axial alpha variables indicated that 20.8 percent of the variance in the dependent variable is significantly explained by adjacency and permeability and relative depth of axial space (**Model 3** in **Table 2**). The prediction is significant at 99 percent confidence level. 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 variables constant results in a corresponding increase in the density of parking on the carriageway.

Prediction using all independent variables

Multiple regression between density of parking on road carriageway and all independent variables as predictors realized that three independent variables significantly explain 63.6 percent of the variance in the dependent variable (**Model 4** in **Table 2**). The relationship is significant at 99 percent confidence level.

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. Storey height (measured as the ratio of average storey height to length of space) has an inverse relationship with the dependent variable.

DISCUSSION

Intensity of undesignated on-street parking in the neighbourhoods

The study established that worst performing neighbourhoods in regard to undesignated on-street parking are those that fall within the middle income category. In the study sample, these are represented by Pangani, Tena and Otiende. A majority of middle income earners are able to afford personal cars whereas provision of on-street parking in their neighbourhoods does not match demand. Many motorists in the neighbourhoods thus end up parking in undesignated on-street areas.

Best performing neighbourhoods, those with the lowest intensity of undesignated on-street parking, fall within the high income (Mitini, Lavington and Parklands neighbourhoods) and low income (Ofafa Maringo, Umoja II and Madaraka neighbourhoods) categories. In the high income neighbourhoods, this is the case because usually there is provision of adequate off-street (within premises) parking. In low income neighbourhoods, the dominant mobility behaviour is walking, given that a majority of residents do not own cars.

The above inferences notwithstanding, it was observed that some motorists preferred parking in undesignated on-street areas even when parking lots had vacant bays. Could there be neighbourhood physical characteristics motivating this behaviour? Seeking answers to this question formed the basis of the second stage of the study whose results are discussed below.

Variables explaining undesignated parking on grassed areas

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. A peripheral road leading into each of the residential neighbourhoods is 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 a public space, that is, the "constitutedness" property of space (Hillier and Hanson, 1984). Permeable buildings have their windows and/or doors facing the public space thus enabling visual connectivity between the two settings. Deeper spaces of residential neighbourhoods have longer stretches of roads neglected by city authorities. This relationship is also confirmed by Moirongo (2011), who in his study of the Nairobi Central Business District, points out that the deeper one goes into an urban settlement, the poorer the quality of road infrastructure becomes. Usually, there is no provision of on-street parking lots in such zones and consequently, visitors end up parking in undesignated areas. Furthermore, such zones are characterized by a lack of a mix of land use activities and fewer pedestrians in public space (Hillier, 1988), hence low surveillance to assure safety in the public space environment. This makes visitors lean towards parking their cars close to the home they are visiting irrespective of the damage this causes to greenery (**Figure 2**).

Constitutedness has a direct relationship with the number of pedestrians and motorists in a public space (Alexander et al., 1977; Hillier, 1988; Baran et al., 2008). If a parking lot is provided in such a space (**Figure 3**) and then it is used to capacity, any additional motorist ends up parking in an undesignated area such as grassed surfaces.

FIGURE 2
Undesignated parking on a grassed area of Buru Buru V neighbourhood
Source: Field survey 2019

FIGURE 3
An on-street communal parking lot at Buru Buru V neighbourood
Source: Field survey 2019

Since constitutedness has power to promote a sense of security in public space (Jacobs, 1961; Hillier, 1988), we cannot afford to get rid of it so as to save grassed areas from destructive effects of undesignated parking. The challenge to neighbourhood planning, therefore, lies in balancing between promoting constitutedness and protecting the quality of grassed areas.

An increase in building setback, in particular where the plot line is not defined by a perimeter fence, simply passes a message that motorists are invited to park their cars at the frontage of the building. A substantial portion of this space is covered with grass and when it is used for parking, the grass ends up being destroyed. This means that if nature is to be protected from the damaging effect of undesignated on-street 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.

Moirongo (2011), points out that the farther the buildings are from the edge of the road, the more the vehicles dominate the space. The increase in traffic volume in the space, besides posing a security risk to pedestrians, is visually disturbing thus robbing residents of the much needed livable environment.

Outdoor lighting fixtures, alleyways making a junction with the space, sidewalks and chemists, are features that attract motorists looking for parking space. This study realizes that motorists want to park their cars in areas that are safe, well-lit and benefitting from public surveillance. Unfortunately, when designated parking lots in such areas are full, motorists park on the adjacent grassed areas. Whereas these public space features and activity magnets are important in engendering humanized environments, it is evident that they contribute to destruction of greenery.

Boundary height has an inverse relationship with density of parking in grassed areas. This implies that as boundary height increases, surveillance of public space from the building or plot goes down and the density of parking in such an area decreases. The finding reinforces the fact that motorists want to park where they are sure of car safety which, in this case, is a function of visual surveillance. Further, this finding is consistent with the stipulation of the Building Code of the Republic of Kenya which requires the height of boundary walls of residential properties not to exceed 1.35 metres:

Boundary walls, screen walls, fences or other means of enclosure of residential plots shall not be erected to a greater height than 4ft. 6 in. where abutting on to a street or in front of the building line of the main building, or 6ft. in any other case (ROK, 1968).

The case of a higher frequency of buildings with setbacks resulting in a lower density of parking on grassed areas is that of fenced and gated buildings. These buildings have been removed from the edge of the public space by some distance but, because of perimeter fences, motorists cannot access the front spaces for parking. The only other available alternative for them is to park along the carriageway.

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 this minimizes undesignated parking. 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 consistent with findings by Baran et al. (2008), which show that residential streets with higher connectivity and control exhibit more walking behaviour. Such high control spaces are characterized with a mix of activities that pull motorists to park close to them rather than on the adjacent grassed areas. A motorist's preference to park in areas that benefit from surveillance also explains why there is a high tendency to park on sidewalks, alleyways and outside chemists.

Variables explaining undesignated parking on carriageway

Adjacency and permeability refers to the constitutedness property of public space. Relative depth of axial space is a syntactic property 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 indicating space which tends to be segregated from the system (Hillier and Hanson, 1984). Spaces that are shallower in the settlement have a higher measure of integration whereas deeper spaces with their higher relative depth values are more segregating in the settlement layout system (Hillier, 1988). 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 have a high encounter rate of people and low burglary rates. Shallower spaces are thus safer environments to operate in as opposed to deeper spaces in a residential neighbourhood. The research establishes that the level of vehicular activity in segregated spaces is much lower than in shallower spaces. Usually, segregated spaces are not accorded priority in infrastructure upgrading programmes of the city authority (Moirongo, 2011). The few motorists who find themselves in segregated spaces do not mind parking on the carriageway. In this regard then, the more segregated a space is, the higher the density of parking on carriageways.

For a residential building with a setback and whose boundary is defined by a fence, parking at the building's front space is not available to any motorist in the public space. It therefore means that the higher the number of such buildings with boundary fences, the higher the density of parking on the carriageway. An increase in the frequency of vehicular road intersections in the space has the impact of creating more permeability, higher control in the space and 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.

Building storey height has an inverse relationship with undesignated parking on the carriageway. This is because when population density in a given zone of public space is increased through provision of multi-storeyed residential buildings, there is increased surveillance and defense of the public space by residents of the adjacent buildings. The residents lay a collective claim to the space and endeavor to get rid of any environmental behaviour that deprives them of convenience in space use. There is also the tendency for owners of such buildings to engage services of security guards who ensure safety in the environment and that motorists do not park in undesignated areas of the adjacent public space. This implies that the multi storey dimension in residential neighbourhood planning is not bad as it helps control the menace of undesignated parking along road carriageways. Besides this, increasing the density of urban areas is a key strategy for accommodating population growth, enhancing community livability and addressing sustainability concerns through minimizing automobile reliance (Buys and Miller, 2012).

CONCLUSION

This paper has established that undesignated on-street parking is most pronounced in middle income residential neighbourhoods partly due to inadequate provision of parking spaces. Further, it has demonstrated that various neighbourhood public space characteristics, such as depth from *Y* space, constitutedness, building setbacks, boundary height, frequency of road intersections with space and presence of lighting fixtures, alleyways, sidewalks and chemists significantly explain undesignated parking on grassed areas in public spaces of Nairobi's residential neighbourhoods. On the other hand, constitutedness, relative depth of space, density of buildings with setbacks, frequency of vehicular road intersections, and building storey height are some of the public space characteristics that significantly explain undesignated parking along road carriageways of the city's residential neighbourhoods. Failure to consider these characteristics in layout of residential neighbourhoods in the city is thus a significant factor explaining the problem of undesignated on-street parking and a threat to environmental sustainability of the public space system. This is evidenced in the remarkable break-up of the public space system which results in segregated and unconstituted spaces which motorists keep away from for fear of safety of their vehicles. Spaces characterised with constitutedness and a higher degree of integration have a diverse mix of activities that attract both pedestrians and motorists. However, parking lots in such zones get full so fast that motorists end up parking in undesignated on-street areas.

RECOMMENDATIONS

By focusing on undesignated on-street parking in residential neighbourhoods of Nairobi, this research seeks to contribute to the international debate on sustainable cities and communities. It identifies key public space characteristics that have an influence on undesignated on-street parking. Findings of the study are a useful reference in informing policy and practice in residential neighbourhood planning and design for environmentally sustainable public space environments.

In order to realize sustainable public space environments, where vehicles are not parked in undesignated on-street areas, this study roots for several areas of action. One, there should be adequate provision of on-street parking in Nairobi's residential neighbourhoods. Relatively, middle income residential neighbourhoods should be provided with more on-street parking lots than high- and low-income neighbourhoods.

Two, residential neighbourhood layout should be guided by insights emanating from application of space syntax in the study of public space. In this regard, residential neighbourhood layout should avoid remarkable break-up as this leads to segregated spaces. Such spaces are usually neglected by the city authorities in provision of public space services such as maintenance of roads and street lighting infrastructure.

Three, greenery and sidewalks in residential neighbourhoods should be protected from damage by vehicles by ensuring that the kerb separating them from the carriageway is high enough to deter vehicles from mounting over. In this regard, a kerb height of 450 millimetres is adequate (Moirongo, 2011).

Four, provide small parking lots that are fairly well distributed in the entire settlement while ensuring their adequacy to meet demand. This is because large parking lots tend to 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. A useful guide to this is ensuring that no more that 9 percent of a land parcel being developed into a settlement is given to parking and that parking lots are spaced at least 30 metres apart (Alexander et al., 1977).

Five, residential neighbourhood planning should provide a rich mix of land use activities fairly well distributed in the settlement. This ensures that deeper spaces of the neighbourhood do not suffer neglect from city authorities and that public spaces are safe as a result of increased human presence in the spatial system.

Six, guard against enclosure in residential neighbourhood planning. This should be achieved by ensuring that buildings have provisions for visual connection with the adjacent public space environment. Plot boundaries, in particular, should not be of a solid wall but of materials and designs that permit visual surveillance of the public space system. However, given that constitutedness promotes undesignated on-street parking and yet we cannot afford to ignore it, residential neighbourhood planning should provide adequate parking lots. It should also safeguard the environmentally vulnerable grassed areas by use of structural methods such as kerbs.

Seven, an increase in population density in residential neighbourhoods, achieved through development of multi-storey residential buildings, should be encouraged as it minimizes undesignated parking along road carriageways. This should be actualized while at the same time providing each of the multi-storey buildings with ample outdoor environments to accommodate specific ground level outdoor space needs of residents. However, in concurrence with Buys and Miller (2012), there is need for further research on the extent to which residents perceive high-density residence and locality to be suitable for raising children.

Lastly, there is need to interrogate the concept of building setback in residential neighbourhoods where buildings do not have a fence defining spatial extents of the plot they occupy. Such buildings should have their front yards defined by a fence that allows visual surveillance of the public space system. Otherwise, there should be no building setback as it promotes undesignated on-street parking.

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