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Research Paper

Modelling Feasibility Scenarios for Achieving Public Space Standards in Nairobi's Informal Settlements under the 2030 Sustainable Development Framework

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Abstract

As the midpoint of the 2030 Sustainable Development Agenda nears, inclusive provision of public spaces in all urban neighbourhoods for all has become crucial. This study examines the progress towards delivering vital public spaces, namely streets, open spaces, and public markets in Nairobi's informal settlements, as a sustainable urbanism indicator. Based on the theories of sustainable development and sustainable urbanism, it uses a descriptive approach, relying on primary and secondary data from interviews with 17 key informants, questionnaires issued to 370 residents and street vendors, mapping of streets, markets, and open spaces using ArcGIS and Google Earth, and mathematical modelling to examine and describe local dynamics in Kayole Informal Settlement against public space prudential guidelines in global policy. Through the findings of this study that were cleaned, analyzed using SPSS, Excel, computations, and validated, the paper recommends alternative synergistic adjustments to policies, programs, and interactions to sustainably deliver functional public spaces, eradicate, and manage risks.

Keywords: Urban poverty; Urban Informality; Public Spaces; Sustainable Urbanism; The 2030 Sustainable Development Agenda.

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1. Introduction

The United Nations (UN) defines a city as a growing continuum, starting from neighbourhoods to broader urban and regional scales. These cities feature key building blocks namely; unique "form, distribution, proximity, diversity, intensity and connectivity" of buildings. Additionally, their neighbourhoods are relatively permanent, highly organized and geographically localized with distinctive economic, social and functional attributes. They reflect national visions and governance culture (UN-Habitat, 2015; UN-Habitat, 2023), and aim to offer improved quality of life for their occupiers. When not well planned and governed, however, these neighbourhoods become chaotic, holistically resulting in disorderly cities, regions, nations, continents and the world. This can, however, be overcome through deliberate efforts that commit to designing, establishing and maintaining urban spaces characterized by vibrance, fun, safety, compactness, integration, walkability, inclusivity, affordability, resilience and sustainability, whether undergoing emergencies or surviving extremely resource-deprived phases, cumulatively leading to more fulfilling lived experiences for their residents (UN-Habitat , 2023; Rud, 2020).

Among the main means for meeting the above benchmarks is the design, development, maintenance and sustained provision of public spaces for all, including in cities of the global south (Rud, 2020; UN, 2017) and their poor residents and neighbourhoods. These spaces should be free, open, accessible and usable to the general public without any discrimination. They include (i) streets (namely urban vehicular, cycling and pedestrian thoroughfares such as boulevards, avenues, plazas, pavements, squares, passages, galleries, bicycle paths, sidewalks, tramways, traffic islands and roundabouts); (ii) open public spaces (undeveloped beautiful and green recreational areas like parks, playgrounds, gardens, waterfronts, riverbanks and public benches that provide open contact with nature, art, culture etc.); and (iii) public facilities like municipal markets, libraries, community centres and public halls (UN-Habitat, 2018; Saferspaces, 2023; Moreno et al, 2021). The open space requirements are covered in policy instruments such as the SDGs (11.7) as detailed in Table 1 below. Specifically, SDG 11.7 calls for the provision of "universal access to safe, inclusive and accessible, green and public spaces, particularly for women and children, older persons and persons with disabilities." A similar evocation is made by the New Urban Agenda (NUA) which appeals to governments (national and local) and the international development community to "promote, provide and protect safe, accessible and green public spaces". Like the NUA, the 2015 Sendai Framework for Disaster Risk Reduction, the 2015 Global Public Space Toolkit and the UN's City-Wide Public Space Strategies Guidebook for City Leaders (2020), all demand for investment in well-planned, ideal, resilient and strategic public spaces as detailed under the Rio +20 framework (Rud, 2020; UN-Habitat, 2019).

Table 1. Recommended Land and space distribution framework for cities (Source: UN-Habitat)

S/ No	Feature	Required Dimensions
i.	Public Spaces	50%
ii.	Streets and sidewalks	30-35%
iii.	Open (green) Spaces	15-20%
iv.	Floor space allocated for commercial use	40% of the ground floor of all buildings
v.	Single-function land (block) use	10% or less
vi.	Residential space reserved for affordable housing	20-50%
vii.	Proposed population density	15,000 people/km² or more
viii.	Road (street) coverage	18km /km² or more
ix.	Street Intersections for Efficient Street Connectivity	100/km² or more
x.	Average walking speed	4.83kms/hour
xi.	Location of basic facilities like markets (compact/15-minute cities principle)	0.4 to 1.2kms radius
xii.	Location of open public spaces	within a 400 metres radius
xiii.	Streets	Mandatory line of trees for city greening
xiv.	Overriding attributes (philosophies) of public spaces	Cost-effectiveness, safety and resilience, connectivity, inclusivity, greenness, sustainability, accessibility

Whereas reviewed literature acknowledges the utility of public spaces and their detailed design considerations in various cities (Serre et al, 2018; Prashar et al, 2023; Khateeb & Shawket, 2022; Okech & Nyadera, 2022), the quantification of their space use as a percentage of available urban space, their classification for meeting recommended standards under the UN framework, and utility in meeting needs has largely not been reported. This study endeavors to address this gap in Kayole Informal Settlement as a case. The study has picked the UN-recommended standards as a benchmark due to their universal relevance in offering standards and filling policy gaps in places where such policies are non-existent, especially in developing economies. Having selected them, we note that the SDGs and NUA already have almost half-spent lifespans respectively. This makes it important to document the progress being made by cities such as Nairobi, the challenges they are facing in their effort to achieve full compliance with it and highlight existing opportunities that can be exploited to ensure the meeting of targets and delivery of liveable urban spaces for all.

The benchmarks build on a longstanding effort (Khateeb & Shawket, 2022) right from the bi-decennial Habitats I (1976), II (1996) and now III (2026). Before them, in 1933, Le Corbusier developed the Athens Charter for the Restoration of Historic Monuments and exhibited his concepts for The Ideal City which suggested the introduction of social reforms through urban design and proposed the creation of great (ideal) city neighborhoods (See Figure 1) that feature abundant green spaces. This was largely ignored due to changes such as increased dependence on automobiles (from the mid-20th Century) that made the need for public spaces peripheral as urban mobility required less walking. Moreover, there emerged a realization that all urban public goods (including land) have commercial value, and privatizing public spaces could shore up financial deficits (Rud, 2020).

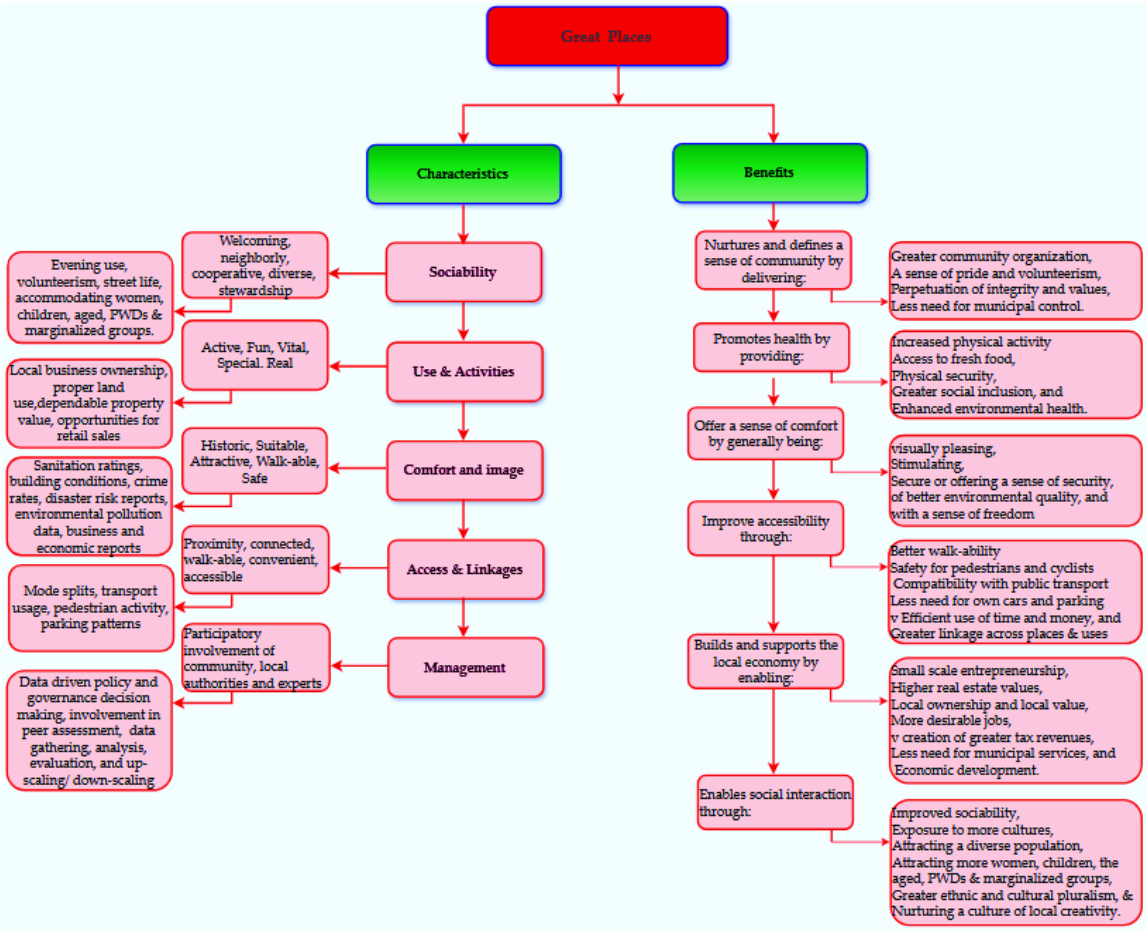


Figure 1. *Characteristics and benefits of great places. Adapted from (Saferspaces, 2023) and* (Harrouk, 2020).

With increasing agitations for climate change action and sustainable development, the significance of public spaces, compactness, biophilia, walkability, public health and having properly planned cities in promoting social, economic and environmental sustainability is fast regaining currency in both research, policy and public administration. For instance, today, in line with Le Corbusier's ideals, endorsements and

investments lean towards building function-based compact (Talbot, 2019) or comprehensive 15-minute cities featuring high-rise modern residential apartment blocks that are constructed along transportation routes, have both private and public amenities, and are characterized by wide spacing to allow construction of large green parks, walkways and cycling tracks (Moreno et al, 2021; Khateeb & Shawket, 2022; Abdelfattah et al, 2020; UN-Habitat, 2016). Such great places are a catalyst for the polluting nature of built-up urban ecosystems. They neutralize the environmental, physical, psychological and health challenges and impacts associated with living in and navigating cities and should feature prominently across every city's landscape (Rud, 2020; Moreno et al, 2021; UN-Habitat, 2016).

By and large, informal settlements and associated trade practices serve the same functions as compact neighbourhoods in the global south, but tend to segregate and concentrate the urban poor in resource-deprived and poorly planned localities and livelihoods (Gorvett, 2019; Peimani & Kamalipour, 2022; Das & Susantono, 2022). Like the compact neighbourhoods, their socio-economic practices also make places where living, working, entertainment and consumption coexist (Odongo et al, 2024a), albeit with no guarantees of safety that one would expect in a standard formal community (Malefakis, 2019). The settlements feature and endure the brunt of the key challenges of urbanization the most. Such include environmental damage (through poor waste management practices, GHG emissions, other forms of pollution and replacement of natural ecosystems by poorly planned and disaster-prone concrete juggles as happens in Nairobi (Odongo et al, 2024a; Odongo et al, 2024b). Additionally, they have among the highest incidences of disease; including the threat of epidemics and pandemics occasioned by poor feeding, exercising, consumption, living, sexual, sanitation and hygiene habits, and limited access to civic amenities. This links closely to their high mortality rates that mostly affect infants, expectant women and the aged that are exceptionally exposed to pathogens and lack of socio-economic safety nets (Gorvett, 2019; Zerbo et al, 2020). This adds to the intrinsic prevalence of social and economic exclusion of these populations, resulting in poverty, inequality, marginalization and discrimination. Consequently, the settlements feature extreme lapses in human security, featuring high crime rates, labour exploitations, sexual, psychological and physical abuses, prevalence of various forms of violence, high poverty indices, illegal trade practices exposing them to consumption of substandard, contaminated or expired goods, and trade in illegal substances. These can together contribute to the likely perpetuation of poverty among residents across their generations due to limited opportunities for socio-economic advancement.

Investing in adequate public spaces in informal settlements and their attendant informal economies through upgrade programmes to ameliorate the urban poor (mostly the most deserving vulnerable population of women, children, youth, aged, disabled persons, and other special interest populations) from their wanton lifestyles is hence key as acknowledged by both SDG11 and NUA. Through sound investment in public spaces, it is envisioned that these settlements will, in addition to bettering indices on the above indicators, experience increased property value, and attract investment in private property development and local commerce, consequently increasing opportunities for better livelihoods and enhancing local development for the communities inhabiting them, ultimately formalizing them. Additional benefits of such upgrades from investment in public spaces include nourishment of local culture, history and architecture for both local hard and soft scapes, enhanced social and cultural interaction, attraction of diverse populations and creativities, better human and environmental health, improved mobility and inclusion for vulnerable groups (whether traders or residents). Formalization also creates reliable standards, strategic, creative and tactically sound city ecosystems (Wyckoff, 2014; Moreira, 2021) devoid of hazards like floods, accidents, crime, sexual abuses, exposure to drugs, human trafficking, robberies and enslavement by criminal elements (UN-Habitat, 2018; Odongo et al, 2024a) and cross-generational perpetuation of urban poverty hence permitting authentic living experiences.

The public spaces can also help develop a stronger bond between the people and their place, turning them into sustainable neighbourhoods, a condiment that is urgently required in cities in emerging economies (especially in Sub-Saharan Africa and the Global South). Ongoing efforts towards this end should be investigated, documented, reported, critiqued and improved for peer learning and sustainability. However, they have not elicited academic research, scrutiny, reporting and debate regarding their feasibility for measuring or improving the liveability of neighbourhoods in long-established informal settlements that feature private land ownership as applies to Kayole in Nairobi. They require investigating, documenting, acknowledging and addressing to bolster investment towards building standard public spaces, formalizing neighborhoods and delivering socioeconomic, environmental and

ergonomic sustainability. That is done within the study area in this paper. Ultimately, discussions and recommendations in it aim to improve public health, reduce disaster risks, enhance human security and liveability of these settlements, hasten slum and informal settlement upgrades in line with sustainability principles espoused in the SDGs and NUA, offer a better quality of life for the urban poor, enhance their access to space justice, and ultimately, inspire further research and investment into the provision of public spaces for poor urban neighbourhoods of the global South, specifically, those in Sub-Saharan African Cities where informality and urban poverty are most prevalent (UN, 2019), but where trends in public space development are under-researched.

2. Theoretical Framework

This study is founded on sustainable development and sustainable urbanism theories. Sustainable development theory is based on the principle that development undertakings should allow the meeting of needs by current generations without denying future generations the ability to do so (UN, 1987; YouMatter, 2020; Odongo, 2017). The theory addresses access to resources justice both at intergenerational and intragenerational levels (Odongo, 2017; Shi et al, 2019) In ideal sustainable development; rural or urban, the goals must logically justify the means (UN, 2018). Informality and associated practices such as injustice, crime, haphazard dumping, grabbing of reserved lands and environmental pollution as witnessed in Kayole and shown through data in Figures 2, and Figures 4-8 work against sustainability.

Linked to this principle is the theory of sustainable urbanism which insists on the development of ''safe, walkable and transit-served urbanism integrated with high-performance buildings and high-performance infrastructure.'' This entails the integration of sustainability and resilience principles into the design, planning, construction and governance (administration) of cities. It adopts compactness and biophilia as the key values that should guide sustainable urbanism but also insist on the development of sustainable practices in some thematic areas of urban living. These include urban public spaces, housing, commerce, transport, energy, air quality, solid waste management, walkability, and disaster averseness. Roggema (2016) states that achieving these requires the establishment of cities that continually plan and effectively govern their affairs. Consequently, cities should sustainably adopt data and technology-driven decisions and solutions to meet the needs of current and future urban dwellers (Roggema, 2016; Bibri, 2020). In Kayole, as shown in descriptions, diagrams and quantitative findings (again, see Figure 2, and Figures 4-8), there exists practises that limit the realization of sustainable urbanism, but which are mitigated through our recommendations.

3. Methods

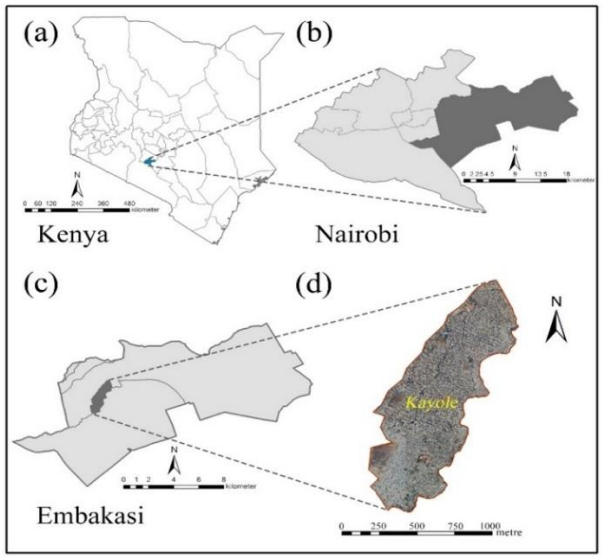
The paper is a product of an applied descriptive study that we conducted in Nairobi between May 2020 and January 2023. It tests the application of theorized best practices in sustainable urbanism, and recommend interventions to improve governance. The study employed a mixed method to investigate its phenomena wherein both qualitative and quantitative data were collected from residents, traders and key informants, and relied upon to compile comprehensive findings against a set-theoretical base as recommended by Tegan (2023), McGough (2022) and Odongo & Ma (2021). The researchers relied on both primary and secondary data that was collected through observation, mapwork (using ArcMap and Google Earth Pro to take measurements or digitize images), computations employing Microsoft Word Equations, Key Informant Interviews (17 purposively sampled respondents including local government officials, NGO/CBO stakeholders and solid waste management sector workers), issuance of structured questionnaires to randomly sampled residents (189 respondents) and informal traders (181 respondents) as shown in Appendix 3, and literature review. To determine the actual sample size of the respondents among vendors and residents, the study adopted a 95% confidence level and a 5% margin of error. Other phenomena such as infrastructure, trade, solid waste, drainage and governance practices were observed in situ and recorded in photographs for use in gauging sustainability of infrastructure establishment and use regimes in offering basic public spaces. SPSS and Microsoft Excel were used to analyze the primary data from interviews, KIIs and observations. Data cleaning, qualitative responses, taking physical measurements, observations, accuracy and consistency checks, and measures of the distribution of responses were used to confirm the validity of responses

4. Results and Discussions

4.1. The Local Context

The emergence of informal settlements and trade in Nairobi is largely attributed to colonial legacy. Wanjiru-Mwita (2021) reports that pre-independence segregation policies (colour bars) restricted blacks from residing in upmarket neighbourhoods or holding certain positions. The racial discrimination of the era birthed and entrenched informality that has refused to go away, instead increasing with sprawl in, spread, proportions and complexity over the years (UN, 2017; Otieno, 2021; Muendo, 2017). A good illustration of this would be a brief description of Kayole informal settlement, formerly, Embakasi Ranch. Kayole is located in Embakasi Division, spreading across Embakasi Central and Embakasi East Constituencies (Maroko,2016). It is bound within an area marked by geographical coordinates -1.259435°,36.923206° to the North, -1.264531°,36.925400° to the East, -1.292652°,36.911380° to the South and -1.289268°,36.906826° to the West. Embakasi Central, hosts Kayole North, Kayole Central and Kayole South Wards with populations of 118,728 people, 42,134 people and 76,594 people respectively. At the same time, Embakasi East is home to Lower Savanna Ward with a population of 70,959. The cumulative population of 308,415 people is spread across an area of approximately four-square kilometres with a proximate population density averaging 77,104 people per square kilometre, which is five times the UN-recommended minimum population density in cities of 15,000 people/km² (KNBS, 2019). See Figure 2 below for (a) a boundary map for Kenya's Counties including Nairobi, (b) a boundary map for Nairobi's Sub-Counties including Embakasi, (c) a map showing the location of Kayole in Embakasi and (d) density images of Kayole.

Started in 1975 (Kinyanjui, 2020), the settlement originally hosted low-income earners (mostly in informal sectors) relocated from the city's CBD and its neighbourhoods (World Bank, 2020a). Today, Kayole largely provides low-cost casual and artisan labour for Nairobi's industries, businesses, homes and construction sites. Furthermore, the slum hosts many refugees from the Great Lakes Countries of Congo DRC, Burundi, South Sudan and Rwanda (Kahenya, 2023). Its population is largely semi-illiterate and is physically confined by natural and man-made barriers that limit its geographical expansion. These include Kayole Junction-Quarry Road, the Ngong River, Kayole Spine Road, Jacaranda Estate and Edelvale Schools. Here, monthly rents are also relatively low. Single rooms with shared ablution facilities approximately cost 30-50 USD, bed-sitters 40-60 USD, one-bedroomed houses 50-100 USD while a two-bedroomed house cost upwards of 90 USD based on online advertisement statistics in 2022. Kayole's landowners do not have title deeds but possess allotment letters to confirm plot ownership. Sampled findings on various aspects of public space management in the area are annexed in Appendix 1.



Figiure 2. *(a) Boundary Map for Kenya's Counties including Nairobi, (b) Boundary Map for Nairobi's Sub-Counties including Embakasi, (c) Map showing the Location of Kayole in Embakasi and (d) density images of Kayole*

4.2. Determining Existing Public Spaces, Gaps and Mitigations by Segment

a) Streets

The Kenya Roads Board (KRB)[1] has provided maps for the roads in Kayole as of 2018 (KRB , 2020). Whereas KRB determined the length of these roads, their widths are not provided making it hard to calculate their area using state data. Based on our modelling and computations using both Google Earth and ArcGIS (See Figure 3), we established that cumulatively, the streets in Kayole are approximately 80kms in length (∑SL) with a total street area (∑SA) (carpeted or earth) of 0.664581 km^2. Noting that the build area under investigation (∑BA) covers 4km^2, and applying the UN-Habitat (Serre et al, 2018) formulae for calculating the length and area of open streets per square kilometers, the following measurements were obtained:

$$\sum \mathrm{SL}/Km^2 = \frac{(Lotal\ Length\ of\ open\ street)}{(Total\ area\ of\ the\ neighborhood)} = \frac{80Km}{4Km^2} = 20KM/Km^2 \quad \ldots\ldots 1$$

$$\sum \mathrm{SA}/Km^2 = \frac{(Lotal\ area\ of\ open\ street)}{(Total\ area\ of\ the\ neighborhood)} = \frac{(0.664581)Km^2}{(4)Km^2} =$$

$$0.166145Km^2/Km^2 \quad \ldots\ldots 2$$

If the above street area were to be calculated as a percentage of the total built-up area (∑BA), the result would be as shown in the equation below:

$$\sum SA\ as\ \%\ of\ \sum \mathrm{BA} = \frac{(Lotal\ area\ of\ open\ street)\times 100}{(Total\ area\ of\ the\ neighborhood)} = \frac{(0.664581Km^2)\times 100}{(4Km^2)} =$$

$$16.614525\% \quad \ldots\ldots 3$$

From equations i-ii above, we can conclude that the roads and sidewalks exist at approximately 20km/ km^2 exceeding the UN-Habitat baseline of 18Km/Km^2 shown in Table 1 (Serre et al, 2018). This is a significant (686.7%) improvement compared to 2007 when a Road Network Inventory[2] showed that Kayole only had 11.65 km of roads. In 2018, another inventory was undertaken by the Kenya Roads Board (KRB , 2020) in which, although the cumulative length of roads in the area was not provided, most of the roads were reported as being new. A majority of both the new and previously existing roads were however reported to be in poor condition[3]. Furthermore, other than the National Trunk Road (Kayole Spine Road) and a few secondary (Class D) roads, the rest of the streets lacked clear classifications using the Kenyan[4] and UN-Habitat criteria (See Table 2). Most roads were merely classified as being new despite having existed for over a decade as seen in historical Google Earth maps, pointing to delays in updating street databases or classifying roads by the roads board as required to determine exact street needs. For this study, however, we will classify the streets based on the researchers' local knowledge and the general state definition of streets by classes (See Figure 3) to facilitate modelling of the impact of likely standardized street development.

Table 2. Categories of Roads as Identified by UN-Habitat (2016)

CATEGORY	FUNCTION	RESERVE WIDTH	SPACING	EXISTING LENGTH IN KAYOLE (KM)
Major Road	Arterial Distributor	100-150 ft	1500-2000 ft	0
Major Road	Secondary Distributor	80-100 ft	1000-1500 ft	3.1Km of Class B & 2.4Km of Class C

[1] The data is available at the Kenya Roads Board Roads Register.

[2] Contained in the *Kenya Roads Act No.2 of 2007*

[3] Chek the Kenya Roads Board Roads Register.

[4] Data Posted by Kenya Rural Roads Authority at: https://www.kerra.go.ke/index.php/kerra-regions/14-faqs/42-3-how-are-roads-categorized

CATEGORY	FUNCTION	RESERVE WIDTH	SPACING	EXISTING LENGTH IN KAYOLE (KM)
Minor Road	Local Distributor	60-70 ft	300-1000 ft	11Km of Class D
Local Street	Access Road	40-60 ft	At building blocks	63.4Km of Class E
Pedestrian/Cycle	Access Road	10-18 ft	Not provided	Non-existent

Going by the approximate area covered by streets in Kayole as obtained from the digitization of maps, we derived the average street width herein as shown in Equation iv:

Assuming that $\frac{(Length\ of\ streets\ (\sum SL) \times mean\ width(\bar{x}sw))}{(Area\ of\ Built-up\ land\ mass\ (\sum BA\ )} \times 100 = Percentage\ of\ land\ in\ streets\ (\sum SA\%)$

Where $\sum SL = 80000 menters\ (\mathrm{m}), \sum A_t = 4Km^2\ (4{,}000{,}000m^2)$ and the percentage is 16.61%,

$\bar{x}w = \frac{(\sum BA \times \sum SA\%)}{(\sum SL)} = \left(\frac{4000000 \times 61.61}{80000 \times 100}\right) m$ =8.3072625 Metres (or 27.25ft)……4

The street area shown in Equation iv does not account for the inexistent pedestrian and cycling lanes as also demonstrated in Figures 3 and 4. Evidently, without increasing street length (which we recommend), it would be necessary to expand the streets' width. We acknowledge the varying street traffic with their classification as described in Table 2 above. However, while the UN-Habitat recommends these widths for various road types, the researchers noted a general lack of recent standardized proportions by length for specific road types as a percentage of the total city road network. (Meijer et al, 2018);(Wanza, 2023) reported findings in the Global Road Inventory Project (GRIP) that used 2015 global road network data according to which 14.93% of roads worldwide were major (consisting of highways and primary roads), 22.57% secondary, 39.52% tertiary and 22.98% were local. The data merely reports findings across road types globally without addressing whether the proportions are adequate for address all urban street needs. Furthermore, it does not set standards for proportions (percentages) of road types in densely populated areas, or acknowledge the absence or insignificance of certain street classes in some areas. This is a gap, which also exists in reviewed UN-Habitat policy guidelines and other previous literature needs filling.

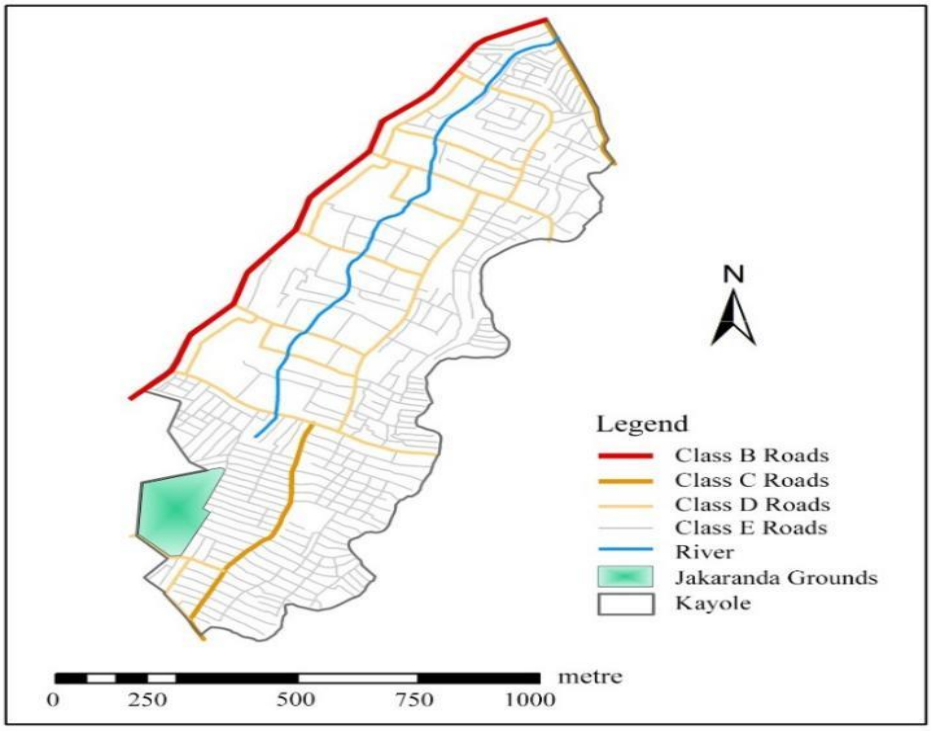


Figure 3. Kayole's Road Network.

As earlier noted, the existing streets in Kayole make up 0.66458km2 in density amounting to 16.61% of the built area against the recommended 30-35%. It means that the area has many street reserves (paved or not) but these are generally thinner than the required standards in Table 2. This is partly due to poor initial land segmentation which ignored standard street reserve recommendations, although it is also possible that the slum came before the rules. Additionally, this largely originates from illegal occupation (grabbing, development and/or use) of public infrastructure corridors by private stakeholders, a practice which is very prevalent in Kayole (See Figure 4). Often, streets are paved without first reclaiming such reserves to their full extent in readiness for future expansion. The illegal occupiers consequently develop these plots and illicitly acquire ownership documents for them complicating future reclamation attempts. Today, over 88% of land in Nairobi is not titled (Wanza, 2023; Thiong'o, 2021).

Figure 4. *Vending Stalls and private property extensions on streets and public infrastructure reserves in Kayole*

With increasing human population, human movement by various means, and increasing ranges and intensity of economic activity, the streets experience heavy but still worsening congestion, especially during peak hours and after rainfall. These will worsen unless this is mitigated through investment in alternative transport options such as Bus Rapid Transit (BRT) lines, Electric Light Rail Transit (ELRT) or subway systems. Whereas these have been recommended for other parts of Nairobi before, none has been developed. Their feasibility in Kayole where finances, technical capacity and if applicable, land for their development will have to be acquired has not been determined. Recognizably, even without the above, reclaiming and developing illegally occupied streets and public infrastructure reserves into standardized streets can open up the neighbourhood and enhance navigability and liveability. The

recommended mean width of streets with their prevailing length under the UN-Habitat framework is calculated below. In our calculations, we do not see scenarios where areas will need standalone pedestrian/cycling lanes because car-owning residents will require access to parking spots next to their houses unless this is separately addressed. Aerial maps of the area showed the prevalence of car ownership and parking in residential areas.

$$Where\ total\ streets\ area\ (\sum SA) = 30\%\ of\ the\ developed\ area\ (4Km^2)\ and\ street\ length\ (\sum SL) = 80Km,$$

$$\sum SA = \left(\frac{30}{100}\right) \times 4Km^2 = 1.2Km^2, and\ width\ (w) being\ \left(\frac{\sum SA}{\sum l}\right) = \left(\frac{1.2Km^2}{80km}\right) \times 1000\ metres \approx 15\ Metres \quad \ldots\ldots 5$$

The above mean street width (49.2 feet) is adequate if local access roads (40-60 ft) were the majority and adjustments were made to accommodate a few distributor roads (60-70 ft) as currently prevalent (See Figure 3). However, if the observation by Meijer et al (2018) in GRIP were to be implemented, consequently requiring that secondary and local distributor streets exist at an estimated ratio of 3:2 respectively, the neighbourhood would extremely struggle to fit these streets into the existing designated neighbourhood layout. Note that the recommended average street width of 49.2 feet is almost double the existing mean one shown in Equation IV (27.25ft). Achieving it requires an aggressive but extremely costly land reclamation which, going by the models we developed using the buffer function in ArcMap Figure 5 that covers (a) Class B, (b) Class C, (c) Class D and (d) Class E roads, will result in massive demolition of existing buildings.

Figure 5. Impact of road expansion to required widths across (a) Class B, (b) Class C, (c) Class D and (d) Class E roads as buffered using the required road width for each class

For instance, using Google Earth, we established that on average, every 1Km stretch of a busy street host approximately 60 developed plots on either side of the road making 120 units on both sides. Additionally, most front-row buildings along major paved roads are 2-4 story apartments, each retailing at approximately 150,000 USD going by online apartment block prices in the area. Conservatively, therefore, compensating land owners along a randomly selected 3.4Km stretch of road will cost the government approximately 61,200,000 USD if all the plots along the route were developed. This is before allocating money for building the streets and installing them with recommended open public spaces and facilities. Further calculations can estimate the total cost of such compensation and standard public space development programs for entire settlements, neighborhoods and cities within any jurisdiction. They point to these projects being difficult to realize under such chaotic land ownership and development

control regimes within the remaining 7 years before the SDGs expire, for instance. Furthermore, consequent to the initial poor demarcation of land for public spaces, these new adjustments will transform the neighbourhood immensely requiring the restructuring of land ownership if local livelihoods and investments for property owners and their tenants were to be protected for sustainability purposes.

To illustrate the above, as applies to most roads in Nairobi, the existing roads in Kayole, including the most recent ones constructed through World Bank Financing under the Kenya Informal Settlements Improvement Project (KISIP) from 2011 to 2019 (World Bank, 2020b; World Bank, 2023a) do not have pedestrian and cycling lanes. Furthermore, the project had a resettlement (compensation) plan for stakeholders affected by the project (Republic of Kenya, 2014) that was not fully utilized to foresee and address future space needs. Had this been financed, executed and utilized effectively, such challenges would have been avoided for future street development projects in the same neighbourhood. Currently, the existing roads are barely usable as shown in Figure 2 because they have been taken over by other activities like street vending, parking and bus hailing and the remaining open streets are shared by pedestrians, motorcycle transport operators, grazing animals that rummage through garbage for food, donkey carts and ordinary vehicular traffic. The existing rudimental multimodal transport system is a strain on street infrastructure due to a lack of clearly stated dichotomized street functions for various modes of transport, and public spaces for other activities. The generic width obtained above (at constant street lengths) can guide the repossession of grabbed infrastructure reserves and the construction of local road networks to restore sustainable local movement and achieve SDG target 11.7.1.

Still, provisions must be made for environmentally sustainable and locally appropriate parking for vehicles and bicycles. Under prevailing space constraints, residents may find it hard to park their cars and bikes. Other residents may also find the parked cars and bikes inconveniencing by blocking streets and limiting mobility in line with recommendations by UN-Habitat (2023) causing conflicts. Furthermore, the permeability of streets for flood risk reduction in the wake of perennial flooding in cities and settlements like Nairobi and Kayole should be addressed through integrated street planning, design and development. As practical and feasible as possible, governments should consider interpreting the 2030 Development Agenda as a comprehensive development framework. Consequently, interventions in one aspect (SDG11.7.1 for instance) should find ways of affordably integrating other aspects of sustainability such as reducing disaster risks (e.g., diseases and flooding by investing in garbage management and drainage infrastructure for instance) as espoused in the Sendai Framework and undertaken at Dalmannkai in Hamburg where a comprehensive functional analysis, design and management of urban networks was deemed necessary for flood risk reduction (Serre et al, 2018) and is also recommended by Prashar et al (2023) who acknowledge the utility of engineering, ecological and socioecological tools. Seen this way, no one, place or aspect of sustainability will be left unattended. The prevailing design for drainages resulted in dumping, flooding and diseases.[5]

Furthermore, unlike the haphazard paving of roads with a slap of tarmac to get rid of dust and mud, ecological connectivity of streets with green spaces complete with seating, resting areas and pocket public parks for neighbourhood recreation activities can reduce space requirements for recreation facilities and should not be ignored. Similarly, consideration can be given to constructing sponge streets with adequate bioswales and similar local facilities that are adapted to combating climate change by absorbing and transforming excess water and heat for other uses to avoid flooding and extreme urban temperatures. Integrating them in initial street design and development is cheaper and should be considered as opposed to adding them later as seems to be the practice in Nairobi (Compare World Bank, 2023a & World Bank, 2023b).

Finally, to ensure that streets play their role in facilitating urban disaster risk reduction (especially for urban flooding and epidemics), the recommended standards for street design should be engrained with designs for drainage and street-based waste management infrastructure with considerations for width, depth, materials used and management criteria in urban neighbourhoods. Such should apply as standard parameters for characterizing and ranking urban streets globally to encourage relevant investment in the global South where if monitoring, evaluation and ranking criteria are not strengthened, adherence to standards and best practices is often ignored as seen in Kayole. UN-Habitat's prudential guidelines on street designs ignore these important condiments.

[5] Check sheet No.5 for our findings here: https://docs.google.com/spreadsheets/d/1i_K0OFBB1khK1tBIoWdfLR-47nbCkevy/edit?usp=drive_link&ouid=115706746267507669517&rtpof=true&sd=true

b) Open public spaces

(Rud, 2020) and (Khateeb & Shawket, 2022) classify open public spaces as either being green, blue or grey, local or neighbourhood (0.04-0.4Ha (located within a 400 metres radius), district or city (0.4-10Ha and serving several neighbourhoods, accessible through various means of transport and accommodating a diverse spectrum of uses and user groups) and national or metropolitan open spaces (50-200Ha and also incorporates natural habitats). Their role in delivering emotional, social, physical, financial and psychological well-being was acknowledged globally during COVID-19 lockdowns (Khateeb & Shawket, 2022). Nairobi generally suffers inadequacy of such spaces and the existing ones are unsafe due to infiltration by criminals (Okech & Nyadera, 2022; World Bank, 2023b; Nyingi, 2020). Kayole (with 308,415 people) being no exception was observed to have only one communal playground; the undeveloped, poorly maintained and overused Jacaranda Grounds whose area is 0.13 km^2 (see Figure 6a & 6b). Moreover, during the most recent election campaigns, presidential candidates promised to build a stadium in it. That would take away the only existing and functional open public space in the neighbourhood. Other than the grounds, the area has two rivers whose total riparian area on both banks as defined in law (NEMA, 2011) was calculated as shown in Equation (vi) below:

$$\sum \mathrm{A}(OPS_r) = (cummulative\ length \times width\ of\ riparian\ river\ bank\ as\ defined\ in\ laws \times 2)$$

$$= \left(\frac{7470 metres \times 30\ metres}{1000000} \times 2\right) = 0.44482 \mathrm{Km}^2 \quad \ldots\ldots 6$$

Figure 6. (a) Kayole's main open public spaces (Jacaranda Grounds and The Ngong River), (b) the neglected Jacaranda Grounds, (c) Active and derelict open cast mines along the Ngong River and (d) Various forms of illegal land occupation along Ngong River.

Whereas these river banks are categorized as public open (green) spaces based on the standard practice in cities that convert them into squares, public parks, walking trails and recreational green areas (UN-Habitat, 2015), these are not useful in that manner in Kayole because (i) they are not developed through greening initiatives; (ii) they are extremely polluted with garbage, dirty water and smell; (iii) some sections of the banks along Ngong River have been converted into active and derelict open cast quarries; and (iv) a good chunk of the banks, especially along the Ngong River, have been grabbed and developed into shanties or converted into dumping zones as shown in Figure 6 (c & d) above and complemented by finding findings in Appendix 1. In some occasions where the banks have not been developed, they are also cordoned off by individuals and gangs and land grabbers that allot themselves the plots for potential future development or sale, hence inaccessible to the public. This abuse is blamed on the conflicting legal basis for defining riparian lands as exists in various instruments namely the Environment Management

and Coordination Act (EMCA) 1999, the Survey Act 299 and the Physical Planning Act 286 (Kiptoo, 2019). They hence don't play their deserving recreational role until reclaimed and customized.

$$\sum SA = \left(\frac{30}{100}\right) \times 4Km^2 = 1.2Km^2, where\ width\ (w) being\ \left(\frac{\sum SA}{\sum l}\right) = \left(\frac{1.2Km^2}{80km}\right) \times 1000\ metres \approx 15\ M \quad \ldots\ldots 7$$

Cumulatively, consequent to the above land use dynamics:

Potential Open Public Space (OPS_p) in Kayole $= (public\ play\ grounds + river\ banks)$

$$= (0.13 + 0.44482)Km^2 = 0.573615Km^2 \quad \ldots\ldots 8$$

Out of this, only the public playground is fully functional. Functional open public space. Therefore, functional (OPS_f) as a percentage of the total potential OPS_p:

$$= \left(\frac{public\ play\ grounds}{Potential\ Open\ green\ space}\right) \times 100 = \left(\frac{0.13Km^2}{0.573615Km^2}\right) \times 100 = 22.66\%\ of\ the\ possible\ area \quad \ldots\ldots 9$$

Using the UN-Habitat recommended formulae for calculating open spaces in equation iii, the percentage of functional and potential open public spaces in the neighbourhood was obtained as shown:

i. Functional open public space as a % of the total built area;

$$= \left(\frac{public\ play\ grounds\ (OPS_f)}{Total\ area\ of\ the\ neighborhood\ (\sum \mathrm{BA})}\right) \times 100 = \left(\frac{0.13Km^2}{4Km^2}\right) \times 100 = 3.25\% \quad \ldots\ldots 10$$

ii. Cumulative potential open space as a % of the total built area;

$$= \left(\frac{Potential\ Open\ green\ space}{(Total\ area\ of\ the\ neighborhood)}\right) \times 100 = \left(\frac{0.573615Km^2}{4Km^2}\right) \times 100 = 14.34\% \quad \ldots\ldots 11$$

Based on the recommendations shown in Table 1, we conclude that merely reclaiming, developing, maintaining and facilitating safe and reliable access to these available open public spaces can push the neighbourhood to almost achieving basic greenness. A minor additional investment in the acquisition and development of land for this purpose within the neighborhoods such as public squares and playgrounds, roadside benches at road street junctions and construction of block-based children's play areas can ensure full compliance and enhance living conditions for the informal neighbourhood, and can accompany any new street developments (Serre et al, 2018; Prashar et al, 2023; Khateeb & Shawket, 2022) as seen in cities like Milan (Okech & Nyadera, 2022). This will significantly improve the quality of the urban living experience here and, together with the other recommendations on accessing public spaces given in this manuscript, lift such areas from informality. Such demonstrates how, with administrative, political and financial commitments, minor investments in implementing already existing policies and land use plans, and consistently maintaining facilities can deliver the desired sustainable urbanism.

Despite the above recommendations, we note the need to ensure proper spacing of buildings to facilitate appropriate urban air circulation. If not done, the public spaces will be overwhelmed by human traffic. They will be the go-to sanctuaries for people living in perditions and want some fresh air. The resulting overuse will eat into their greenness and leave them vegetationless, polluted, and occupied by criminals (muggers, rapists and drug peddlers etc.) (Okech & Nyadera, 2022), cering the population density of informal neighborhoods as reported in Kayole. To deliver this, proper collaboration between plot owners with political support from local and national leaders, followed by an amalgamation of plots and state or secondary investor-financed standard redevelopment can ensure the small plots are

extended and developed in ways that free space for the creation of other amenities such as wider streets, garbage bins, conveniences' highways, private green spaces and urban kitchen gardens which facilitate carbon sequencing.

c) Access to Community Markets

Marketplaces are public spaces which facilitate trade as a component of the urban public infrastructure matrix (Serre et al, 2018). They enable trade in goods and services and the interactions between people. Additionally, if well planned and (participatorily) managed, markets can improve mobility and functioning of neighbourhoods, and lower violence and crime rates. They also avail opportunities for formal and informal economic activities in a clean and user-friendly environment, provide a variety of goods and services, improve household diets and hence enhance public health in informal neighbourhoods by directly linking them to sources of fresh farm products. Furthermore, public markets avail relevant opportunities to diverse users, and open avenues for affordable living by the most marginalized poor who access products easily through the elimination of intermediaries in the supply chain. For the producers and sellers, public urban markets offer opportunities for economic development, especially among the semi-literate women, youth, the elderly, people with disabilities and other marginalized groups who own farms in villages and stalls in community markets; or offer trade-supporting services. The markets hence aligning cities and slums with NUA's conditions need to deliver sustainable urbanism for all (UN, 2017).

The community markets often house informal businesses. In Kenya, in 2015, the informal sector generated 83.6% of all the jobs and contributed 33.8% of the GDP (FKE, 2021). This shows the degree to which the country drowned in informality, but also, the significant role of informal sectors in supporting poverty-alleviating or life-sustaining livelihoods despite their downsides. In Nairobi, the utility of community markets or street vendors where these markets are lacking has been acclaimed. They decentralize access to goods and services that would take people to commercial districts. Through them, neighbourhoods stop being congested and concerns such as heavy human and vehicular traffic are reduced. Because of their accessibility, convenience and low cost of goods, community markets are preferred by a good population of people, including ex-pats, who shop from their informal merchants. Oftentimes, their products are cheaper and fresher, especially if they have direct linkages with rural farms that supply goods faster by avoiding middlemen.

Based on the above, community markets, as public spaces, facilitate the fulfilment of human rights by creating opportunities for economic independence and development by the most vulnerable in society, including women, youth, elderly people, children and PWDs, especially in developing countries like Kenya where over 50% of the workforce is informal (Abdelfattah et al, 2020). Moreover, unlike the purely informal economy which survives on marginal capital, the existence of properly functioning markets can attract investment and improve the quality and range of goods and services available for local consumers. Through this and their peaceful and functional nature, markets, like parks, walkways and other public spaces, can help improve physical and mental health outcomes. Moreover, they limit exposure of urban food products to pathogens by enhancing hygiene and sanitation, inspection and proper handling through structured government-facilitated investment in accompanying infrastructure and training to sellers. Unlike street vending which causes flooding through poor waste management, the markets reduce the risk of myriad urban disasters (floods, accidents, fire and epidemics) when adequately installed with amenities such as water, ablutions, energy (electricity), communication, and proper (participatory) local public and emergency governance.

There is a global call for aggressive investment in legislation, policy, norms and practices that ensure such markets are consciously designed, built, protected, utilized and managed. These undertakings should be conscious of principles of social inclusion, multiculturalism, gender equality, sustainability, enhancement of livelihoods and environmental protection and conservation. This makes waste management key in ensuring markets as public places do not contribute to pollution through poor waste management. By controlling garbage at the source. This way, markets can help with urban greening initiatives (Abdelfattah et al, 2020). However, unlike in streets and open public spaces where the UN recommended the allocation of a specific percentage of total built-up space, there is no standard recommendation regarding how much land should be allocated for markets. Instead, the UN merely states

that 40% of neighbourhood floor space be allocated for commercial use by, for instance, turning the ground floor of all buildings into commercial space.

The above is not viable in all places because in cities like Nairobi, and in informal settlements and slums: (i) most property, apart from public spaces, belong to private developers outside direct government control; (ii) some of this property (buildings) is not storeyed (Example in Kayole as also applies to other Nairobi's slums and informal settlements); (iii) even storey buildings have extensions within the plots that complicate the allocation of space for commerce, (iv) in some cases, the design of storey buildings and layout of streets and plots means that some rental spaces are located deep in the building, blocked from the streets by partitioning and poor ventilation or illumination among other factors, making them unattractive to traders; (v) high illiteracy levels, recklessness, illegal electricity connections, over-densification of illegal structures and retail shops and lack of proper training and awareness creation can increase the frequency and impact of fire and flooding incidences (see Appendix 1); and (v) most buildings have four storeys or less and allocating the ground floors for commerce may result in an oversupply of commercial space.

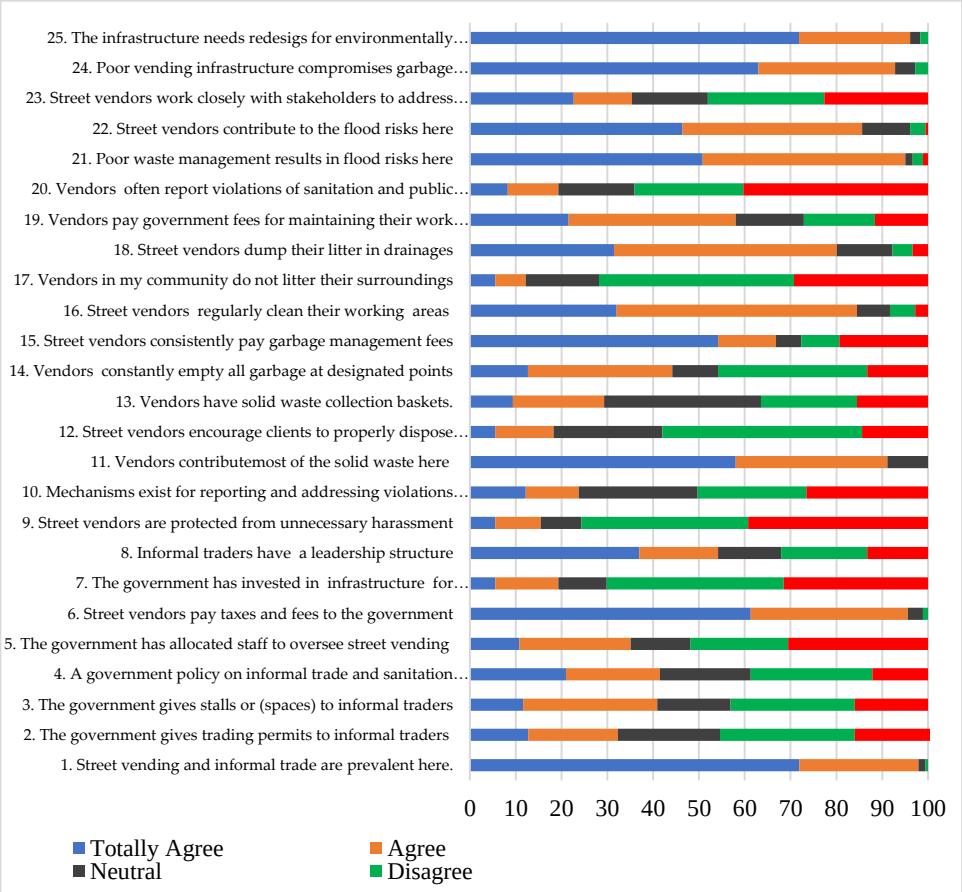


Figure 7. Findings (%) on the various aspects of street vending in Kayole, Nairobi as reported by residents and vendors.

Other than the above, the rents in these neighbourhoods may be prohibitive for the majority of small-scale informal vendors who dominate these streets with stocks worth between 1 to 100 USD at any given time. Resizing the ground floor rooms to fit their budgets and stock may increase risks of fires, pest infestation, and overcrowding, significantly reducing safety, hygiene and sanitation standards. Instead, in Kayole for instance, the traders prefer illegal and unsafe practices as described in Figure 7 above. These practices pollute the surrounding public spaces; limit the usual guarantees on the quality of vended goods and services; are an avenue for evading inspection; taxation, rent, regulations and labor standards and fair-trade practices that characterise the informal economy world over as have previously been acknowledged (UN, 2017; UN, 2018). However, they are preferred by informal traders for reducing operating costs (including initial capital needs, labour costs and taxes), limiting state and local government control over them, and giving them access to cheap supplies due to the limited need to verify product sources and comply with the law in the production and distribution of wares.

We observed that Kayole has only 4 developed public markets (See Figure 8) which cumulatively occupy 0.01615Km^2 (0.404% of the total built-up areas). These cannot meet the daily fresh food supply needs for the population of 308,415 people resulting in the prevalence of street vending in all her streets. Furthermore, some places within the settlement are as far as 1.6Km from the nearest public market against a UN recommendation of 400 metres and are not serviced by pedestrian walkways or cycling lanes. Accessing such on foot or bicycles can be strenuous when carrying loads of shopping. It justifies the prevalence of street vending in the wake of a high population density and unemployment that leads to heightened demand for cheap goods and services. The poorly regulated street vending leads to excessive dumping of solid waste into open public spaces, streets, drainages and rivers, consequently resulting in incidences of poor sanitation-related disease and flooding. This points to lapses in the provision and governance of public spaces resulting in secondary disaster risks.

The practices have been blamed for (i) pollution of the river ecosystems for adjacent rivers, (ii) leakage of plastics into food chains, (iii) emerging urban cattle rearing practices due to the abundance of waste food from food kiosks, affecting navigability of streets and posing risks (Hassell, et al., 2023), and (iv) prevalence of rodents on streets. These frustrate the likelihood of achieving sustainability. They should be countered with strategic investment in proximate community markets.

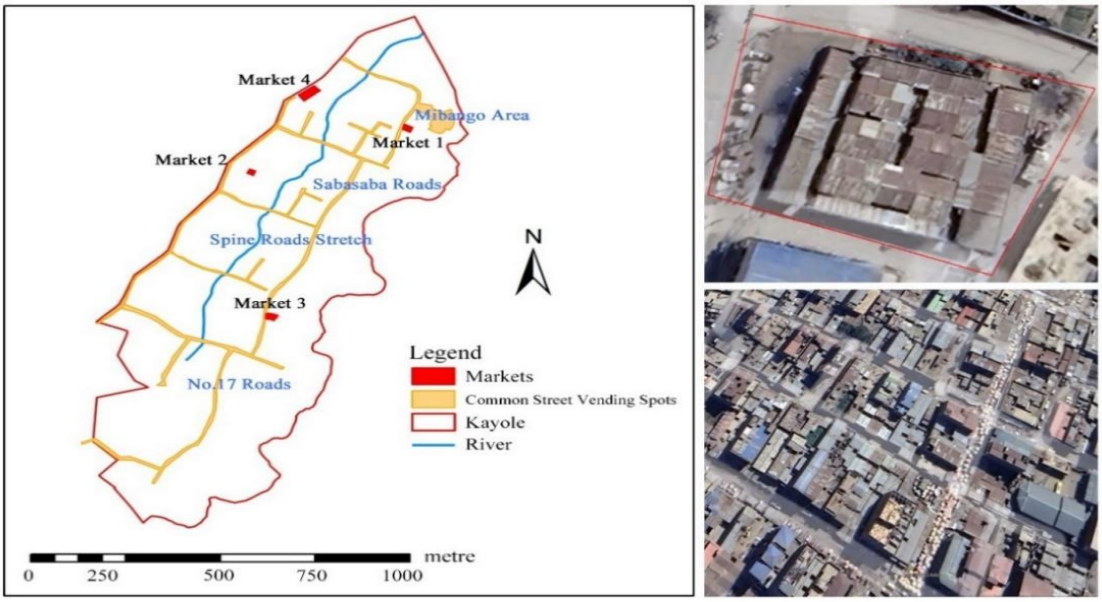


Figure 8. (Right) A Map of Kayole Showing the Location of Markets and Major Vending Hotspots. Top-Left is idle Market 3 while Bottom-Left is a busy informal market 1.3 km away from it on Quarry Road based on Google Earth Images taken on 21st July 2023.

Conclusion

In this study, we have described the prevailing undercurrents regarding the provision of public spaces in Nairobi's urban informal neighbourhoods against underpinning philosophies and frameworks outlined by the sustainable development and sustainable urbanism theories, the UN within SDG11.7, the NUA and UN-Habitat's prudential guidelines. This is in acknowledgement of the unique need to "provide universal access to safe, inclusive and accessible, green and public spaces, particularly for women and children, older persons and persons with disabilities" in marginalised poor urban communities who inhabit and survive in informal settlements and sectors where consistent access to safe spaces is not guaranteed. Consequently, using UN-recommended mathematical formulae, and cognizant of the need to entrench sustainability in urban infrastructure development and lifestyles, we have examined the achievability of outlined public space targets in Kayole informal settlements as a sampled representation of likely space governance undercurrents in Nairobi and other cities located in the global south, and particularly, in Sub-Saharan Africa. We note that even in these supposedly chaotically established and governed settlements, initial land use plans may exist as observed in Kayole that can be used to hasten

the delivery of public spaces, enhance liveability for the marginalised, needy and most deserving urban poor who live in vulnerability enhancing conditions hence leaving no one behind, and facilitate faster elimination of slums and urban informality for their benefit while protecting their existing assets, livelihoods and ecosystems.

As demonstrated in the paper's thematic subsections, realizing this requires deliberate stakeholder commitment and equity that may not be guaranteed in the wake of glaring poverty, violation of laws, underfinancing by governments, private interference and prevalence of urban gang-related grabbing of land reserved for public spaces. A sponsoring framework is developed for Nairobi (See Appendix 2 below) and envisions wholesome stakeholder engagement in the design, financing, development, and day-to-day management of these spaces for sustainability. Otherwise, under the prevailing circumstances, and considering the non-existent, inadequate or ineffective investments in public spaces by governments like that of Nairobi and her partners as illustrated earlier, such cities are running out of time to alleviate poverty, ensure the liveability of all their neighbourhoods within allocated timelines. Provisionally, their scarce finances are repeatedly and haphazardly pumped into half-measure projects. It is our observation that comprehensive public space planning can lower the costs and reduce the time required to fully provide the spaces in these areas, and protect the vulnerable populations and assets of the cities from disaster risks.

Recommendation

In light of the above discussions and alive to the urgency in achieving the 2030 Sustainable Development Agenda targets, we recommend that where most land is privately owned as applies in Nairobi, government-financed-and-led remodeling of the ground floor of selected buildings be undertaken so that they can offer decent accessible retail space for vendors and buyers. These can affordably be let to vendors at subsidized taxes for owners to encourage retailer take-ups and eliminate abuse of streets through illegal vending. Additionally, we find it necessary that vertical zoning of high-rise neighbourhoods be insisted upon to standardize heights of property and deliver compactness, beauty and mixed uses for all. Here, governments should encourage the adoption of green roofing, especially in emerging apartment blocks that are replacing shanty-towns to increase the available green spaces for residents. Additionally, through government support and financing, land owners in each block can amalgamate their tiny plots and develop them into well-planned bigger, taller and more spacious buildings with enough unbuilt space for green areas, kitchen gardens and most significantly, free air circulation. This will prevent perpetual overuse and pollution of open public spaces in densely populated informal neighbourhoods like Kayole.

We find it necessary that governments, through affordable housing and other equity programs, provide cheaper (subsidized) financing for the development of private property, under the criteria provided above, that also allocates space for local formally recognized businesses to provide decent jobs that cater for the social welfare and security of workers and consumers as opposed to street vending where these needs are absent. Such social protection measures include access to life, accident, medical and consumer insurance, product inspections, retirement savings, and membership in unions, and should be mandatorily accepted and facilitated to ensure holistic planning and development for spaces and attendant urban concerns. This is in addition to insisting on the enhanced role of local governments and the local population in planning, development and daily management of public spaces whose use should also be distinctly stated and enforced as outlined in policy. Undeniably, achieving this requires a close working relationship between city and neighborhood stakeholders to adopt/acquire, develop, maintain, and encourage community ownership and use of public spaces under a sustainable stakeholder engagement framework for participatory governance of urban public spaces as recommended by Odongo et al (2024b) and also shown in Appendix 2. The desired change in stakeholder attitudes toward the delivery and sustainable use and perpetual existence of these public spaces can be attained through continuous training, dissemination and knowledge sharing.

Finally, it is our recommendation that already existing informal or private central nodes for urban transport, recreation and trade be acquired, redesigned and developed to effectively play these roles as vibrant acupunctured mixed-use public spaces that serve as community markets, local recreation spots and transport hubs. To achieve ecosystem sanity, street vending can alternatively be made an element of local identity, improved, embraced and planned for in urban designs, or be discouraged for its role in

polluting and damaging public spaces and entrenching ills of corruption, crime, illegal trade practices, environmental pollution through illegal dumping and encroaching onto public spaces. While doing this, we also find it necessary that the provision of public spaces be tied to the need to reduce urban disaster risks such as urban flooding resulting from street design flaws and fires resulting from allocation of commercial spaces in cramped up informal neighbourhoods that fire services cannot access easily.

Limitation

The researchers undertook a spot check in Kayole instead of a city-wide survey and modelling due to financial constraints, noting that this research did not receive any funding. The research however benefits from the lead researcher's decade-long experience living in and researching on the city.

Opportunities for Further Research

Following the discussions presented throughout this paper, the researcher identifies the following themes as requiring further academic inquiry: (i) Comparative studies of trends and opportunities for participatory delivery of public spaces in informal and emerging urban neighborhoods in Nairobi and other Sub-Saharan African Cities, (ii) cost-effective design options for urban streets and open public spaces to deliver ecologically sound safety and ergonomics in already established slums and informal settlements without uprooting lives and livelihoods, and (iii) A study of the impact of street vending and poor solid waste management regimes on sustainable provision of public spaces in Nairobi, Kenya.

Informed Consent Statement and Patient consent statement

Informed consent was received from all human respondents who took part in the study. Moreover, the manuscript did not result from an experiment on living beings including patients. No such consent was therefore required from them as no specimens from any living things were collected and used.

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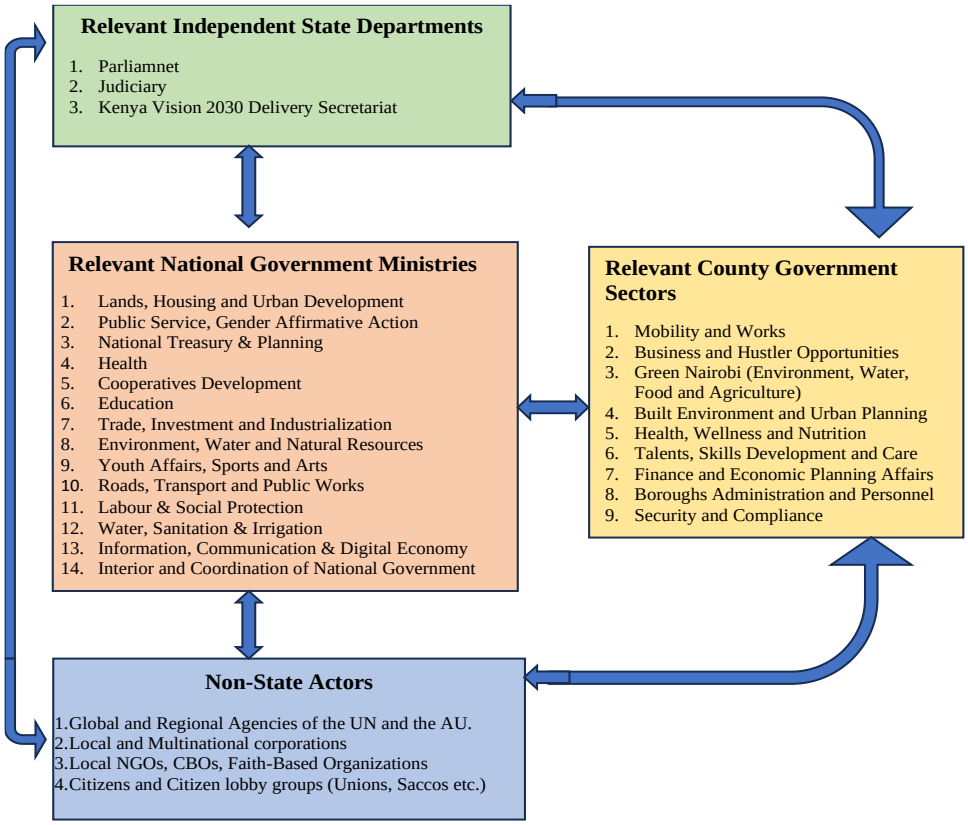
List of Appendices

Appendix 1: Findings on various aspects of public space and flood risk management reported in the study area

Appendix 1: Findings on various aspects of public space and flood Risk management as reported in the study						
Question	**Totally Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Total (%)**
Neighborhood Infrastructure Management						
The government is working on improving public infrastructure service delivery to my neighbourhood	40.21	26.46	10.58	12.17	10.58	100
My neighbourhood has government offices/official's regularly overseeing the management and/or upgrade of this neighbourhood	13.76	37.04	15.34	20.63	13.23	100
It is possible to legally acquire, own and develop land in this neighbourhood without fear of future property demolitions.	19.58	23.28	14.81	25.93	16.40	100
Landlords and land owners in my community are guaranteed that their properties will not be confiscated and/or demolished by state	10.05	13.23	24.34	25.93	26.46	100
The National Construction Authority approves construction of privately owned buildings in my neighbourhood.	39.68	32.80	16.40	6.88	4.23	100
Property owners in my neighbourhood are never harassed by government officials	11.11	29.10	8.47	34.39	16.93	100
Prevalence of Informal Markets in the Area						
Street vending and informal trade are prevalent in my neighbourhood.	71.96	25.93	1.59	0.53	-	100
Vendors contribute a great chunk of the solid waste generated	58.01	33.15	8.84	-	-	100
There exists government policy guiding informal trade and sanitation standards	20.99	20.44	19.89	26.52	12.15	100
The government has allocated staff to oversee street vending	19.34	44.75	11.05	13.81	11.05	100
The government has invested in supporting infrastructure for informal trade	5.52	13.81	10.50	38.67	31.49	100
Vendors have solid waste collection baskets.	9.39	19.89	34.25	20.99	15.47	100
Vendors constantly empty all solid waste at designated collection points	12.71	31.49	9.94	32.60	13.26	100
Traders consistently pay all the government fees for maintaining their work environment.	21.55	36.46	14.92	15.47	11.60	100
Vendors often report colleagues who violate sanitation and public health protocols	8.29	11.05	16.57	23.76	40.33	100
Prevailing Solid Waste Management Practices						
We have a solid waste management regime in my neighbourhood	46.03	21.16	4.23	16.40	12.17	100
We have a central community garbage collection point	5.82	41.27	12.70	24.34	15.87	100
Residents in my neighbourhood strictly restrain from illegal dumping.	2.12	8.99	32.28	34.39	22.22	100
I know the final destination for solid waste from my neighbourhood	8.47	9.52	14.81	28.04	39.15	100
The involved agency has workers to handle community garbage	30.69	25.93	15.34	14.81	13.23	100
Garbage collection points are regularly cleared and maintained	10.58	7.41	13.76	33.33	34.92	100
There are regular public health awareness campaigns on solid waste and community health in my neighbourhood.	7.94	14.81	26.98	19.58	30.69	100
There is a working solid waste, transportation, treatment, disposal and incineration program for Kayole Slums?	6.88	9.52	17.99	25.93	39.68	100
Effective public participation and cooperation for community solid waste management in public spaces exists in my neighbourhood	8.47	13.23	24.34	26.98	26.98	100
Waste Management and Flooding Risks						
My neighbourhood (or Kayole Slums) experiences flooding	48.68	27.51	2.65	14.81	6.35	100
Poor solid waste management contributes to flood risks in my neighbourhood	50.83	44.20	1.66	2.21	1.10	100
Street vendors contribute to the flood risks in my neighbourhood	46.41	39.23	10.50	3.31	0.55	100
Street vendors work closely with stakeholders to address flood risks	22.65	12.71	16.57	25.41	22.65	100
The design of vending infrastructure contributes to poor solid waste management	62.98	29.83	4.42	2.76	-	100
There is need for a stall design change to make street vending more environmentally friendly	71.82	24.31	2.21	1.66	-	100

Appendix 2: A multi-stakeholder framework for public space design, development, use and governance for Nairobi



Appendix 3: Distribution of the study respondents

S/No	Category	Population (Adult)	Sample Size
i.	For residents of Kayole, 192 questionnaires were issued to adults (52.1% of total population) with a 98.44% response rate.	160,684	189
ii.	Informal traders within Kayole. 50% of the general public questionnaires were allocated. 192 questionnaires were issued with a 94.27% response rate.	84% * adults = 134,975	181
iii.	Neighbourhood sanitation workers (waste collectors and drainage cleaners- government workers or employees of private contractors). 3 respondents were selected per Ward for 4 wards. 83.33% cumulative response rate	Unknown	10
iv.	Purposively selected County Government representatives from the Department of Trade, Tourism, Industry and Cooperatives Development.	4	2
v.	1 purposively selected County Government representative from the Department of Environment, Energy and Water	1	1
vi.	1 purposively selected County Government representative from the Disaster and Emergency Management Sector	1	1
vii.	1 purposively selected County government officers in charge of public works- roads and drainage	1	1
viii.	2 purposively selected National government's local administrators (Senior Chiefs)	2	2