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URBAN SECURITY IN KIBERA BEFORE AND AFTER THE MISSING LINK #12. Integrating MapKibera Trust Participatory Mapping and Space Syntax Analyses.

Francesca De Filippi; Grazia Giulia Cocina; Chiara Martinuzzi

ABSTRACT

The UN-Habitat Safer Cities Programme states that urban safety is threated by crime and violence rates, by insecurity of tenure and by natural or artificial disaster risks (UN-Habitat, 2007). In fact, the actual pressing urban population growth, the gentrification processes and the climate change, are increasing the perception of unsafety of inhabitants throughout the most vulnerable areas of the cities, both in developed and developing countries. Thus, it is fundamental to face this issue with an holistic approach, where institutional preventive actions, community engagement and physical environment improvements are synergically undertaken. In the Space Syntax theory, public spaces planning is a crucial element in enhancing crime prevention as well as the street configuration is a determining factor in the pattern of urban crime (Hillier, 2004).

This paper reports the results of an on-going research at the Department of Architecture and Design of Polytecnic University of Turin in which the urban security in the context of Kibera slum in Nairobi is investigated using and combining different analytical datas. In particular, the participatory mapping of MapKibera Trust about security is integrated with the Space Syntax analyses developed by the authors in order to understand the relevance of streets layout, dealing with security.

The research aims to develop an innovative methodology of analysis able to define the link between the criminal activities and the spatial configuration of the street network, in order to draw some recommendations to prevent unsafe conditions in the slum after the construction of the *Missing link #12*, a new road that will cross Kibera and modify completely the integration of its parts (KDI, 2018).

KEYWORDS

Space Syntax analysis, Urban Security, Kibera, MapKibera Trust, Missing Link #12

1. INTRODUCTION

In recent decades, several institutional Organisations and authors have faced the topic of urban security to investigate the role of urban planning as a crime preventive strategy. In 2007, UN-Habitat defines the *urban safety* as a public good and a human right that guarantees the wellbeing of city dwellers. Specifically, it is considered as the right to have free access to all the resources and opportunities connected to an urbanised environment and it encompasses a wide range of issues, from basic needs, such as food, health, tenure, to collective needs, such as protection from crime, violence, natural hazards and terrorism (UN-Habitat, 2007; De Filippi, 2009). As regards the relation between urban security and criminality, recent reports show a slight decrease in the global victimisation trends in the last decade. However, it is still a concerning threat to urban security, both in developed and developing countries (UNODC, 2015). According to UN-Habitat, the main factors influencing the occurrence of a criminal event are: cultural and social aspects, poverty and inequality, rapid population and urbanisation growth, poor urban planning and management, youth unemployment and transition towards democratic policies (UN-Habitat, 2007). These factors affect both the actual incidence rates and the fear of crime, which strongly influences the social behavior of dwellers in public space (Safer Cities, 2002). The consequences of high crime rates have repercussions at the national level, on economic growth, tourism and the attractiveness for international investors, and at the local level, with the stigmatization of some neighborhoods as "no-go areas".

The relevance of this topic is also highlighted by the large number of authors who have dealt with it. In 60's and 70's, two main theories emerged: Jane Jacobs' ideas, described in her book *The Death and Life of Great American Cities* (1961), and Oscar Newman's theory of *defensible space*, in the homonym volume (1972). The authors disagreed about how a safe place and its natural policing should be planned. Jacobs believes that permeable and open design allows movements through a neighborhood and thus its natural surveillance. Density, in terms of number of inhabitants, flows of people and activities increase the security of the area (Jacobs, 1961). On the other hand, Newman suggests that a closed environment is safer and easier to monitor. The concept of territoriality, one of the pillars of the theory of *defensible space*, explains that inhabitants surveil a part of the surrounding public space as an extension of their dwelling unit. Urban design should shape the public space to enhance this effect and divide it in small clusters with fences, vegetation and street furniture, thereby discouraging strangers from entering the surveilled area. Indeed, Newman believes that density creates anonymity, which improves the chances of criminals to finalise their action (Newman, 1972). However, the authors have also some points in common. They agreed about the necessity of a good visibility and a well-designed illumination in the public space. They also aim to maximise the number of windows that surveil the main street in front of buildings and to differentiate clearly between private and public space in order to avoid ambiguity about the respective uses.

Some other contributions enlarged the literature about urban planning for safe environments. In Paul and Patricia Brantingham's *crime pattern theory,* public space is composed by attractive nodes (schools, workplaces, supermarkets, dwellings), the usual routes that people follow to move through the nodes and the *awareness areas,* where city dwellers feel more comfortable and can orient themselves better. Each inhabitant, including criminals, has a different *awareness area.* Moreover, a

crime is more likely to be committed close to an attractive node, where the awareness areas of criminals and possible targets overlap (ICURS, 2018; Mora, 2013).

Kelling and Wilson argued the importance of maintenance of public space. Their *broken windows theory* explains that a degraded environment affects the identification process between citizens and their neighborhood and thereby their surveillance attitude. If the institutional system does not take care of a building with broken windows, then the dwellers will not feel responsible for its care but will probably develop the interest of breaking other windows and worsening the initial situation (Kelling, 1997).

Finally, Bill Hillier deals with the topic of *urban security* in his book *Space is the machine*. He does not take sides either with Jacobs or Newman, but he believes that both could be correct, depending on the context. First, he questioned Jacobs' concept of permeability, showing that a space with high connectivity value, but not supported by a good integration value could become a security hazard especially in housing states (Hillier, 2004). Secondly, he also comments Oscar Newman's idea of natural surveillance, because of his static conception. In Newman's theories, public space is monitored only by dwellers in static position inside their houses, while Hillier strongly believes in a more dynamic idea of natural policing, in which people movement flows have an active role. More in general, Hillier explains that integration values describe pattern of movement and of co-presence in public space, generating the *virtual community*. The most integrated spaces are naturally surveilled. The integration values depend on the configuration of space, therefore there will be a different perception of the *virtual community* considering the position in the configuration. However, Hillier states: "If a space is designed wrongly, then natural patterns of social co-presence in space are not achieved. In such circumstances, space is at best empty, at worst abused and a source of fear." (Hillier, 2004, p. 141). A bad urban and architectural design could create social malaise. Another interesting aspect emerged with Space Syntax studies is that anti-social use of space occur neither in surveilled areas, nor in the segregated ones, but in the most integrated areas free from natural policing. Empirically, criminals seek out locations with good movement flows and patterns of privacy that provide them with possible targets, but no witnesses. Finally, further studies developed with Space Syntax have shown the strong relation between social behavior, spatial configuration and time (Hillier, 2004; Hillier, Sahbaz, 2005; Hillier,Sahbaz, 2008; Tarkhanyan, 2013; Setola, 2013; Lee, Ha, 2014; Buoncore, Cutini, 2016; Cocina, 2016, 2017).

In this research, the theories emerged from the analysis of literature will be compared with the observations of the case study – the slum of Kibera in Nairobi – with the aim to investigate the role of participatory mapping (De Filippi et alt., 2016; De Filippi, Coscia & Guido, 2017; De Filippi, Coscia & Guido, 2018) and city planning strategies in enhancing crime prevention in informal settlements. Drawing upon the main literature about crime prevention through environmental design and the crucial contribution of Space Syntax theories, the authors chose some parameters to identify the key environmental elements that affect the security in an informal context. The dataset of the research is based on the information gathered from the participatory mapping of MapKibera Trust and from the Space Syntax analyses elaborated by the authors. The information from these two sources were

combined in order to achieve a more complete interpretation of the context and to understand the effects of comparing qualitative information with quantitative datas.

The case study: Kibera

Kenya and, in particular, the slum of Kibera in Nairobi were chosen as case study for a variety of reasons. First, developing countries clearly suffer from most of the factors generating criminality identified by UN-Habitat, especially poverty, inequality, unemployment and corruption (UN-Habitat, 2007). In particular, Kenya was considered an interesting context because of its fragile political situation that caused the post-electoral violence of 2007. After this event, security is a main concern for development in Kenya, dealt with at national and local level (Roberts, 2009; NCRC, 2017). Another relevant aspect deserving further analysis is the informal settlement, often stigmatized as a dangerous place (UN-Habitat, 2003; Davis, 2007). Although *Crime Prevention Through Environmental Design* (CPTED) theories usually took into consideration social housing or poor residential estates, slums are rarely dealt with. Several projects showed the positive impact of slum upgrading programmes and physical improvement of public space in urban security (UN-Habitat, 2008; UN-Habitat, 2011; Mitra, Mullingan, 2017).

Kibera, with an extension of 2,56 km^2, is the biggest informal settlement in Kenya and is located in the South-west of Nairobi city, next to the railway line. Although the opinions about the population of Kibera are still multiple[1], reliable sources estimated a number of 235.000 – 270.000 inhabitants (Marras, 2010). It is divided in 13 villages, mostly according to the ethnic origin of the people. Kibera is crossed by several water streams that flow into the Ngong River and the Nairobi dam. These are strongly polluted by garbage that blocks the water flow and causes floods during rainy seasons. Hygienic conditions are extremely poor, without adequate toilettes and garbage management. Houses are shanties made up of rusty metal sheets, pieces of wood and garbage. Economic conditions of residents are precarious: it is estimated that 60% of youth is unemployed and crime rates are high (Hagen, 2011). Kibera was founded in 1902 by British colonists, as a military reserve for Nubian soldiers. Few years later the government claimed the land and all the inhabitants became squatters. Only in 2017 did president Uhuru Kenyatta issue the Nubian community with a title deed for 1,18 km^2 of land in Kibera, which was the original perimeter of the military site[2]. However, the pressing urban growth caused the expansion of the settlement over the years and the future prospect of the slum shows the unbinding nature of the land deed. Indeed, in July 2018 construction works started for a new road - *the Missing Link #12* - that will improve the traffic conditions of Nairobi, passing through Kibera and destroying housing, schools and services (KDI, 2018). The *Missing Link #12* was announced in January 2016 by the government of Kenya as a part of the *Nairobi Integrated Urban Development Master Plan* by 2023. The people of Kibera have never been involved during the

[1] See http://www.mapkibera.org/blog/2010/09/05/kiberas-census-population-politics-precision/ (Davis, 2007; Desgroppes, Taupin, 2012; Marras, 2010).

[2] https://www.nation.co.ke/news/Uhuru-issues-title-deed-to-Kibra-Nubians/1056-3953204-9jfwvk/index.html

decision-making process, almost 11500 people have been evicted, and 13 schools have been closed or moved without any compensation.

The sad notoriety of Kibera has drawn the interest of almost 400 international organisations that collaborate with the community to improve the quality of life in the slum. One of those is MapKibera Trust, founded in 2009 on the basis of the pilot project of Erica Hagen and Mikel Maron, developed to create the first public map of the settlement. Today the organisation carries out activities such as voluntary mapping and participatory journalism and aims to share information about Kibera with the people living inside and outside the slum, in order to involve them in the public discussion and raise awareness. Specifically, it has produced several thematic maps dealing with the urgent issues of the settlement, such as security. Arguing about criminality in Kibera, the current project chief of MapKibera Trust explains that probably the main causes are related to extreme poverty and youth unemployment.

In this research, the security map of MapKibera Trust and the maps obtained from Space Syntax analyses were the bases on which the parameters identified from the literature were applied, in order to achieve a better comprehension of urban security in the slum.

The methodology of the study and the results of the analyses are showed below. Then, some recommendations are proposed for a safer planning of public space. The observations of the current situations are the starting point to define new urban strategies for the future: the Missing Link #12 will completely change the spatial configuration and the social dynamics of Kibera. Therefore, the insights provided by this research aim to contribute to the future prevention of criminality.

2. DATASETS AND METHODS

The study described in this article is part of a broader research project developed by the Department of Architecture and Design of Polytecnic University of Turin. Within the research project, the parameters chosen from the study of the main theories about CPTED and Space Syntax are*: integration, illumination, vitality, visibility, natural surveillance, territoriality* and *maintenance*. These parameters were used to define the role of urban planning for crime prevention, both at large and small scale. At territorial level, the analyses provided a systemic comprehension of crime occurrence, taking into account configurational features of space; while, at the local level, it was investigated the relation of architectural aspects and each specific hot-spot, which is a place considered as prone for crime actions. In this article only the territorial analyses about *integration, illumination* and *visibility* of the current spatial configuration of Kibera are described. Here below is described the dataset of the research, composed by the participatory mapping of MapKibera Trust and the Space Syntax analyses, that describe the current and the future layout of Kibera public space.

2.1 Security mapping by MapKibera Trust

The first security map of the organisation was completed in the 2010 thanks to the support of UNICEF, to monitor the violence in the slum and make residents aware about the safe and unsafe areas. It was upgraded in 2013 and in 2017, before the national elections in order to prevent unfortunate episodes. The merit of MapKibera Trust's work is related to a strong interest in involving

all the relevant stakeholders while defining safety of an area and in valuing their knowledge (Demartis, 2013). In this way, they established trust with citizens and got more information about those crimes, not often reported to police officers in informal contexts (Safer Cities, 2001; Safer Cities, 2002).

As illustrated in figure 1, the map gathers all the relevant element of security, which are: street lighting, bars, black-spot, hatari-spot, police stations, gender-based violence supports, chief camps and other organisations that provide security. The organisation distinguished black-spots, dangerous places where criminal activities have been registered, and hatari-spot, possible unsafe places due to physical and spatial features. Specifically, a place is considered as a black-spot when residents reported more than one criminal action on it and thus there are reasons to believe that is a crime-prone area. In this research black-spots and hatari-spots were dealt without distinctions. The choice to map also bars of Kibera is justified by the alcohol sale, that often cause danger in several informal settlements[3]. On the other hand, police stations, chief camps and support groups are mapped as safe spots benefitting from active surveillance. MapKibera Trust provided more detailed information for each element of the map: for example, every light sources has an ID code and it is described by the type of light (which could be street light or Adopt-a-light type[4]) and by the maintenance status (operational, not operational, or uninstalled). The reported hot-spots are 37, taking into account both black and hatari spot. Some of them have indications about the occurred crime, which could be pickpocketing, robbery, mugging, murder or rape. Others marked an increased risk during the night. These information were useful to define the research methodology: while the indication of the crime type were not detailed enough, the information about time seemed to be more accurate. Therefore, in this study hot-spots are distinguished between "nocturnal" (15/37), which have a declared increased risk during the night, and "general" (22/37), which have no specific relation with day- or night-time.

[3] See also *Spatial Collective* projects in Kayole Soweto slum, Nairobi. http://mappingnobigdeal.com/2017/01/07/linking-perceptions-of-safety-to-infrastructural-upgrading-in-informal-settlements/

[4] See Slum Lighting Initiative of *Adopt-a-light Limited* project. http://www.adopt-a-light.com/about_us.php

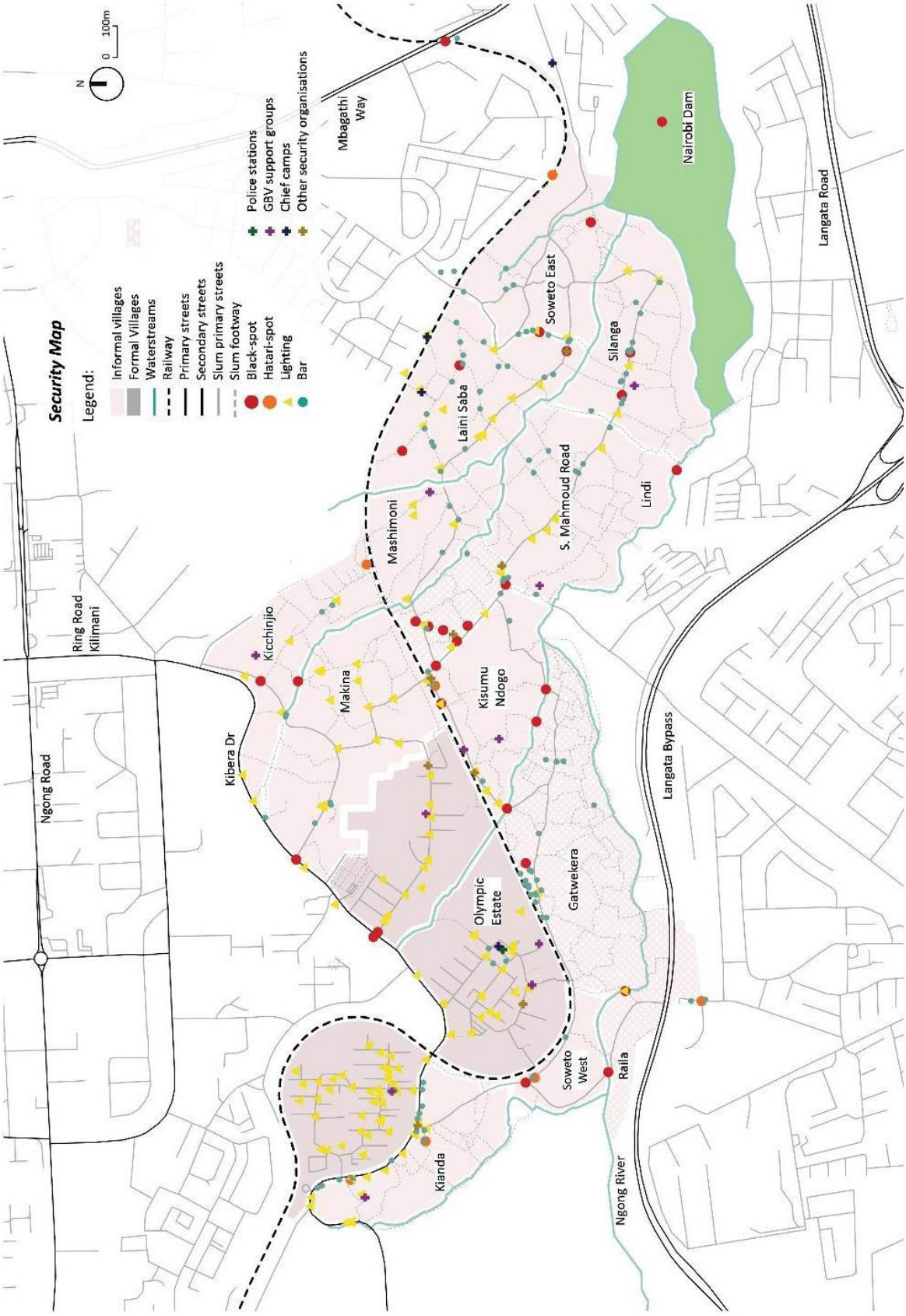

Figure 1, Security map of Kibera Slum (Elaborated by the authors, from the data of MapKibera Trust).

2.2 Space Syntax analyses

The application of Space Syntax aims to generate more information regarding patterns of movement and visibility in the context of the informal settlement. Thus, the analyses carried out with Space Syntax were the Axial lines Analysis and the Visibility Step Depth Analysis. Firstly, it was calculated the Global Integration values of both the current and future layout of Kibera in order to define how the new road will affect the slum and the whole city. Secondly, the configurational information of the current layout were integrated with the security map of MapKibera, taking into account the parameters of *integration, illumination* and *visibility*. In particular, the relation of crime and visibility was investigated counting the visual Step Depth between hot-spots and highly visible spaces. Here below is described the process followed for the Space Syntax analysis.

The current axial map was drawn by the authors through QGIS Space Syntax Toolkit with the information of OpenStreetMap on-line platform. When the information about the built structures lacks in OSM, they were implemented with Google Satellite pictures. The axial map cover the entire slum with a buffer area of 1,5 km^2.

Before discussing the results, it is important to underline some aspects. Firstly, the railway that passes through the settlement is used by dwellers as a path, in which many informal activities and housing are settled, thus it was marked as a street and the intersections with other paths are linked. In this way, the model is more congruent with the actual movement patterns of the settlement. Secondly, the global integration values (R = n) were divided in different range depending on the output colours. The more integrated is the axial line, the higher is the defined value: 10 is referred to red axial lines, 9 for orange and so on until 1 for blue lines. In this way, the interpretation of the outputs is more clear and a qualitative comprehension of the context is achieved.

In figure 2a, it is possible to see outputs of the current and the future spatial layout of Kibera. Regarding the current configuration, the main integrated axial lines are described by the two main roads placed out of the slum at North, (Ngong Road, direction West-East; and Ring Road Kilimani, direction North-Sud) and at East (Mbagathi Way, direction North-Sud). Other spaces highly integrated inside the slum are Kibera Drive, the road defining the east border of Makina, Kicchinjio villages and Olympic Estate, a section of Sheikh Mahmoud Road, which pass through Makina, Kambi Muri, Lindi and Silanga villages, and the railway line. This aspect highlights the importance of the railway as pedestrian path in the informal settlement. In general, streets of the slum are quite irregular and intricate, which means that axial lines are quite short. Kibera has few accesses and the mains are located at North from Ring Road Kilimani and at East from Mbagathi Way. The most segregated axial lines are placed in the South of Kibera, far from the main accesses.

Focusing on the future layout, the initial model was modified depending on the demolitions carried out on the site. Some axial lines referred to internal paths were eliminated and it was introduced the new connection passing through the slum. The information about the Missing Link #12 project are very poor and it is not yet specified which will be the relation between the new road and the streets of Kibera. Thus, it was supposed that all the intersections are permeable, as is already happening with Kibera Drive road. Only the railway is unlinked with the new road.

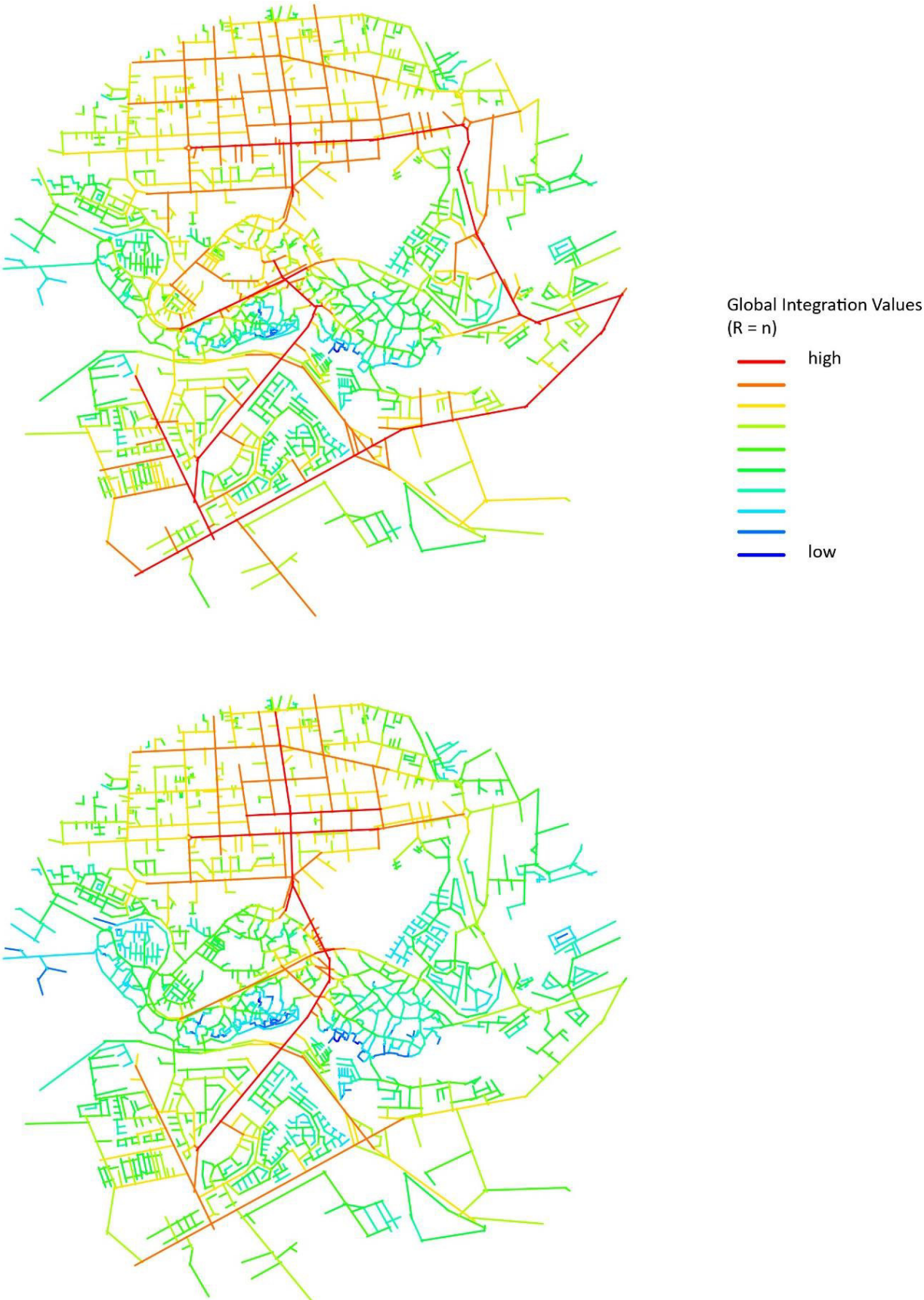

Figure 2, Axial maps of the current (top) and the future (bottom) configuration of Kibera public spaces (Elaborated by the authors)

While the city traffic created a "ring" around the slum in the first configuration, with the introduction of the Missing Link #12, the movement flows of Nairobi change completely. Indeed, the axial lines describing the new road are the most integrated and the movements through the streets of Kibera Drive Road, Mbagathi Road and Langata Road decrease. However, the railway keeps a relevant role in the new layout, with a high integration value. The east access from Mgabathi Way results less integrated than in the first layout. In general, the construction of the Missing Link #12 will definitely improve the traffic conditions of the city. For what concerns Kibera, the new road caused the dislocation of thousands of residents and the demolition of several schools and services. However, the introduction of the new connection is likely to improve the integration of the settlement within Nairobi, resulting an increment of opportunities for slum dwellers.

3. RESULTS

Here below are reported the results of the integration between the configurational information of the current layout and the security map of MapKibera. Three parameters were investigated: *integration, illumination* and *visibility*. In the table 2, the environmental conditions of each hot-spot are summarised, to define a systemic comprehension of crime occurrence. Finally, few recommendations are proposed in order to improve the environmental conditions for future preventive strategies after the introduction of the Missing Link #12.

3.1 Crime and Integration

Each hot-spot mapped by MapKibera Trust has a global integration value, that is the value of the axial line in which is located, as illustrated in figure 3. The average integration value of all the hot-spots is 6,89. Specifically, analysing the table 1, 12/37 hot-spots have a global integration value of 8, while 8/37 a value of 7 and 7/37 a value of 6. Thus, it could be argued that the hot-spots generally are placed on more integrated axial lines. Moreover, distinguishing the "nocturnal" and "general" hot-spots, more interesting information emerged. In fact, the average integration value of "nocturnal" hot-spot is 7,47, while regarding to "general" hot-spot is 6,50. Indeed, 53% of "nocturnal" hot-spots have a integration value of 8.

Table 1, Integration value of hot-spots spaces.

Integration value (R = n)	Hot - spot	"general" hot - spot	"nocturnal" hot - spot
10	-	-	-
9	5	3	2
8	12	4	8
7	8	6	2
6	7	5	2
5	1	1	-
4	1		1
3	2	2	-
2	-	-	-
1	1	1	
	37	22	15

This aspect clarifies that crimes occurred in the night or hot-spots that have an increased risk during the hours of dark, are mainly located on high-integrated spaces. The results are coherent with Hillier's theories suggesting that anti-social behaviors occur "in the first integrated space free from natural surveillance" (Hillier, 2004, p. 121). It agrees also with the observations proposed by Hillier and Sahbaz, showing that night crimes mainly occur in high integrated lines (Hillier, Sahbaz, 2008).

3.2 Crime and illumination

As already mentioned, MapKibera Trust has mapped the light sources in the public space of Kibera, which have been categorised considering the maintenance status (operative, not operative and not installed) and the typology (street light or adopt-a-light). In this research, it has been considered only the current operative lighting. For each light source it has been drawn the area that covers considering the typology of the source. While the streetlights are installed at an estimated high between 5-8m[5] and cover an approximated area of radius 20m, the adopt-a-light masts are almost 20m high and the effects of the lighting power decrease after a radius of 100m (The Steadman Group, 2006). Thus, in the figure 4 it is possible to see the illuminated area of Kibera compared to hot-spots locations. In general, the light sources are mostly placed on the main streets of the slum, characterised by wide transversal sections that allow vehicular movements and relative high integration values. Some villages are completely without public illumination, such as Kambi Muri, Kisumu Ndogo, Gatwekera, Raila e Soweto West. Analysing the results, only 6 hot-spots are inside the illuminated areas, while most of the dangerous places remain in the dark zones. Moreover, only one "nocturnal" hot-spot is illuminated. It is evident that illumination is a striking factor for criminals defining their action area. However, it should be underlined also that lack of illumination it is not a sufficient condition to choose a spot. In fact, the amount of hot-spots on narrow, dark and intricate paths is consistently less than the number on more integrated, not continuously illuminated streets. Thus, criminals of Kibera prefer to set on integrated lines with poor illumination rather than segregated area completely dark.

[5] The height has been estimated considering Google Street View.

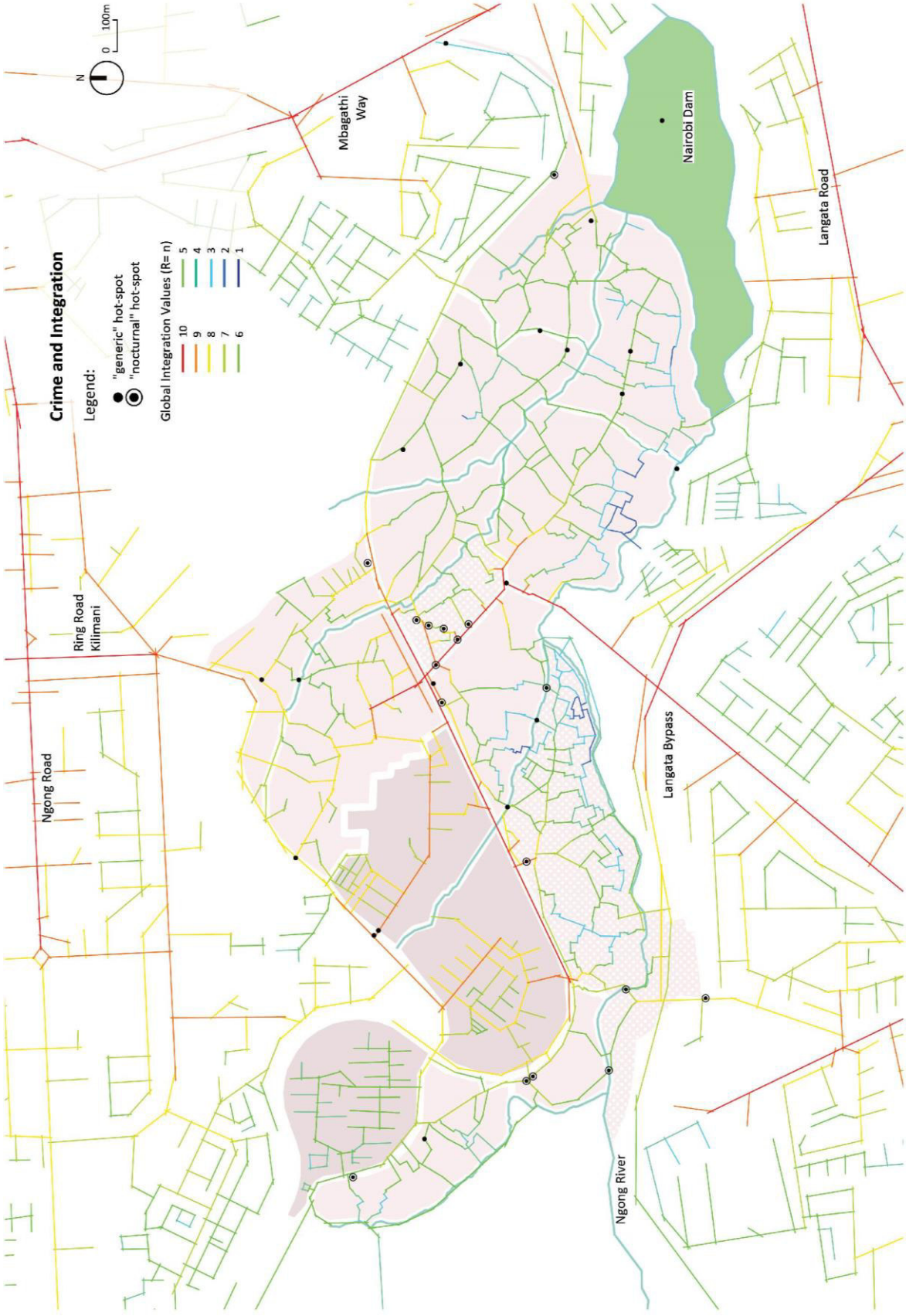

Figure 3, Correlation between crime and global integration in Kibera (Elaborated by the authors).

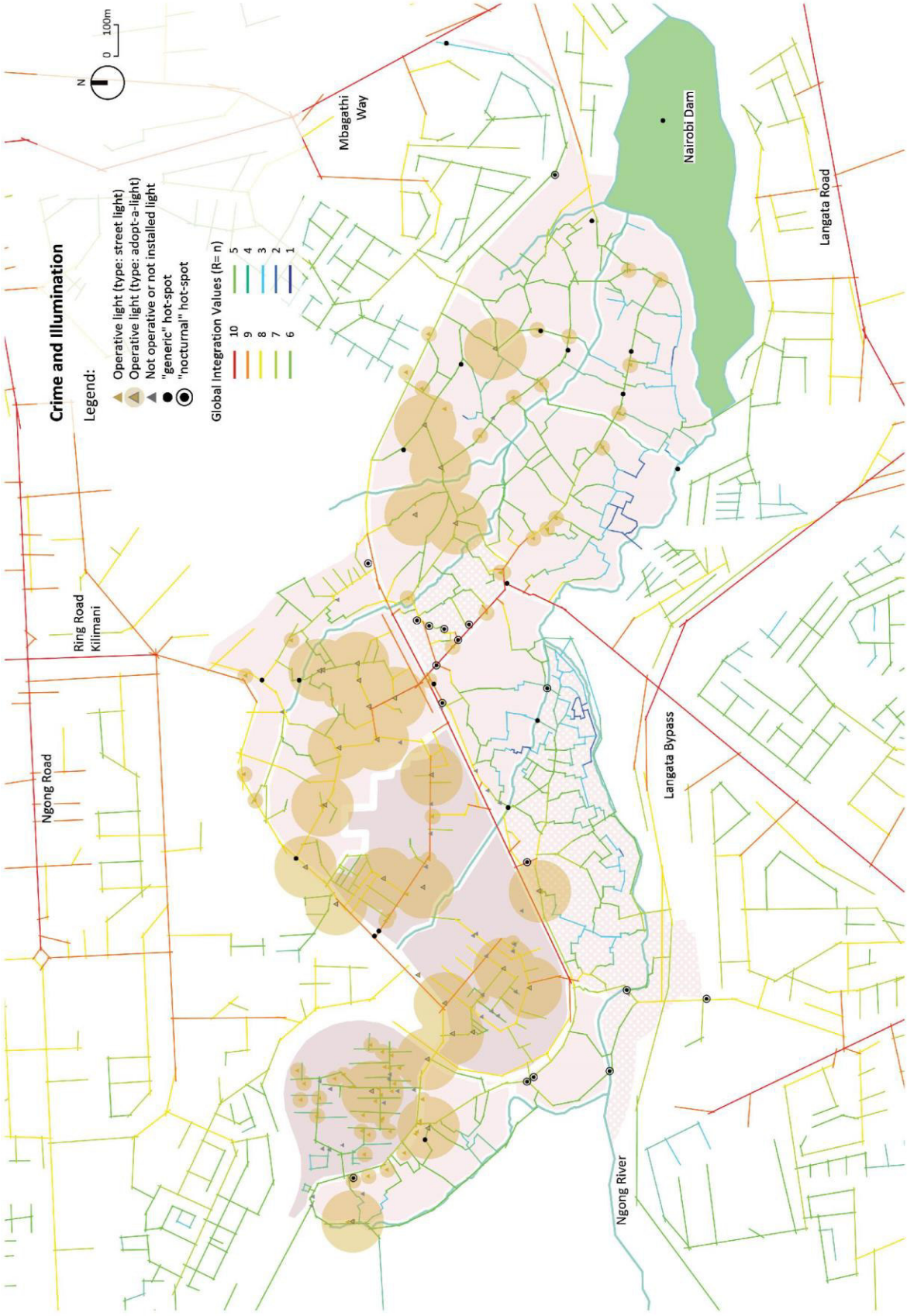

Figure 4, Correlation between crime and illumination in Kibera (Elaborated by the authors).

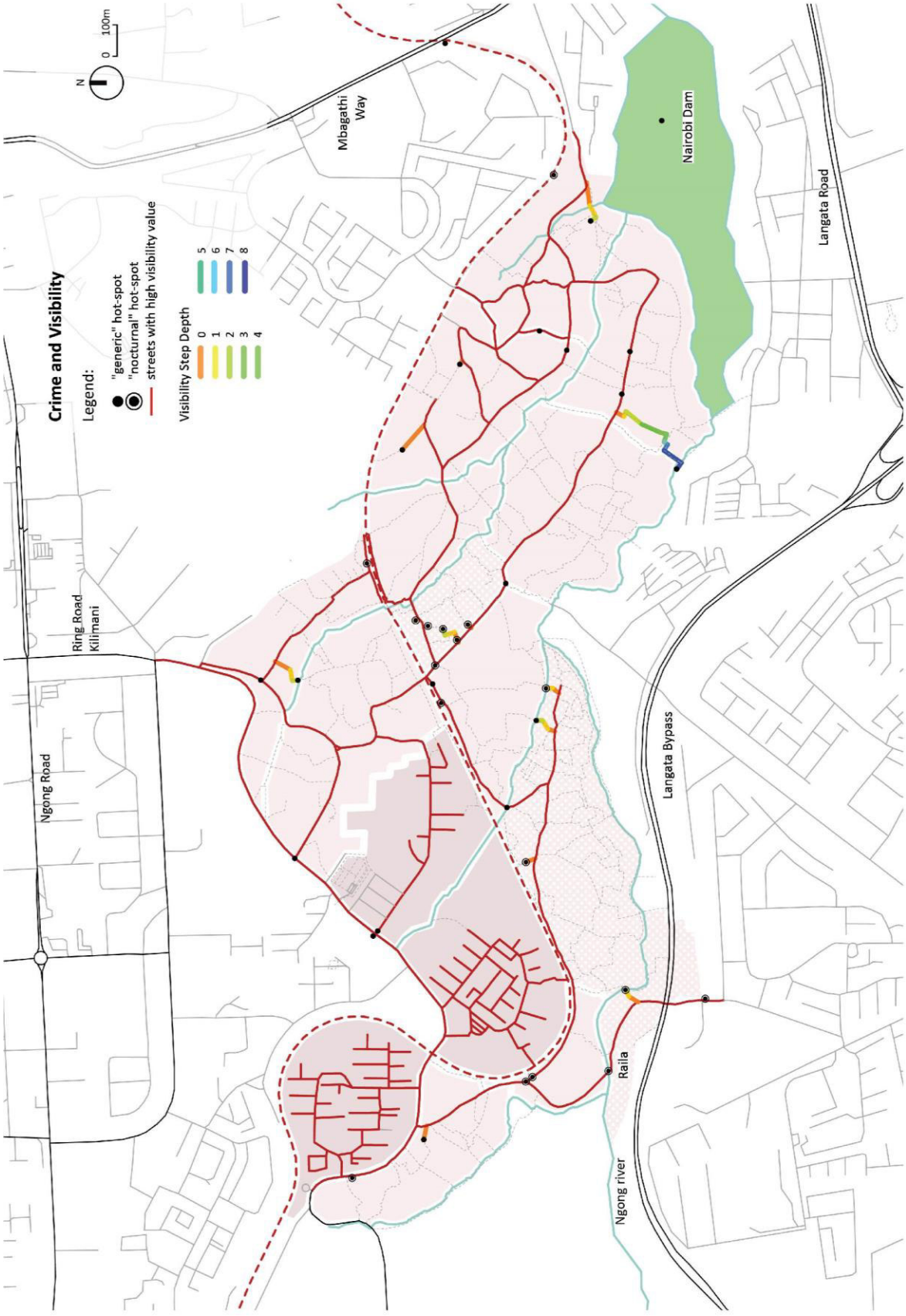

Figure 5, Correlation between crime and visibility in Kibera (Elaborated by the authors).

3.3 Crime and visibility

Visibility is a spatial feature that depends on the configuration of built structures and on street furniture collocation. A space with good visibility allows people to keep surveilled the public space and prevent anti-social behaviors. In crowded informal settlements such as Kibera, open spaces are limited and good levels of visibility are rarely achieved. For these reasons, in this research it is supposed that spaces with good visibility are safer. These are often related to main streets, enough wide to allow vehicular transits. Moreover, these spaces benefit from higher movement flows, which prevent in itself criminal actions. The Visibility Step Depth between safer streets and hot-spots were analysed, in order to define whether criminals mainly act in more visually integrated or segregated areas.

In the figure 5, spaces with high visibility levels are identified, depending on the wideness of the transversal section. Using OSM information and Google Satellite pictures, streets with wideness between 5 and 16 meters were chosen as safe spaces with high visibility. The visual Step Depth of each hot-spots and the closer high visibility space were calculated. 20/37 hot-spots are located on high visibility spaces or with 0 Step Depth distance. 8/37 have 1 Step Depth distance and thus they need only one visual change to reach the main visually integrated area. Considering the hypotheses, this striking aspect highlights again the interest of criminals in positioning themselves in more integrated areas instead of visually segregated, with the aim of monitoring coming targets. Deepening the relations of the Step Depth measurement and the actual position of each hot-spot in the urban layout, it emerged that 10 hot-spots with 0 Step Depth are located closed to crossings.

Figure 6, Step Depth analysis of the hot-spots in Kibera (Elaborated by the authors).

In the figure 6 a zoomed image of Kibera layout shows this second aspect. Therefore, hot-spots located on crossings benefit from high visibility value, remaining hidden from the view of coming targets. No relevant distinction between “general” and “nocturnal” hot-spots were detected.

Table 2, Hot-spots information summary.

hot-spots information				integration	illumination		visibility	
ID		crime	Notes	R = n	light	type	street wide	Step Depth
712964757	hatari			7	yes	adopt	4	1
712890336	hatari			8	yes	street	16	1
612007130	black		crossing	8	yes	adopt	13	0
712884575	black			3	no			10 +
712891350	black			7	no		9	0
712908180	black		bridge	7	no		5	0
712903911	black		bridge	3	no		1,7	3
713027609	black		crossing + bus stop	9	no		9	0
948311711	black		nys road	6	no		10,3	0
948311715	black		nys road	6	no		9,2	0
712884565	black		nys road	6	no		8,8	0
612009744	black			7	yes	adopt	3,6	3
2117408674	black		bridge + railway	5	no		7	0
712916686	black	pickpocketing	crossing + bus stop	9	no		10,3	0
713194093	black	robbery	nys road + crossing	8	no		9,4	0
713194103	black	robbery		6	yes	street	9,6	0
713194146	black	robbery	crossing	6	no		4,3	1
713194153	black	robbery	courtyard	7	no		5,5	2
712884579	black	robbery + pickpocketing	dam	1	no			10 +
712884580	black	robbery + pickpocketing		7	no		3,4	3
713194111	hatari	robbery + raped	railway	8	no		7	0
713194076	hatari	robbery + raped	railway	9	no		12	0
Average of "general" hot-spots				6,50	22,7%			
712964089	hatari		crossing	8	no		4	1
712964098	hatari		crossing	8	no		6,3	0
712903697	hatari		crossing	7	yes	bar	11,4	0
712903771	black		bridge + crossing	4	no		3	2
713074380	black			9	no		2,7	1
713124716	black		bridge	8	no		3,2	2
713124731	black		bridge + crossing	8	no		5,3	0
712964083	black		crossing	8	no		9	0
712890332	black	murder	crossing	8	no		1	1
712892550	black		crossing	9	no		13,2	0
712890340	black	mugging + murder	crossing	6	no		2,1	1
712890334	black	mugging	courtyard	7	no		4	1
712876953	black	raped	crossroads	8	no		10,7	0
712890333	black	murder		6	no		1	3
712890337	black	murder	crossing	8	no		3,5	0
Average of "nocturnal" hot-spots				7,47	6,7%			
Average of total hot-spots				6,89	16,2%			

4. CONCLUSIONS

The analyses carried out show that in an informal settlement like Kibera, the highest number of crimes occurs in more integrated spaces, rather than segregated areas. In this case study, most of the hot-spots, in particular the "nocturnal" ones, are located in axial lines with high global integration values free from natural surveillance. In this way, criminals benefit from high movement flows of possible targets and avoid possible witnesses present in the most integrated lines with value of 10 and 9. Then, most of the hot-spots are located out of the illuminated areas of the slum, but close to it. Infact, villages completely unprovided with light have less hot-spots than illuminated villages. This aspect allow criminals to monitor public space and coming targets, without being noticed. Finally, more than 50% of hot-spots are 0 Step Depth far from spaces with high visibility and more than 25% are located closed to crossings. Thus, local configuration of buildings helps criminals to intercept coming targets and remain out of their visual field.

Therefore, most threated areas by crime are not the highest integrated streets, with good illumination and visibility, nor segregated areas, with no light and bad visibility. Instead, criminals seek out for those places directly connected to the highly integrated lines, in which light is not continuously installed and local configuration creates hidden spots.

Moreover, the results of this research suggest that after the construction of the new road, *the Missing Link #12*, the spatial configuration of the slum will change, and with it the patterns of crime. Basing on the results achieved, the areas directly connected to the new road are likely to be at risk.

The Missing Link #12 is likely to be a good opportunity for Kibera development and an occasion to intervene in the surrounding areas of the decanting site. For instance, illumination is lacking and the installation of new light sources could be a deterrent for future criminal actions. In addition, local configuration defined by buildings disposition should aim at safer layout. However, it is important to involve the local community before define any further design decision.

The current research still presents some weaknesses such as the lack of a direct experience of Kibera from the authors and the difficulty to define statistical results caused by the small amount of hot-spots reported. These limitations can be represent as starting points for future research opportunities in which the knowledge of the place, the involvement of the local organisation and the community will provide a better understanding of crime patterns in Kibera and make the study more detailed. Moreover, a further possible development could be the update of the security map after one year from the end of the road construction, showing how security has changed in Kibera and thus enriching the research.

The most relevant contribution of the research is to provide an innovative methodology of analysis able to define the relation between crime and space, combining different data and approaches: the configurational analysis of Space Syntax and the participatory mapping of MapKibera. The methodology converts some theoretical parameters identified through the literature review in practical parameters by comparing qualitative and quantitative data from the two different analysis tools used and obtaining results that can help to understand which are the most important spatial elements that influence criminal behavior.

The methodology, currently tested in a real case study, can be also applied in other slums of Nairobi where MapKibera Trust is already involved in participatory mapping projects or in different contexts in other parts of the world.

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