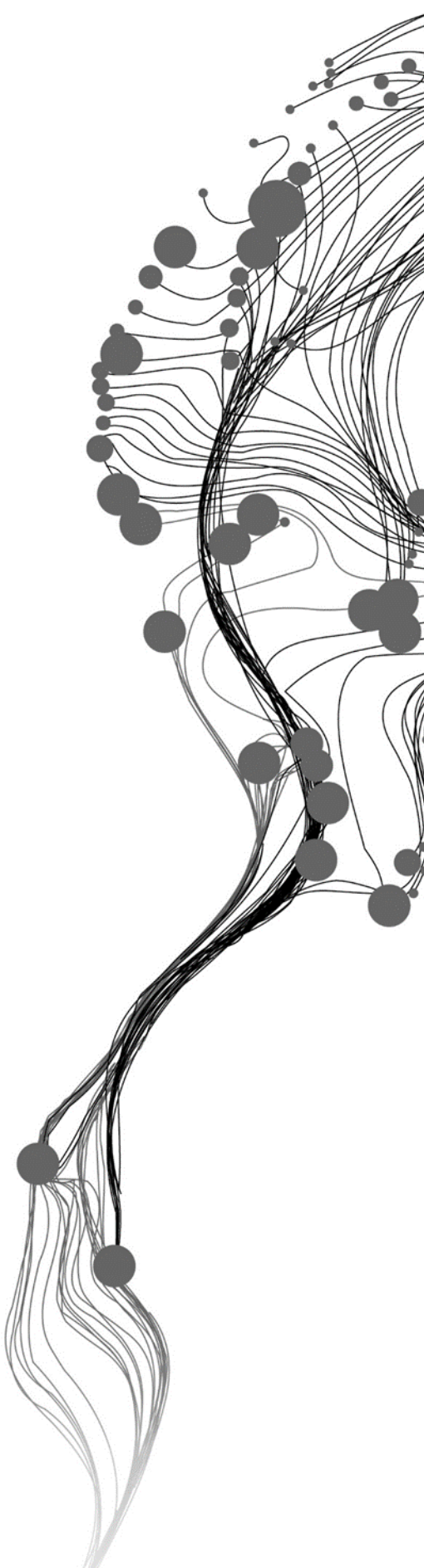


# **THE TRANSITIONING OF AN INFORMAL SETTLEMENT TO A SLUM: CASE STUDY OF KISUMU NDOGO AND MUKURU KWA REUBEN IN NAIROBI, KENYA.**

VIOLLA ACHIENG OKOTH  
June, 2020

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## ABSTRACT

Informal settlement (IS) and slums are seen as a by-product of failures to cope effectively with urbanization complexities. This is evidenced in Sub Saharan Africa (SSA) countries as they continue to confront transitioning of the IS to slum. As population increases, there is a need for constantly affordable housing, pushing into the formation of a slum, which spirals into uncertainty and patterns of its decay. Many authors have also studied IS and slum interchangeably focusing on their policy intervention, theorizing their development and monitoring them through mapping. However, little is mentioned about their transitioning which is significant.

This study aimed to identify the indicators and drivers for transitions in Kisumu Ndogo informal settlement and Mukuru Kwa Reuben slum, in Nairobi Kenya. The indicators and drivers identification were first selected using literature review and then subjected to key experts, Focus Group Discussion with Nyumba Kumi representatives and residents to further identify relevant ones in the study context. To analyse the data, descriptive statistical analysis, that is frequency distribution and mean, were used to rank the indicators and drivers. The concept of Object-Based Image Analysis (OBIA) and rule base classification method was used to extract features from Quickbird imagery. Six features were extracted including built-up area, vegetation, road accessibility, bare land, water and shadow, and the final output analysed in the ArcGIS environment. Spatial metrics was also applied to analyse the complexity and the compactness of shapes and built-up area.

The main findings revealed that only three indicators classified and identified the transition of informal settlement and slums. They included vegetation, built-up density and shape and location to CBD/industries and railway substation. On the other hand, three categories of drivers; physical, socio-economic and social-cultural factors accelerated transitioning of an IS to a slum.

In conclusion, the following vegetation and location to CBD/industries and railway substation indicators and drivers were able to differentiate IS and slums and thus considered significant to map the transitioning.

**Keywords:** Informal settlement, slum, indicator, driver, transition

**Dedication:**

To my husband, Julius and son, Jevan:

You were my pillar and motivation that made it easier to hang in there.

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My gratitude to My God for this moment that I have been under His wing and till this moment Isaiah 41:10 “So Do Not Fear, For I Am With You; Do Not Be Dismayed, For I Am Your God. I Will Strengthen You And Help You; I Will Uphold You With My Righteous Right Hand.”

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To my wonderful twinny who has been the mother to my son and all my loved ones and pastor Joseph with all Unfailing love Ministries members. Thank you for your unwavering support.

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## LIST OF ABBREVIATION AND ACRONYMS

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IS : Informal Settlement

KND : Kisumu Ndogo

MkR : Mukuru Kwa Reuben

OBIA : Object Based Image Analysis

RS : Remote Sensing

# 1. INTRODUCTION

## 1.1. Background

Indications that the world population could grow to approximately 8.5 billion in 2030, and 9.7 billion in 2050 are continually unfolding in this urban era (UN-Habitat, 2019). Remarkably, Sub-Saharan Africa could account for more than half of the world's population growth between these years and is still expected to continue growing (ibid). However, most cities in Africa are certainly not ready for the multifaceted problems related to urbanisation, such as marginalisation of the urban poor characterised by informal and slum settlements. As many cities sprawl, informal settlements and slums are either proliferating or consolidating and with poverty increasing cities become too costly for the newcomers (UN-Habitat, 2016).

Further, informal settlements (IS) and slums are seen as by-products of failure to effectively cope with the complexity of urbanisation (Jones, 2017). Most prominent elements with these settlements are a high concentration of poor people having low income and inadequate access to health services and safety risks to the vulnerable such as the aged and women (Debnath, Bardhan and Sunikka-Blank, 2019; Kohli, 2015). Also, they live in poorly constructed houses, proving that there is a disparity between the built supply and the need of the people (Abebe, 2011).

Until now, numerous researches have studied IS and slums interchangeably with an intense focus on three standpoints: policy interventions, monitoring the informal settlements through mapping and theorising the informal settlement development (Park, Fan, John, Ouyang and Chen, 2019). These sectors have been explored to acknowledge and assimilate the settlements in the city to improve their overall quality of life (Nabutola, 2004; Schwarz, Flacke and Sliuzas, 2016).

Although an IS and a slum has a high congruence level, it is crucial to differentiate them as studied by Akhmat and Mahroof (2011) differentiating an informal settlement in four levels based on population density, thresholds and housing conditions: *the affluent settlement* has substandard, but better quality of housing with less than 15% of housing stock and accommodates fewer than three households; *the moderate settlement* has lesser housing quality and can accommodate three people in a less than 15% dwelling stock. The *disadvantaged settlement*, on the other hand, has lower quality structures which are small, covers more than one-third of its housing stock and constitutes four persons. A *slum settlement* is a consequence of the informal settlement deterioration to a state of complete lack of basic services and accommodates more than four people in a dwelling unit. Secondly, an informal settlement may be contained in different pockets of its territory (a city or rural areas). A slum, in contrast, is confined within the urban area setting evidenced when cities take advantage of economies of scale (Galiani, Cooper, Undurraga, Martinez and Ross, 2017). Besides, an informal settlement based on its spatial distribution (urban or rural) often is not located in a risk-prone area. However, most slums are located in areas susceptible to hazards and are environmentally fragile. Lastly, intervention approaches used to address both informal settlement and a slum are different. Informal settlement mitigation can be through adherence to the zoning and planning regulations. However, to intervene in a slum, strategic options of resettlement schemes and upgrading need to be applied to guide its development better since it cannot be entirely controlled (Sliuzas, 2004).

Many authors use the terms informal settlement and slums interchangeably while bringing out either their severity, identifying them or indicating their urgency for intervention. To define IS and slums, core elements are applied, showing their differences and similarities as described in Table 1 below

Table 1: Indicators used in defining an Informal settlement and slum

Source	(Mason and Fraser, 1998)	(Kombe, 2001)	(Hofmann, 2008)	(K. K. Owen and Wong, 2012)	(UN-Habitat, 2018a)	(UN-Habitat, 2006)
Criterion						
No tenure security	✓	✓	✓	✓	✓	✓
Non -Conformity to planning regulations	✓	✓	✓		✓	✓
Self-constructed	✓	✓	✓	✓		
Illegal/unplanned development	✓	✓				
Traditional Land	✓	✓				
Public or private land	✓					
Lack of sanitation					✓	✓
Lack of water					✓	✓
overcrowding	✓	✓				✓
Dilapidated housing (poor quality)	✓					✓
Little vegetation cover				✓		
Irregular street network				✓		
Poor accessibility					✓	✓
<b>Category</b>	<b>IS</b>	<b>IS</b>	<b>IS</b>	<b>IS</b>	<b>IS</b>	<b>S</b>
*IS- Informal settlement *S-Slum						

Source: Author

It can be deduced that an informal settlement and a slum lack tenure security and do not conform to planning regulations (Mason and Fraser, 1998; Kombe, 2001; Hofmann, Stroble, Blaschke and Kux, 2008; UN-Habitat, 2006; 2018). Besides, Mason and Fraser (1998); UN-Habitat (2006) & Kombe (2001) point out that an informal settlement and a slum do not have access to water, sanitation and are overcrowded. Informal settlement uses core elements such as self-construction, illegal/unplanned, non-conformity to planning and zoning regulations, built on either traditional or public/private land, little vegetation cover, irregular street networks and poor accessibility to distinguish it. Then again, UN-Habitat (2006; 2018) has adopted some elements of informal settlement elements to identify a slum as lacking tenure security. Also, they do not conform to planning regulations, are overcrowded, lack water and sanitation and the housing structures are dilapidated (poor quality). It is, therefore, clear that overlapping similarities makes it hard to distinguish them when broadly defined, raising the need to identify and point out their transitioning.

To measure informal settlements from slums, Owen and Wong (2013) proposed a total of fourteen indicators and found that only seven indicators were significant (Fallatah, Jones, Mitchell, Kholi, 2019). In their analysis, Indicators were replicated for IS in the Middle East and acknowledged that to a certain degree, a subsection of the indicators was successful. The unsuccessful use of all indicators was because of limitation

of geographical data acquisition on updated informal settlement maps. Indicators used included vegetation extent, lacunarity of housing/open space, road network, roofing extent, the texture of built-up area and dwelling size. To map slums, (Kohli, Sliuzas, Kerle and Stein, 2012) use Building characteristics, access to a road network, Density, settlement shape, location and neighbourhood characteristics. This approach provides a generic ontology that addresses vagueness in defining slums while guiding its classification. The case study will apply both informal and slum indicators used by (Kohli *et al.*, 2012 & Fallatah *et al.*, 2019) in developing countries since they more or less show similar characteristics.

Drivers are interrelated factors that drive the advent of an informal settlement and slums (UN-Habitat, 2015). Rapid urbanisation is revealed by (UN-Habitat, 2016) as a significant driver which generates multiple forms of deprivations and exclusion, creating spatial inequalities. Studies related to drivers of IS and slum growth has been studied by Sietchiping (2005) to model the prediction of the growth and expansion of IS in different categories, including physical (topography), economic drivers (informal economic sectors and socio-cultural (places of worship, cultural and ethnic groups). Further, Sliuzas (2004), categorises the drivers dependent on the data applicability regarding the interest of the urban planners, including the environmental, physical- spatial factors (proximity of services within its environment) and socio-economic focusing on the legality of tenure and population characteristics. Besides, a study done by (Mahabir *et al.*, 2016) reveals ill-defined policies and rural-urban migration as constructs in driving the growth of IS and slums.

Drivers are interrelated factors that drive the advent of an informal settlement and slums (UN-Habitat, 2015). Rapid urbanisation is revealed by (UN-Habitat, 2016) as a significant driver which generates multiple forms of deprivations and exclusion, creating spatial inequalities. Mutisya and Yarime (2011) also reveal that the unprecedented rate of urbanisation is caused by natural growth and massive migration. In line with migration (UN-Habitat, 2016) state that they are largely rural-urban which poses a challenge in providing adequate housing burgeoning informal settlements. Likewise, Poor governance is also considered a significant driver as revealed by Alliance (2019), Olajuyigbe, Popoola and Adegboyega (2015) in their argument that while planning the government does not acknowledge the IS and slums thus failing to respond to their plight and signifying the system weakness.

Along with poor governance, the rigidity of the planning policies to include informal settlement and slums in infrastructure plans has been excluded (Fekade, 2000; Olajuyigbe *et al.*, 2015). The drivers have also, gone beyond theory to apply local expert knowledge which, when tested in Tanzania for urban growth modelling acknowledges population density as a significant driver (Abebe, 2011). Failure to address these drivers leads to acute scarcity of housing in the urban setup leading to informal settlements. Housing demand and proximity to work in the centre of the city endlessly puts pressure on landowners, their tenants and housing stock. This intensification makes the informal settlement inevitable leading to uncontrollable fragmentation including the construction of smaller houses and room tenancies. Moreover, the increasing population and smaller sized plots cause the maximization of the set building standards making informal settlements pervasive and unpredictable (Jones, 2017).

In the management of public policy Kemp, (2001) defines transition as a process that is continuous and change occurs where the structure of society transforms. These transitions show a large scale of change and time. It occurs with a variety of development paths whose direction, size and speed government policy can influence but in no way completely control. Little has been researched into the perspective of transitioning of informal settlement and slum, making this study very relevant and engaging, especially in the dimensions of speed time and size (Kemp, 2001). The study, therefore, is beneficial to the policymakers because it brings out the understanding of the triggering factors of slums formation and helps them to prevent the formation of new slums. It is also useful in recognising the root causes of informal settlements by knowing its transitional factors to make better policy and plans

## 1.2. Research problem

Currently, cities in most Sub Saharan Africa countries are confronting transitioning of informal settlements to slums. As the population increases and need for constantly affordable housing pushes into the slum formation, thus spiralling into uncertainty and patterns of its decay (Kemp, 2001). Despite the growing multidisciplinary approaches to address the informal settlement and slums, more focus has been on monitoring the development of informal settlements through mapping and theorising (Park *et al.*, 2019a), there is little about their transitioning mentioned. Therefore, it is vital to focus on indicators and drivers of transition while studying the dynamics of informal settlement and a slum (Wang, Pijanowski, Yang, Zhai, Omrani and Li, 2018). Indicators such as housing structures, and drivers, including population density that can monitor, analyse and map the transition of this transformation are required for their in-depth understanding (Kemp, 2001). This study borrowing from the recommendation of (Schwarz, Flacke and Sliuzas, 2016) therefore, attempts to go beyond the generalisation of informal and slum terminologies to analyse their transitioning.

## 1.3. Research Objective

The main objective of this research is to identify indicators and drivers of the transition of an informal settlement to a slum.

### 1.3.1. Research sub-objectives

1. **To identify the indicators for informal settlement and slum formation**
  - a) What are the indicators of informal settlements?
  - b) What are the indicators of slums?
  - c) Which indicators differentiate the informal settlements and slums?
2. **To map the indicators of informal settlements and slums for different periods**
  - a) What is the spatial pattern of the informal settlement and slum indicators over time?
  - b) Which key indicators point to the transitioning of an informal settlement to a slum over time?
3. **To identify drivers of informal settlements and slums**
  - a) What are the drivers of informal settlements and slums?
  - b) Which drivers increase the chance of an informal settlement transitioning into a slum?
4. **To discuss the policy implication of informal settlements and slums**
  - a) How do the key indicators influence policies?
  - b) How can policies address the drivers of transition?

## 1.4. Thesis structure

The structure of the thesis is as follows

**Chapter 1:** This section introduces the study detailing the background and justifying the gap to be addressed. It also includes the main objective and sub-objectives that guides the study to answer the main objective.

**Chapter 2:** This section looks into the literature review of the four main concepts used in this study that is Informal settlement, slum, indicators and drivers. It also details the conceptual framework that has been developed to summarise the concepts studied.

**Chapter 3:** This section details the methodological framework used to conduct this research and its limitations.

**Chapter 4:** This section presents in detail the results and discussions of the study.

**Chapter 5:** This section gives a conclusion of the overall results achieved in the study and recommendations for further research areas.



## 2. LITERATURE REVIEW

### 2.1. Diversity of IS and slums

Globally UN-Habitat (2003) in an effort of ‘catch-all’ settlements diversity has categorised IS and slums into two broad categories; slum of hope ‘progressing’ settlements characterized by new, settlements that are self-built and slums of despair ‘declining’ settlements in which the environmental conditions and domestic services are degenerating or degenerated. The diversity in the settlement levels of IS and slums has also seen their further variations as seen in the study of Akhmat and Mahroof (2011) which he categorises the IS and slums into four levels as the affluent settlement, the moderate settlement, the disadvantaged settlement and the slum settlement. This is based on the proportion of the apartments, population density, number of individuals per dwelling unit and housing conditions. Also, Soliman (2019) categorises IS in three levels as legally owned but unregulated land subdivision in the cadastre; illegal squatting on land that belongs to government or privately owned and is also referred to as exformal or hybrid because of their degree of informality. Lastly, it can be a legally owned land but is informal for partly or fully not conforming to the planning regulations.

In Kenya, Githira (2016) reported that diversity of IS and slums had been attempted in Nairobi in 1971 and settlements categorised in the concept of uncontrolled development in 4 levels semi-permanent rural; semi-permanent urban temporary urban and temporary and semi-permanent infills. The categorization focused on among others population density, employment and commercial activities, land tenure and location. The classification is no longer applicable in Nairobi because the city is mostly urban than rural.

Another researcher such as (Lemanski, 2009) identified unique settlement types in South Africa dwellings and emphasized the need to study IS and slums as a way of showing their diversity.

### 2.2. Ambiguity of definition of an IS and a slum

From these studies and efforts to carefully use terms and definitions to emphasise the differences between IS and slums, there is still lack of a coherent definition due to the continuous transformation of IS (Park *et al.*, 2019; Kovacic *et al.*, 2019). According to Park *et al.*, (2019) the lack of provision of vital public services at the early stage of an IS and only provided a later stage of IS deterioration in response to population growth cannot peg IS to the definition of tenure security only but should also consider the dynamic components of IS. This shows that IS and slums not only face challenges in establishing an operational definition of concepts but also there exists challenges of explaining the variations between these settlements (Githira, 2016). The term “slum” is part of general linguistic usage today its synonyms such as “informal settlement,” “shanty,” “squatter,” “favelas” or “Ghetto” (Kraff and Taubenbo, 2014). IS on the other although engraved in the slum synonym such as “squatter,” “spontaneous” or “shanty towns” (Hurskainen, 2004). In Kenya, the term IS is associated with the synonym “*Mtaa*” translated to English means “a better off village” than the slum itself. The slum synonym is “ghetto”. These synonyms overlap still testify imprecise connotations (Kraff and Taubenbo, 2014). However, for consistency and discussions this study the term IS and slum will be used interchangeably with the synonyms of “*Mtaa*” and “*Ghetto*”

**Informal settlement**

The term informal settlement (IS) is defined as a poor and unplanned neighbourhood of low economic value with little if there exists any zoning restriction on the dwelling structures (Owen and Wong, 2013). This definition is considered to vary in various ways that are conditioned to the planning and legal constitutions of the country in which it exists (Ali and Sulaiman, 2006). According to UN-Habitat (2003a), a slum is used as a term for IS to refer to different ranges of settlements. However, Fallatah *et al.* (2019) point out that a slum has a lower housing quality than an IS. Low-quality housing, then again, it is caused by the inability of the local authorities to respond adequately to the housing demand and control to meet the needs of the people (Akhmat and Mahroof, 2011). Akhmat and Mahroof (2011) point out that an IS environment is conceived when individuals and occupants construct their houses separate from the guidance of professional advice, and besides it takes place frequently in a simultaneous manner. UN-Habitat (2018) categorised IS into three main criteria; lack of security of tenure, neighbourhood usually lack formal basic services and infrastructure and housing may not comply with building and zoning regulations that exist. Also, an IS can be occupied by all levels of urban dwellers, both affluent groups and the poor (ibid). This study adopts the UN-Habitat (2018) definition to define an IS as an area that is not formally planned but is illegally occupied where houses are constructed without having formal approval and compliance to existing building regulation.

**Slum**

One of the most studied settlement is the slum as seen in the studies of (Kohli *et al.*, 2012; Gilbert, 2007; Mahabir *et al.*, 2018; UN-Habitat, 2010; 2003; Schwarz, Flacke & Sliuzas, 2016; Kuffer *et al.*, 2016) among others. A slum is defined as the most deprived and excluded form of informal settlement deprived of one or more or all of the following indicators a) lack sufficient living space b) lack durable housing c) lack access to improved water sources d) lack access to improved sanitation facilities and e) lack of security of tenure (UN-Habitat, 2003; 2010; 2018). Park *et al.* (2019) & Kraff and Taubenbo, (2014) add to these indicators overcrowding; squalor environmental conditions characterised hazardous locations as well as social and economic deprivation. Housing (2013) adds that a slum is a human settlement characterised by overcrowding, abject poverty and is excluded from planned physical development. Also, Gilbert (2007) states that a slum is habited by very poor people that are is not often recognized or addressed as an integral and equal part of the city (Sliuzas, Mboup and de Sherbinin, 2008). This Sietchiping (2005) attributes the lack of insecurity of tenure and don't comply to planning regulations. Based on a careful literature review of the slum definition, this study adopts (Housing, 2013) understanding to define a slum as a densely populated area characterized by poor housing structures and squalor lacking basic services and are overcrowded. The IS and slum criterion of definition also adopt the criterion indicators summarized in table 2.

Table 2: Criterion of indicators developed to define and differentiate the IS and slum that apply to this study developed by UN-Habitat, (2018).

Table 2: Criterion for defining and differentiating IS and slum

Criteria defining IS and slums		
Indicators	IS	Slum
Security of Tenure	✓	✓
Sufficient living area (overcrowding)	✗	✓
Structural durability and location	✓	✓
Access to sanitation services	✓	✓
Access to water	✓	✓

✓ -used

✗ - Not used

source: (UN-Habitat, 2018)

## **2.3. Policy overview of IS and slums in Kenya**

### **History of policy development**

Informal settlements and slums in Kenya can be traced back to the colonialism; it is seen as a product of the colonial period (Obudho and Aduwo, 1989). The growth and policy formulation is described in three phases; colonial period; post-independent period to 1974 and mid-1970s to now (ibid).

### **Colonial period**

From the onset of planning Nairobi, spatial planning was based on racial segregation. Planning was done in three sections these included: the 1898 plan for the railway town; the 1926 plan for the settlers in the capital and the 1948 master plan designated as the European zone described as 'areas of economical residential development' and the Asian and African zones described as 'official housing zone or 'workers housing' (Borsay and Tingle, 1999). The 1898 and 1926 plans were specifically developed to segregate the racially where whites were confined to the higher best grounds while the natives of the land were limited to the environmentally inapt East. The Asians were restricted to the northern side of the capital, referred to as the commercial district (Owuor and Mbatia, 2008). The eastern part where the Africans stayed was further characterised by undefined land uses. This Mutisya and Yarime (2011) argued that the development plan excluded the Africans hence essential services to their settlements such as roads linking them the city was not provided to them.

Further, The African resident was expected to be a temporary resident of the city working directly for the colonial government with the condition that the residency status was restricted to the African male and were not permitted to bring their families to the city. However, some Africans still found their way to the city and their illegitimate status could only construct shanties in unused land. This led to their eviction with the enactment of the 1922 vagrancy Act that made provisions to evict, segregate, arrest and limit the movement of the indentured workers and the natives. The Act saw the demolition and forceful throw out of the natives back to the rural areas (Macharia, 1992).

### **Post independent period to 1974**

Upon independence, all native Africans were given the right and freedom to live anywhere and everywhere of their choice abolishing the restriction law that heavily restricted them to the city in the previous regime. This excitement caused many people to migrate to the city in search of better life opportunities such as jobs and higher education. The city was indeed ill-prepared to handle such an influx of population (Obudho and Aduwo, 1989). Lack and inadequate housing provision led to the expansion of the IS and the government's effort to control it through demolition failed. The failure to control the IS expansion saw the establishment of the 1<sup>st</sup> policy formulation known as the 1973 Metropolitan Growth Strategy (MGS) for Nairobi city (Wanjiru, 2017). This strategy was formulated under the heavy influence of British Colin Buchanan and partners a foreign firm which prepared a contrary plan, that is instead of dismantling the social, racial and spatial segregation it reinforced the status quo (Olima, 2001).

### **Mid-1970's to date**

Over time IS have gotten the attention of the policymakers, urban researchers, and international bodies outlined the dangers of slums to humanity (Mutisya and Yarime, 2011). However, the complexities that surround the IS and slums in the city has made it difficult for any workable policy to be passed by the Government which if implemented the right way would improve the life of slum residents (Mutisya and Yarime, 2011). The government's effort to address the IS and slums has led to the formation of strategic plan papers and policies that are embedded within the broader framework of City planning dedicated to acknowledging and improving the IS and slums plight. These policies and strategies have been minimally implemented and do not adequately address the lack of security of tenure (Mutisya and Yarime, 2011;

Githira, 2016). The broader framework of City planning includes the launching of Kenya's vision 2030 in 2008, the opening of Department of Urban and Regional Planning in 2003, creation of a new National Land Policy in 2009, preparation of Nairobi master plan in 2010 (Githira, 2016).

Until recently, the current government has formulated and embedded priority to the poor and the IS and slums in the 'Big 4 agenda' comprising of universal healthcare, affordable housing, manufacturing and food security in the Third Medium Term Plan of the Kenya vision 2030, and the Sustainable Development Goals (SDGs) (Omolo, 2019). Concerning affordable housing, it is envisaged to see the successful delivery of affordable housing units to all, including the IS and slum to reduce poverty. The Big 4 agenda seeks to be achieved through the development of a delivery framework and regulation fund which has seen the production of Housing Fund Act under the Legal Notice No. 238 in which every worker is subjected to pay a housing levy of 1.5% of their wages. Omolo (2019) argues that there is a litigation against it, and the High Court has suspended its implementation after hearing an application that public participation was never done as a requirement by law in coming up with this housing levy. a summary of the policy overview (table 3) gives an indication of the policies implementation in addressing IS and slums.

Table 3: a summary of policy implementation in Kenya

Period	Year	Policy type and purpose	Source
Colonial	1898	<ul style="list-style-type: none"> <li>Plan for the settlers in the capital</li> </ul>	(Borsay and Tingle, 1999; Owuor and Mbatia, 2008)
	1926	<ul style="list-style-type: none"> <li>Plan for the railway town</li> </ul>	
	1948	<ul style="list-style-type: none"> <li>The master plan designated as the European zone described as 'areas of economical residential development' and the Asian and African zones described as 'official housing zone or 'workers housing</li> </ul>	
	1922	<ul style="list-style-type: none"> <li>vagrancy Act: provisions to evict, segregate, arrest and limit the movement of the indentured workers and the natives.</li> </ul>	(Macharia, 1992)
Post independent period to 1974	1973	<ul style="list-style-type: none"> <li>Metropolitan Growth Strategy (MGS): formulated to address the influx of the native's migration into the city after independence</li> </ul>	(Wanjiru, 2017)
Mid-1970's to date	2003	<ul style="list-style-type: none"> <li>Department of Urban and Regional Planning</li> </ul>	(Githira, 2016) (GoK, 2012b; Lands, 2009;(County, 2014)
	2008	<ul style="list-style-type: none"> <li>Kenya's vision 2030- provide adequate and decent housing to all the population in the country in a sustainable environment.</li> </ul>	
	2009	<ul style="list-style-type: none"> <li>National Land Policy- locate and provide serviced land for developing houses for the poor at an affordable rate.</li> </ul>	
	2010	<ul style="list-style-type: none"> <li>Nairobi master plan- comprehensive and integrated urban development framework and extensive measures to tackle perennial challenges such as inadequate housing</li> </ul>	
	2018	<ul style="list-style-type: none"> <li>Big four agenda- provide affordable housing units through a tax levy on workers' monthly wages</li> </ul>	(Omolo, 2019)

## 2.4. Case studies

Many studies have been done in mapping IS and slums and how it can be quantified using various indicators. IS and slums have also been measured using population estimation, assessment of socio-economic status, growth models and predictions (Owen and Wong, 2013), which is an effort to extract spatial information to understand better their morphological characteristics allowing the distinction of clustering of different types of sub-standard settlements (Kuffer *et al.*, 2013). From the different studies conducted, four fundamental case studies have evaluated indicators of IS settlements to understand their identification and classification as seen in the studies (Owen and Wong, 2012; Owen and Wong, 2013; Kohli *et al.*, 2012; Fallatah *et al.*, 2019).

According to (K. K. Owen and Wong, 2012) indicators are crucial to producing a multivariate and spatially precise assessment of a settlement composition. This is achievable when key datasets have access to elevation data and high-resolution images while omitting ancillary data, field surveys and building outlines. Consequently, a total of 24 indicators derived from literature are tested twice to investigate their significance level. The first test reveals 14 indicators as relevant in distinguishing IS and formal settlements and indicates that the excluded indicators either have missing data dependant on census and ancillary data unavailable in many developing countries or high multicollinearity. The second test using regression trees and discriminant function analysis reveals six indicators as the most relevant in distinguishing an IS from a formal settlement. These include Lacunarity, vegetation, nature of road segment, road accessibility, texture measures and slope of terrain (*ibid*). Further, in the of in the study of Basureros of Owen and Wong (2013) using six significant indicators from their previous study in Guatemala revealed that only four proves significant in differentiating the rural and suburban informal settlements namely road structure and accessibility, land cover materials-vegetation, Image texture and geomorphology-slope.

Using a different approach Kohli *et al.*, (2012) developed a contextual framework methodology that provides potentially relevant indicators related to the morphology of built environment able to achieve a full description of spatial characteristics that identifies slums through mapping. The contextual framework, when applied across 16 countries in 3 regions namely Asia, Sub Saharan Africa and Latin America, reveals that Building attributes, road accessibility, shape, density, location and neighbourhood characteristics indicators are vital in classifying slum (Kohli *et al.*, 2012). Using the slum ontology Fallatah *et al.*, (2019) noted that lacunarity/vacant land, road accessibility, Texture measure and dwelling size were the most significant indicators in the case study of Jeddah.

Different approaches were applied in measuring the indicators including statistical analysis (Owen and Wong, 2012; 2013), Object Oriented based analysis (OOA) (Kohli *et al.*, 2012) Object Image based analysis (OBIA) (Fallatah *et al.*, 2019).

### Statistical analysis

To distinguish the IS and formal settlement, Owen and Wong (2012) applied statistical analysis. The first test reveals 14 indicators as relevant in distinguishing IS and formal settlements and shows that the excluded indicators either have missing data dependant on census and ancillary data unavailable in many developing countries or high multicollinearity. The second test using regression trees and discriminant function analysis reveals six indicators as the most relevant in distinguishing an IS from a formal settlement. Their results showed that indicators can be used to quantify settlement structure without the need for ancillary data, field surveys and building outlines which is limited in developing countries. Owen and Wong (2013), further tested transferability and reliability of the statistical results using two different Informal settlement location in the suburban and rural and revealed that only four indicators were applicable in differentiating the rural and peripheral informal settlements. The results show that there is a difference in the characters of the informal settlements using the same indicators and as a result, there is a need to analyse the different settlements using more physical indicators for a better improvement in differentiating them.

### Object oriented image classification

In their study Kohli *et al.*, (2012) developed a framework using a set of image-based parameters from the input of expert knowledge in different countries having different slum characteristics to show different indicators were applicable across different slums. The Generic slum ontology constitutes three levels; three levels; the environment level which revealed hazards as a strong indicator; settlement level which showed texture measure as a strong indicator and object level showed buildings and road characteristics as strong indicators.

Fallatah *et al.* (2019) combine the indicators used by (Owen and Wong, 2013; Kohli *et al.*, 2012) and uniquely classifies the informal settlement using Object Image Analysis (OBIA) to differentiate the IS from a formal settlement. The results showed that it as a useful method of mapping IS indicators in the Middle East. On the other hand, the generic rule set for mapping the IS is still elusive, and each indicator is subject to local tuning for better classification. This study, therefore, partly adopts the use of OBIA to classify the IS and the slum and show the transitioning of an IS to a slum.

Table 4 summarises the indicators developed from the case studies and the highlighted indicators were found relevant for distinguishing IS and formal settlements and IS within the urban and rural areas.

Table 4: Summary of indicators used to classify IS and slums

Indicator	Author
Vegetation	Owen and Wong, 2012; 2013; Fallatah <i>et al.</i> , 2019
Road accessibility	Owen and Wong, 2012; 2013; Kohli <i>et al.</i> , 2012; Fallatah <i>et al.</i> , 2019
Texture measure	Owen and Wong, 2012; 2013; Kohli <i>et al.</i> , 2012; Fallatah <i>et al.</i> , 2019
Lacunarity of a housing structure	Owen and Wong, 2012; Fallatah <i>et al.</i> , 2019
Geomorphology	Owen and Wong, 2012; 2013
Roofing materials	Kohli <i>et al.</i> , 2012; Fallatah <i>et al.</i> , 2019
Proximity to CBD and social services	Kohli <i>et al.</i> , 2012
Building density	Kohli <i>et al.</i> , 2012
Neighbourhood characteristics	Kohli <i>et al.</i> , 2012
Building characteristics	Kohli <i>et al.</i> , 2012
Proximity to hazards	Kohli <i>et al.</i> , 2012
Road segment type and materials	Owen and Wong, 2012
Consistency of housing orientation	Owen and Wong, 2012
Dwelling consistency of orientation	Owen and Wong, 2012

From the above, this study has adopted indicators (Owen and Wong, 2012; 2013; Kohli *et al.*, 2012; Fallatah *et al.*, 2019) to identify further significant indicators that distinguish IS and slum and thus also shows the IS transitioning to slums. These indicators include vegetation, road accessibility, texture measure, roofing materials, proximity to CBD, neighbourhood characteristics, building density, dwelling shape, dwelling size.

#### 2.4.1. Vegetation

Vegetation cover is the amount of surface or objects covered by vegetation (Fallatah *et al.*, 2019). Vegetation cover or green areas are characterised by open spaces, playgrounds and parks (Sugiyama, Leslie and Owen, 2008). According to the authors, neighbourhood green spaces are conducive to better health and wellbeing of the residents and also enhances social ties within the community (Gopal and Nagendra, 2014). Ridd (1995) recognises vegetation in his V-I-S model as one of the fundamental components of an urban area which transforms within and at the periphery with a change in impervious surface and bare soil. (Hofmann, Strobl and Nazarkulova (2011) put vegetation also as an essential player since it affects urban climate through increasing humidity and moderating temperature hence better quality of life.

Further, desirables of vegetation include increased view screening and visual amenity. However, Sugiyama, Leslie and Owen (2008) contradicts visual amenity stating that it can act as an insecure zone when it obstructs the line of vision of those who are walking. For example, is a tree that obstructs the views of those walking in the green spaces, reduces the chances of seeing ahead.

Green spaces are not always evenly distributed (Hofmann, Strobl and Nazarkulova, 2011). Normalised difference vegetation index (NDVI) is used to classify vegetation cover, which often needs an evaluation of their parameters (Owen and Wong, 2012; Fallatah *et al.*, 2019). Owen and Wong (2012) on the other hand state that IS lack vegetation cover and if it is present, it typically covers 5-10% public spaces while the formal settlements cover up to 30% of the public spaces. In most cases, vegetation cover is an important indicator to examine the quality of life and monitoring development in informal settlements. In this study, vegetation includes trees and grasslands, and its decreasing or increasing percentage could be an indicator to distinguish the Kisumu Ndogo and Mukuru Kwa Reuben settlements and their transition over time in the context of Nairobi city.

#### **2.4.2. Road accessibility**

Road connectivity is a public road within any settlement in a city or town that has buildings on one or both sides for connectivity purposes (Kohli *et al.*, 2012). It can also be taken to mean the degree with which a settlement is connected to the transport network (Rusu, Man and Moldovan, 2013). Likewise, according to Heinrichs and Bernet (2014), accessibility is the ease with which one can reach their destination within and without an area. The authors highlight different perspectives of accessibility focused on different disciplines such as transport planners are more concerned on how to improve road usability by focusing on connection to residents and destination; Land use planners, on the other hand, are more into the spatial accessibility that is connectivity, land use mix, walkability and densities. The social planners focus is on the ability of the people to use the services and the opportunities to access the road. These disciplines capture multiple aspects of spatial interactions and opportunities presented throughout the geographic space (Zhang and Kukadia, 2005).

According to (Litman, 2014) study in Canada, a well-connected transport network is characterised by many short links, many intersections with minimum cul-de-sacs or dead ends which connects within and without in a given settlement and other arterials. These characteristics are a complete opposite when quantifying an informal settlement as derived by (Kohli *et al.* 2012; Owen and Wong, 2012) who quantify IS as having irregular network access with roads which are often too narrow for vehicular movement and a high proportion of dead ends and few intersections existing. Kohli, (2015) also reveals that number of nodes and the length and width of roads act as an important parameter in measuring roads since roads with the IS and slums are characterised by many nodes compared to planned roads and have many access paths within IS and slums compared to planned roads. According to Kenyan roads regulation (Roads, 1979), adopted 6m road in rural areas to be applicable within the Informal settlements as a way of increasing accessibility. This study adopts (Kohli *et al.*, 2012; Owen and Wong, 2012; Roads, 1979; Kohli, 2015) thresholds to quantify road accessibility in distinguishing the IS and slums.

#### **2.4.3. Texture measure**

Several forms of informal textures exists that is a room to multiple rooms addition as a result of infill, spatial division or extensions (Kamalipour, 2016). This is echoed by Owen and Wong 2(012) who defines as dwelling areas merged into agglomerated building patches. According to the Kamalipour (2016), a room-by-room addition is a crucial indicator and often takes place both in a linear and district Informal settlement types. The extensions occur mostly when a family wants to invest and add a room to the house for rent, and although it is incremental, it is always achieved overnight with reliance on either availability of construction materials or local know-how. This speed also adds multiple rooms when needed resources are available or

ready. It is also dependant on how much land is available for further encroachment, and if not, then vertical development starts mushrooming ((*ibid*). In SSA, most types of structure are detached while in the Asian context, the IS are attached (Kohli *et al.*, 2012). In order to classify the texture measure of the built-up areas, Grey level co-occurrence matrix was applied and ranged between (0,1). The GLCM has potential to detect slums especially contrast and can also be used to map IS and slums changes such as expansion because most often they are organic and thus high entropy witnessed (Kuffer, Barros and Sliuzas, 2014). GCLM entropy and GLCM contrast were replicated by Fallatah *et al.* (2019) study; however, it yielded very low accuracy in the classification of the IS and failed to extract the settlement.

#### **2.4.4. Roofing materials**

A building can be defined as a structure with a roof and vertical partition (Kohli *et al.*, 2012). When there is a lack of affordable housing, people are often left to fend for themselves a shelter on land that they have no legal claim to when they are not evicted they start developing at their pace. This is seen on the physical development ranging from crude mud thatched structures to multi-story buildings which are dependent on their stay and income accrued over time (Neuwirth, 2016). UN-Habitat (2003) reports that there are set standards of minimum requirements for residential developments. However, slums are associated with very substandard structures that are often unsuitable for use given the local conditions and climate. Roofing materials vary from place to place; for example, Sub Saharan Africa use tin or iron sheets as their roofing material indicator (Kohli *et al.*, 2012).

On the other hand, the Asian context ranges from mud, straw-thatched or plastic roofs, among others with different colours used as the distinguishing features (UN-Habitat, 2003; Kohli *et al.*, 2012). Different built-up indices have been applied, such as shape size pattern and brightness, which can be used as a distinctive feature in their distinction (Fallatah *et al.*, 2019).

#### **2.4.5. Location**

Demand for affordable housing and proximity to the inner city locations puts much pressure on the existing landowners, settlers, and their housing stock intensifies informal settlement and leads to the emergence of slums (Jones, 2017). Similarly, the Informal settlements tend to follow features such as railway corridors, roads, edges of rivers, electricity easements, steep slopes or flood zone areas among others where (Jones, 2017; Kohli *et al.*, 2012). These areas are often unutilized public land that is available, and therefore the residents have no option but to gravitate to it. According to Owen and Wong (2012), an informal settlement is located further away from the CBD, city services, industrial areas or market areas. The implication of distance varies from one country to another and remote sensing can be used to locate probable slum settlement based on height information and GIS layers of the area (Kohli *et al.*, 2012). This study employs quantification of the location to proximity to the CBD, industrial areas, other business centres and location to hazard zones. In classifying the IS and slums further Antos *et al.* (2016) reported that network analysis using RS data provided an insight into the structure and position of the IS and slums in the city provide insight into the internal spatial structure of a city. This study uses network analysis to classify the IS and slum.

#### **2.4.6. Neighbourhood characteristics**

Slums in most developing countries are known to exist in posh neighbourhood areas or middle-income areas because the latter attracts people for economic gain, and they opportunities exist within these areas inside and the exterior of the big cities or towns (Hussain *et al.*, 2019). For example, this neighbourhood in the cities often creates employment experience and income opportunities, pleasant environment with access to social services and good infrastructure creating and serene and secure life. The study conducted by the authors reveals that the neglect of Islamabad city and its underdevelopment because of the low-class income and the unskilled labour residing there to seek for employment led to the growth of the settlement towards



various construction sites over time (ibid). This, according to Jones, 2017 and Kohli *et al.*, (2012) state that they are also attracted to existing informal settlements which are of low socio-economic areas that are accessible and affordable.

The slum settlement growth is as a result of occupying vacant government land and the long neglect and ignorance which leads establishment and addressing their need to reach workplaces and save on transportation expenses (Ragheb, El-Shimy and Ragheb, 2016). Adverse effects associated with slum proximity to other neighbourhood areas include crimes, theft, air pollution and environmental degradation, diseases and prostitution, among others. This has also a negative impact on the cost of rent valuation on residential properties, among others (Hussain *et al.*, 2019).

#### **2.4.7. Density**

In many studies, density has been perceived as being either high or low (Kohli *et al.*, 2012). According to Alexander (1993), perceived density may only concentrate on the effects of mental wellbeing, which makes perceived density differ between countries as well as communities (Kohli *et al.*, 2012). Density is considered as one of the most important indicators in housing, human settlement and slum identification (Acioly and Davidson, 1996 & Kohli *et al.*, 2012). (Acioly and Davidson, 1996) describes density in two types that are net density and gross density. While net density includes only areas allocated to residential development, gross density includes both the built-up, public space and roads, among others. The authors study assumes that the better the utilisation of infrastructure. On the other hand (Sori, 2012) notes that if high densities are not guided, then overcrowding, infrastructure overload and urban inefficiencies are witnessed, and this is very expensive since there are unguided density expansions.

Often people refer to densities as low, medium or high, making it ambiguous. To quantify density in slums (Kohli *et al.*, 2012) notes in her study creates a threshold that roof coverage of greater than 80% is perceived as high density lacking vegetation cover and open spaces and between 30-50% is found in informal settlements in Asia. However, to determine the thresholds appropriate for any type of settlement (Sori, 2012) states that it is vital to refer to the physical planning statutes in which the country is being conducted.

In this research, net density (building footprints) is employed to distinguish and investigate transitioning of an IS to a slum in the case study of Kisumu Ndogo and Mukuru Kwa Reuben settlements. While individuals might provide a subjective evaluation on density, Net density offers an objective assessment of spatial characteristics of the settlements.

#### **2.4.8. dwelling shape**

Informal settlements are termed as very dynamic through time and over space, and reliable spatial information is key for any improvement in the living situation (Hofmann *et al.*, 2008). The authors describe that they are often characterised by dense structures of housing and infrastructure with its impact felt on segregation leading to distinct and spatially separated types of housing structures. (Jones, 2017) categories the shapes and patterns by which Informal settlement claims its space namely a) by attaching onto an existing structure of formal city b) insertion onto vacant land within existing urban boundaries c) settling on an initial occupied land which begins to morph into a village or a town.

Kohli *et al.* (2012) show that shape as an indicator can be measure as elongated or linear, and in some areas, it is irregular shaped. It is therefore worth noting that building heights also vary from one country that is the existence of a vertical mix of commercial activities on the ground floor and residential on the first floor (Kamalipour, 2016). With these variations and their shape not conforming to the planning standards (Kohli *et al.*, 2012), a conclusion on the shape is best derived in contextual studies.

The application of (Kohli *et al.*, 2012) study in sub-Saharan Africa using this indicator, makes it relevant to be adopted for this study to investigate further its significance in distinguishing an IS from a slum. Dwelling density measures will be quantified as either elongated that is attaching of units to existing main houses, linear as following main features such as roads, railway and river channels, among others.

#### **2.4.9. dwelling size**

The increase in population and smaller sized structures and plots signify maximization of the building footprints (Jones, 2017; Kuffer, Barros and Sliuzas, 2014). This limits the provision of accessibility and right of way for emergency services and provision of services such as water and sanitation (Jones, 2017). Dwelling size is also seen as an important predictor to residential satisfaction, and it is perceived that the bigger the size, the more satisfied an individual is with the structure (Kshetrimayum, Bardhan and Kubota, 2020; Iben and Aduwo, 2013). To quantify the dwelling, (Friesen *et al.*, 2018) in their study recognises that the mean dwelling sizes in Cape Town, Rio De Janeiro and Mumbai have similar sizes between 16m<sup>2</sup> and 40m<sup>2</sup> and adds that more sizes are also exhibited in the slums of Cape Town which are as small as 15m<sup>2</sup>.

### **2.5. Drivers of IS and slums**

Drivers are interrelated factors that accelerate the advent of any growth, and there is need for decision-makers to understand the factors that drive their very expansion in order to formulate policies that promote urban development while minimising the environmental impact it can produce (UN-Habitat, 2015; Seto and Kaufmann, 2003). Various studies have identified drivers in different fields such as economy, demographics, natural environment, urban land-use change and informal settlement growth (OECD, 2014; Huang, Zhang and Wu, 2009; Sliuzas, 2004; Sietchiping, 2005). Huang, Zhang and Wu (2009) state that drivers are not universal, but rather their relative weights are critically dependant on the context within which the development occurs. Generally, drivers are categorised into three groups: socio-economic drivers, biophysical factors-these do not directly cause land use change but can cause land cover change example climatic changes and third is the proximate causes ( dealing with land management variables).

In relation to informal settlement growth, further categorisation of drivers has been studied by Sietchiping (2005) to model the prediction of the growth and expansion of IS. The categories include Physical- relates to transport network existing pockets of slums and topography; economic drivers- deals with informal economic sectors); socio-cultural- deals with places of worship, cultural and ethnic groups. On the other hand, Sliuzas (2004), categorises the drivers dependent on the data applicability in regard to the interest of the urban planners. The categories include environmental- covers the site conditions; physical- spatial looks at physical development both on the site and proximity of services within its environment; and socio-economic- focusing on the legality of tenure and population characteristics. Besides, the study done by (Mahabir *et al.*, 2016) reveals ill-defined policies and rural-urban migration as constructs in driving the growth of IS and slums. From the above categories, drivers can be grouped into non-measurable drivers and Measurable drivers (table 5).

Table 5: summary of categories of drivers of IS and slums

Category	Variable	Source
Physical-Spatial	Building materials and quality of construction	(Sliuzas, 2004)
	Housing types	
	Land use and building density	
	Structure and condition of road layout	
	Quality and quantity of basic infrastructure provision (water, sanitation solid waste, telecommunication)	
	Proximity to social services (transport, employment education etc.)	(Sietchiping, 2005; Sliuzas, 2004)
	Proximity to undeveloped land	
	Topography	(Sietchiping, 2005a)
	Transportation network	
	Existing pockets of slums	
Socio-economic	Land tenure	(Sliuzas, 2004)
	Housing tenure	
	Land value and property value	
	Community organisations	
	Demographic characteristics	(Sietchiping, 2005; Sliuzas, 2004)
Economic activities (source of income and type)		
Socio-cultural	Places of worship	(Sietchiping, 2005)
	Culture	
	Ethnicity	
Environmental	Slope of terrain	(Sliuzas, 2004)
	Environmental hazard areas (flood risk areas, earthquakes etc)	
	Soil bearing capacity	
	Ground water level and soil drainage capacity	
Governance and Ill-designed policies	Lack of political will	(Mahabir <i>et al.</i> , 2016)
	corruption	
	Long Bureaucracy	
	Outdated planning regulations	
	Stringent development application policies	
	Lack of community participation in planning and decision making	
	Lack of acknowledgement of IS and slums in plans	

From the summary table above the highlighted variables were selected as applicable to this study for further analysis in identifying their significance in transitioning an IS to a slum.

### **2.5.1. Physical-spatial drivers**

#### **Basic infrastructure provision (water, sanitation and garbage disposal)**

One of the long-lasting legacies of inadequate provision of basic infrastructures such as water, sanitation and solid waste disposal evidenced in the IS and slums emanates from the colonial era development plans (Sliuzas, 2004; Mutisya and Yarime, 2011). Mutisya and Yarime (2011) argue that the Africans were segregated and essential services were not provided for them and the continual negligence of the IS and slums with the government after independence has spiralled the to a deplorable state characterised by lack of water, hygienic sanitation and lack of solid waste management facilities. Even with some of the IS accessing piped water, Cheseto (2013) argue that there is a lot of contamination due to infiltration of foul water through the broken pipes. This and lack of sanitation accounts for many illnesses and diseases in the IS and slum (Sclar, Garau and Carolini, 2007; Mutisya and Yarime, 2011). The continual decline of the condition of IS is also attributed to the overwhelming population influx pressure on the capacity and ability of the city to provide services to the residents (Cheseto, 2013). On the other hand, solid waste services are rare in most IS and slums since the county does not provide services to them and as a result, they have continued to live among heaps of garbage and vermin (ibid). Similarly, Mutisya and Yarime (2011) that Waste collection services are provided only sporadically to low-income areas because of poor accessibility and very high waste generation, which cannot be handled with available vehicles and equipment.

### **2.5.2. Proximity to social services (transportation and employment, other IS and slums, undeveloped land)**

In relation to proximity to services, Abebe (2011) states that proximity to principal transportation axes, the CBD, industries, to the harbour have had a substantial role in the evolution of IS in Tanzania on the other hand when determining the probability of their expansion, he noted that proximity to the roads and other informal settlements had a negative effect on their expansion. On the other hand, proximity to undeveloped land had a strong effect on the IS and slum growth (ibid). Moreover, Shekhar (2012), noted that proximity to other IS and slums and availability of undeveloped land in Pune. Sliuzas (2004) using housing pattern to show the IS and guiding elements to its expansion once it is established notes that proximity to major roads increased the probability of the IS expanding.

### **2.5.3. Socio-economic drivers**

#### **Economic activities**

In relation to population growth, Arimah (2001b) states that urban growth demographic shift result is the urbanisation of poverty whereby the concentration of poverty is moving to the urban centres from the rural areas. Urban poverty pupation is on the manifestation of IS and slums with a reflection of low levels of income readily apparent. Likewise, Mutisya and Yarime (2011) point out that high levels of unemployment and low income give rise to IS deteriorating to a slum. The likely consequence of low levels of income and high poverty rates is due to their developing countries inability to leverage financial resources to address slum and squatter settlements upgrading programs. The increasing poverty rates especially in rural areas mostly act as a trigger of waves to urban centres with IS and slum settlements being the destiny for these many new migrants (Arimah, 2001).

#### **Socio-cultural drivers**

On the other hand, Subasinghe (2015) states that net migration from rural to urban areas brings different people from the country and is often associated with socio-cultural ties. The study observes that the migration is generational in three stages in the case study of Indonesia. The first generation has lived more than 30 years, the second generation is the children of the first generation, and the third generation are the children born in the place. These generations are highly linked either by relation, marriage, friendship or occupation (ibid).

## **Migration**

Migration and population growth continue to drive a significant portion of urbanisation in Africa (Teye, 2018). UN-Habitat (2016a) states that migration primarily rural-urban migration causes a problem in providing adequate housing provision. Housing demand and proximity to work in the centre of the city, according to Jones (2017) endlessly puts pressure on landowners, their tenants and housing stock. This intensification makes the informal settlement inevitable leading to uncontrollable fragmentation including the construction of smaller houses and room tenancies. Moreover, the increasing population and smaller sized plots cause the maximization of the set building standards making informal settlements and slums pervasive and unpredictable.

## **poor urban governance and Ill-designed policies**

Likewise, poor governance is also considered a significant driver as revealed by Alliance (2019) arguing that the governments continual fail to acknowledge the rights of the urban poor and include them in with urban planning accelerates the formation of informal settlements and slum growth. Also, many countries have failed to respond to rapid urbanisation fast enough as people are migrating to the city faster than the planning process can and they build shacks before the government has the chance to notice their existence (ibid). Olajuyigbe, Popoola and Adegboyega (2015) further notes that rigidity of planning policies is also another important driver to formation of IS and slums. This Mahabir *et al.* (2016) adds in their study of Cote d'Ivoire that the rigidity has led to slow development pace resulting in unaffordable housing for a large population. Other factors such as unresponsive financial systems as is the case of Nigeria the process of acquiring land can be as much as 27% of the property value presenting a challenge for the IS and slum residents with limited finances. Other associated factors such as corruption, nepotism and poor governance. These lead to a severe shortage of urban housing and, land and infringement of building regulations. All these drivers lead to high land rates and continue to quicken the proliferation of IS and slums due to poorly functioning land markets (Olajuyigbe, Popoola and Adegboyega, 2015; Mahabir *et al.*, 2016; Fekade, 2000). Mahabir *et al.* (2016) state that it can further be the issue that some government simply lack political will to address the issue of informal settlements and slums.



### 3. METHODOLOGY

This chapter gives a detail description which the study followed in executing the research. It describes the overall methodology workflow, study area the data capture and the data analysis.

#### 3.1. General approach of the study

This study used a mixed approach that is quantitative and qualitative. From the onset, an in-depth literature review was conducted to justify the research gap and identify the potential indicators and drivers of transition from an informal settlement to a slum. Two case study areas were identified that is Kisumu Ndogo (KND) informal settlement and Mukuru Kwa Reuben (MkR) slum, which were used to implement the research. In order to identify relevant indicators and drivers in the study areas, local knowledge was applied through interviews and questionnaires, which were semi-structured and used open-ended questions. They were administered to the identified key experts, Focus Group Discussions (FGDs) with the village elders and questionnaires surveys with the residents of the study areas. Once data was collected, mapping was done for the selected key indicators. Mapping of the indicators involved developing rule sets for classifying the indicators for the two settlements, i.e. KND informal settlement and MkR slum. Indicators related to shape and density were further analyzed using spatial metrics, and location indicators were analysed using network analysis. The results of both indicators and drivers were then discussed. The overall methodology is shown in Figure 1 and described in the subsections below.

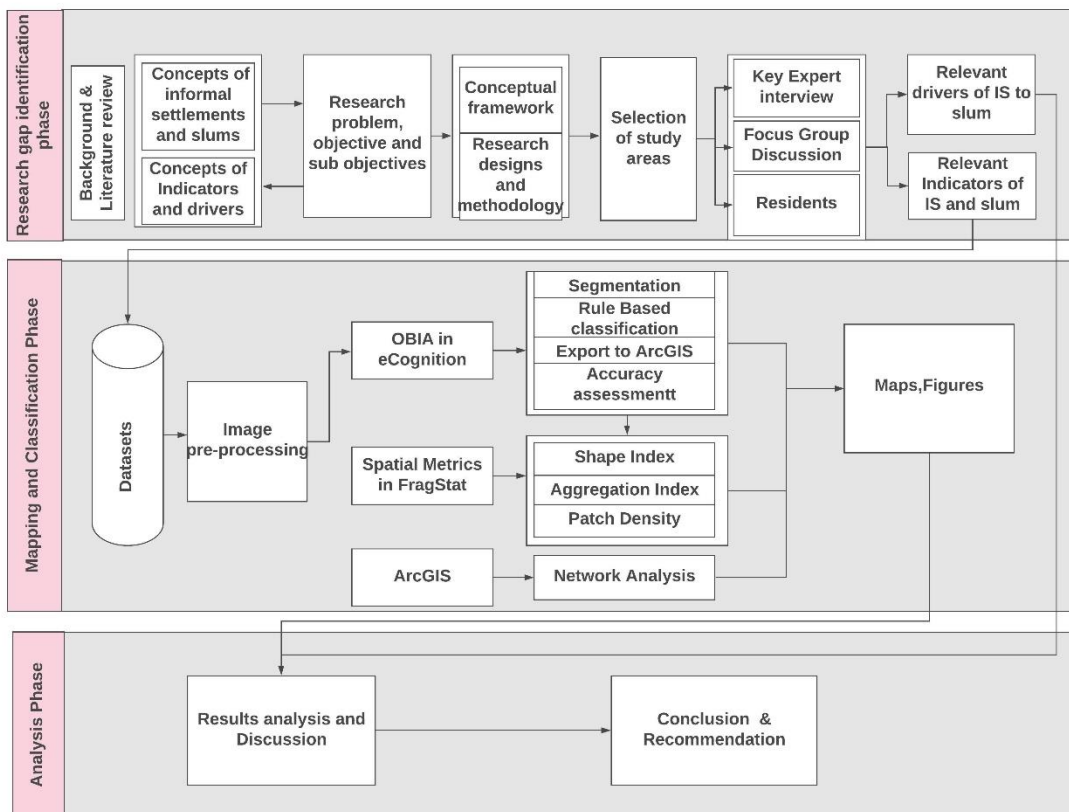


Figure 1: Flow chart of the study methodology

## 3.2. Study Area

### 3.2.1. Selection of the study areas

Nairobi is home to over 139 IS and slums in Kenya (Pamoja Trust, 2009), characterised by socio-economic challenges including insufficient infrastructure, sprawling, lack of basic services and varying built-up densities (Darkey & Kariuki, 2013). While some IS and slums tend to occupy marginal lands, such as quarry sites and flood areas among hazardous areas, others are located along railway tracks and have substandard structures (Darkey & Kariuki, 2013). Although most of IS and slums have a historical foundation, some have occurred recently. This study focuses on Kisumu Ndogo (KND) and Mukuru Kwa Reuben (MkR) settlements in Nairobi City. The site selections were based on the careful review of the satellite images from 2002 to 2006 which showed evidence of transitioning from an informal settlement (IS) to a slum taking place in MkR over time as KND remained static. The settlements will be studied using identified indicators in chapter 2, to distinguish them and map their transition.

### 3.2.2. Nairobi City

Nairobi County is the capital city of Kenya, covering 695km<sup>2</sup>, while its metropolitan region is 32,000km<sup>2</sup> (Otiso, 2017). It is situated on the southeast longitude 36° 45'E and latitude 1°18'S, and its elevation is 1,798 meters above sea level (Nairobi County, 2018). Administratively, Nairobi County has 11 constituencies (Starehe, Kamkunji, Kasarani, Roysambu, Ruaraka, Makadara, North Embakasi south Embakasi, Embakasi Central, Embakasi East, Embakasi West, Dagoretti North, Dagoretti South, Langata, Westlands, Kibera and Mathare), 86 wards (Nairobi County, 2018). Moreover, the County is traversed by two major rivers Ngong and Mathare (Otiso, 2017), that are characterised by footprints of unplanned informal settlements and slums driven by urban poverty and rapid population growth among others (Tibajjuki, 2007) such as study areas in Figure 2. Approximately 25% of Nairobi's land cover is under residential use, making it the second-largest use after open land covering 28%.

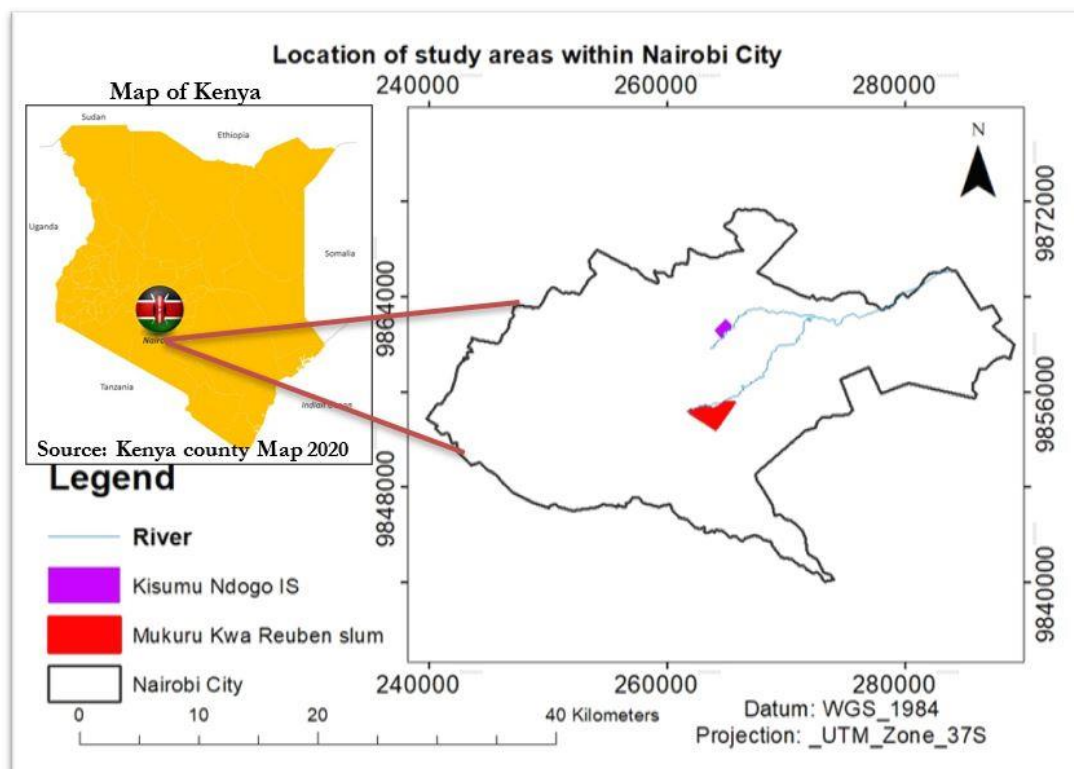


Figure 2: Location of the study Area



### 3.2.3. Mukuru Kwa Reuben (MkR) Slum

Mukuru is known to be the second-largest slum after Kibera slum in Nairobi City County (SPA, 2017) and sits approximately seven kilometres from the Central Business District (CBD) within the constituency of Embakasi. It has four administrative wards, Mukuru Kwa Reuben, Mukuru Kwa Njenga, and Viwandani (Figure 3), surrounded by the industrial zone of Nairobi and several growing middle-class housing real estates. The study focuses on Mukuru Kwa Reuben which covers approximately 121 Ha and is bound by Ngong river along the Northern. To the west it is bound by Viwandani and Kenya railways line (SPA, 2017).

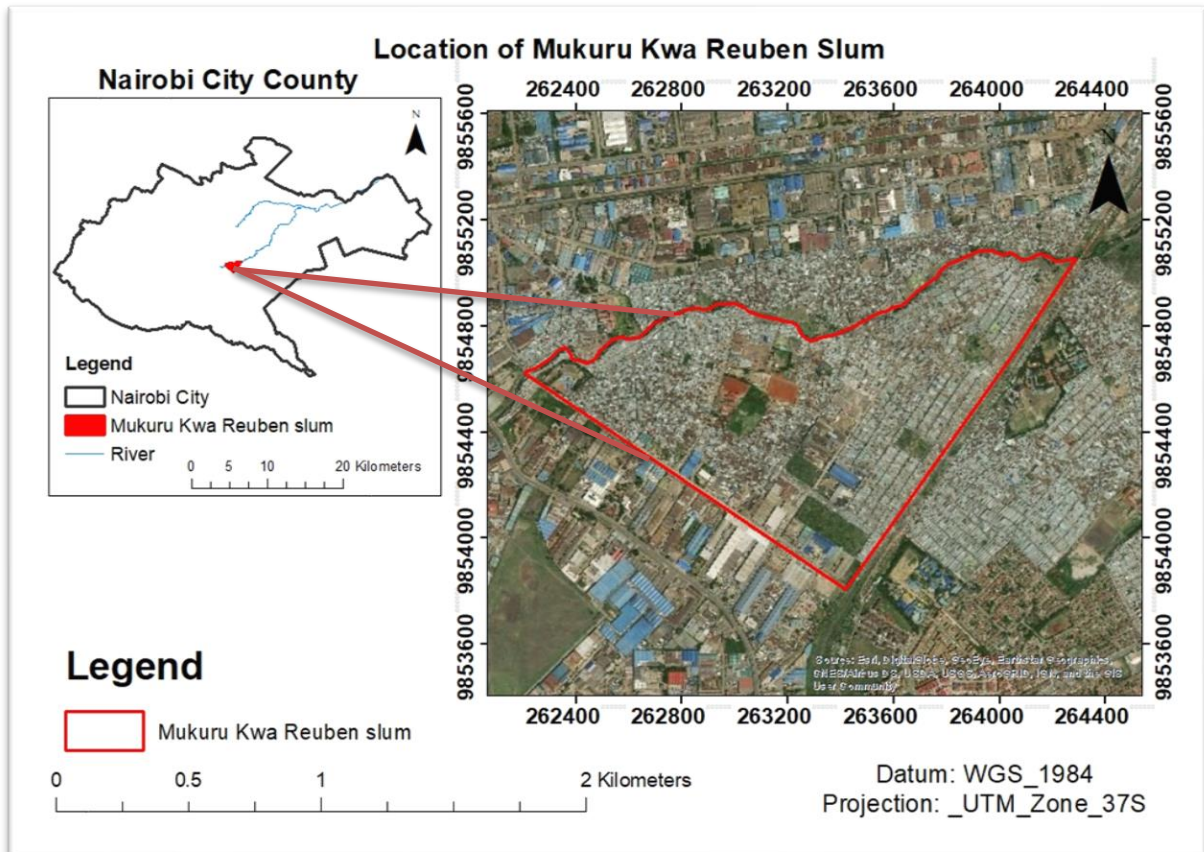


Figure 3: Location of Mukuru Kwa Reuben slum within Nairobi City County

### 3.2.4. Kisumu Ndogo (KND) informal settlement

Korogocho slum is located east of Nairobi in Kasarani constituency and is approximately twelve kilometres from the CBD. It has eight villages, namely Gitathuru, Grogan A and B, Highridge, Korogocho A and B, Kisumu Ndogo and Nyayo (Kago, 2009). This research focuses on Kisumu Ndogo village as an informal settlement that has remained informal after resettlement despite other villages within Korogocho transitioning to a slum (Figure 4). The informal settlement covers approximately 5 ha. The Nairobi river bounds it to the East and Market road to the western side. To the south, it is bound by Nyayo settlement and Korogocho A settlement to the north.

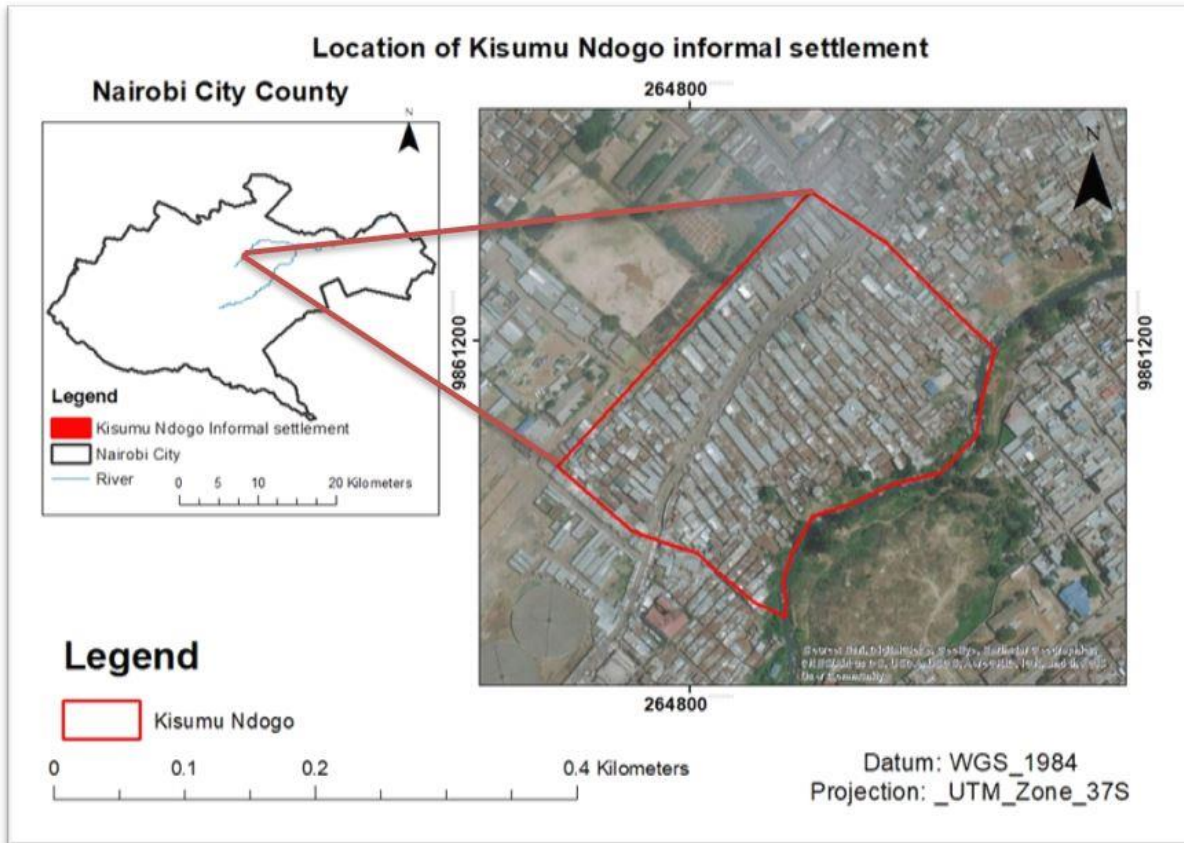


Figure 4: Location of Kisumu Ndogo Informal settlement within Nairobi City County

### 3.3. Secondary data capture and analysis

Secondary data capture applied literature review to get adequate knowledge and understanding of indicators and drivers' concepts that influence transitioning of an IS to a slum. The data formed the backbone of the 'introduction' and 'literature review' chapters of this study. Sources of data capture included published journals, websites and databases, among others. This data capture also proved useful in defining the parameters of indicators and drivers that transitions an IS to a slum as reviewed from previous studies of (Fallatah *et al.*, 2019; Kohli *et al.*, 2012; Owen & Wong, 2013).

Various steps have been undertaken to map the indicators and show the transition of the IS to slum. These steps include the selection of satellite imagery, image pre-processing, Object Image based Analysis process, spatial metrics and ArcGIS network analysis.

#### 3.3.1. Selection of satellite imagery

This study required the extraction of relatively small objects (considering buildings as the objects) in which detailed classification is dependent, therefore, acquiring very high-resolution imagery that can offer detailed information on the dynamism of the rapidly changing IS and slums were essential (Kuffer *et al.*, 2016). Also, since the study was looking into the trend of transition, archived remote sensing (RS) imagery was most suitable, and therefore Quickbird (QB) imagery was selected. The images were retrieved from the European Space Agency (ESA) by requesting for them and were availed for this research free of charge.

Quickbird imagery provided has a resolution of 0.6m for the panchromatic image and multispectral image of 2m resolution having four bands (red, green, blue and Near Infrared). Different criteria were applied, in selecting the images such as maximum cloud cover of 15% and off-Nadir of between 0°-15° (Globe, 2012). Images that did not meet the criteria were dropped; these included 2005 and 2007 images which had dense cloud cover. The final images used are 2002, 2003, 2004 and 2006, also shown in the summary Table 6.

Table 6: summary of Quickbird RS Imagery data

Archive order	Tasking Order				Product parameters			
Catalogue ID	Collecting date	Sensor ID	Cloud cover	Off Nadir	Type	Kernel	Bands	Projection
10100100001CB800	11/02/02	QB02	0°-15°	Max. 15% c	Ortho-Ready Standard (OR2A)	4x4 Cubic Convolution	Bundle (PAN + MS)	UTM WGS 84
10100100018E8000	14/01/03	QB02						
101001000347C600	20/09/04	QB02						
10100100051CEF00	31/07/06	QB02						

### **3.3.2. Image pre-processing**

According to the DigitalGlobe Quickbird product guide, there are three levels of processing basic, standard and ortho ready imageries. For this research ortho, ready imagery was used since they are radiometrically, sensor geometrically corrected and orthorectified (Globe, 2006). Because of the low multispectral resolution and high panchromatic resolution, pan-sharpening was implemented to fuse their geometric details yielding good performance of high-resolution techniques (Lin *et al.*, 2015). The pan-sharpened images usually shift after fusion and therefore, to rectify the shift a coregistration was performed (Langheinrich, 2014). The coregistered images were then subset to the areas of interest for further analysis. The pre-processing was performed in ERDAS Imagine.

### **3.3.3. Ancillary data**

The nature of roads within KND informal settlement and MkR slum are earth and mud road. These roads also act as main access to the settlements and are difficult to segment because of their high heterogeneity. The main roads of access were therefore digitised from the Open Street Map (OSM) which provided better results in separating the adjacent settlements during segmentation. Also, the water body was digitized and embedded to make it easier to detect when segmentation is performed. This approach was also based on different studies such as (Kohli *et al.*, 2012; Pratomo, 2016) that used roads data and water body that saw an improvement in segmentation.

### **3.3.4. Object Based Image Analysis**

Object Based Image Analysis (OBIA) was applied in the initial phase of mapping the indicators. This is a process of partitioning an image into objects and segments, and its application is focused on identifying and classifying urban features (Blaschke, 2010). QB imagery and thematic layers were at first loaded into eCognition software where a multiresolution segmentation was done using different scale parameters to generate the target objects within the IS and slum. Once a satisfactory segmentation was achieved, rule-based classification was applied using spectral and object features. Two levels of classification were then applied, i.e. object-level and settlement-level. The object-level used spectral features to classify the vegetation and water, and object feature, i.e. brightness was used to classify shadow. The settlement level, on the other hand, applied the object features that targeted more heterogeneous objects such as the settlements and unpaved roads within the IS and slum. The final maps were then exported to the ArcGIS for accuracy assessment, analysis and discussion. A summary of the methodology is shown in Figure 5 and after discussed below.

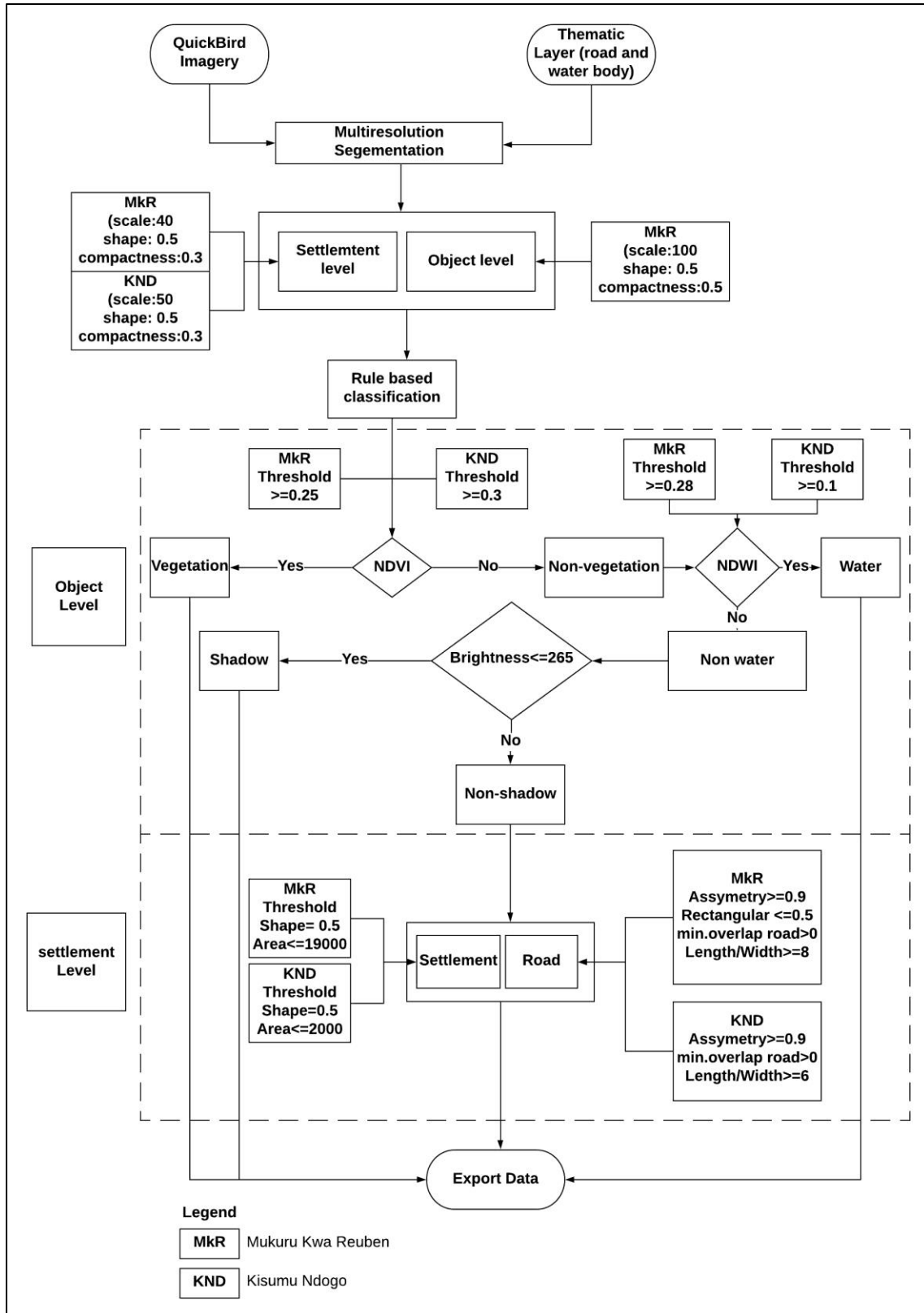


Figure 5: OBIA methodology for Mkr and Knd settlements

### 3.3.4.1. Image segmentation

Image segmentation is the first step of OBIA which is a process that partitions images into a moderately homogeneous area called segments (El-naggar, 2018). Segmentation has three parameters of operation embedded in the multiresolution segmentation algorithm. These include scale, shape and compactness. These parameters have a significant impact on the accuracy of the results since all the steps that develop, constructs and union the objects among others are dependent on it. The scale parameter is most crucial and directly affects the accuracy of the segmentation results. Determining the best scale is time-consuming and challenging since no known method gives specificity for setting scale parameter. It is also for this reason that issues like oversegmentation and undersegmentation usually occurs because it is on a trial-and-error basis (El-naggar, 2018; Sori, 2012). The shape, on the other hand, is the relationship between colour and shape criteria, i.e. its criteria determine the extent that shape influences segmentation compared to colour and has a maximum range of 0.9. Similarly, compactness reveals the solidity of an image, i.e. the length and width over pixel numbers and operates within the ranges of 0.1 to 0.9 (El-naggar, 2018).

Image segmentation was categorised into two levels that is object and settlement levels for MkR slum and one level that is settlement level for KND informal settlement (Figure 6). Object level applied in MkR had a higher scale parameter because the objects were more homogeneous and were easy to classify; these included vegetation, water, shadow and bare land. On the other hand, the settlement level had a lower scale to allow classification of the smaller objects such as built-up areas and the unpaved roads, which also showed much heterogeneity in their classes. In addition, KND was segmented using settlement level because it had fewer land cover and were not complicated to classification process, i.e. vegetation, water and built up. Figure 6 shows the segmentation results applied in MkR and KND at different levels.

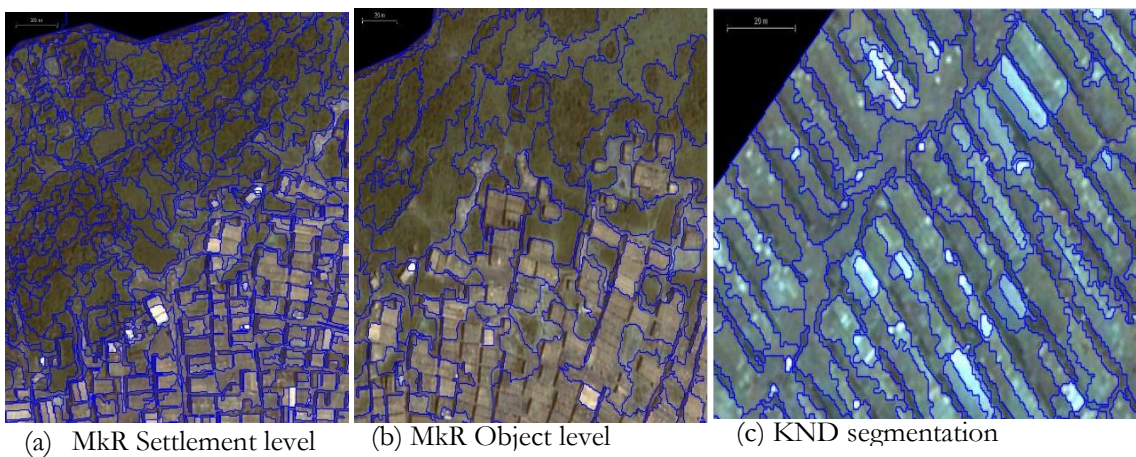


Figure 6: Image segmentation at different levels for MkR and KND settlements:

- a)** SP=40, shape ( $W_{shape}$ )= 0.5 and compactness ( $W_{compact}$ )=0.3      **b)** SP=100, shape ( $W_{shape}$ )= 0.5 and compactness ( $W_{compact}$ )=0.3      **c)** SP=50, shape ( $W_{shape}$ )= 0.5 and compactness ( $W_{compact}$ )=0.3,

### 3.3.4.2. Image classification

Image classification was the second step of OBIA. Classification uses the characteristics of the segment to sort objects into individual classes. Six land cover classes were identified including vegetation, water, bare land, shadow, roads and buildings then rule based classification was then used to assign the classes threshold values that defined the target object separately. Defining these rules are too demanding, especially when dealing with heterogeneous objects because they can overlap or cause opposition to each other, reducing the accuracy level. At the same time, it is known to yield better results which can be easily described in a set of rules (Veljanovski, Kanjir and Oštir, 2011). Two levels of classifications that is object level and settlement level were applied in MkR slum and one level, i.e. settlement level for KND informal settlement.

#### object level classification

Object level classification took into consideration the non-built up areas which comprised of vegetation, water, bare land and shadow. The common indices used to measure them included NDVI, NDWI, and Brightness.

##### 1. Normalized Difference Vegetation Index (NDVI)

the Normalised difference vegetation index (NDVI) was used to extract vegetation cover using a threshold value of  $\geq 0.25$  for MkR slum and  $>0.3$  for KND informal settlement.

The NDVI formula applied is:

$$NDVI = (NIR - RED) / (NIR + RED)$$

##### 2. Normalized Difference Water Index (NDWI)

Normalized Difference Water Index (NDWI) was used to extract the water body. A threshold value of  $\geq 0.28$  for MkR and  $\geq 0.1$  for KND respectively were applied to separate water body from other built-up and non-built-up.

The NDWI formula used for its extraction is:

$$NDWI = (GREEN - NIR) / (GREEN + NIR)$$

##### 3. Shadow

Shadow influences the segmentation of the surrounding areas, and as such, it was necessary to extract it to be excluded from the subsequent classification. It was classified as anything with the value of zero and to extract it the mean brightness value of  $\leq 265$ . Shadow extraction value was applied to both settlements and is also based on a trial and error technique.

#### Settlement level classification

Settlement level classification focused on the built-up and the road network

##### 1. Road Network

Road networks were classified using Asymmetry of value  $\geq 0.9$ , rectangular fitness  $\leq 0.5$  and ratio of length to width  $\geq 8$  thresholds for MkR. KND roads were extracted using asymmetry values of  $\geq 0.98$  and ratio of length to width value of  $\geq 6$ . Rectangular fitness in the case of KND was not applied because the built-up was elongated threshold ranges was applicable. While the roads within the settlements were characterised by irregularity and dead ends, regular road segments were located on major roads. Further, Road data digitized from the OSM was added to show the main roads within the settlements and using the threshold of minimum overlap value of  $>0$ . This computes the minimum overlap that exists between the image and the vector object in percent.

## 2. Built-up level

Dwelling shape was first determined by the scaling of the segmentation to identify the shapes of the features using a threshold of 0.5. To extract the dwelling units, Area of features of value  $\leq 19000$  pixels was applied on Mkr slum and Area feature value of  $\leq 2000$  pixels for KND informal settlement. The extraction of single dwelling units was not possible in this case because of the compactness of the buildings.

### 3.3.4.3. Accuracy assessment

Accuracy assessment was applied to evaluate the quality of classification results to reveal how well the desired objects were extracted. In order to validate the accuracy of classification, the final results of mapping were exported to GIS platform in which reference data of 150 samples were trained for Mukuru Kwa Reuben slum and 75 samples for Kisumu Ndogo and assigned to their various land cover classes (Figure 7 (a-b)). The sample size of the two areas was notably different because of their sizes where Mkr covers approximately 121 Ha, and KND covers approximately 5 Ha and therefore the sample size of Mkr is higher for better sampling coverage contrary to KND. The samples A confusion matrix was prepared and the overall accuracy compared across the different years to see their overall classification performance (Table 7 and Table 8)

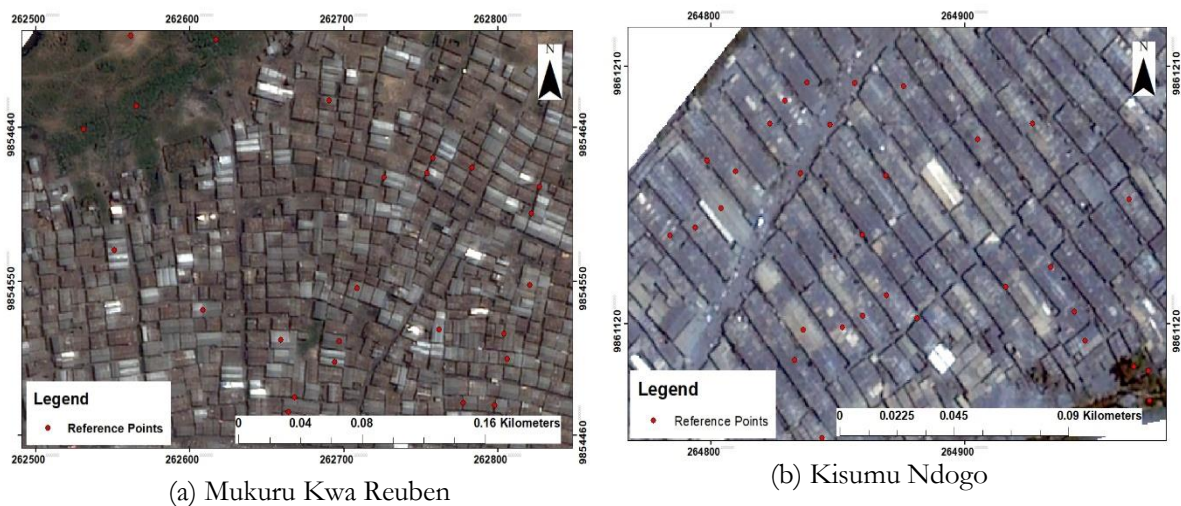


Figure 7: Random points selections for Mkr slum and KND informal settlements

Table 7: Mkr Accuracy assessment 2002-2006

Year	2002		2003		2004		2006	
	producer (%)	User (%)	producer (%)	User (%)	producer (%)	User (%)	producer (%)	User (%)
bare land	100	100	0	0	67	67	50	50
buildings	95	78	100	79	93	67	100	71
roads	45	71	50	71	36	67	63	100
water	-	-	88	88	71	100	-	-
vegetation	93	100	77	83	94	89	88	88
Overall Accuracy	<b>84</b>		<b>77</b>		<b>77</b>		<b>80</b>	



Table 8: KND accuracy assessment 2002-2006

Year	2002		2003		2004		2006	
Land Use	Producer (%)	User (%)	Producer (%)	User (%)	Producer (%)	User (%)	Producer (%)	User (%)
Shadow	57	89	31	90	47	74	73	100
Roads	87	100	83	66	27	100	70	100
Settlement	93	85	90	75	100	54	100	77
Vegetation	100	71	100	75	83	68	100	79
Water	100	100	83	100	100	100	100	100
Overall accuracy	87		78		71		89	

From Table 8 above, It was noted that water was not classified in 2002 and 2006 for KND settlement since the NDWI failed to pick the values because it had very low reflection as that one of the roads.

### 3.4. Spatial metrics

Spatial metrics was used to quantify the shape and built-up area of KND informal settlement and MkR slum using Mean Shape Index (MSI), Aggregation Index (AI) and Patch Density (PD). The land use maps for KND and MkR were converted to grid format with a 1.5m by 1.5m cell size and 5m by 5m cell size, respectively. The cell sizes were based on the resolution of QB imagery and computed using class metric level computed using 5\*5 moving window method.

#### Mean Shape Index (MSI)

Mean Shape Index measures the patch shape in relation to the spatial intensity of heterogeneity (Gerais *et al.*, 2018). When the MSI is equal to one, then the patches are all polygon, this indicates that the shapes are less complex and more homogeneous. Conversely, when the MSI patch is larger than one, it portrays heterogeneity of more complex shapes. In this study, the shape uses MSI calculation to analyze the complexity of the built-up footprints and also evaluate the transitioning pattern of the IS to a slum

#### Aggregation Index (AI)

Aggregation index measures the ratio of the number of like adjacencies that are observed and maximum possible numbers of like adjacencies comprising of each patch type and given in percentage. When the AI is zero, then the patches are disaggregated, and when it is 100, it is maximumly aggregated.

#### Patch Density (PD)

Patch Density measures the number of patches per unit area basis that facilitates comparison among landscapes of varying sizes (Liu *et al.*, 2017). This means that the greater the density of patches are, the higher fragmentation of the landscape is and vice versa (Marks, 1994).

### 3.5. Network analysis

ArcGIS was used to spatially analyse the location to CBD/industries and railway substation and the IS and slum classification since the QB imagery did not cover the CBD and also the analysis covered the whole county. Location proximity was analysed using the Euclidean distance. A 15km buffer distance from the CBD applied was adopted from the work of (Antos *et al.*, 2016). A fishnet of 0.5x0.5km grid was created, which produced points that were exported into a new layer. Distances for all the points were then created by joining the fishnet FID the new layer distance column and distances for all the areas of interest

summarized into five classes and visualised using maps. The final map distance was then compared to the thresholds provided by the key experts during the analysis.

### **3.6. Primary Data capture**

The literature review showed well-defined indicators that were adopted and presented to the key experts, FGDs and residents of Kisumu Ndogo and Mukuru Kwa Reuben settlements. Questions addressing the identification of indicators if an IS and a slum, identification of drivers of an IS and a slum and policies recommendation sub-objectives were administered to them as detailed below.

#### **3.6.1. Key expert Interviews**

##### **Sampling strategy**

The initial step to selecting key experts for an interview was done through purposive sampling based on different disciplines with knowledge and understanding of IS and slums in Nairobi. Another criterion of selection was also based on the researcher's working experience, and interaction with most of the key experts made it easier to identify them during my fieldwork preparation. To have the key experts interviewed, they were contacted through phone calls, and messages and emails were used as a follow-up. Meetings were scheduled on their availability, allowing more time to exchange ideas and perspectives of this research objectives. Although a total of 8 key experts were identified, during the interviews referrals to other key experts were recommended and appointments scheduled increasing the number to twelve. Interviews were conducted face-to-face and discussions were guided by the use of the prepared questionnaires administered by the researcher.

##### **Interview instruments**

Three key themes were covered in the questionnaire used for the expert interview, they included;

- a) The definition of the IS and slum; to evaluate their understanding of definitional difference between an IS and slum useful in the discussion process;
- b) Listing of indicators identified from literature and their parameters; to rank the indicators and add more and also to give the relevant parameters for the indicators
- d) Identify existing policies used to address the indicators and drivers and their levels of implementations and
- e) Listing of drivers that increase the chance of transitioning of an IS to a slum

Further, the interviews also had provisions for suggestions and answers in case the respondent considered any additional critical factors. (Appendix B 1)

### Administration

Key experts identified were from different sectors, as shown in the summary.

Table 9. The diversity of experts created a broad range of rich knowledge in understanding the indicators and drivers that transitions an IS to a slum. Moreover, there is awareness of the existing IS and slum strategies and policies, coupled with their implementation.

Table 9: Key experts interviewed, offices and department within Nairobi County

Level	Offices	Department	Number interviewed
Key Experts	Ministry of Transport, Infrastructure Housing and Urban Development	Housing and Urban Development	3
	Ministry Lands	Kenya Informal Settlement Improvement Programme (KISIP)	4
	Nairobi City county	Housing	2
	University of Nairobi	Urban Planning Department	2
	Technical University of Kenya	Urban Planning Department	1

Capturing data involved note-taking in the questionnaire and recording the interview sessions were employed. Note-taking was important since the researcher self-administered the questionnaire and was able to note the important comments and ideas made. Likewise, a recording was done to assist in filling the gaps that were not recorded or omitted through notetaking. To record, verbal consent was required from the respondent and when they agreed then the recording was done and also it was made clear that they could stop it anytime they felt uncomfortable or did not want to continue.

Before the interview, the objectives of the study were introduced to key experts and expected outputs of the made clearer. A consent form (appendix A) was given for signing as a way of ensuring confidentiality and ethical standards of the data collection practise. The interviews took approximately 1hour to 1hour 30 minutes.

#### 3.6.2. Focus Group Discussion (FGD)

Under the guidance of the Nairobi county key expert, the researcher was advised to seek the consent of the village elders also known as Nyumba Kumi representatives in both Kisumu Ndogo IS and Mukuru Kwa Reuben slum before administering questionnaires to the residents. This was necessary because the village elders are seen as the gatekeepers of the settlements, and it would reduce the tension arising from the presence of the researcher and her team when collecting data. A Focus Group Discussion (FGD) was proposed since it was an abrupt notification and the had the planned research schedule differed from the village elders.

## **Kisumu Ndogo settlement**

### **Sampling strategy**

To identify respondents for the FGDs in KND and MkR settlements, a list of contacts was provided including the Chairman, secretary, treasurer and one member as Nyumba Kumi representatives. It was then narrowed down to the chairman since they are the head of the villages having the authority of the people and are also knowledgeable in their areas of settlement as relevant for this study. KND village elders were contacted through the overall chairman via phone call, and the purpose of the field study explained to him. Once he consented, he contacted all the chairmen, and a meeting was scheduled for 28<sup>th</sup> January 2020. A total of eight chairmen were present for the FGD.

### **Interview instrument**

An introduction of the objectives, study outcomes and benefit of the study was explained to the members present, and before the discussions commenced, they were asked to sign consent as approval to use their information and accept to give the same. The group discussion was face-face, and the moderator was the researcher who guided the process of discussions using a semi-structured questionnaire.

Because the FGD was abrupt and no questionnaire was drafted to fit the discussions, the key expert interview questions (see expert questionnaire) were administered but with adjustments to eliminate technical questions considered irrelevant to the target group. (Appendix B 2) The final questionnaire administered included

- a) list of indicators distinguishing the IS from slum- this was to investigate the knowledge of the village elders on indicators best described their settlement.
- b) The number of years spent in the settlement – to investigate knowledge of the existence of their settlement area.
- c) Suggestions that would improve the situation of indicators in their settlement. The questionnaire maintained the provision for suggestions as it was administered to the key expert.

### **Administration**

To capture the information received from the discussion, note-taking and recording were done. Important to note is that recording was done after verbal consent was requested by the researcher. Before the discussion, the members were briefed about the study objective and the expected outputs of the research made clearer. The discussions (Figure 8) took approximately 1-hour, giving a chance to have all members contribute as much as they could.

## Mukuru Kwa Reuben- Focus Group Discussion



Figure 8: Focused Group Discussion with Kisumu Ndogo residents

### Sampling strategy

The sampling strategy used in KND selection was also applied to the MkR residents. On the other hand, the area chief was the point of contact to access the Nyumba Kumi village elders. A meeting with the FGD members was scheduled for 1<sup>st</sup> February 2020. Before the meeting commenced a courtesy call was made to the area chief led by the local guide. The purpose was to introduce the researcher and her team and to brief the chief about the study. The meeting was held in the chief's compound with a total of eleven Nyumba Kumi representatives attending the FGD.

Because of tension in the area that threatened the security of the researcher and her team, a security officer was assigned to guard them while conducting field survey.

### Instrument of interview

The same questionnaire administered to the Focus Group Discussion in KND settlement, instruments of conducting and administration during FGD were also administered to the MkR (see Kisumu Ndogo). The meeting took approximately 1-hour.

### 3.6.3. Household questionnaires

#### Kisumu Ndogo

##### Sampling strategy

The selection criteria of the residents to be surveyed focused on those that had lived within the settlement for a minimum of 10 years. This was based on their rich knowledge and the perception that they would identify the indicators and drivers within the settlement. Purposive sampling was done with the guidance of Nyumba Kumi chairman and his secretary because of their knowledge of targeted groups of residents. A total of 40 questionnaires were administered.

### **Instrument of interview**

Three key themes were included in the questionnaire used for the expert interview. These included

- a) Definition of an IS and slum - to know their understanding of the difference between the IS and the slum;
  - b) ranking the list of indicators identified from the literature - to rank the indicators and add more
  - c) the settlement period of establishment, their period of stay and condition of the settlement over time:- their acquaintance to the study area
  - d) the drivers and their measures that increase the chance of transitioning of an IS to a slum
  - e) policies that are used to address their problems- awareness level on the policies being implemented.
- Further, the interviews also had provisions for suggestions and answers in case the respondent considered any additional critical factors. (see appendix B 3)

After the administration of the first ten respondents, the researcher noted that most questions were unanswered an immediate modification was done on questionnaires which were comprehensible to the respondents understanding of the data required. (Appendix B 4) It also had three themes including;

- a) rank the indicators describing their settlement
- b) their period of stay in the settlement area and
- c) Drivers of IS and slum
- d) any recommendation to improve their settlement

### **Administration**

The data captured was written down in the questionnaire by taking notes. In this case, no recording was done because the respondents were in public places and were uncomfortable because of the unwanted attention they were getting. The questions took approximately 20 minutes longer than expected because of the interruptions when attending to their businesses which typically would have taken approximately 5 minutes.

### **Mukuru Kwa Reuben slum**

The selection criteria for MkR residents followed the KND process, with a total of 40 questionnaires administered to the selected respondents. Besides, the instruments of conducting and administration survey were the same (see Kisumu Ndogo). The meeting took approximately twenty minutes.

## **3.7. Qualitative data analysis**

To evaluate data received from the field survey, two methods were employed that is a content analysis and descriptive statistical analysis.

### **3.7.1. Content analysis**

Data from key expert interviews, FGD and questionnaires were captured using various instruments such as note-taking, recordings and open-ended questions, photos. Content analysis was applied and was guided by the sub-objective of the study.

In order to quantify a structured questionnaire, descriptive analysis was employed and presented on a Likert scale level of 5 and 4. This was applied to the Key expert interview, FGDs and residents of the IS and slum to first get a basic understanding of the feature of data in this research. Data collected involved combining the ideas and contributions of the responses using focused coding that aimed at putting together all discussions in the three sections that was provided in the questionnaire. Utilising this technique, according to Nyumba *et al.*, (2018), can generate quantitative results that can draw a comparison from target groups, especially on the ranking of indicators and drivers. Data captured were statistically analysed using SPSS software and Excel. The analysis used included mean frequencies and mean to quantify the responses, and for visualisation graphs and tables were used. Both indicators and drivers applied Likert scale a to answer sub-objective 1 and 2 and the process of its ranking it is summarised below.

### 3.7.1.1. Identifying indicators of IS and slums

To get the highest-ranking and the highest median applied as a strong indicator. Responses that had median ranging from 1 to 3 on the indicators were ranked as weak and given (-) sign while 4 and 5 were ranked as strong and given (+) sign. Four combinations were created that cuts across both key experts and residents of KND and MkR responses as a guide to selecting key indicators that differentiate an IS from a slum.

The first combinations contained all (+) responses considered as strong indicators received from the key experts. These indicators include road accessibility, Neighbourhood characteristics, dwelling shape, location, texture measure, density and location and vegetation.

The second combination included (-) and (+) responses that were coming from the residents. In this combination, (- +) or (+ -) was considered a strong indicator in differentiating the IS from the slum. The indicators in this combination include road accessibility, dwelling shape, neighbourhood characteristics and location.

The third combination combines all (+) from the experts and (-) from both settlements. In this combination, the experts response and considered a strong indicator and is considered an indicator to be analysed. This includes the vegetation.

The fourth combination contains all (+) responses from the three groups. In this combination, it is (+ + +) and is considered a weak indicator because it is not able to differentiate their settlement. These include texture measure and density.

The fifth combination contains all (-) responses from all groups having (- - -), and it is considered a weak indicator for lack of differentiation. These include dwelling size and roofing materials.

### 3.7.1.2. Identifying drivers of IS and slum

In assigning weights, 1 was categorised as not applicable, no. 2 was categorised as weak and given the sign (-) while 3-4 was weighted as strong and given the sign (+) as shown in Table 17. To identify the most important category of drivers different combinations were categorised as follows;

The first combination contains all the (+ + +) across all groups of respondents is considered a very strong driver and strong and relevant in this context.

The second combinations contain all the (- ++ ) from the respondents are considered as somewhat strong

The third combination contains all the (- - -) from the respondents are considered not applicable. The combinations also took into account the literature review on the combinations for a more grounded and informed selection.

## 4. RESULTS AND DISCUSSION

This chapter presents the history of the study areas, results and discussions addressing the main objective of this study. Four issues are analysed and discussed, and they are based on indicators of IS and slums, mapping of the indicators using on images from Quickbird, Drivers of IS and slums and policy recommendations. Information gathered from the literature review, key experts, Focused Group Discussions and residents of Kisumu Ndogo IS, and Mukuru Kwa Reuben slum in Nairobi City County is also presented. Results and discussions are based on the research objectives and questions.

### 4.1. Historical development of Kisumu Ndogo and Mukuru Kwa Reuben

Historical background of Kisumu Ndogo and Mukuru Kwa Reuben documents how changes and events through time have contributed to creating what they are today.

#### 4.1.1. Kisumu Ndogo

Korogocho slum emerged in the early 1960s with quarry workers who settled there and built temporary structures (UN-Habitat, 2012). However, it grew in the 1970s as a resettlement scheme for slum evicted from the inner parts of the City (IFRA, 2019). A total of eight villages, namely Gitathuru, Grogan A and B, Highridge, Korogocho A and B, Kisumu Ndogo and Nyayo (Kago, 2009) emerged from the resettlement.

Kisumu Ndogo, formerly known as Githua estate, grew as a result of the expansion of Korogocho A and Korogocho B villages in 1979 (Kago, 2009). The allocation and subdivision of the land in this area was started by local elders, namely John Githua, Pamba, Njau Kimethu and Mama Ngéndo. The team also comprised of a chief and his assistant and leaders of the then ruling party KANU. During the allocation of plots, Key political members that influenced the allocation included Mathare MP Dr Munyai Waitaki and politician Kimani Ngumba. When other most politicians specifically from Nairobi knew about the ongoing allocation they sent squatters from different IS to be allocated plots in a bid to remove them from the prime location of Garden estate that was to be developed into residential and commercial use (Table 10). At the end of the exercise, about 480 plots of size 50x20 feet had been curved out. A 12ft wide space was left between the plots for access (Kago, 2009).

Regarding ownership of land, UN-Habitat (2010) stated in situational analysis report of Korogocho that only two parcels of land have formal ownership of the land and the rest of the land belongs to the government. Although most residents claim that the land was verbally allocated to them by the former president in 2001, the land was given over to the office of the Nairobi Provincial Commissioner for its management and its tenure is still disputed.



Table 10: History of Kisumu Ndogo settlement

Year	Major Changes/events
1976-1980	Paths and village road established
	Shanty houses improved from boxes to mud houses
1981-1985	Death of elder Pamba
	A riot occurred because other people said he was murdered
1981-1990	Electricity installed
	Road constructed
1991-1995	Construction of Drainage system
1996-2000	Further installation of Electricity
2001-2005	Election of village elders
2005-2010	Post-election violence
	Road expansion started
	Biogas toilet constructed

Source: adapted from Kochogocho final plan, 2010

#### 4.1.2. Mukuru Kwa Reuben

'Mukuru' which is a Kikuyu word meaning a valley is as old as the history of Nairobi itself. It dates back to the colonial era in which a British Army named Jack Reuben after the world war was awarded a vast land and he established a farm ranch known as Reuben haulage empire and sisal farming. The vastness of the land saw him need labour, and thus he constructed a labour camp to accommodate his employees (Keter, 2017). After independence in 1963 and the death of Reuben, the employees were left jobless and settling on the land as squatter; hence the name Mukuru Kwa Reuben came into existence. In 1971, one of the former employee called Gatope, started constructing commercial structures. These prompted former employees including Munyao and Njenga to construct dwelling units for accommodating the influx of the poor population from the rural areas in search for jobs and affordable accommodation leading to the initial growth of the Informal settlement (Wanjiru and Matsubara, 2017).

Between 1970 and 80's the Government acquired the land and evicted the squatters subdividing and allocating it to both wealthy and well-connected individuals with a condition to develop it within two years. When the majority of the allottees failed to fulfil this condition, they either sold their land to companies or used them as collateral to acquire bank loans leaving the land undeveloped (Keter, 2017). (Table 11). Meanwhile, the rural and urban migrants within the city slowly came in and grew faster due to the demand for cheap accommodation. The industrial zone surrounding the land attracted casual workers and newcomers to the land (Keter, 2017). Further, the local administration allocated plots at a small fee through the chiefs, which to date has no legal claim because of its informal allocation and squatting. The failure to develop the demarcated land by the alleged new owners accelerated the slum development, making it turn out into today's Mukuru Slum.

Table 11: History of Mukuru Kwa Reuben slum

Year	Major event/Change
1900's	British Army Jack Reuben Awarded land and develops labour camp to accommodate his workers
1963	Kenya gets independence from Britain
	Reuben dies and leave the employees jobless and as squatters
1971	Gatope construct commercial structures with his three daughters
	Munyao and Njenga construct dwelling units to accommodate new residents
1970-80's	Government evicts and acquires the land
	The land is demarcated and allocated to wealthy and well-connected individual
	A condition to develop the land into industrial use within two years is issued
	The allottees fail to fulfil this condition. They either sell the land to companies or use it as a collateral to get loans from banks
	The land is left vacant for an extended period
From 1980's to date	Population both from the rural and within start settling in the land
	Local administration allocate land to residents through the chiefs at a small fee
	Residents have no legal claim of tenure due to the informal nature of land allocation and squatting.

## 4.2. Indicators of Informal settlement and slums

In this section, two research questions are analysed together to answer the first sub-objective. The first question addressed is “*what are the indicators of an IS?*” and the second question addressed is “*what are the indicators of a slum?*” The different questions presented to the various groups of respondents asked for indicators that could distinguish the settlements. The key experts the question was “*which indicators do you know can distinguish an IS from a slum?*” On the other hand, the residents and Focus Group Discussion question was “*from the indicators provided, how would you describe the place you are living in?*” The responses of the were analyzed as discussed below.

### 4.2.1. Vegetation cover

Vegetation cover is the amount of surface covered by vegetation or green space or open space (Fallatah *et al.*, 2019). It is often considered a vital indicator in a community, especially for social interaction, clean environment and healthy development. It has also been established through literature that it improves the wellbeing and quality of life (Hofmann, Strobl and Nazarkulova, 2011), making it of such significance in our day-to-day life.

Key experts interview in Figure 9 revealed that 67% of them agreed that vegetation is a strong indicator to classify an IS and a slum. Moreover, as 23% consider it as a weak indicator, 8% of them viewed vegetation as a not applicable indicator.

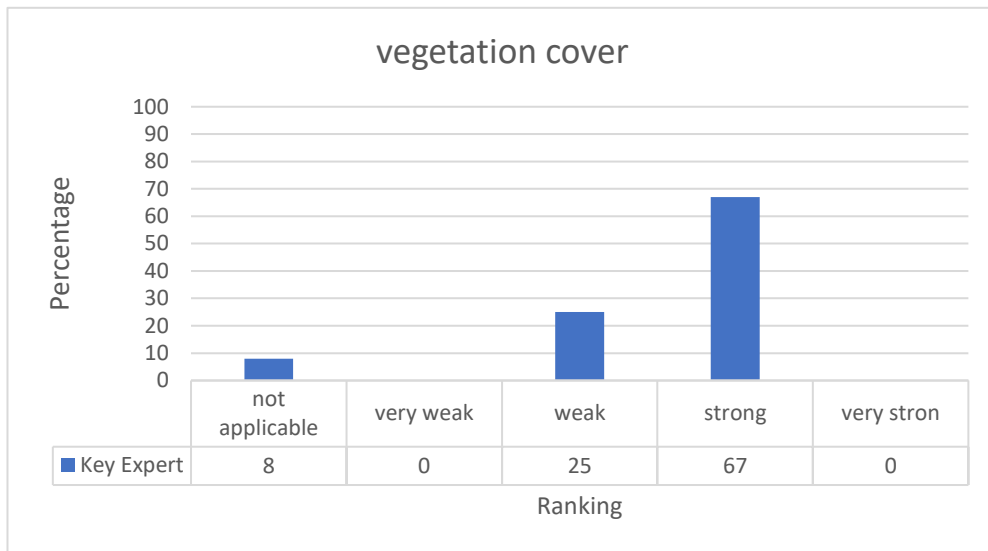


Figure 9: Key experts ranking on vegetation cover

Figure 10 and **Error! Reference source not found.** show perception of the residents of Kisumu Ndogo (KND) and Mukuru Kwa Reuben (MkR) residents revealed that the while majority 60% of KND respondents and 25% of MkR residents stated the indicator as very weak, 40% of KND and majority of MkR that is 75% noted that it was not an applicable indicator.

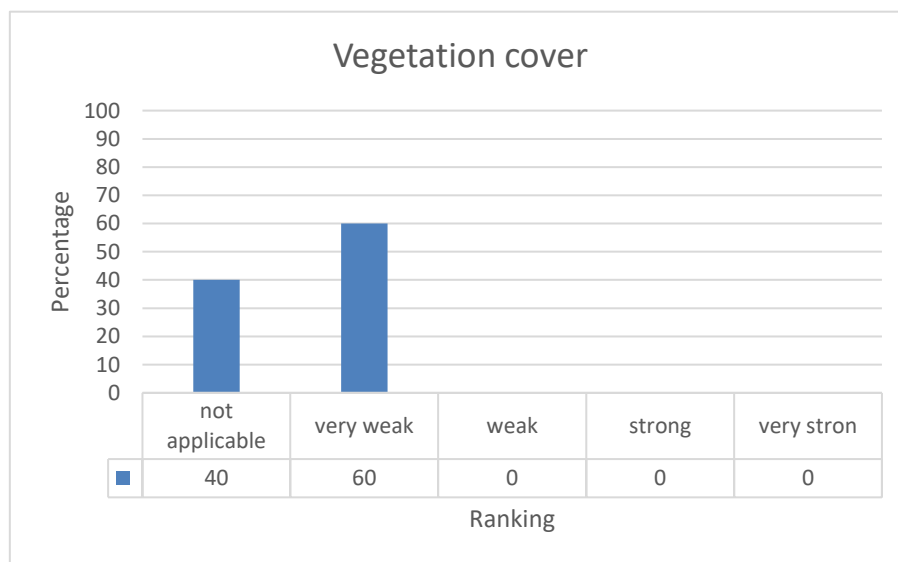


Figure 10: KND ranking on vegetation

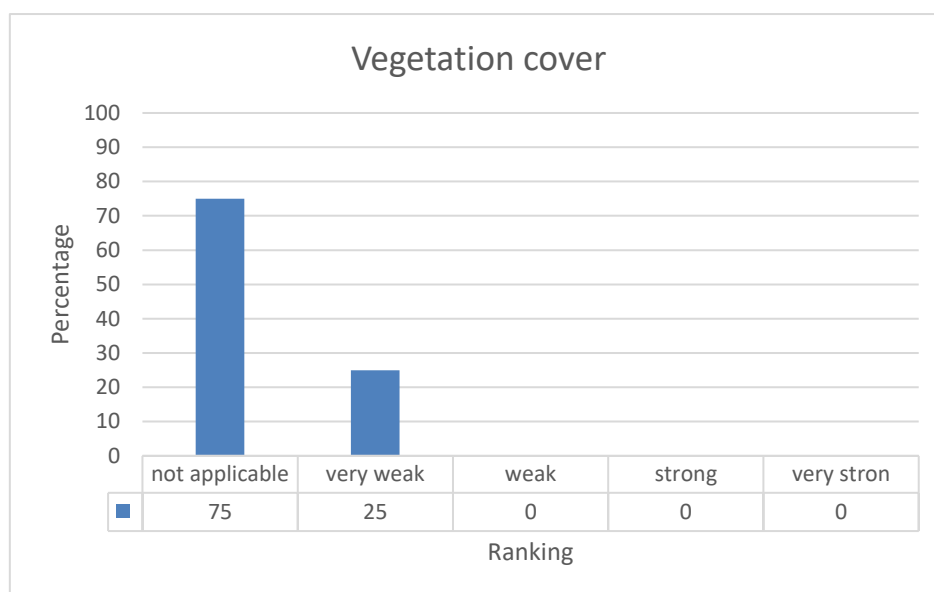


Figure 11: Mkr ranking on vegetation

Analysis in Figure 9, Figure 10 and Figure 11 respectively show that vegetation indicator had differing standpoints from the respondents. Only the key experts acknowledge it as a strong indicator which they viewed as an ideal situation that an IS has vegetation within the settlement or open spaces. Their view aligns to the findings of Hofmann, Strobl and Nazarkulova (2011) findings that green spaces are not often evenly distributed even if they exist. Also, the finding aligns to Fallatah *et al.* (2019) who argue that vegetation cover has a high potential to differentiate informal settlements from its neighbourhoods. On the contrary, majority of the respondents from KND and Mkr settlement, few key experts and discussions held by the FGDs in both settlements found vegetation cover to be weak or very weak for the reason that buildings constructed have no orientation leaving no space for playgrounds and socializing spaces. Findings by Owen (2012) revealed that different squatter statements are assumed to have very little due to the persistent increase of buildings within the IS and slums. One member in the FDG meeting held in Mkr settlement stated that

*'This is a threat to our security because most idle people go and waylay passersby and therefore we decided to develop houses there to finish insecurity.'*

This statement aligns to Sugiyama, Leslie and Owen, (2008) findings that the open space viewed as a visual amenity can act as an insecure zone when it obstructs the line of vision of those who are walking that is the presence of trees and buildings surrounding vegetation compromises the security of the people it becomes unsafe to walk in the open or vegetated area at specific periods.

A considerable number of the respondents also found that vegetation is not an applicable indicator for classifying an IS from a slum from the perception that they live in the area and have not seen any green spaces. Also, the key experts that work with the IS and slums based their response of not applicable to their experience and field visits. These responses are further echoed by (Owen and Wong (2012) that it is difficult to find vegetation cover in IS and slums because of their dense nature.

**4.2.2. Road accessibility**

Accessibility plays a critical role in any settlement to ensure that there is an acceptable level of access to all individuals and their destinations which is also dependent on the degree of connectedness to transport network (Rusu, Man and Moldovan, 2013).

Figure 12 revealed that 67% and 33% of the experts view road accessibility as a strong and very strong indicator to classify an IS and a slum, respectively.

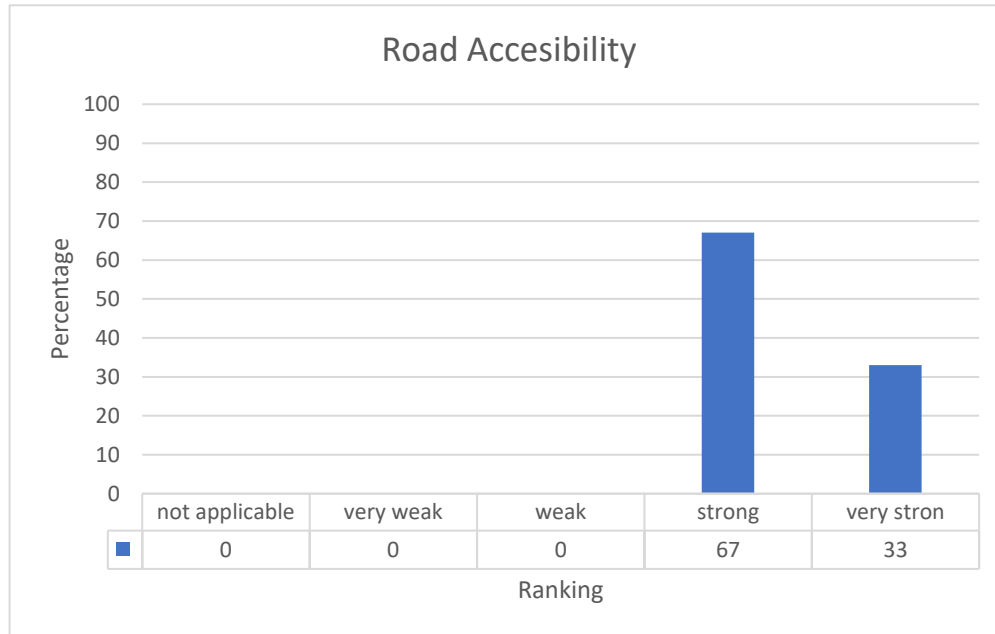


Figure 12: Key experts ranking of Road accessibility

Results of the data from the residents and the FGDs discussions in Figure 13 shows that 68% and 30% of the KND respondents and the FGD discussions indicated accessibility as a Strong and very strong indicator agreeing with the experts' opinion. On the other hand, Figure 14 reveals that 63% of MkR and 3% of the KND respondents stated it is a weak indicator and 37% of MkR respondents indicated that road accessibility was very weak.

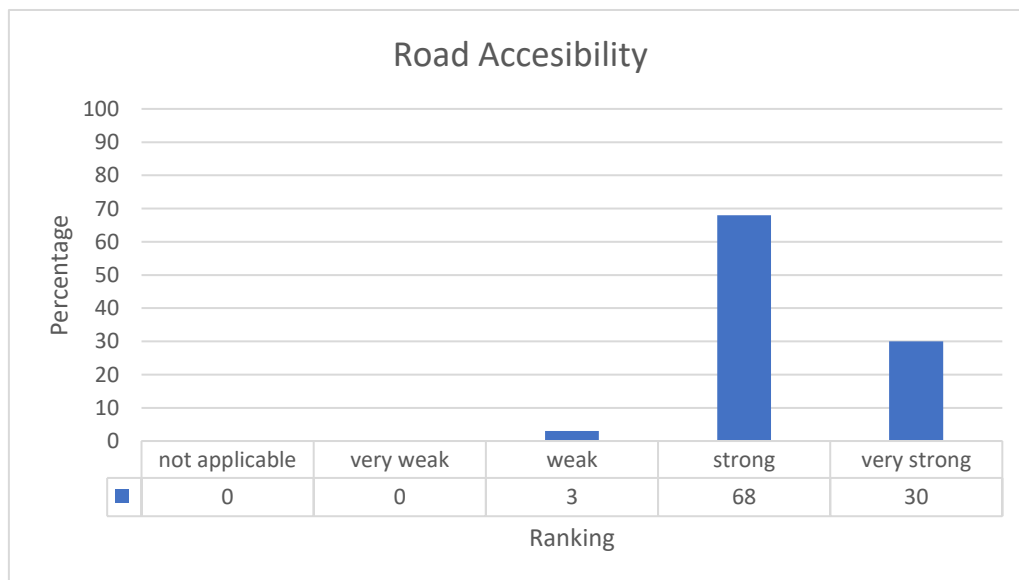


Figure 13: KND ranking for road accessibility

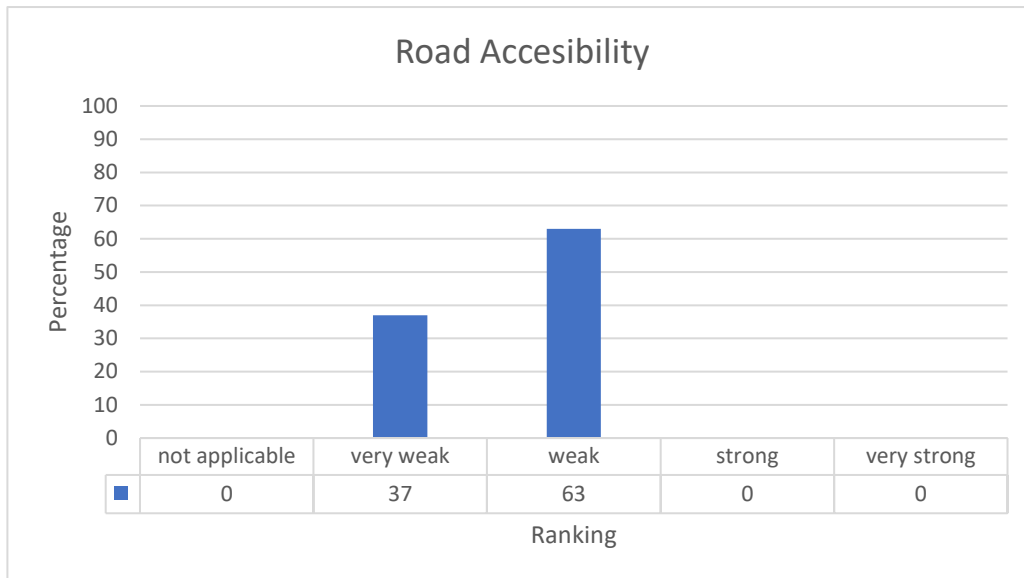


Figure 14: Mkr ranking for road accessibility

The results in Figure 12 and Figure 13, both the experts and the KND residents prioritized road accessibility as both strong and very strong indicators reasoning that roads have been expanded within the area increasing accessibility. The response aligned to the report done by Gathuthi *et al.* (2010) that documented KND road expansion, making it very significant in differentiation the IS from other slums. Likewise, the findings also align with the roads width statutes (Roads, 1979) which provide 6m road width as the minimum allowable access for informal settlements in rural areas and the same was adopted as acceptable for the informal settlement upgrading system conducted in 2010. one member from the focused group stated that,

*'Since the opening of the road, many opportunities such as jobs have been accessible, and thus it is much easier to commute and be punctual.'*

The statement echoes Heinrichs and Bernet (2014) study which identified different disciplines and their focus, and specifically the transport planners that are most concerned with improving road usability through increased road opening.

As a weak and very weak indicator shown in Figure 14, most Mkr respondents reasoned that there are narrow roads that have a lot of dead ends within the settlement thus limiting access to areas such as Mombasa village in Mukuru Kwa Reuben settlement. On this note, Owen and Wong (2013) argued that accessibility within the slum and informal settlements diminishes rapidly with increased build-up density that reduces the connectedness and increases numbers of dead ends indicating isolation of the residents from the society. A few residents of KND stated that road accessibility is a weak indicator could be attributed to the response given by one of the key experts stating that there may be a road that is designed on the map in the area but has never been surveyed and constructed for use. The failure to open designated roads further exposes the weakness in the implementation of planning policies by the government that has led to buildings being constructed on top of the mapped road.

### Dwelling size

Dwelling size is seen as an important predictor to residential satisfaction that is the bigger the house, the more satisfied a resident is (Kshetrimayum, Bardhan and Kubota, 2020; Ibem and Aduwo, 2013). The mushrooming of smaller housing sizes in informal settlements set transitioning to slums as a result of too much pressure on the available housing stocks (Jones, 2017).

According to the results in **Error! Reference source not found.**, 42% and 8% of the experts showed that dwelling size was a very weak and weak indicator. This is in contrast to 33% and 17% experts who stated that it was a strong and very strong indicator to classify an IS from a slum.

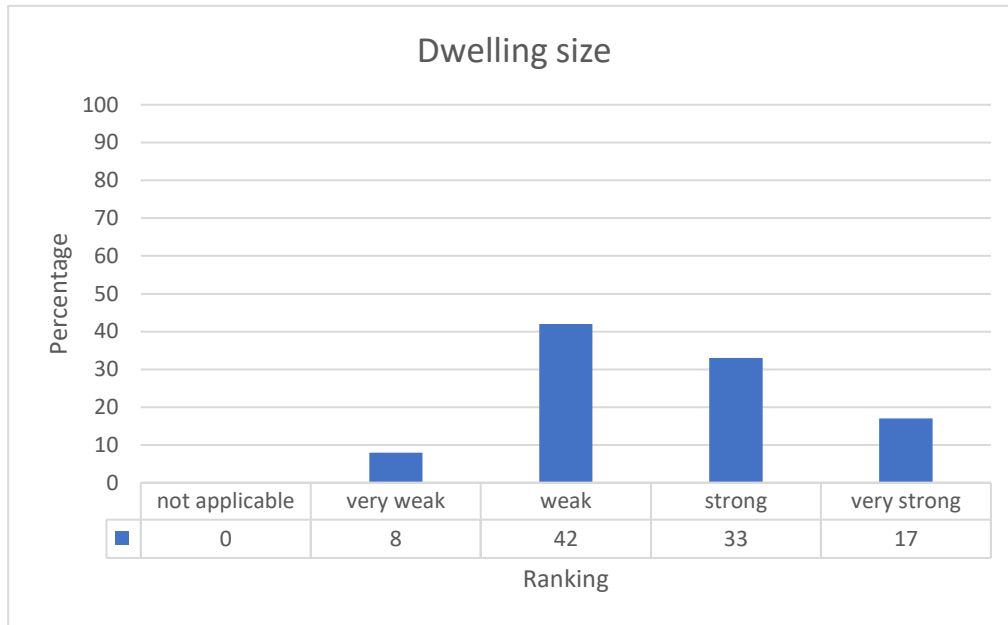


Figure 15: Key experts ranking for dwelling size

On the other hand, results in Figure 16 and Figure 17 revealed that 50% of KND and 33% of MkR respondents stated that the size was a weak indicator while 9% and 48% indicated that it was a very weak indicator. 41% of KND and 20% of MkR residents stated that it was a strong indicator.

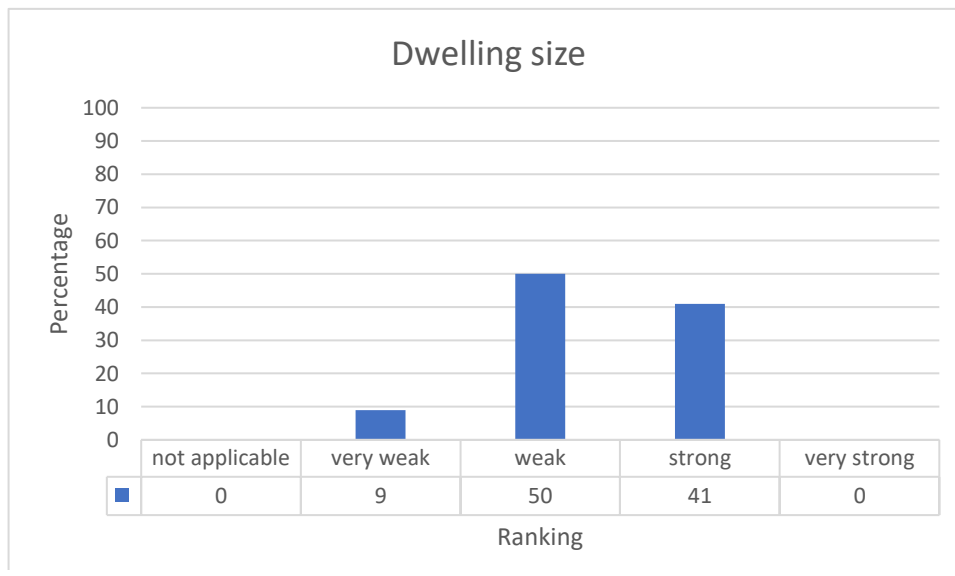


Figure 16: KND ranking for dwelling size

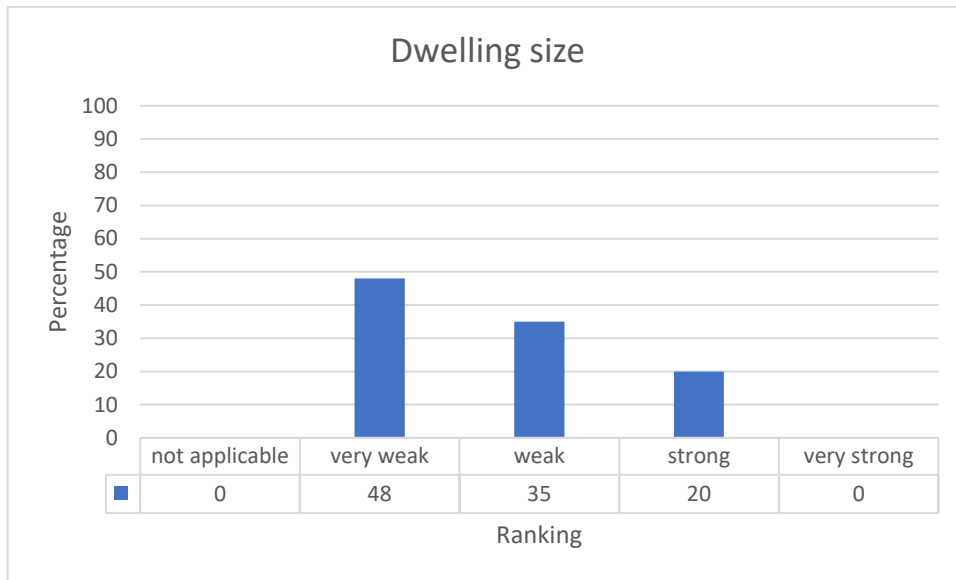


Figure 17: Mkr ranking for dwelling size

As a strong and very strong indicator, the respondents reasoned that most dwelling units varied because of the level of ownership. Focus group discussions held in Mkr premises also reiterated that most building that varied in sizes were occupied by the landlords and their families which is a small representation of the larger families residing within the area. The varying sizes align to Fallatah *et al.* (2019) study which recognises dwelling size as an important indicator ranked among the top four in distinguishing the informal settlement in the Middle East. The building sizes of the IS ranged between 380m<sup>2</sup> to 100m<sup>2</sup>. The reasons given by the FGD can also be deduced that more interviews need to be conducted to have a true representation of the housing sizes within the settlements.

On the other hand, dwelling size was also considered a weak and very weak indicator by all the groups because of similar size ranges which measures a minimum of 3.05m by 3.05m far smaller and contradicts Fallatah *et al.* (2019) IS and slum settlements that was found in the Middle East. Friesen *et al.* (2018) findings also reveal that the mean dwelling sizes are similar across Cape Town, Rio De Janeiro and Mumba ranging between 16m<sup>2</sup> and 40m<sup>2</sup> with Cape Town having as smaller size 15m<sup>2</sup>. Further, a member from the Focus Group Discussion in Mkr area stated that;

*‘Size does not matter because all the people want is accommodation when they come looking for a job and also because it is cheap here. Another thing you need to know is that they are not permanent residents, and they can move out anytime.’*

This statement aligns to Li *et al.*, (2014) study arguing that the tenants in China did not care for size because they were immigrants and occupied the IS and slums settlements temporarily.



### 4.2.3. Dwelling shape

A dense structure of housing often characterizes informal settlements and its impact felt on segregation leading to distinct and spatially separated types of housing structures (Hofmann *et al.*, 2008).

Based on this understanding, results shown in figure 18 revealed that 75% and 8% of the experts showed shape as a very strong and strong indicator, respectively. On the contrary, 17% showed that it is a weak indicator.

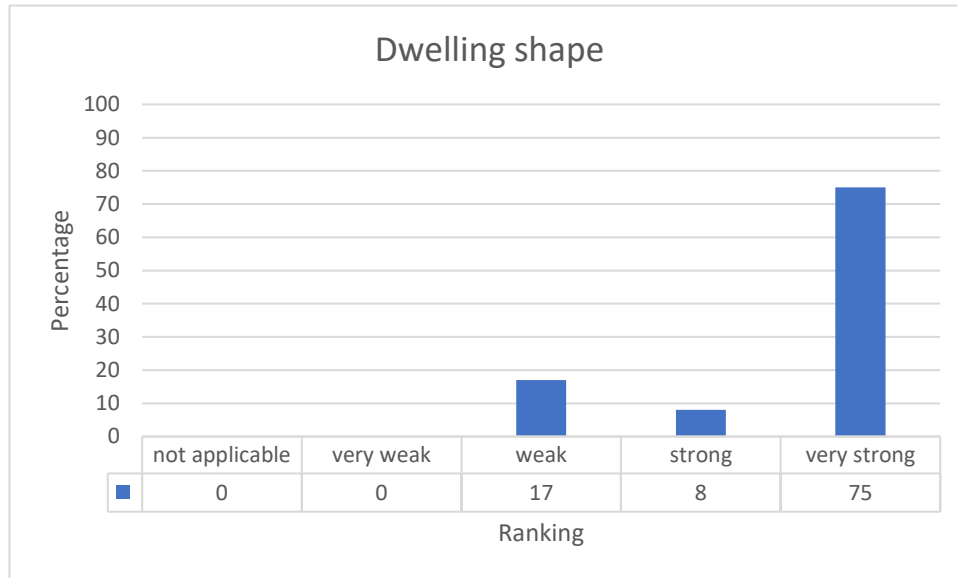


Figure 18: Key experts ranking for dwelling shape

Figure 19 and Figure 20 revealed that 15% of the KND respondents perceived the shape as a strong indicator. This was reiterated by 50% and 18% of the MkR respondents stating that shape is a strong and very strong indicator respectively. On the other hand, 33% of KND and 22% of MkR respondents indicated that shape was a very weak and weak indicator.

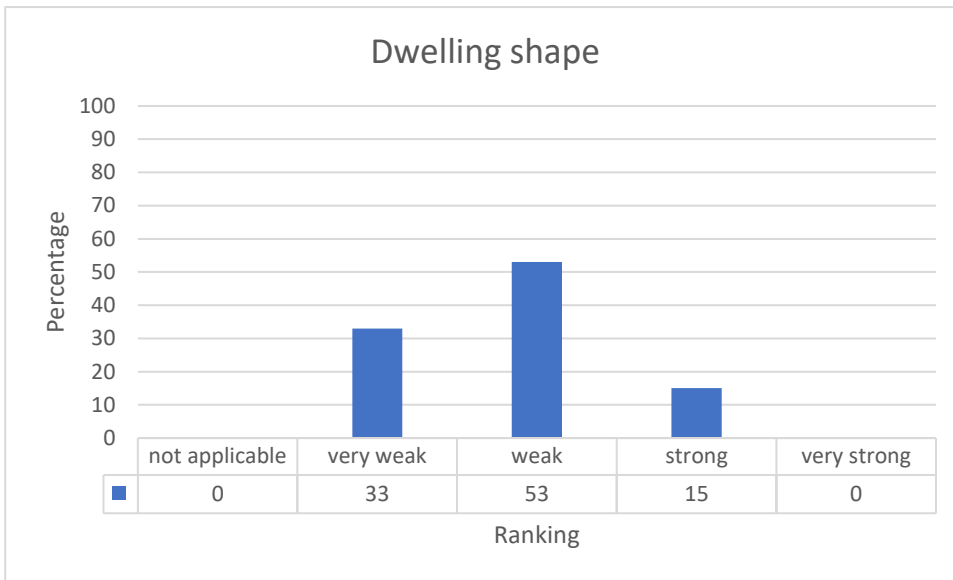


Figure 19: KND ranking for dwelling shape

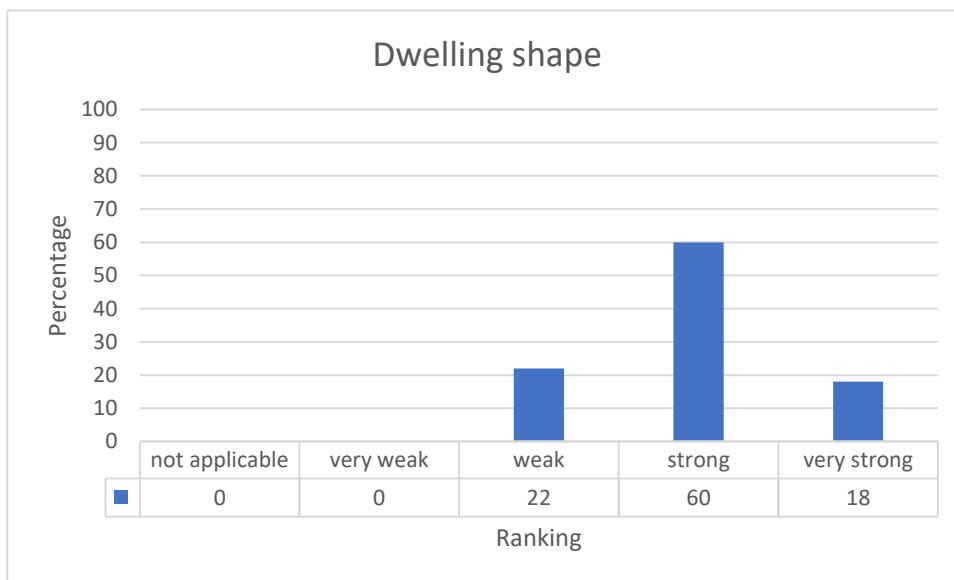


Figure 20: MkR ranking for dwelling shape

From the analysis, majority of the respondents in MkR can identify the shape of their dwelling as a very strong and strong indicator which echoes the experts' opinion that it can identify and IS from the slum. The experts stated from their knowledge that various shapes characterize informal settlements as they try and occupy the space while creating their demarcations. On the other hand, the slums emerge when the informal settlement dwellers start adding extensions attaching them to the main house. This is also in agreement with Dovey (2013) findings that most slums settlements have consistent shapes arising from organization and constructions of one-by-one room increments. The Focus Group discussions in MkR settlement also stated that “Structures are now taking vertical expansion in the area to absorb the overwhelming population influx because there is no more space on the ground.” This echoes Kamalipour, (2016) study in Thailand that the informal settlements were adopting vertical expansion to cope with the demand for cheap housing.

Results also revealed that as a weak and very weak indicator in figure 19-1 is attributed to the field observation that the researcher made showing that the settlement had varying shapes. This is also in line with Kohli *et al.* (2012) stating that most structures are elongated or linear and in some areas irregular shapes.

**4.2.4. Roofing Material**

According to Kohli *et al.* (2012), a building can be defined as a structure having a roof and walls. Different roofing materials are often seen on the informal settlement structures ranging from mud, plastics, tins and iron sheets, among others (Neuwirth, 2016).

Figure 21 revealed that 58% of the experts agree that roofing material is not an applicable indicator in distinguishing an IS from a slum. On the other hand, 25% and 17% state that it is a very weak and weak indicator.

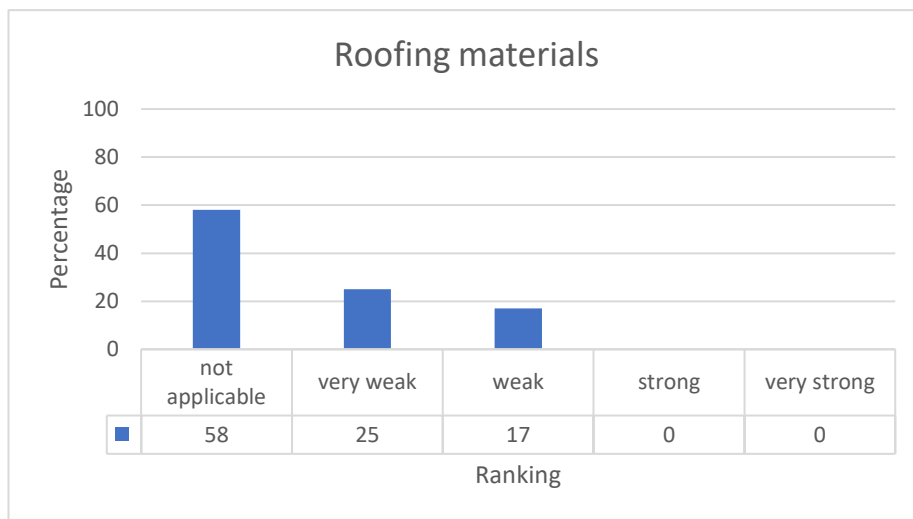


Figure 21: Key experts ranking on roofing materials

In agreement with the experts' opinion, were 63% of KND and 65% of MkR residents indicate that roofing material is not an applicable indicator (Figure 22 and Figure 23). In comparison, 38% of KND, 28% and of MkR agree that it

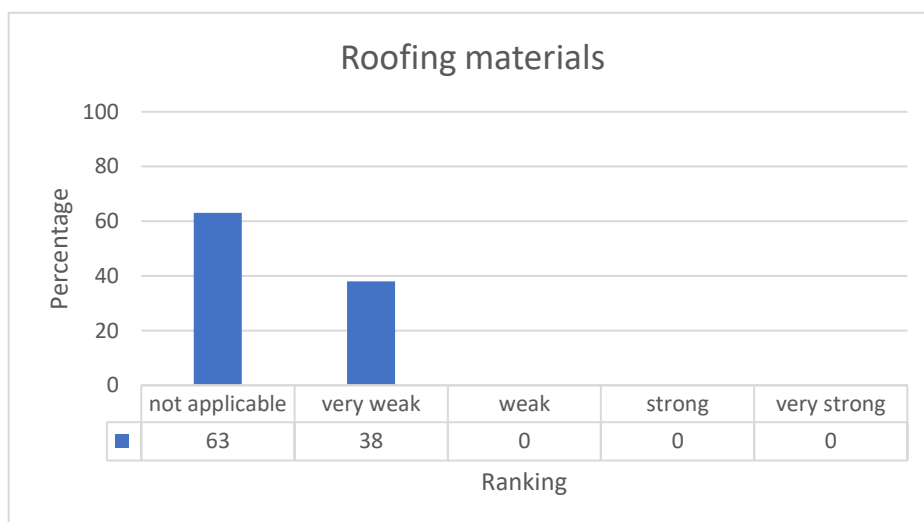


Figure 22: KND ranking for roofing materials

is a very weak indicator and 8% of MkR residents state roofing materials is a weak indicator in describing their settlements.

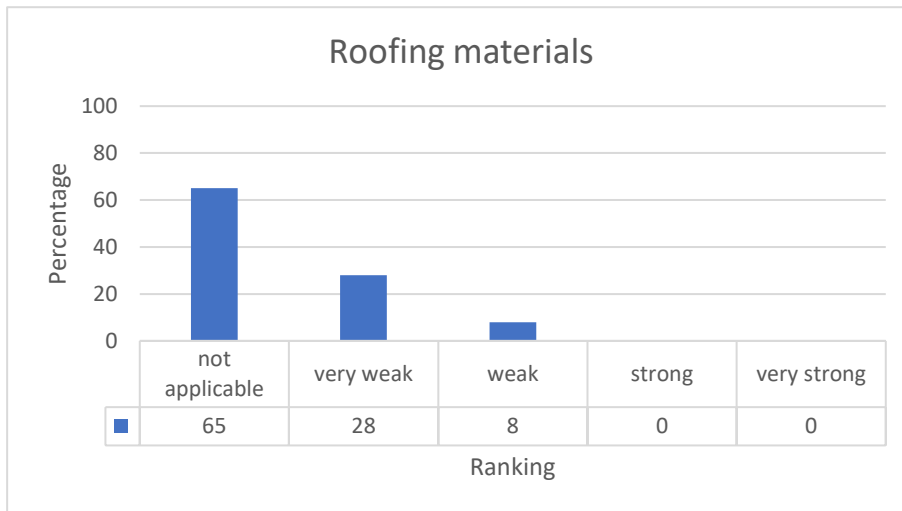


Figure 23: MkR ranking on roofing materials

Regarding roofing materials, the majority of the residents viewed it as not an applicable indicator. The main reason was that the roofing materials are iron sheet and similar across both settlements and would not be a viable indicator to measure or distinguish IS and a slum. Likewise, discussions held with the FGD from both settlements revealed that availability and affordable roofing materials such as iron sheets have gradually replaced the cardboards and tins that used to identify the settlements. On the other hand, as a weak and very weak indicator, the experts agree that it can be a better indicator if the roofing measured in area coverage. Their response aligns with the results from Fallatah *et al.* (2019) which rated the roofing extent as the third most important indicator and considered the roofing coverage as opposed to the materials to distinguish the informal settlement.

**4.2.5. Texture Measure**

Several forms of texture measure exists that is a room that is detached to multiple rooms as a result of infill or extension and by nature, patching itself to the existing structures (Kamalipour, 2016).

Figure 24 reveals that 67% of the experts indicated that texture measure is a strong indicator in distinguishing IS from a slum. Conversely, 33% of them show it as a weak indicator.

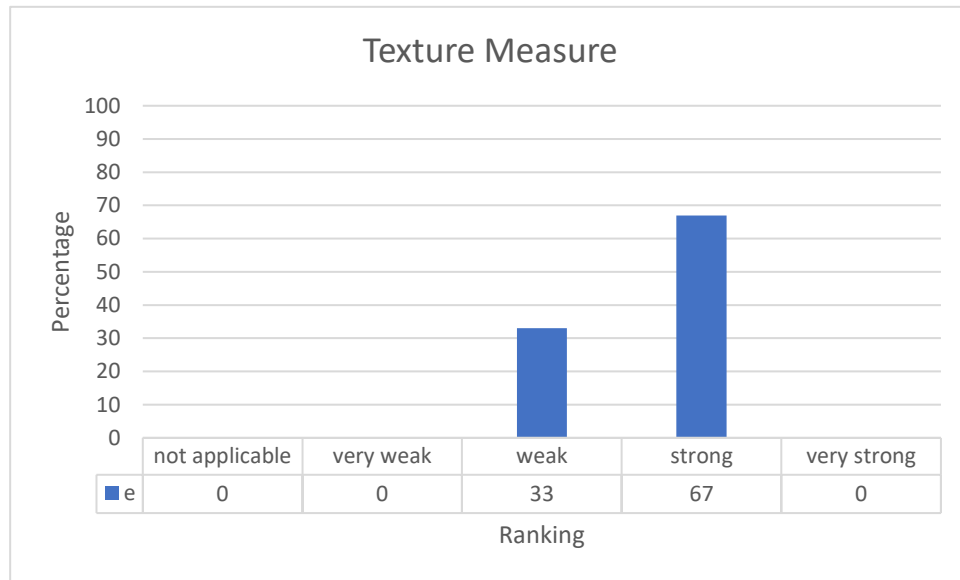


Figure 24: Key expert ranking on texture measure

According to Figure 25 and Figure 26 shows that 55% of KND and 70% of MkR residents are in agreement with the experts in indicating that texture measure is a strong indicator with 25% KND residents stated that it was a very strong indicator. On the other hand, 15% of KND, and 30% of MkR residents stated that it was a weak indicator, and only 7% of KND showed texture measure as a very weak indicator.

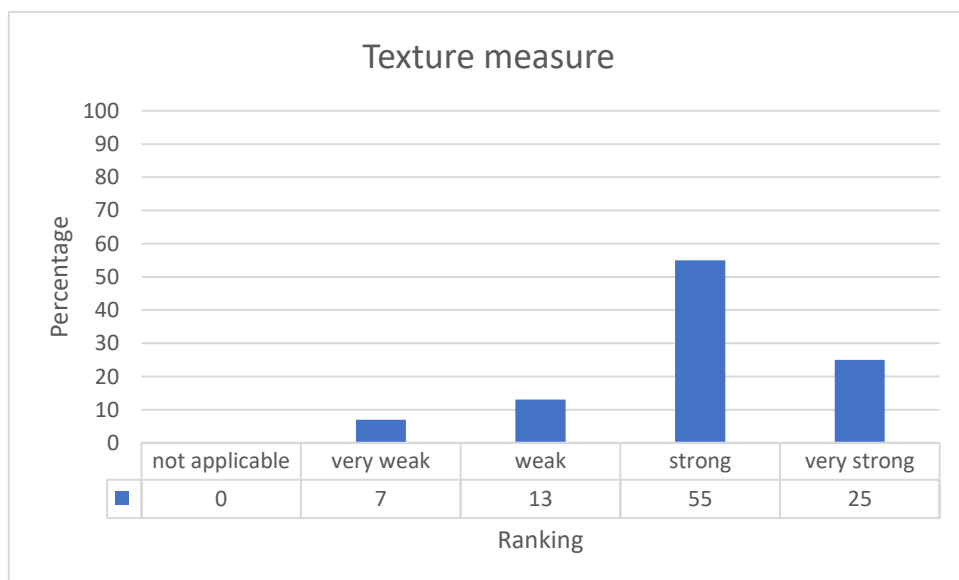


Figure 25: KND ranking for texture measure

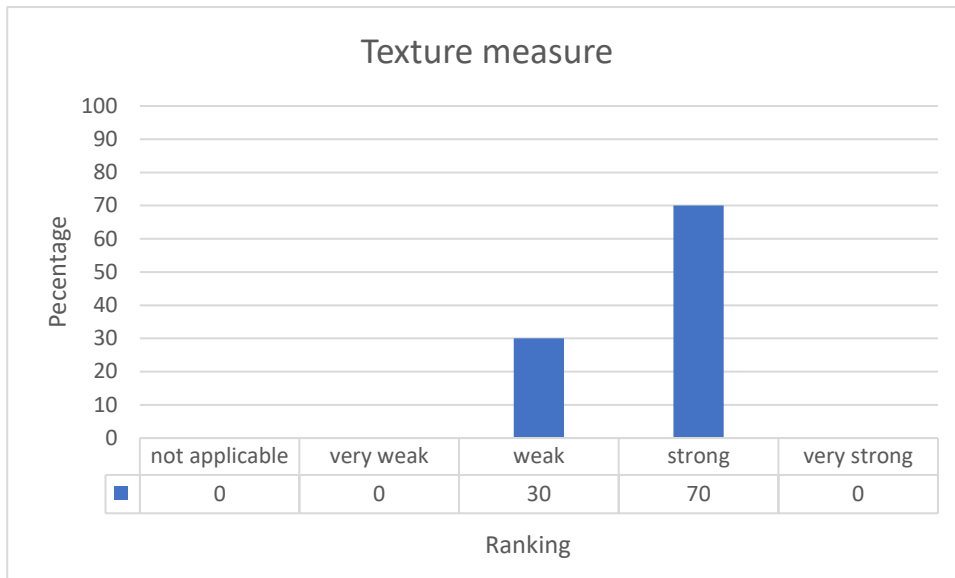


Figure 26: MkR ranking on texture measure

The results from the respondents show that there is a strong and very strong connection with the texture measures. This can be reasoned the experts' responses stating that a slum is characterised as organic and more attached to one another. Kohli *et al.* (2012) findings align to this response showing the same character in the Asian context that the slums are attached. Kamalipour (2016) also adds to the justification of the study results that room-by-room addition is a key indicator, and often, linearly takes place within informal settlement types. It is often incremental and occurs as a result of a family wanting to have an extra source of income and is also associated with an overnight building speed dependant on the availability of resources.

On the other hand, weak and very weak responses came from the accrued reasoning of both FGDs in KND and MkR premised stated that some of the long term residents who had become the landlords were still leaving in standalone dwelling units with a little open space within their settlement. One of the residents interviewed in KND informal settlement stated that; *"there is a small variation in the texture measures within my settlement and the only standalone units available are close to the river, not the main road."* This is also attributed to the same reasoning given by the FGD of KND that settlements are closer to the road for security, accessibility and fear of flooding along the Nairobi River. Additionally, the experts reiterated that in several situations, informal settlements are usually inorganic because most residents want to have their space and more inclined to privacy. In tandem with this reasoning is Kohli *et al.* (2012) in her study and involvement of stakeholders from 3 regions argued that in Sub Saharan Africa region IS conformed more to the inorganic settlement and Asian region to the organic or attached settlement. It can be understood that texture measures vary and are unique to every context, and so is the variation of the IS and slums.

**4.2.6. Neighbourhood characteristics**

Slums in most developing countries are known to exist in posh neighborhood areas because of the attraction it offers for example access to infrastructure, employment experience and income opportunities among others (Hussain *et al.*, 2019).

Figure 27 revealed that 75% and 17% of the key experts ranked neighborhood characteristics as a strong and very strong indicator for distinguishing informal settlements in slums, respectively. However, 8% of the experts contradicted the former responses rating it as a weak indicator.

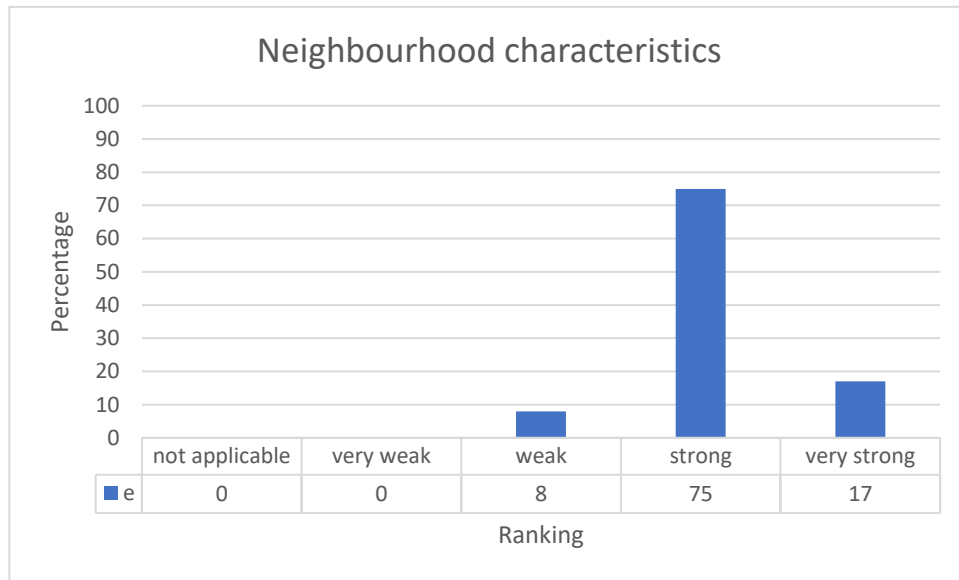


Figure 27: Key expert ranking on Neighbourhood characteristics

Results from the residents in Figure 28 and Figure 29 show that 56% and 10% of the KND residents surveyed identified Neighborhood characteristics as a very weak and weak indicator. On the other hand, 22% and 12% indicated it as a strong and very strong indicator. In contrast, 85% and 15% of the Mkr residents are in accord with the experts as they stated that Neighborhood characteristics is a strong and very strong indicator.

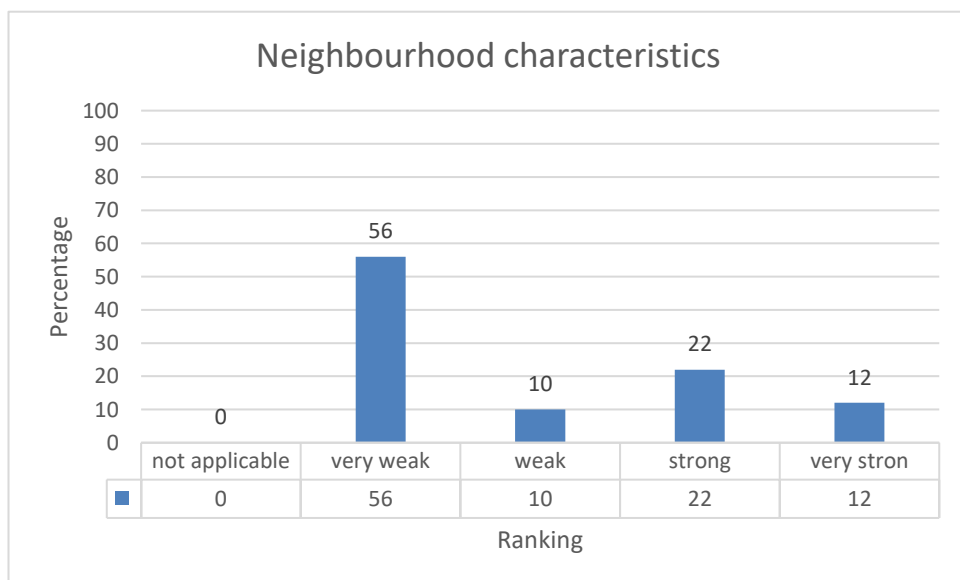


Figure 28: KND ranking for Neighbourhood characteristics

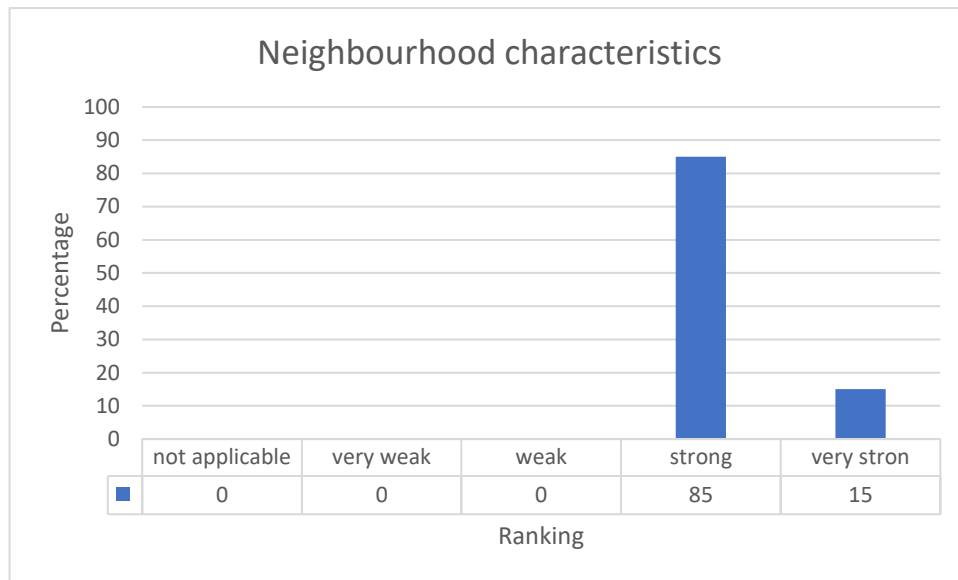


Figure 29: MkR ranking for Neighbourhood characteristics

The results of the analysis show that neighbourhood characteristics scored a strong and very strong rank indicating that it plays an important role in identifying slums as opposed to the IS. This can be attributed to the attraction of the high socioeconomic status, which most often attracts low income and unskilled jobs within an area (Kohli, 2015). It is also common to find the slum mushrooming from the existing IS which presents itself as a strategic location such as Industrial areas which also saw MkR settlement grow and as such seen as an attraction to low-income earners and unskilled labour. The results align to Hussain *et al.* (2019) study of Islamabad which grew from neglect and underdevelopment of the settlement of low-income earners that settled close to various construction sites. This continuously attracts low socioeconomic groups since it is affordable and easily available as opposed to the formal residential areas (Jones, 2017; Kohli *et al.*, 2012), gripped with high cost and standard of living.

On the contrary, the respondents who stated that Neighborhood characteristics is a weak indicator can be attributed to the high-value land that they were evicted from because they could not afford hence forced to seek for land farther from the big cities and towns and therefore further away from the posh neighbourhood. This is in line with IFRA, (2019) report on the history of eviction of KND residents in the early 1980s to pave the way for a luxurious Garden city residential and commercial centres in highly valued land.



**4.2.7. Location**

Demand for affordable housing and proximity to the inner city locations puts much pressure on the existing landowners, settlers, and their housing stock intensifies informal settlement and leads to the emergence of slums (Jones, 2017).

Figure 30 revealed that 75% and 25% of the expert agree that location is a strong and very strong indicator in distinguishing an IS from a slum.

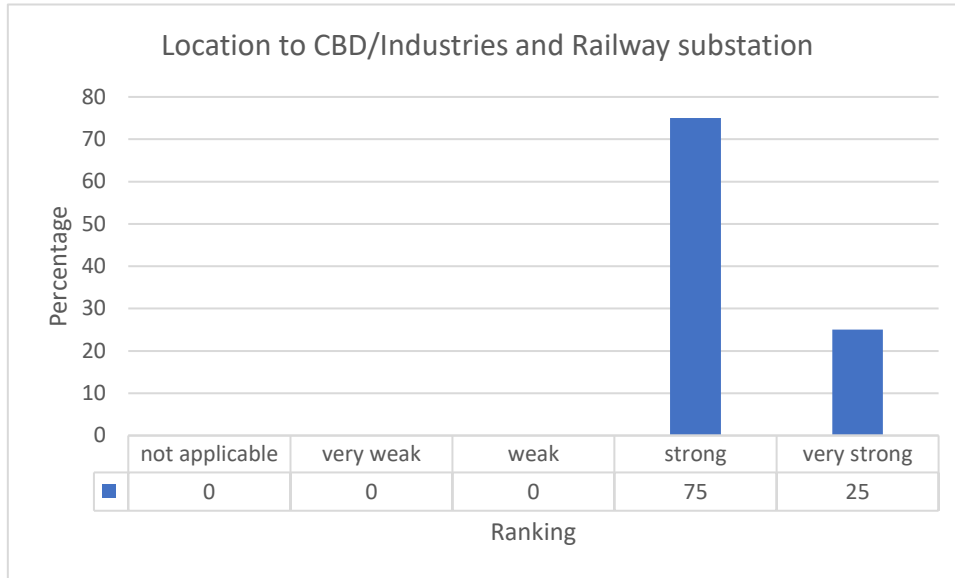


Figure 30: Key experts ranking on location

Figure 31 shows that 42% and 30% of the KND residents indicated that its location is a weak and very weak indicator and only 12% and 16% of them agree it is a strong and very strong indicator. On the other hand Figure 32 30% and 70% of MkR residents reiterated the experts by stating it is a strong and very strong indicator, respectively.

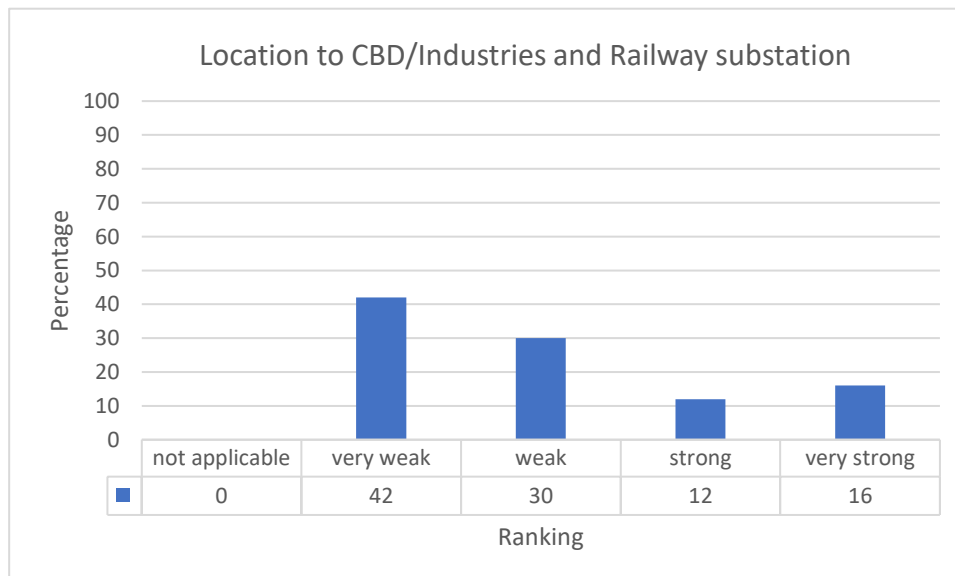


Figure 31: KND ranking on location

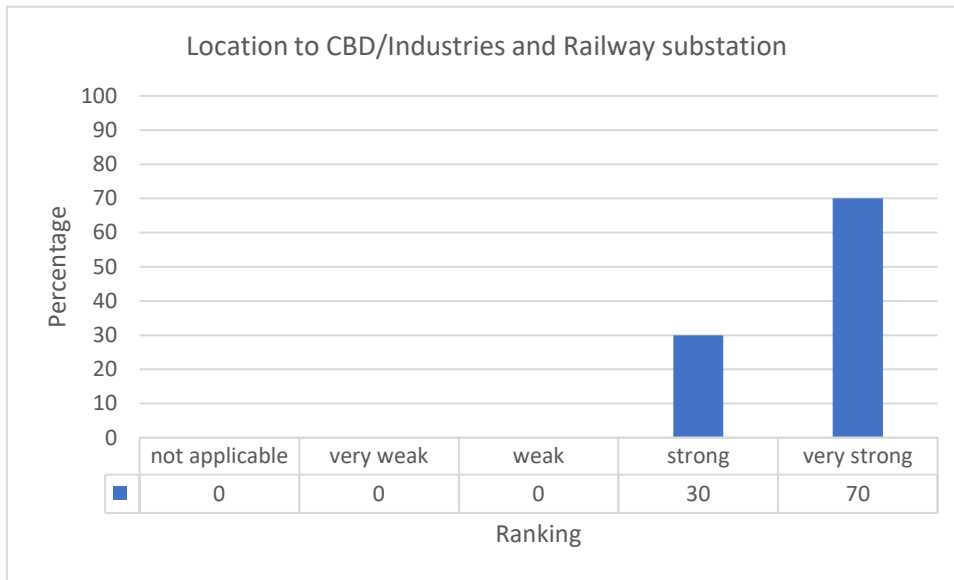


Figure 32: MkR ranking on location

The respondents that stated location as a strong indicator can be understood from the expert's point of view that IS and transitioning of a slum is attracted to areas that offer job opportunities such as industrial zones as is the case of Mukuru settlement. Key expert No. 8 stated that *“It always starts in a safe area but because they settle on public land they sprawl farther to hazardous places such as river channels, flood-prone areas steep slopes among others.”* The statement is in line with Jones (2017) and Kohli *et al.* (2012) findings, arguing that the IS and slums tend to follow features such as roads, railway corridors among others and because these are public land the residents usually have no option but to gravitate to it.

Most residents in KND settlement, on the contrary, stated that it is a weak and very weak indicator. This the FGD of the IS analysis reasoned that location to CBD, industrial zones and other commercial centres could to be close to because the rent closer was very high and also acquiring land anywhere close to the job opportunities areas was an impossible mission because of their meagre income. This is in agreements with O’Kelly and Bryan (1996) findings which stated the theory of Von Thunen’s model stating that the closer the CBD is the higher the land rents and hence unaffordable to informal settlements. The FGD discussions also revealed that lack of permanent jobs also accelerates residents settlements within the IS and slum.

#### 4.2.8. Density

In many studies, density has been perceived as being either high or low. Perceived density, according to Alexander (1993), may only concentrate on the effects of the mental wellbeing of the dwellers and therefore differs between countries and communities.

Dwelling density gives an important clue that informal settlement in this context and analysis, as shown in figure 28. 90% and 10% of the experts state that it is a very strong and strong indicator, respectively.

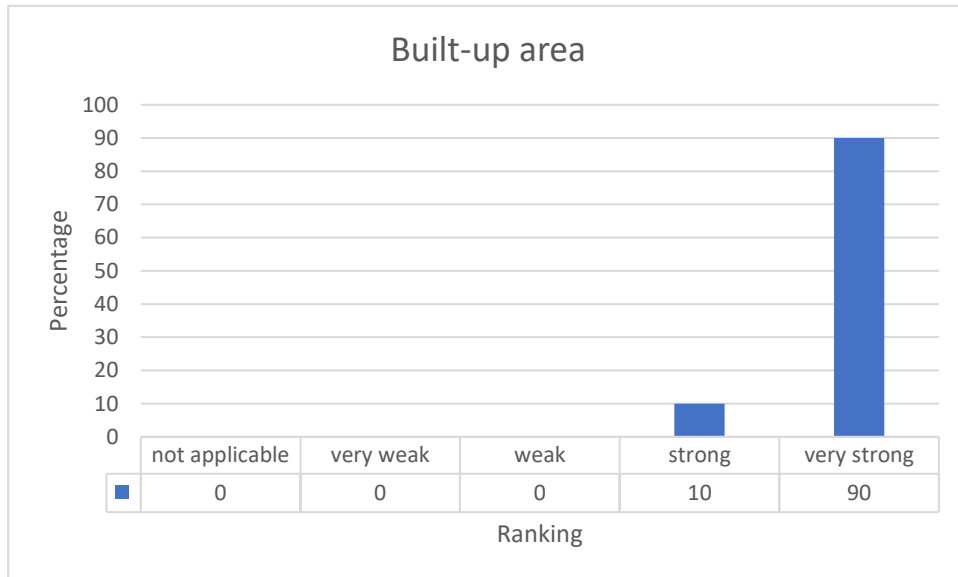


Figure 33: Key experts ranking on built-up area

From Figure 34 and Figure 35, 67% of KND and 93% of Mkr residents agreed that Density was a very strong indicator. Likewise, 33% and 7% of KND and Mkr residents respectively reiterated that it was a strong indicator

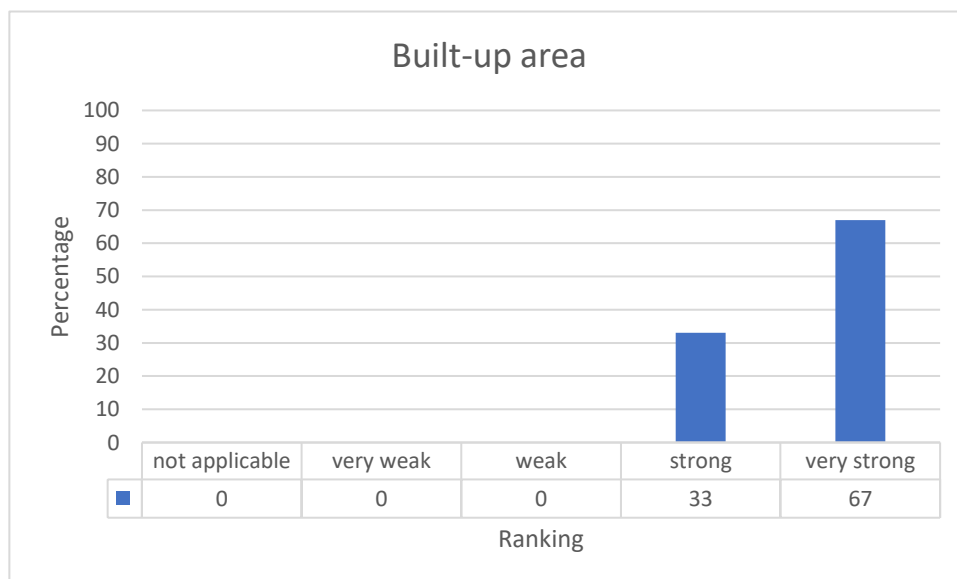


Figure 34: KND ranking for built-up area

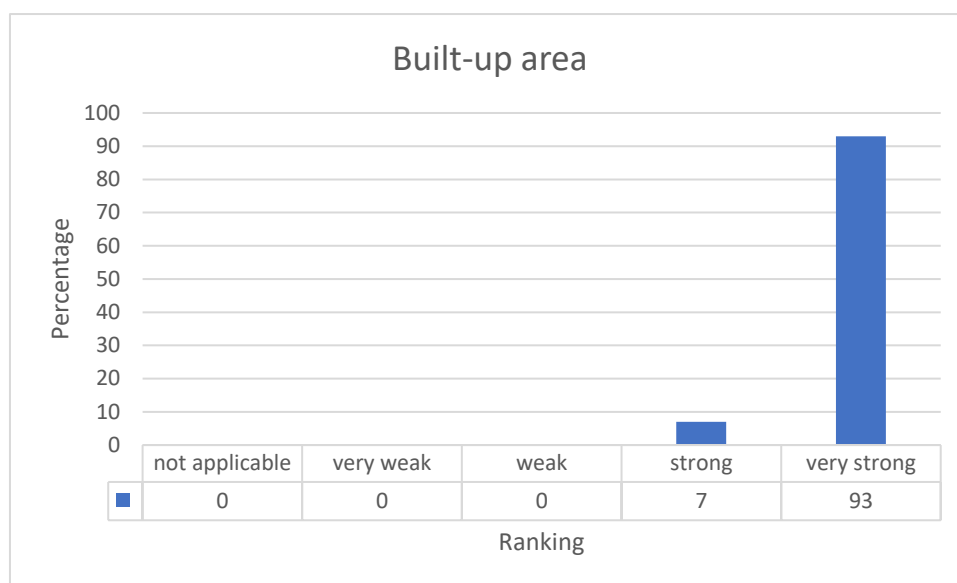


Figure 35: Mkr ranking for built-up area

Responses from the key experts, FGDs and residents agree that dwelling density revealed that as a very strong and strong indicator. Experts also articulated high densities and high roof coverage as an indicator for high density because the settlements such as Mkr overtime has attached itself to existing structures covering every open space available and when observed from satellite images, one cannot see also accessibility within. This result is in agreement with (Kohli *et al.*, 2012) study which argues that high roof coverage is a significant indicator in a typical slum identification. It portrays the reality of high densities characteristics in a slum than in an IS. The Focus Group Discussion form KND pointed out that in reference to density, they are just like any other Acioly and Davidson (1996) & Kohli *et al.* (2012) also notes density as one of the most important indicators in housing, human settlement and slum identification.

### 4.3. Key indicators that differentiate IS from slums

The third research question of the first objective is: “What are the key indicators that differentiate IS from slums?” Based on the results analysed from the reformulated research question, indicators that are considered key in distinguishing informal settlement from the slum were ranked in a Likert scale of 5 which included 1-not applicable, 2 (very weak), 3-weak, 4- strong and 5-very strong.

Likewise, the final selection incorporated derived from literary works of (Owen and Wong, 2012; 2013; Kohli *et al.*, 2012; Fallatah *et al.*, 2019) which was useful in making a final selection of applicable indicators differentiating IS from a slum. A summary of the selected indicators is shown in Table 12.

Table 12: ranking and selection of indicators

Ranking and selection of indicators						
No	Indicators	Key experts	KND (residents)	MkR (residents)	Literature	Selection
1.	Road accessibility	+	+	-	+	Yes
2.	Dwelling shape	+	-	+	+	Yes
3.	Vegetation	+	-	-	+	Yes
4.	Location	+	-	+	+	Yes
5.	Density	+	-	+	+	Yes
6.	Texture Measure	+	+	+	+	No
7.	Neighbourhood characteristics	+	+	+	+	No
8.	Dwelling size	-	-	-	-	No
9.	Roofing materials	-	-	-	-	No

Out of the nine indicators, five indicators were selected from the combination criteria. These include road accessibility, dwelling shape, vegetation, location, and density. The excluded indicators are dwelling size, roofing materials, Neighbourhood characteristics and texture measure.

Dwelling size was also omitted because the sizes were relatively the same as was described by the experts' parameter description of the houses and residents' perceptions. In line with this was Owen and Wong(2013) findings that IS and slum-dwelling sizes are relatively the same.

Texture measure was considered a weak indicator because the experts, residents stated that they were very dense, and they are all attached. This agrees with Fallatah *et al.* (2019) result that produced a low accuracy for texture measure.

Finally, roofing materials was also omitted as a weak indicator because they are of the same materials, that is iron sheets and will be impossible to use it an indicator for differentiating an IS from a slum. The same was echoed by (Kohli *et al.*, 2012) which argue that key experts reiterated that roofing materials were all similar, especially in Sub Saharan Africa.

#### 4.4. Spatial pattern of the informal settlement and slum indicators

This section mapped key indicators selected by the experts, residents and based on literature review for recording transition of IS to slum over time. The indicators mapped included vegetation, road accessibility, Building shape, built-up density and location to CBD, industries and railway station. The question addressing the mapping is “*which indicators differentiate Kisumu Ndogo informal settlement and Mukuru Kwa Reuben slum?*” To analyse it in detail, interviews held with the key experts (see appendix A) presented the question as “*What parameters/ measures do you use to indicate when an informal settlement ends and a slum starts?*” Thresholds used were produced when mapping by the researcher and the results analysed in comparison with the thresholds proposed by the key experts and literature to differentiate an IS and a slum and their transition.

##### 4.4.1. Vegetation cover

Vegetation is expected to be higher in an IS than in a slum (Owen and Wong, 2013). These characteristics have also been explored in identifying the amount of vegetation cover that exists in MkR slum and KND informal settlement

##### Mukuru Kwa Reuben slum

Table 13 shows the overall coverage of different land uses that were mapped in MkR. In regard to vegetation, at 2002, 2003, 2004 and 2006 its coverage were 179 (acres), 189 (acres), 93 (acres) and 102 (acres). Against the settlement area of 69(acres), 64(acres) 139 (acres) and 141(acres). The start of 2002, shows vegetation as higher than settlement and is ascribed to the original pattern concentrated to the south while the rest of the land is vacant. In 2003 there is an increase in the vegetation cover by 6% as the settlement decreases by 2%. The increase is seen as a result of vegetation taking over the bare land that is in existence. This means there was a rainy that contributed to the growth of the vegetation and was uninterrupted by human settlement. 2004 records a sharp decrease in vegetation by 32% and a drastic increase in settlement by 25%. The vegetation decrease and settlement increase can be attributed to the long duration the land remaining undeveloped. This could have attracted the migrating population looking for employment in the industrial area. Also, the area is located within the boundary of the industrial zone hence the migrants attraction. There is a slight increase of the same by 3% for vegetation and 2% for the settlement in 2006. The fluctuation of vegetation is evidence that as time progresses, there is depletion that is taking place and only in wet seasons as 2003 and 2006 it records increase.

Table 13: vegetation cover in Mukuru Kwa Reuben 2002-2006

year	2002		2003		2004		2006	
	area(acre)	(%)	area(acre)	(%)	area(acre)	(%)	area(acre)	(%)
Bare Land	44	15	17	6	58	19	34	11
Shadow	9	3	25	8	6	2	20	7
Slum	69	23	64	21	139	46	141	47
Vegetation	172	57	189	63	93	31	102	34
Water	6	2	5	2	4	1	3	1

### Kisumu Ndogo (KND)

Table 14 shows that vegetation covered 1 acre through the years of 2002, 2003, 2004 and 2006 respectively in KND informal settlement. Against the settlement of coverage of approximately 10, 11, 12 and 12 acres respectively. Vegetation has remained constant throughout the study periods at 8%. This is because the vegetation is located on the riparian of Nairobi river, which is under strict monitoring the National Environmental Management Authority (NEMA) and thus no settlement is allowed. The vegetation also acts as a demarcation of the areas beyond which settlements are not allowed. The settlement growth does not affect the vegetation because of its closeness to the river, which often floods during the rainy seasons, and thus the residents are not comfortable to settle close to it. Increase in the settlement takes place in 2003 by 8% and 7% by 2004. The increase is seen as the bare land disappears through 2003-2006, meaning that there is high infilling of settlement in the areas covered by the bare land.

Table 14: vegetation cover in Kisumu Ndogo for the period of 2002 to 2006

Year	2002		2003		2004		2006	
	area (acre)	(%)	area (acre)	(%)	area (acre)	(%)	area (acre)	(%)
Bare land	1	8	0	0	0	0	0	0
Buildings	10	77	11	85	12	92	12	92
roads	1	8	0	0	0	0	0	0
water	0	0	1	8	0	0	0	0
vegetation	1	8	1	8	1	8	1	8

#### 4.4.2. Road accessibility

Roads are considered as one of the main factors that contribute to accessing services, destinations and activities within and outside any settlement or environment (Heinrichs and Bernet, 2014). In this study, we assume that a settlement that has limited access to these fundamental services has a higher chance of being classified as a slum than an IS. The higher the nodes are in a settlement connected in shorter distances the higher the chances are it is a slum (Kohli, 2015). The ration of length to width in this study also adopted from the study of (Kohli, 2015) explores the level of concentration of access paths in KND informal settlements and MkR slum.

#### Mukuru Kwa Reuben

Table 15 shows that in 2002, the number of nodes are 885 with a mean of 3.45. The number of nodes are high because of the concentrated settlement in the one area and paths to access their dwellings. Also, the main road accessed from the south into the slum abruptly ends towards the Northern part and in addition other roads within are characterised by unconnected nodes, as seen in the subset image in Figure 36. 2003 records a reduction in the nodes by 168, revealing the condition of the roads as earth and mud which disappears when vegetation covers increases. In 2004 the nodes increased by 177 and were seen to spike as the settlements increases. Further, an increase is also witnessed in 2006 by 127 of 3.97, which also marks the highest connectedness within the settlement. This is characterised by longer roads separating settlements created in alignment of back to back pattern seen in 20004 and 2006. Although accessibility has improved, the roads are still characterised by dead ends.

Table 15: road network within Mkr settlement 2002-2006

Year	No. of nodes	mean of Length and Width (m)
2002	885	3.45
2003	717	2.45
2004	894	3.08
2006	1022	3.97

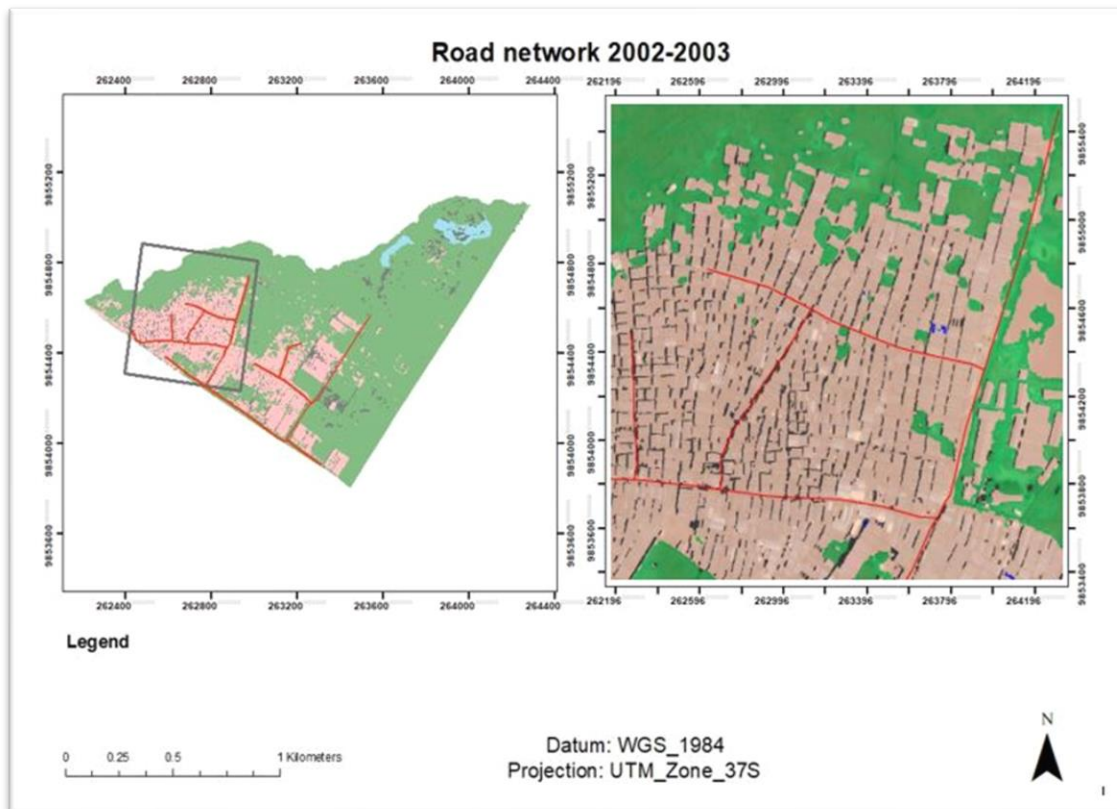


Figure 36: Road network in 2002 and 2003

### Kisumu Ndogo (KND) informal settlement

shows that in 2002 there were 62 nodes in KND with a mean length and width of 2.5. These roads are long and linked to one major road connecting the settlement to the rest of the city (Figure 40). 2003 shows a sharp decrease in the number of nodes which is important to note that it was as a result of the image quality that hindered correct classification of the roads nodes as well as the length and width. The sudden increase in 2004 by 107 is attributed to the improved quality of the imagery give more data on the nodes. 2006 saw a decrease by 50 nodes to register a 2.2 m mean length and width of the road connection. In the case of KND, the nodes are few and the length and width are long and narrow as it takes the orientation of the buildings which are long and shows that it is better connected towards the main road.



Table 16: road networks in KND 2002-2006

Year	No. of nodes collected	Mean of Length/Width (m)
2002	62	2.5
2003	25	1.4
2004	132	2
2006	82	2.2

**4.4.3. Dwelling Shape**

Shape index is seen to describe a shape’s complexity and its orientation thus giving the objects their true geometry in the real world that is consistent and complete. (Zhang and Atkinson, 2016). In SSA, most IS are characterised by various shapes, while slums are described by elongated structures (Kohli, 2015). The study has adopted these characteristics as most relevant in analysing the differences found in the IS and slum of the study context.

**Mukuru Kwa Reuben**

In 2002 the mean shape index (SI) showed that the complexity of the shapes are irregular and this is because it was the beginning of the settlement and built-up area that show further the orientation of the shapes (Figure 37). 2003 records a very small decrease in the dwelling shape by 0.02 and then a steady increase through 2004 and 2006. The steady increase of the dwelling shape is attributed to the building becoming more regular and compact from its heterogenous form (Figure 38 subset 2). This further indicates that the mean shape index can recognise the optimum shape within Mukuru and identify possibilities of transitioning through time.

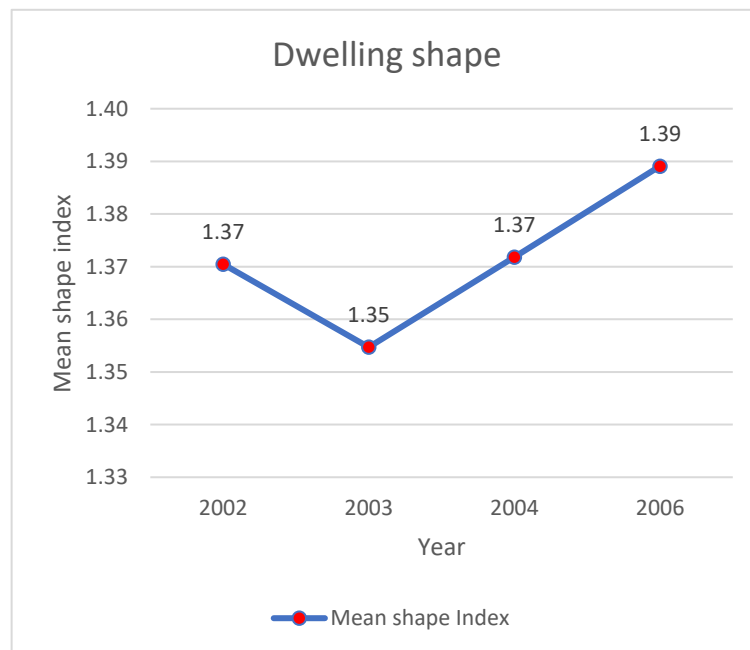


Figure 37: Mean Dwelling shape in Mukuru from 2002-2006

Figure 38 represents dwelling shapes from 2002 to 2006 in which 2002 has been used as the reference year to show the changes. Two subsets of the image were selected for two reasons; the first subset consists of the original dwelling shapes that were developed in the area, and subset 2 shows the building footprints that appear in the subsequent years. From subset 1, building footprints are in various shapes that are small and remained the same through the years. This can be related to the limited space built up within the area that is not sufficient for more buildings to be constructed. Subset 2, on the other hand, reveals that no structures were existing in 2002. A change is witnessed in 2003 by the emergence of built up footprints that are the same as 2002. In 2004 the built up footprints start taking up elongated characteristics with few of the buildings taking various shapes and then become more compact and organised in 2006 diverting from the original heterogeneous shape to a homogeneous shape.

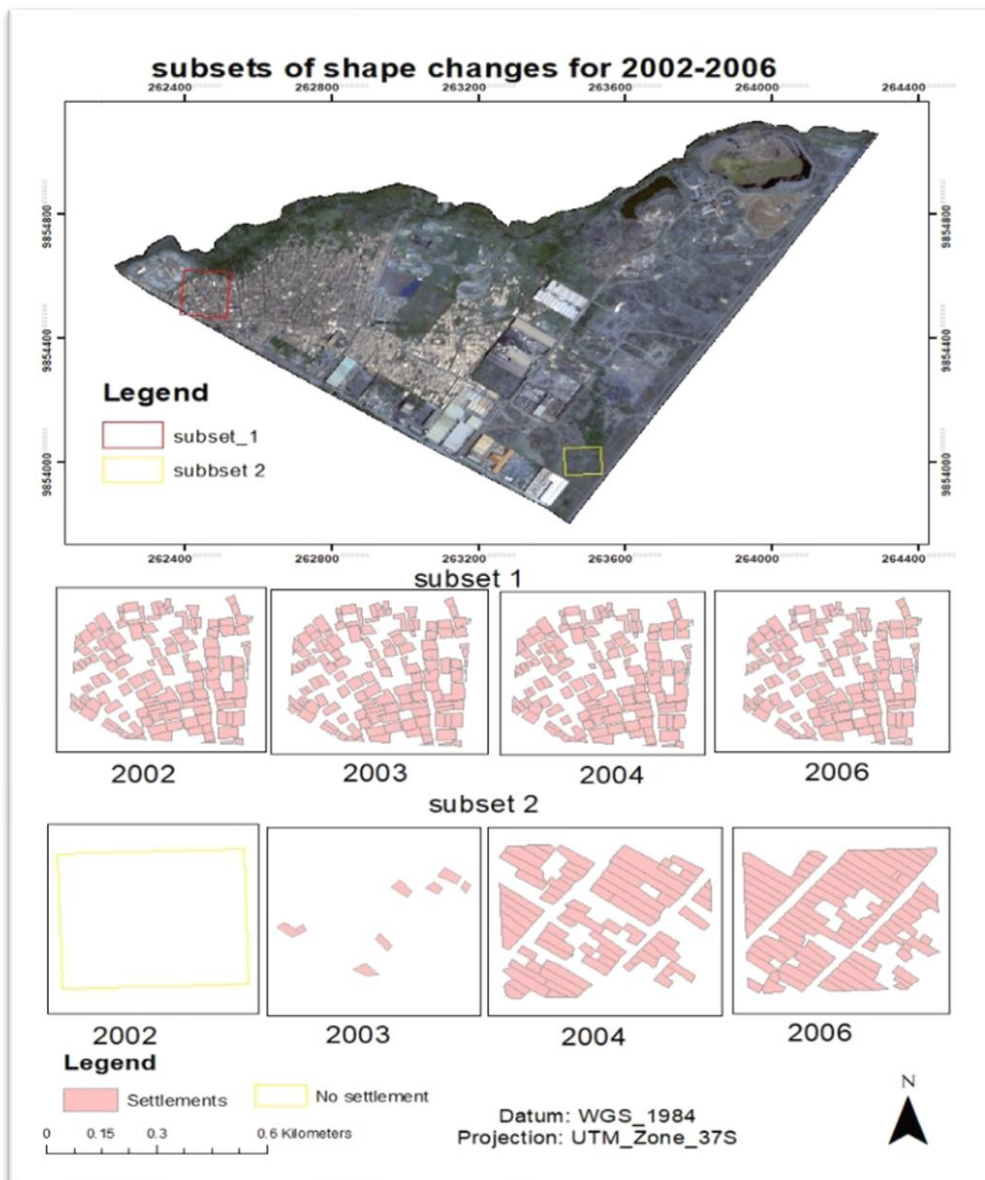


Figure 38: Shapes of dwelling units in MkR for two subsets (2002-2006)

**Kisumu Ndogo**

Figure 39 shows KND as having more defined shapes that are less complex in their appearance. This also reflects in the mean shape index for 2002, which recorded a value of 1.90. there is a decrease in their uniformity in 2003 by 0.03. The reduction is attributed to the demolition of structures close to the river line by NEMA enforcement officer in their regular monitoring of encroachments of settlements. On the other hand, 2004 sees an increase equivalent to the value of 2002 by 0.03 and further 0.06. The increase in structures is seen as a continual occupancy of the available spaces by the residents, and thus SI in KND shows an almost perfect shape with the high of 1.96 in 2006.

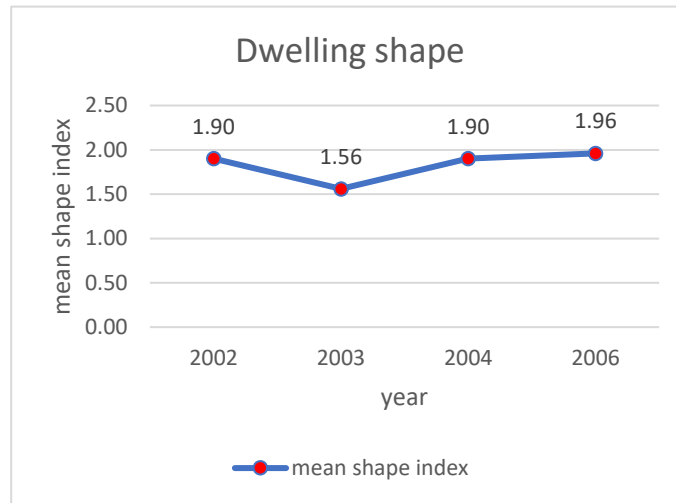


Figure 39: Kisumu Ndogo Mean dwelling shape Index

Figure 41 shows a visual representation of the building footprints showing the area as an almost perfect shaping with negligible complexity and limited continuity. The roofing of the settlements completely covers the smaller roads within giving a homogeneous appearance in the area.

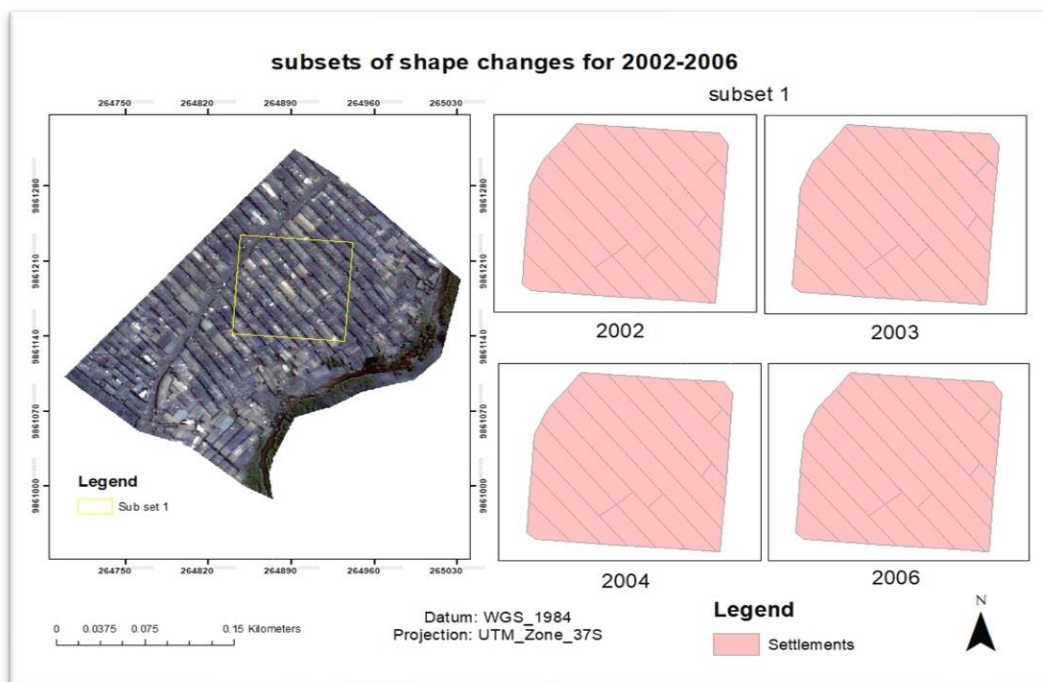


Figure 41: Kisumu Ndogo dwelling shape (2002-2006)

#### 4.4.4. Built-up area

One of the most common ways of measuring a slum is by using built-up density which can also be translated to mean that the higher the density, the higher the chances are that transitioning of the IS is possible to a slum. This study adopts the characteristics identified in Owen and Wong (2013) study and hypothesises that a slum is recognised by its high built-up density while a low built-up density characterises the IS to identify.

#### Kisumu Ndogo settlement

Figure 42 (a-b) shows that the percentage of built-up decreased in 2002 from 93% to 78% in 2003, which implies a reduction in distribution of the built-up. There is an increase in the patch density from 73m<sup>2</sup> to 569.3m<sup>2</sup>, implying fragmentation occurring in the settlement. A drastic increase is seen in 2004 by 10% and a further 4% in 2006, which saw a decrease in the patch density in the same years. This reveals that there is infill of the already dense area. The trend characterises compact development in the area revealing an almost optimum fill-up of the patches, which is 100%.



Figure 42: the built up density and area density in KND

Figure 43 reveals that there has not been much change in Kisumu Ndogo in the shape of the built-up during the study period. Over time the built-up has evolved to almost a single patch making it much more compact.

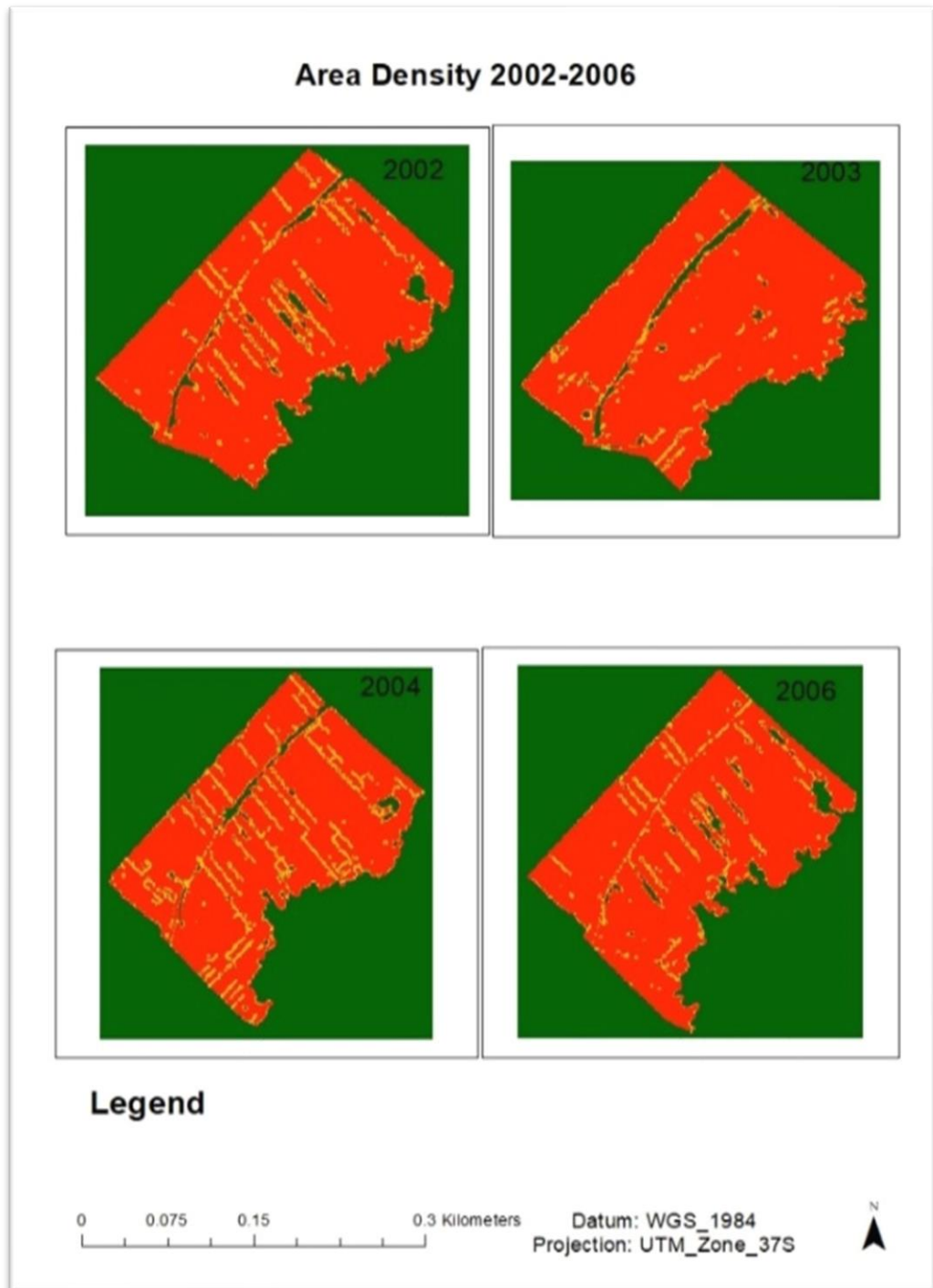


Figure 43: Built up and non built up area of KND 2002-2006

### Mukuru Kwa Reuben settlement

Figure 39 reveals a reduction in the aggregated index (AI) between 2002 and 2003 by 10%, leading to an increase in the number of patches by 100m<sup>2</sup>. This indicates there is a reduction in the built-up distribution (figure 40). The Built-up area was at its lowest by 27% in 2004 attributed to low construction period and immediately a drastic increase by 37% in 2006. It is important to note that the disparity of these values between 2004 and 2006 could be as a result of missing data of 2005 that was not used because of heavy cloud cover. It is therefore attributed to very rapid expansion in the built-up area that also saw the patch density decrease by 882m<sup>2</sup> making it compact.

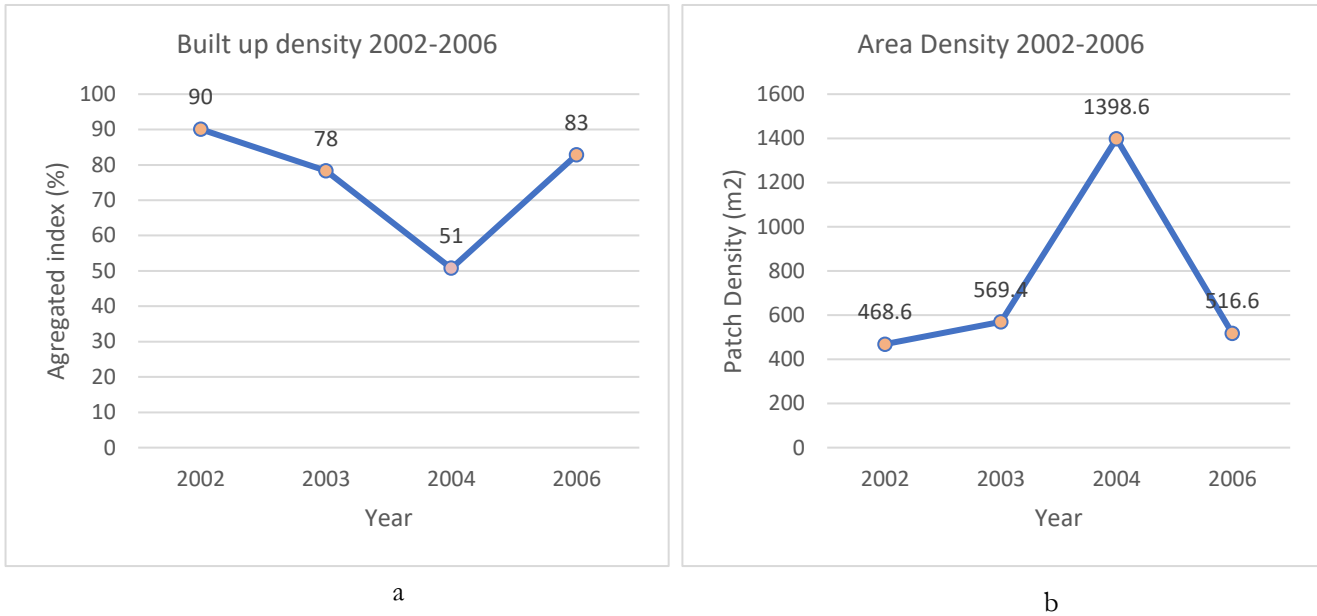


Figure 44: Built up density and area of Mukuru 2002-2006

Figure 45 highlights the transitioning pattern in the built-up from being highly fragmented to consolidating in 2006 progressively towards the north.

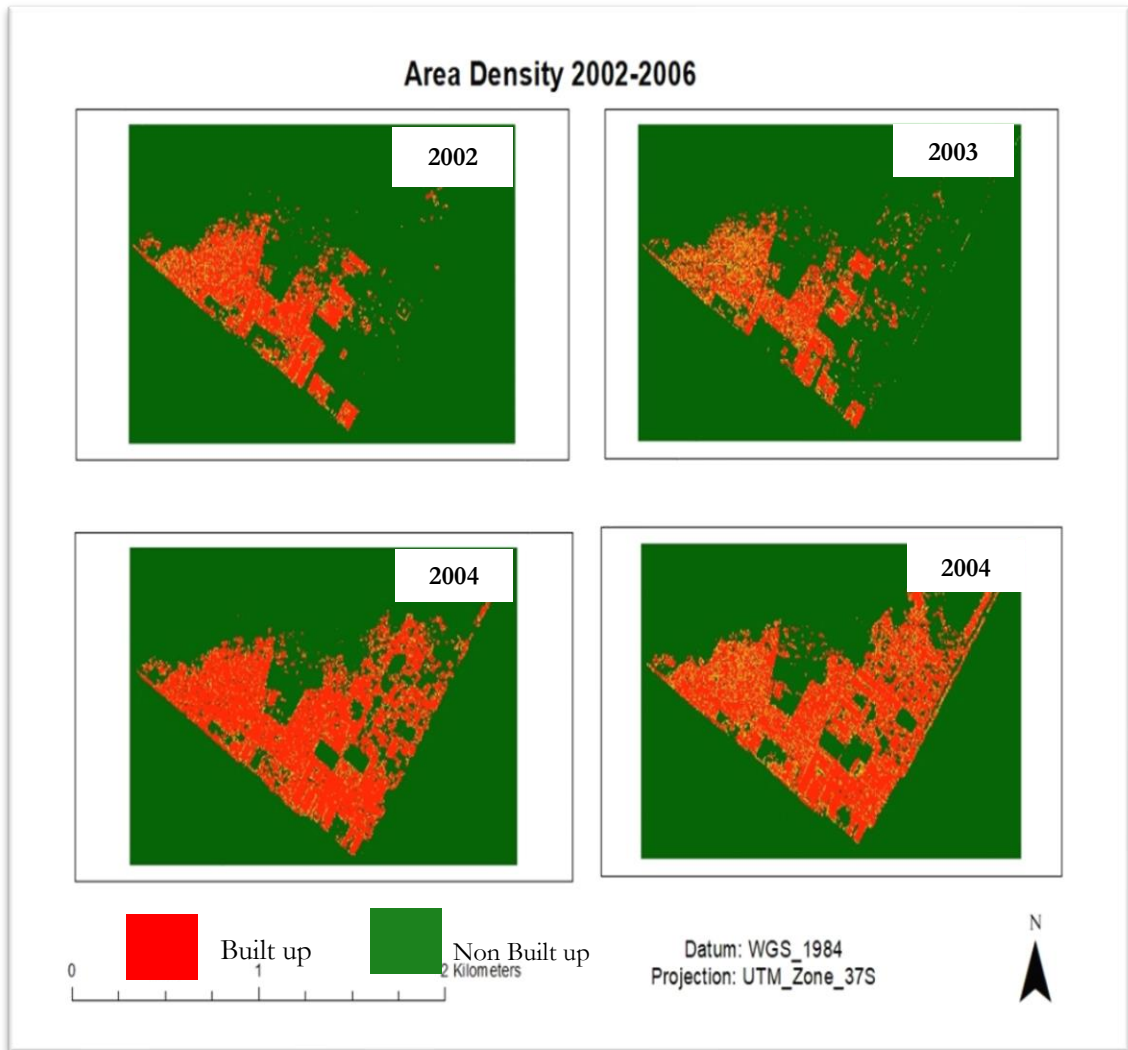


Figure 45: Built up density of Mukuru Kwa Reuben 2002-2006

#### 4.4.5. Location to CBD, Industries, Railway substation and major roads

Availability and accumulation of most public services in the city often act as a remedy for attracting road networks and Industries to supply their goods to the larger population. This has drawn the settlement of high densities attributed to the slum while the informal settlement at the periphery of the city is looking for better life and jobs (Abebe, 2011). This study adopted the 15km buffer parameter done by (Antos *et al.*, 2016) to try to find out whether the location can classify KND informal settlement and Mkr settlements.

#### Mukuru Kwa Reuben and Reuben

Figure 46 reveals that at 5km distance, neither Mkr nor KND is within the proximity of the CBD. This is because land value within this zone is high and owned and controlled by the Government for commercial and administrative purposes. On the other hand, Mkr slum is nearer the 5km than KND which can be the other reason why it attracts population increase for being in a strategic location to the basic service provisions offered within the area such as water, road connections among others (figure 41).

In regards to industries and railway substation, Mkr slum is located approximately 1km Makadara railway substation and 0.7km from the industrial area while KND is located approximately 4.5km. Mkr compared to KND, shows that it is strategically located and has continued to attract more low-income earners looking to access to job opportunities within the industrial areas and the railway substation as well as affordable accommodation. Besides, the railway substation has increased informal economic activities emanating from Mkr residents that target the commuters from CBD.

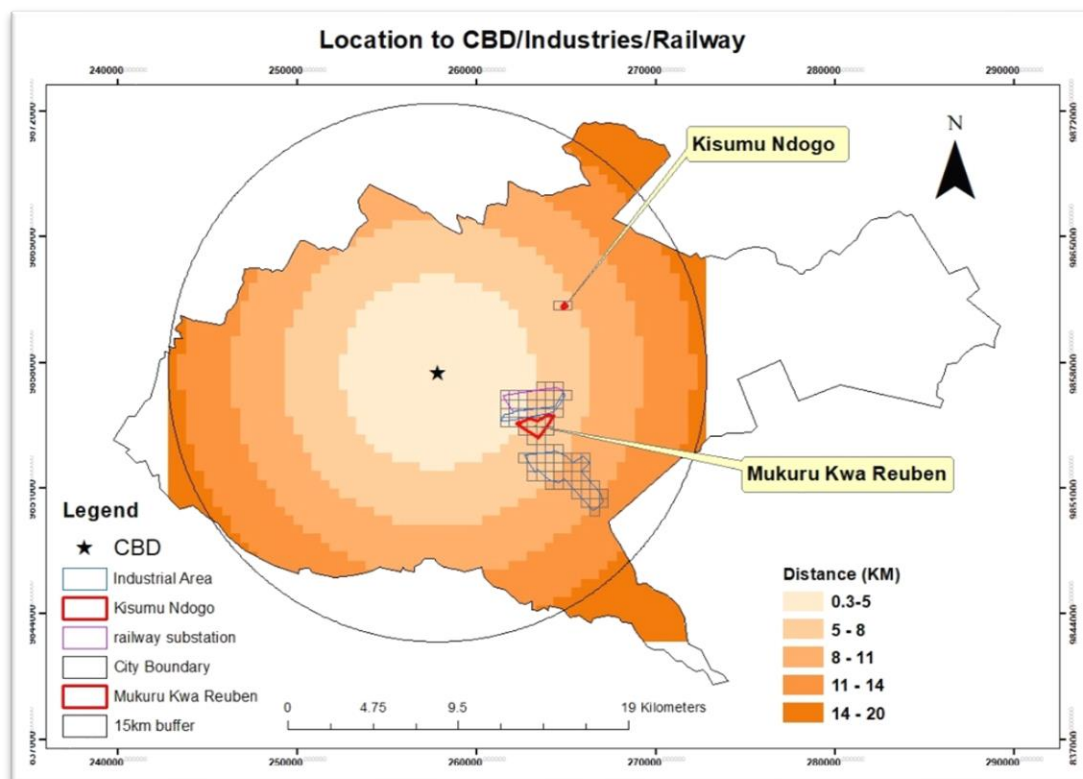


Figure 46: location of KND informal settlement and Mkr slum to CBD/Industries/railway substation



#### 4.5. Key indicators that point to the transitioning of an informal settlement to a slum

In this section, the question addressed is “Which key indicators point to the transitioning of an informal settlement to a slum over time?” The research question is a further step to analysing the selected indicators from both the quantitative and qualitative data. To get qualitative information, the key experts were asked (see appendix A), “What parameters/measures do you use to indicate when an informal settlement ends, and a slum starts?” The analysis from the mapping are discussed in comparison with the key experts' thresholds (Table 17), and a conclusion is drawn on key indicators that show the transition in the cases of KND informal settlement and MkR slum.

Table 17: summary of indicator thresholds from the Key experts

Indicators	Threshold for IS	Threshold for slum
Vegetation	<ul style="list-style-type: none"> <li>• coverage of 50-20%</li> </ul>	<ul style="list-style-type: none"> <li>• Coverage of less than &lt;20</li> </ul>
Road accessibility	<ul style="list-style-type: none"> <li>• Road width of 9-3m</li> <li>• Connected to the main road</li> </ul>	<ul style="list-style-type: none"> <li>• Narrow road of less than 3m</li> <li>• Dead ends within the settlements</li> <li>• No straight connection to the main road</li> </ul>
Building shape and density	<ul style="list-style-type: none"> <li>• Various in shapes</li> <li>• Number of houses per acre 3-6 house</li> </ul>	<ul style="list-style-type: none"> <li>• Elongated structures</li> <li>• &gt;8 houses</li> </ul>
Location to CBD and industries	<ul style="list-style-type: none"> <li>• Proximity to CBD and industries is &gt; than 5km</li> </ul>	<ul style="list-style-type: none"> <li>• between 3-2km to CBD</li> <li>• Less than &lt; 2km to the industrial area and the railway</li> </ul>

#### Vegetation cover

Results from Table 13 and Table 14 reveal that there is a difference in the vegetation cover between KND informal settlement and MkR slum. MkR registered vegetation cover of 34% in 2006 and KND vegetation covering 8% in the same year.

From the interviews held with the experts, a threshold of 50-20% vegetation coverage was agreeable by all the experts to be used for describing an informal settlement. While 58% and 42% of them stated that vegetation cover is less than 10% and 20% respectively characterises a slum.

The findings in MkR slum is in agreement with the minimum IS threshold supporting key expert no. 6 statement that “*Informal settlement is mostly characterised with few trees and open space in areas that are not occupied.*” Similarly KND characteristics is aligned to a slum characteristics as pointed out by key expert no. 10 stating that; “*A slum typically has no vegetation cover, but few open spaces exist in small patches within the settlement.*”

The findings and the thresholds of the experts on KND are in line with study of Kohli *et al.* (2013) stating that vegetation cover is less than 10%. Likewise Owen and Wong (2012) report that vegetation cover existing in the slum is between 5-10% of public space. This shows that vegetation cover in a slum conforms to of uneven distribution characteristics including small open spaces (Hofmann, Strobl and Nazarkulova, 2011). On other hand, MkR findings aligns to Owen and Wong (2013) study that show there is a striking difference in the vegetation cover between an IS and a slum because an IS has abundance of vegetation cover mixed with settlement.

The assessment performed on vegetation using NDVI reveals producer accuracy of 100%, 100%, 83% and 100% in 2002,2003,2004 and 2006 respectively. KND producer accuracy was 93%, 77%, 94% and 98 respectively for the same years meaning vegetation was accurately classified. This aligns to Fallatah *et al.*, (2019) study that showed vegetation as the most significant indicator in differentiating the IS from the formal settlement. The findings of vegetation cover also reveals that it can show transitioning of IS to slum as seen in the case of KND and MkR.

### **Roads accessibility**

The threshold provided by key experts in road accessibility stated that road with of 6-3m that are able to connect to the main road describes an IS and road width below 3m which are characterised by dead ends and not accessible to the main road depicts a slum.

Figure 14 reveal that MkR road accessibility varies considerably over time with an approximate mean between 3-4m while Figure 13 KND shows inconsistency in its road networks with an approximate mean of 2m. MkR aligns to the key experts IS threshold of minimum road width but contradicts it accessibility to the main road since it is characterised by dead ends within the settlements. On the other hand KND road width of 2m is in agreement with the slum threshold but just like the MkR its roads are able to access the main road. The contradicting differences in the road characteristics is attributed to the building orientation of the dwelling as well as their location. While KND aligned itself to the main road from the onset of the settlement, MkR is situated within the industrial area that buffers it from the main road such as enterprise road accessed by most industrial plots. (image in the appendix to put).

The results in relation to literature show that MkR contradicts the study of Mathenge (2011) stating slums are characterised by 3-4m road width. Though the author did not map the roads for reasons of their nature that unpaved and could not be classified, he applied the threshold given by the experts in the case study of Kisumu slums. This difference is attributed to the location of the slums which are in different regions and thus display unique characteristics within their environments.

KND results findings and threshold of the roads is in line with the study of Kohli (2015) which she noted in observation of Kisumu slums that their road width are between 1-3 and are unpaved access paths. Likewise, the MkR thresholds for road descriptions is in line with Owen and Wong (2012) and Fallatah *et al.* (2019) studies that found roads to be characterised by dead ends, are unpaved, irregular, too narrow and not easily accessible by vehicular means. Also worthy to note is that these attributes are evidenced in KND settlement. The intertwining characteristics between the two settlement shows that the road accessibility is not able to show transition of the IS to a slum.

### **Dwelling shape and built up area**

From the key experts interviews, a threshold of 3-6 houses per acre was proposed to be an IS settlement and more than eight houses per acre indicates the presence of a slum. Another threshold is that detached dwelling units with low density are associated with informal settlement while slums are characterised by attached structures and high density. Due to the unavailability of detailed information on housing units, and population density, the study combined it with the shape for a comprehensive analysis for transition. Therefore it is assumed that when the dwelling shape is detached the area shows low density on the built up area and vice versa.

The findings in Figure 43 and Figure 44 show that KND has remained compact and attached over the study period and MkR shows fragmentation and detached building of various shapes and then begins to be compact and elongated. KND is in agreement with the key experts threshold that characterises a slum by attached and elongated structures.

Key expert no. 8 stated that;

*“The slums have no space between the structures overtime since they the owners have constructed new houses through by attaching it to the old existing buildings forming elongated shapes that are organised than IS.”*

On the other hand, MkR took the characteristics of an IS in 2002-2003 which aligned itself to key expert no. 12 statement that; *“The informal settlement is structures are detached and often distributed within the settlement.”* Important to note is that these structures started having an attached characteristics similar to KND in 2004 to 2006 indicating the thresholds of the slum description.

The results and threshold data of KND are also in agreement with the study of Kohli, Stein and Sliuzas, (2016) as they argue that one of the most reoccurring factors besides dwelling shape, and size is the Built-up density that is compact, attached and is often high in the slum areas. Likewise, KND is aligned to the study of Owen and Wong (2013) findings that a the slum is often attributed to high density while the low density is associated with the IS. On the other hand MkR is aligned to Owen and Wong (2012) stating that built up area in an IS less compact and more spacious. The findings are also in line with Kohli *et al.*, (2012) study points out that Sub Saharan Africa IS has various shapes and slums have elongated dwellings. In this study, though built-up density is not able to differentiate KND informal settlement and MkR slum because of their similarity overtime, it shows that MkR slum is a good settlement in monitoring the transitioning pattern.

#### **Location to CBD/Industries, and the railway substation**

The interview results revealed that a threshold of greater than 5km from to the CBD pointed out by the experts characterises the IS and 3-2km to the and less than 2km forms a slum. During mapping, the study adopted (Antos *et al.*, 2016) buffer distance of 15km that was applied to map the location of KND and MkR to analyse the possibility of their transition in relation to proximity of the thresholds given by the key experts.

From Figure 46, revealed that MkR is located closer to the CBD/Industries, and the railway substation while KND is at the periphery. The results of MkR is slightly aligned to the proposed thresholds of 1km and 5km radius stated by Key experts indicating that within these distances the illegal settlement is a slum. This was also confirmed in a statement of key expert no. 8 that; *“Only slums exist within this threshold.”* MkR also shows a strong monocentric affiliation to areas that are having opportunities to all population

Likewise, KND justifies the threshold of the experts that that beyond 7 km the settlement qualifies to an IS. Key expert No. 7 commented that; *“it is hard for an IS to transition very fast when it is far from the essential job opportunities.”* This could be reasoned that the existence of the air field and private ownership of plots and houses surrounding it cannot allow it to be closer to the CBD/Industries or railway substation.

The analysis of this study for MkR settlement and the key experts proximity threshold is in agreement with Antos *et al.*, (2016) study that found Slums to be within 4-6km proximity as is the case of Nairobi. Though studies done by (Kohli *et al.*, 2012; Owen and Wong, 2013) use general proximity measures without distance ranges, the study findings and the experts opinion are in agreement with their results stating that slums are located close to industries and major transport corridors. Location to CBD/Industries/ railway substation.

Based on the five indicators mapped, three indicators point to transition an IS to a slum these include vegetation cover, built-up area and shape and location to the CBD/Industries, and the railway substation. Vegetation is most significant since it evidently shows the diminishing cover over the study period. Secondly, location to the CBD/Industries, and the railway substation point to transitioning characters of MkR over KND using proximity thresholds of both the key expert and as seen in the case of Nairobi study by Antos *et al.* (2016). Lastly, the built-up area and shape using MkR were also useful in showing transition of an IS to a slum.

#### 4.6. Drivers of informal settlements to a slum

From the literature review (discussed in section 2.4), four categories of drivers were identified (Table 18) and subjected to the opinions of the key experts and residents. Even though residents outcome were collected, it is not used in this section because it reveals differences in their settlement than transitioning. The study instead has considered the Focus Group Discussion and the key experts interview results for its analysis. The question asked was ‘*which drivers increase the chance of informal settlements transitioning to a slum?*’

Table 18: Categories of Driving factors of IS to a slum

Category	measure
Physical-site	Quality and quantity of basic infrastructure provision (water, sanitation solid waste,) (photos of the area)
	Proximity to undeveloped land
Socio-economic	Employment
	Level of income
	Type of job (temporary or permanent)
Socio-cultural	Places of worship
	Culture
	Ethnicity
Policies	Long Bureaucracy
	Outdated planning regulations
	Stringent development application policies
	Lack of community participation in planning and decision making
	Lack of acknowledgement of IS and slums in plans

##### 4.6.1. Physical-site factors

###### 4.6.1.1. Quality and quantity of basic infrastructure

Regarding the quality and quantity of basic infrastructure, interview results revealed that it is a very strong and strong driver as pointed out by 75% and 17% of the key experts respectively (Table 19). This could be attributed to the exposure of piped water lying dangerously over the foul water and open drainages that are prone to contamination. Different from the response of the majority was key expert no. 5 who pointed out that basic infrastructure was a weak driver since there is the existence of piped water in both settlements accessed at communal water points. Concerning sanitation, all the key experts agreed it was very strong driver reasoning that there were very few sanitation blocks existing within the settlements serving the large population. On the other hand, garbage management, according to the experts, is non-existent since the continual deterioration of accessibility does not allow the county services to collect the garbage.

Table 19: Key experts responses to the quality and quantity of basic infrastructure

Ranking	No. of respondents	Percentage
Not applicable	0	0
very weak	0	0
weak	1	8
strong	2	17
very strong	9	75
	12	100

Similarly, FGDs held with the MkR, and KND representatives indicated that basic infrastructure is a very strong driver. MkR members attributed it to the deterioration of the services to frequent contamination from burst pipes positioned on the sewer, and open drainages have leaked into the connections leading to many water-borne diseases (Figure 47) echoing the key experts opinion on contamination of water. Also, information gathered during the field visit indicated that frequent bursting of pipes is as a result of using poor quality pipes and illegal connections due to lack of adequate provision by the Nairobi Water and Sewerage Company. Comparatively, KND members reasoned that lack of consistency in the flow of water is as a result of the numerous illegal connections that diverts the water to other places as a commercial business. One of the KND members stated that;

*“We usually access to water twice a week and the rest of the days we buy it, which is very expensive and the situation is getting worse with the increasing illegal connections.”*



(a) Water point connections in MkR



(b) Communal water points sold to residents and connected to the toilet in KND

Figure 47: water connections within MkR and KND

In regards to sanitation, there are only five sanitation blocks in MkR which are charged Kshs. 5 for every use as one member pointed out that;

*“Not everyone can pay money whenever they are to use the toilet and also the children are charged the same amount. So people have often openly excreted in the night wherever they can, and it makes this place worse than it is imaginable.”*

Also, KND has two sanitation blocks serving all the residents in the area, and it is situated close to the river. This the members highlighted as a big challenge since everyone has to go down towards the river to access it. One of the members stated that;

*“People cannot go out at night for fear of their security, and they excrete in the polythene bags throw them up, landing on the roofs of other structures.”*

Field observation also revealed that there is no distinction of use between men, women and children (Figure 48). This poses the risk of infection, especially the children who use them unattended to and also the women.



Figure 48: Sanitation blocks in MkR slum

Regarding garbage management, both FGDs agreed that the county services are not availed to them, and the people have continued to dispose of their garbage anyhow making the area worse than it was (Figure 49).



(a) Garbage disposal in MkR



(b) Garbage disposal in along Nairobi River in KND

Figure 49: Garbage disposal methods in MkR and KND

From the above analysis, as a very strong and a strong driver, both the experts and the focus group opinions are in agreement with Mutisya and Yarime (2011) study that the continual negligence of the IS and slums with the government after independence has spiralled the to a deplorable state characterised by lack of water, hygienic sanitation. Also, Cheseto (2013) study is in line with the finding that even with access to piped water, there is a lot of contamination due to infiltration of foul water through the broken pipes. Limited access to collect the garbage as stated in the study findings agrees with the World Bank (2010) argument that because of limited access to the IS and slums the predominant method of disposal is dumping within the neighbourhood which is a characteristic seen in the deteriorating settlements.

#### 4.6.1.2. Availability of undeveloped land

Interview results indicated that availability of undeveloped land is a very strong driver since all the key experts were in agreement with it. Key expert no. 9 stated that *“The status of their illegality gives them a lot of freedom in squatting almost anywhere that they find an opportunity.”* This can be taken to mean that the closer an IS is to an undeveloped land the higher the chance is that it will transition IS to a slum since it acts as pull factor to the urban poor looking for almost free accommodation while integrating within the city.

Equally FGDs with the MkR members indicated that undeveloped land close to their settlement is a very strong driver and this they reasoned that it was because of the high density of population within the settlement. One member stated, *“we are so many, and everyone can grab such an opportunity.”*

KND likewise, indicated that it is a very strong driver reasoning that some want to settle there for free while others were willing to buy it to settle with their families. This brings out an interesting view that some of them will squat as others want to legally own it, hence the difference of who is a landlord and a tenant evidenced.

From the analysis proximity to undeveloped land is viewed by all as very strong driver. This is in agreement Abebe (2011) and Shekhar (2012) research findings indicating that proximity to undeveloped land has a strong effect on the transitioning of informal settlement to a slum. Also Sietchiping (2005) noted that unexploited or abandoned plots is a trigger for an existing IS to duplicate itself and serve a bridge for transitioning an IS to a slum. This also shows that availability of large scope of land offers accelerates transition of IS and slum is seen in the case of MkR (Limbumba, 2010).

#### **4.6.2. Socio-economic factors**

Kenya has a high share of IS and slums that are in dire socio-economic conditions driven by unemployment, low level of income and housing are all characterised by poverty.

Responses obtained from the key experts identified socio-economic factors as a very strong driver, specifying that unemployment resulting from the low level of education hinders the probability of the youth in the IS and slum residents getting professional jobs. Additionally, they also mentioned that most job availability for the residents in the IS and slums is usually on a temporary basis. Key expert no. 1 stated that: *“On average the residents get Kshs. 200 for their daily wages. This cannot even pay for the three meals that people are supposed to have in a day.”*

Key expert no. 12 also stated that: *“The urban poor because of their uncertainty of their job security cannot get access to loans which is a requirement for the financial institutions guarantee to lend money. Also, the financially able friends and relatives are not ready to be their guarantors for fear of them failing to pay back the loan.”*

The FGDs in MkR and KND iterated that socio-economic factors are a very strong driver. The members from both settlement stated that high unemployment rate is the most significant driver evidenced by the idle youth that rob people and cause a lot of insecurity in the area just to fend for themselves. In regard to the level of income and job conditions, they echoed the response of the key experts adding that, it gets worse with the increasing cost and standard of living within the confines of the city. One member from KND stated that :

*“Life has become so expensive in Nairobi and the fact that our salary does not change makes the situation in our environment worse”*

From the above analysis, findings on low income are in line with the study of Wekesa, Steyn and Otieno (2011) which argue that the urban IS and slum dwellers live on less than a dollar daily. This confirms that majority residents in MkR and KND are casual workers and hardly are able to raise money sufficient to sustain them leave alone move out of the environment they are in, continuing the culture of poverty. Also aligned to this findings is Mutisya and Yarime (2011) study that high levels of unemployment and low income give rise to IS deteriorating to a slum. These are characterised by high rise in crime rates and stress as the residents try to keep up with the increasing standard and cost of living within the urban set up (Wekesa, Steyn and Otieno, 2011; Owusu, Agyei-mensah and Lund, 2008). Moreover, Wekesa, Steyn and Otieno (2011) note that the poor urban dwellers are often excluded from the financial institution products and services including housing and land mortgages for lack of collateral assets, saving and uncertain job employment status because of their low wages.

### 4.6.3. Social-cultural factors

An extensive literature on social-cultural factors has been studied, and documentations have been done on the correlation of new migrants preference to settle in areas of similar backgrounds. This could, therefore, be argued that factors such as ethnicity, relations and religion in existing informal settlements can provide useful in witnessing formation transitioning of IS to slums (Sietchiping, 2005).

From the interview results, 83% of the key experts state that social-cultural factors are not applicable driver in the formation of an IS and slums. This they reasoned that most migration that is taking place is not subject to any socio-cultural affiliation of low-income earners, but they come from all parts of the country and also not all are poor. On the other hand, 17% of them said that it was somewhat important, and they reason that most immigration is associated with one or two social ties within the settlement.

According to FGDs, socio-cultural factors is a strong driver. MkR members reasoned that majority of the residents who were living here traced their existence through their parents and marriage ties. One member stated that:

*'My parents were the first to settle here, and when they were old, they went back to the village, leaving me this house and now that I am married my children are also staying here. I will do the same when I am old. I will leave this plot and house to my children as inheritance and settle in my village.'* This also could be attributed to the evidence of older people that are still living in the area.

On the other hand, KND focus group discussions also stated that socio-cultural factor as a strong driver one member stated that *"We have gained the access of this place through our people."* This could be attributed to their ethnicity that can be traced from the name of their settlement. Also evident was that the majority of the residents within the settlement came from the same ethnic background.

The findings from the focus group are mostly linked to generational migration, as observed in the study of Subasinghe (2015) that the social-cultural can be caused by generational migration in three phases. The first is based on a generation that has lived more than 30 years, the second is based on children of the first generation and the third is based on children that now live there. This also shows evidence that the presence of the older people is a good indication to observe as the IS settlement transitions a slum. Further connection through marriage and family relation is found to be highly connected in the transitioning of IS and slum as most of the residents find their way into the urban areas (Sietchiping, 2005). On the other hand, ethnical affiliation is in agreement with the study of Mensah (2014), arguing that it was a strong factor in transitioning the IS to a slum. Social cultural factors are closely attributed also to strong ethnic affiliation which is denoted on the names of the settlement of the two case studies. 'Mukuru' means valley in Kikuyu it is associated with the Kikuyu tribe while 'Kusumu Ndogo' is means small Kisumu named after the city of Kisumu known to be home for Luo. The strong affiliation in an attraction of the same tribe and people who are associated with the names that tend to migrate to the place and form a social networking through families and friends among others (Limbumba, 2010).



#### 4.6.4. Policies

The interviews conducted revealed that all the key experts agreed that policies is a weak driver reasoning that the government has put in the effort to involve the people in the planning process through community awareness sensitization and participation.

Key expert no. 2 pointed out that;

*“The government has been working hand in hand with the IS and slums as is seen in the president’s Big 4 agenda. We are at the moment looking into various of involving everyone into the agenda to eradicate the slum by contributing money monthly from our wages towards building the 500,000 for the IS and slums by 2022.”*

This could be taken to mean that there is a positive attitude displayed by the people to help the IS and slums have a better standard of living as perceived by the experts. Further, 2 key experts stated that the policies and strategies in place have been successful in addressing the issues of the IS and slums such as road widening has seen the successful projects implemented. A casing example of Kibera slum upgrading was put forward by key expert no. 2 stating that;

*‘The Government has been working hard using the Kenya Slum Upgrading Strategy to open roads and build houses for the IS and slums, for example, Kibera and as we speak, we are giving keys of the completed buildings to the residents who were registered in the enumeration process.’*

In the discussions held with the MkR representatives revealed policies as not an applicable driver to transition giving a reason to the recent declaration that the area has been declared special and the government is working on upgrading the area. One member stated that; *“we are happy that the government is working together with us to formulate the best way of upgrading this area and we have been having a lot of meetings and discussions of how to implement it”*.

The KND also stated that the policies are not an applicable driver. This they gave reason to the Kenya Informal Settlement Improvement Strategy that was initiated and has been implemented in the area. It can be deduced from the discussions held in both settlements that policies have already been formulated targeting the IS from transitioning to a slum hence an opportunity of having a planning toolkit that addresses the larger IS and slums in the region. Another observation made with the members was their awareness of the existing law that permits them to be legal owners after 12 years if there is no claim from the registered owners. This has seen many of them desire and intentionally stay longer and can be taken to translate to the transitioning of the IS to a slum

The findings contradict the United Nations (2007) which reported that there is excess use of bureaucratic processes coupled with issuing development and building permits are key policy factors that influence the IS to get to a squalor state. Ngetich *et al.* (2015) also observed that high technical standards and a long process of development approval accelerated the transitioning of the IS. The findings, on the other hand, agree with the Ministry (2009) which has provided a clause to protect individual, family or community to own any land they have settled on for 12 years from not only being evicted but also have rights to own it as shown in the excerpt of Mombasa case.

#### 4.6.5. Which drivers are key in transitioning informal settlements and slums

In identifying key drivers that transitions the IS to a slum, the responses were ranked using frequency distribution. Based on the Likert scale of 4, the ranking ranged from not applicable, weak, strong and very strong. In assigning weights, 1 was categorised as not applicable, no. 2 was categorised as weak and given the sign (-) while 3-4 was weighted as strong and given the sign (+). A frequency distribution was produced, showing the overall ranking of key driving factors as shown in Table 20:

Table 20: Key drivers of IS and slums

categories	Factors	Key Experts	MkR	KND	Literature	Ranking
Physical-site	Quality and quantity of basic infrastructure provision (water, sanitation solid waste,)	+	+	+	+	Strong
	Proximity to undeveloped land	+	+	+	+	
Socio-economic	Employment	+	+	+	+	Strong
	Level of income	+	+	+	+	
	Type of job (temporary or permanent)	+	+	+	+	
	Education level	+	+	+	+	
Social-cultural	Culture	-	+	+	+	Somewhat strong
	Ethnicity	-	+	+	+	
Policies	Long Bureaucracy	-	-	-	+	Weak
	Stringent development application policies	-	-	-	+	
	Lack of community participation in planning and decision making	-	-	-	+	Weak

Out of the four categories, three were considered to be key in acceleration the transitioning of an IS to a slum. The physical-site and socio-economic factors are considered the most important. Physical and socio-economic are in agreement with (Mutisya and Yarime, 2011; Cheseto, 2013; Abebe, 2011; Shekhar, 2012) findings which found that proximity to undeveloped land was a fast trigger to transitioning. On the hand, Cheseto (2013) attributes the lack of basic services and poor services to the prevalence of diseases within the slum that is deteriorating. This could also mean that when there are many disease outbreaks, especially waterborne then the IS is evidenced as transitioning to a slum. It can, therefore, be deduced that lack of physical infrastructure and low socio-economic activities are the top triggers of IS transitioning to a slum.

Social-cultural category is ranked third, and in this study compared to the policies and is aligned to the findings of Subasinghe (2015) relating to generational migration and occupation of land. Also, Sietchiping (2005) study show that social-cultural affiliation resonates with family and relatives.

Policies are ranked as weak and at the bottom of the ranking because it was attributed to consistency of the government requirement that all IS and slum residents have full engagement in the planning processes of their land as it is also stipulated in the National Slum Upgrading and Prevention Policy (NSUPP). This is

targeted as a way of easy transitioning of implementation of projects through a sense of ownership to the residents of IS and slums.

#### **4.7. Policy implications for informal settlements and slums**

This section addresses two questions to answer the sub-objective of policy implications for IS and slums. The first question was “*How do the policies influence key indicators?*” and “*how can policies address drivers?*” the information gathered from the Key experts revealed the existing strategies and policies of IS and slums that are existing as detailed below.

##### **4.7.1. Existing policies/regulations/measures**

The outcome of the interview revealed that the Government had put effort into initiating various interventions that can address the indicators mentioned in this study. These include the Kenya Slum Upgrading Program (KENSUP) in 2004, Kenya Informal Settlement Improvement Program (KISIP) in 2010, National Slum Upgrading and Prevention Policy in 2016 and most recent is An Integrated Area Development Plan (AIADP) also known as Special Planning Area (SPA).

###### **4.7.1.1. Kenya Slum Upgrading Program**

Kenya Slum Upgrading Program (KENSUP) is a joint initiative of UN-Habitat and Kenya Launched in 2004 and was piloted in Soweto East in Kibera slum. Its specific objectives were to develop and improve houses; provide physical infrastructures such as access roads, water supply and sanitation and stormwater drainage; provide social infrastructure such as recreational facilities among others (UN-Habitat, 2004). According to 2 key experts, KENSUP has been a success in housing implementation because the beneficiaries have started moving into the newly constructed buildings at a subsidized fee to give room for *in situ* upgrading that the government intends to undertake.

###### **4.7.1.2. Kenya Informal Settlement Improvement Program (KISIP)**

KISIP, on the other hand, was a collaborative initiative started by the Government is a new initiative started by the Kenyan Government in with the World Bank, Swedish International Development Agency (SIDA) and French Agency for Development (AFD). It was launched in 2011 and covered a total of 13 municipalities having IS and slums. It was also initiated to complement the KENSUP in that it concentrated on developing the physical infrastructure while KENSUP focused on housing and strengthening tenure security (Muraguri, 2012). Among the IS that KISIP has been implemented is Korogocho IS and according to one of the key expert it has been a success and the outputs seen in the completion of plot survey (an excerpt attached in the appendix), roads opened up, and residents are soon hopeful of settling the land tenure dispute.

###### **4.7.1.3. National Slum Upgrading and Prevention Policy (NSUPP)**

This is the first policy that was designed to address the plight of the IS and slums in 2012. It was formulated on the basis that interventions of KENSUP and KISIP programs had been hampered by the lack of a comprehensive and legal framework (Housing, 2013). This policy seeks to integrate the IS and slums within its framework in a systematic manner. According to one of the key expert no. 4, the policy is yet to be implemented. The reason for its delay is attributed to the long bureaucracy that has had it pending and waiting to be passed in the by the senate in the parliament.

###### **4.7.1.4. An Integrated Area Development Plan (AIADP)**

The AIADP is the latest of the Government’s effort to address the indicators of IS and slums rolled out in 2016. It was an initiative by the County Government of Nairobi in a consortium with the professionals and academic institutions of the University of Nairobi, Strathmore University, University of Berkeley, SDI Kenya and Akiba Mashinani Institute. Its focus is to prepare a Special Planning Area in the Mukuru slum

to profile and map all structure and services and profile it to be integrated with the Nairobi County Integrated Development Plan. The SPA is known to the residents of MkR as confirmed by the focus group discussion indicating the government's effort to involve them as key stakeholders in its planning

#### **4.7.2. Policies' impact on drivers**

Several policies exist that are not directly related to addressing drivers but are used to protect public land. These laws give them the authority to demolish the settlement, auction their possession to pay the cost of demolition these policies (GoK, 2010) Wayleaves Act. On interviewing the experts, it was observed that despite the constant battle and need to avoid the IS and slums transitioning is a slow process and often done in piecemeal. Another policy that is widely recognized is the Environmental Management and Coordination Act (NEMA) a wing of the government that protects riparian serves and waterbodies (GoK, 2012). This Act like the others mentioned above empowers that authority to demolish or remove settlements or anything that pose as a threat to the river, wetland and lake, among others (GoK, 2012).

Although the IS and slums strategies and plans have been reported by key experts as successful, the World Bank (2011) noted that prioritization of the residents in these programs rather focused on areas without legal disputes which are not dense and located in hazardous areas giving a reason to limited funding. Besides, Githira (2016) argues that the implementation of these projects are conducted without proper guideline leading to difficulty in evaluating their performance. This could mean that there still exists a gap on the accountability of handling the process within the institutional coordination and harmonising of various policies such as land management in different departments that have created duplication of responsibilities (GoK, 2012).

#### **4.8. Limitation of the study**

This study has contributed to identifying the indicators and drivers of the transition of an IS and a slum. However, the study also reports limitations faced and how they were addressed

##### **Missing maps**

The analysis of this study used satellite images for 2002, 2003, 2004, and 2006. The unavailable map for 2005 was purposely left out because of the dense cloud cover and shadow over the areas of interest. This removal of this map caused inconsistency in the data figures showing drastic fluctuations, and hence the researcher highlighted it as part of the finds and reason for certain fluctuations (Table 13).

##### **OBIA- Feature extraction**

VHR imagery that was very useful for physical image classification. This study applied VHR to analyse the indicators of the transition of IS to a slum. However, the research found that it is also possible to have challenges with feature extraction especially object features such as shape among others and the thresholds to extract the settlement using rule base classification was hard given the fuzzy nature of the settlements in which there is no exact boundary between and within the settlements. This was worsened by the lack of building footprints that were only digitized to show the changes in shape. This was solved through a constant iteration process that gave basic classification land covers sufficient for the study.

##### **Primary data collection**

Because of the expert's busy schedule, frequent rescheduling was evidenced, and that meant that they would fall on days of the resident's survey, which was cumbersome. Further, limited time of preparation meant no data training was done, and therefore, meetings took longer than anticipated. On the other hand, the method of asking questions was adjusted as the interview progressed to reduce on time spent per respondent to approximately 1 hour.

Regarding FGDs, there was an issue with translating the English word for IS was difficult to find and thus much time was spent trying to explain indicators of IS. To better understand the term, the word 'Mtaa' was used for the connotation of IS, and it somehow got understood.

Many interruptions from customers because most people surveyed were self-employed and arrogant, especially from Mukuru residents who were not interested in taking part in the survey besides being aware of the purpose of the study. This was overcome by additional identification of residents to replace them.

## 5. CONCLUSION AND RECOMMENDATION

This chapter provides the conclusion, limitation of the study and recommendation scope of future work.

### 5.1. Conclusion

The main aim of this study was to analyse the transitioning of an informal settlement to a slum using a case study of Kisumu Ndogo informal settlement and Mukuru Kwa Reuben slum in Nairobi. Many researchers have used IS and slum interchangeably to bring out their severity or urgency for intervention, but this study tried to identify the indicators and drivers that can differentiate them. The findings and conclusion are detailed below.

#### **Indicators of informal settlements and slums**

To understand transitioning, relevant indicators were identified from the literature review. Because of their overlapping characteristics, the study explored the opinions of the key experts, Focus Group Discussions and residents to rank the indicators that differentiated IS and slums. Overall the study successfully identified vegetation, dwelling shape, built-up density, location, and road accessibility as key indicators that differentiated the IS and slums. Using residents and focus group discussions in this study also proved that the locals have rich knowledge in the understanding of their settlements which complemented the opinions of the key experts and also aligned to the literature used in this study.

#### **Mapping of indicators of Informal settlements and slums over time**

The key indicators were mapped to classify them further. Using Quickbird imagery, four-time periods were applied that is 2002, 2003, 2004 and 2006 to analyse their transition patterns. Parameters for measuring the indicators were identified from the literature and subjected to the key experts to identify the relevant parameters applicable to IS and slums in the context of Nairobi. OBIA was applied to classify the indicators and was supplemented by spatial metrics to analyse further the shape and built-up area and network analysis to analyse the location proximity of KND informal settlement and MkR slum. The study used the researcher's formulated parameters and literature parameters and evaluated them with the key experts' parameters. The study found that out of five indicators mapped, only three that is vegetation, dwelling shape and built-up density and location to CBD/Industries and railway substation were key in pointing to transitioning of an IS to a slum. The study further recognised that parameters provided by the key experts were aligned to both the formulated and literature parameters. Therefore the continual involvement of different local key experts is vital in understanding the dynamics of contextual studies of transition and differentiating IS and slums.

#### **Drivers of informal settlement and slums**

Part of understanding transition also required analysis of drivers. Five categories of drivers were identified from the literature that is physical-site, socio-economic, social-cultural and policies. The categories were subjected to key expert's opinion, and Focus Group discussions in KND and MkR members to identify the relevant drivers that were key in transitioning an IS to a slum. The study concluded that physical-site and socio-economic were the most important, followed by social-cultural. The study considers that though the experts found social-cultural as not an applicable driver, the FGDs revealed that it is a significant driver paving the way for the need to study social-cultural the dynamics and IS transition in this context.

**Policy implication for informal settlement and slums**

Policies and strategies that address the IS and slums in the study context that have been implemented are Kenya Slum Upgrading Program ( KENSUP) and Kenya Informal Settlement Improvement Program (KISIP). Other strategies and policies that are yet to be implemented or realised included National Slum Upgrading and Prevention Policy (NSUPP) and most recent are An Integrated Area Development Plan (AIADP) also known as Special Planning Area (SPA). The implemented projects, on the other hand, have no record of the evaluation of their success, progress or monitoring mechanisms. This leaves the upcoming policies and strategies without a threshold of monitoring and evaluation. It is therefore vital that monitoring techniques and evaluation be conducted and thresholds set against which other projects policies can also be monitored.

**5.2. Recommendation**

- Because the study used short time frame for mapping, there were discrepancies realised in the data such as very high fluctuating figures and therefore recommends that indicators and drivers of transition should be integrated into the projects and policies and thresholds formulated that can be used to monitor the transitioning an IS to a slum over a long time.
- Replicate the process and mapping of both indicators and drivers in relatively larger areas of IS and slum and see their relationship to transitioning of an IS to a slum.
- Analysis of the perception of the residents on social-cultural factors and their role in transitioning an IS to a slum.

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## APPENDICES

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Appendix A: Consent Form

### UNIVERSITY OF TWENTE-ITC INTERVIEW QUESTIONS/QUESTIONNAIRE

*MSc Research project 2018/20*

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Informed Consent:

Thank you for participating in this interview. Your feedback is important. Please answer the following questions as honestly as possible. These questions concern *the transition of an informal settlement to a slum*.

The purpose of this survey is to help the researcher *to identify the indicators for informal settlement and slum formation, to map the indicators of informal settlements and slums for different periods, to identify drivers of informal settlements and slums and to discuss the policy implication of informal settlements and slums*.

I do not anticipate that taking this interview will contain any risk or inconvenience to you. Furthermore, your participation is strictly voluntary and you may withdraw your participation at any time without penalty.

All information collected will be used only for my research and will be kept confidential. There will be no connection to you specifically in the results or in future publication of the results. Once the study is completed, I would be happy to share the results with you if you desire. In the meantime, if you have any questions please ask or contact:

<Violla Achieng Okoth & okoth@student.utwente.nl>

Or

<Dr. Nina Schwarz & n.schwarz@utwente.nl>

By signing, you are verifying that you have read the explanation of the study, and that you agree to participate. You also understand that your participation in this study is strictly voluntary

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Signature

---

Date

Appendix B:

Appendix B 1: Interview questionnaire guide for key experts

**EXPERT INTERVIEW**

1. How do you define;

a. An informal settlement

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b. A slum

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2. What indicators do you know can distinguish the informal settlement from a slum?

Indicator	Not applicable	Very weak	Weak	Strong	Very Strong
Vegetation cover					
Road accessibility					
Dwelling size					
Roofing extent					
Texture measures					
Neighbourhood characteristics					
Location					
Dwelling size/shape					
Density					

3. What parameters/measures do you use to indicate when an informal settlement ends and a slum starts?

Indicator	Measure	Specify
Vegetation cover	( specify % cover of vegetation found >80-50; 50-30; <20	
	( specify % cover of open spaces found >80-50; 50-30; <20	
Road accessibility	Road width 9m-6m; 6m-3m; <3m	
	Connection to the main road or other roads	
Dwelling size	(Specify the range of building sizes typically found > 150 m <sup>2</sup> 150-100m <sup>2</sup> 100-80 m <sup>2</sup> <80m <sup>2</sup>	
Dwelling shape	Elongated	
	Various shapes	
	Circular	
Roofing extent	Roof material ( e.g. iron sheets, concrete, polythene bags etc.)	
Texture measures/Building structure	Building type (attached or detached)	
Neighbourhood characteristics	Close to other informal settlements <100m 100-300m 200-500m >500	
	Close to other slums <100m 100-300m 200-500m >500	
	Close to a middle- or high-income residential areas <100m 100-300m 200-500m >500	
	Close to other business centres <100m 100-300m 200-500m >500	
Location	Close to CBD >5km 5-3km 3-2km <2km	
	Close to industries >5km 5-3km	



	3-2km	
	<2km	
	Close to the railway transport	
	>5km	
	5-3km	
	3-2km	
	<2km	
	Number of houses per hectare	

In this section the research is looking at two settlements shown on the google earth image (Korogocho (Kisumu Ndogo) and Mukuru (Kwa Reuben). Kindly use the responses mentioned above to provide information below.

4.How long has Kisumu Ndogo been like this?

<b>No. of years</b>	
More than 15 years	
2000-2005	
2005-2010	
Last 5 years	

5.How long has Mukuru Kwa Reuben been like this?

<b>No. of years</b>	
More than 15 years	
2002-2010	
2010-2015	
Last 5 years	

6.What policies/regulations/measures have been put in place to address the indicators mentioned?

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7. In your own opinion how effective are these policies/regulations/measures in addressing these indicators

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In this section we are looking at drivers which cause informal settlements to transition to a slum. Drivers are interrelated factors that push the beginning of an informal settlement probability of transitioning to slums (UN-Habitat, 2015). Based on this definition, kindly answer the questions that follow.

8. In your own opinion which drivers cause an informal settlement transitioning into a slum

Driver	Not applicable	Important	Somewhat Important	Not Important
Rapid urbanization				
Population growth				
Governance				
Policies				
Socio-cultural factors				
Urban poverty				

9. Which key drivers increases the chance of informal settlements transitioning to a slum?

Driver	Not applicable	Important	Somewhat Important	Not Important
Rapid urbanization				
Population growth				
Governance				
Policies				
Socio-cultural factors				
Urban poverty				

10. What policies/regulations/measures have been put in place to address the drivers mentioned?

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11. In your own opinion how effective are these policies/regulations/measures in addressing these drivers

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12. What recommendations would you suggest to improve the situation informal settlements and slums

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Appendix B 2: questionnaire guide for Focused group discussions

**RESIDENTS/REPRESENTATIVES (KOROGOCHO (KISUMU NDOGO) AND MUKURU (KWA REUBEN))**

1. How long have you stayed in this area (years)

2. From the indicators below how would you describe the place you are living in?

Indicator	Not applicable	very weak	weak	strong	very strong
Vegetation cover					
Road accessibility					
Dwelling size					
Roofing extent					
Texture measures					
Neighbourhood characteristics					
Location					
Dwelling size/shape					
Density					

3. How has the condition of Kisumu Ndogo been like over time?

No. of years	
More than 15 years	
2000-2005	
2005-2010	
Last 5 years	

*In this section we are looking at drivers which cause informal settlements to transition to a slum. Drivers are interrelated factors that push the beginning of an informal settlement probability of transitioning to slums (UN-Habitat, 2015). Based on the above information, kindly answer the questions that follow;*

4. Which key drivers increases the chance of informal settlements transitioning to a slum

Driver	Not applicable	Important	Somewhat Important	Not Important
Rapid urbanization				
Population growth				
Governance				
Policies				
Socio-cultural factors				
Urban poverty				

5. What recommendations would you suggest to improve the situation of the place/area you are staying

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**RESIDENTS/REPRESENTATIVES (KOROGOCHO (KISUMU NDOGO) AND MUKURU (KWA REUBEN))**

1. How long have you stayed in this area (years)

\_\_\_\_\_

2. From the indicators below how would you describe the place you are living in?

Indicator	Not applicable	(very weak)	(weak)	(strong)	(very strong)
Vegetation cover					
Road accessibility					
Dwelling size					
Roofing extent					
Texture measures					
Neighbourhood characteristics					
Location					
Dwelling size/shape					
Density					

a) How do you define:

a. An informal settlement

\_\_\_\_\_

\_\_\_\_\_

b. A slum

\_\_\_\_\_

\_\_\_\_\_

*In this section the research is looking at two settlements shown on the google earth image (Korogocho (Kisumu Ndogo) and Mukuru (Kwa Reuben). Kindly use the information of the indicators mentioned above to provide information below;*

***KISUMU NDOGO SETTLEMENT***

b) How long has Kisumu Ndogo informal settlement been in existence ?

<b>No. of years</b>	
More than 15 years	

2002-2010	
2010-2015	
Last 5 years	

c) How has the condition of Kisumu Ndogo been like over time?

No. of years	Don't know	Good	Bad	Worse	No change
More than 15 years					
2002-2010					
2010-2015					
Last 5 years					

**MUKURU KWA REUBEN**

d) How long has Mкуру Kwa Reuben slum been in existence

No. of years	
More than 15 years	
2002-2010	
2010-2015	
Last 5 years	

I

e) How has the condition of Kisumu Ndogo been like over time?

No. of years	Don't know	Good	Bad	Worse	No change
More than 15 years					
2002-2010					
2010-2015					
Last 5 years					

In this section we are looking at drivers which cause informal settlements to transition to a slum. Drivers are interrelated factors that push the beginning of an informal settlement probability of transitioning to slums (UN-Habitat, 2015). Based on the above information, kindly answer the questions that follow;

f) In your own opinion which drivers cause an informal settlement transitioning into a slum

Driver	Not applicable	(very weak)	(weak)	(strong)	(very strong)
Rapid urbanization					
Population growth					
Governance					
Policies					
Socio-cultural factors					
Urban poverty					

g) Which key drivers increases the chance of informal settlements transitioning to a slum

Driver	measure	(not applicable)	(very weak)	(weak)	(strong)	(very strong)
Rapid urbanization	Rapid development					
	Migration of population to the city					
Population growth	Low mortality rate					
	High birth rate					
Governance	Lack of accountability of a government					
	High level of corruption					
Policies	Stringent development application policies					
	Lack of acknowledgment of informal settlement in the plans					
	Harsh strategies to deal with IS and slum (forceful eviction)					
Socio-cultural factors	Ethnic affiliation					
	Family ties					
	Religious reasons					
Urban poverty	Income level					
	Ownership of assets (Radios, Tvs, etc)					
	Access to basic services					

h) What policies/regulations/measures have been put in place to address the drivers mentioned?

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i) In your own opinion how effective are these policies/regulations/measures?

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j) What are the challenges limiting the policies/regulations/measures from being effective?

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k) What recommendations would you suggest to improve the situation here ?

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Appendix B 4 questionnaire administered to the residents

**RESIDENTS/REPRESENTATIVES (KOROGOCHO (KISUMU NDOGO) AND MUKURU (KWA REUBEN)**

1. How long have you stayed in this area (years)

2. From the indicators below how would you describe the place you are living in?

Indicator	Not applicable	very weak	weak	strong	very strong
Vegetation cover					
Road accessibility					
Dwelling size					
Roofing extent					
Texture measures					
Neighbourhood characteristics					
Location					
Dwelling size/shape					
Density					

3. How has the condition of Kisumu Ndogo been like over time?

No. of years	Don't know	Good	Bad	Worse	No change
More than 15 years					
2002-2010					
2010-2015					
Last 5 years					

*In this section we are looking at drivers which cause informal settlements to transition to a slum. Drivers are interrelated factors that push the beginning of an informal settlement probability of transitioning to slums (UN-Habitat, 2015). Based on the above information, kindly answer the questions that follow;*

4. Which key drivers increases the chance of informal settlements transitioning to a slum

Driver	Not applicable	Important	Somewhat Important	Not Important
Rapid urbanization				
Population growth				
Governance				
Policies				
Socio-cultural factors				
Urban poverty				

5. What recommendations would you suggest to improve the situation of the place/area you are staying

Appendix C  
Appendix C 1: Road network in KND

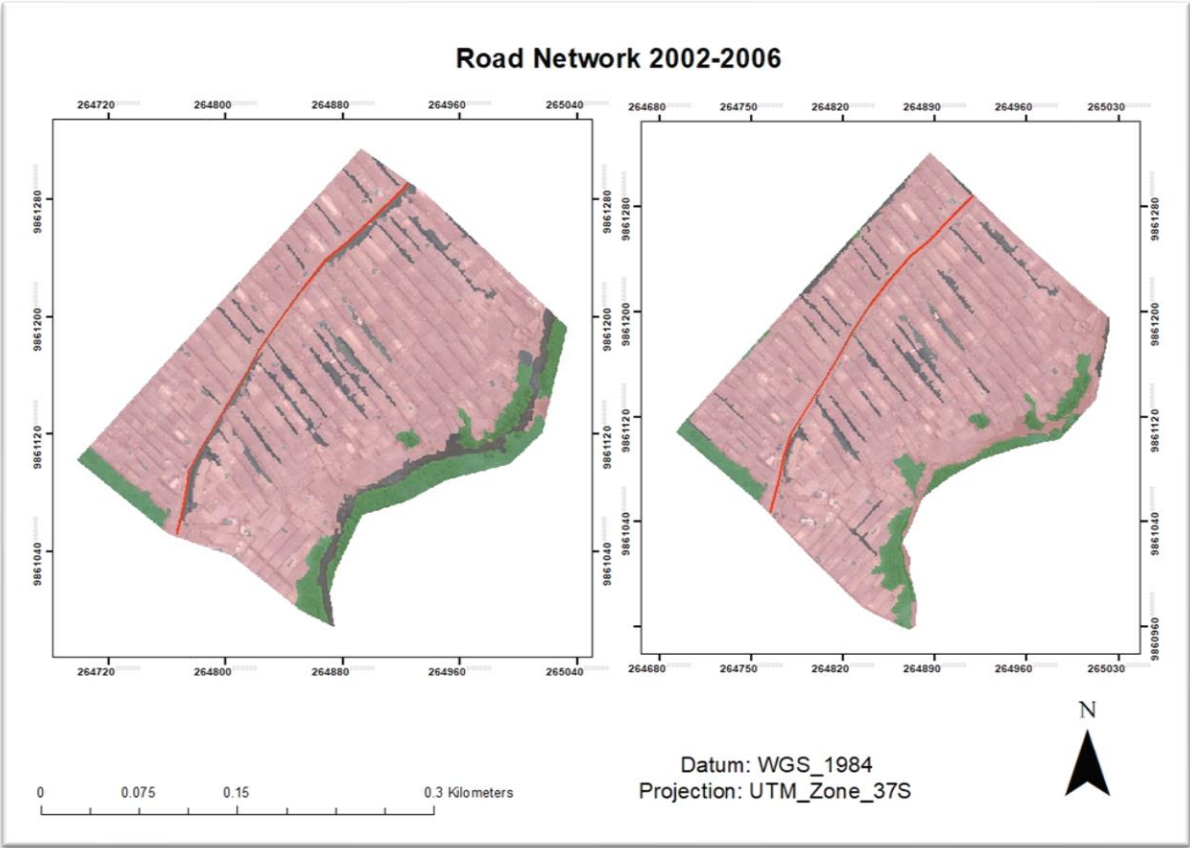


Figure 50: the road network within KND 2002-2006



Appendix C 2: Road network in MkR

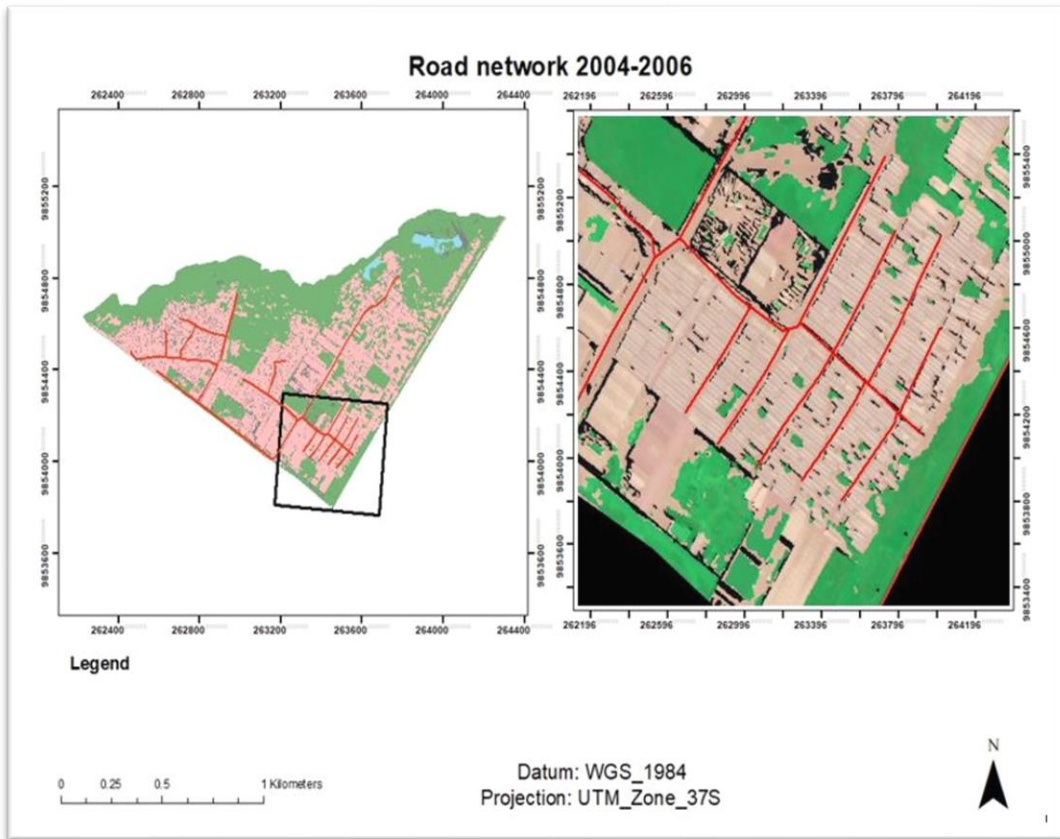


Figure 51: road network in 2004 and 2006

Appendix D: Vegetation cover in MkR

