University of Nairobi

School of Engineering

DEPARTMENT OF GEOSPATIAL AND SPACE TECHNOLOGY

Use of Open Source Geo-solutions to Develop a Cadastral Model for Informal Settlement in Nairobi.

Case study of Redeemed Village in Huruma Informal Settlement

By

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Declaration

I, Malachi Odongo Atieno, hereby declare that this project is my original work. To the best of my knowledge, the work presented here has not been presented for a degree in any other Institution of Higher Learning.

Odongo Malachi Atieno

Name of student Date

This project has been submitted for examination with our approval as university supervisor(s).

Dr. David N. Siriba ……

Name of supervisor Date

Dedication

I dedicate this project to my family for the support they gave me during the study period. Special dedication also goes to the residents of Redeemed village for their openness in highlighting their plight and the hospitality they gave me during data collection.

Acknowledgement

I acknowledge my supervisor Dr. David N. Siriba for his enormous contribution and insightful thoughts given to me during my research period. Your wealth of knowledge sharpened my outcomes giving me new approaches in tackling the subject matter.

I acknowledge the entire Geospatial and Space Technology fraternity starting with their staff members who gave valuable critiques to my model and your inputs made it better. Special acknowledgements also goes to the head of KISIP, Mr. George Arwa, KENSUP Director Mr.Charles Shikuku and the community leaders in Redeemed village for their time and contribution during the interview sessions.

Finally, I acknowledge my family starting with my dear spouse Quilent and our children Immanuel and Abby for their support and giving me time to study, my late parents who inspired me in the area of education and above all the Almighty God for His strength, protection, care and favour during my study period.

Abstract

Sprawling of informal settlements in Kenya has been a major challenge due to the high rate of urbanization in towns and cities to the extent that decent housing and security of tenure in such areas has been deficient. Land Administration in terms of acquisition, transfer through sale or even inheritance continues to operate informally with little or no documentation of the interests existing in such informal settlements. Most of that information is often held by the village elders and sometimes with the area chiefs verbally or in a paper-based form, which is prone to tear and wear, therefore a model to capture their houses/dwellings as well as their personal details in an integrated and GIS based database system is paramount.

This study explored the fit-for-purpose geospatial data collection approaches which included digitization the structures from aerial/satellite Imagery to constitute the spatial unit which was given a unique identification to link it with dummy party information through a social tenure relationship under a customized Social Tenure Domain Model (STDM).

The study used open source geo-solutions to map current informal dwellings, integrated with their personal details of residents and generated prototype beneficiary certificates from the cadastral database. Both the structure owners and tenants were captured by the database and their social tenure relationship linked to the structure of interest, and a continuum proof of tenancy auto-generated that would form the first stage of recognition and registration of the informal rights.

The model was found to be applicable to all the different informal settlement typologies with slight modification for the informal settlements on customary land under typology five where the structures could be blocked into the land parcel. Therefore with the land policy (2009) and other legal frameworks already established such as the Land Registration Act (2012), the model could form the bridge towards formalization process.

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List of Acronyms

GIS: Geographical Information System

CBD: Central Business District

ID: Identity

LADM: Land Administration Domain Model

STDM: Social Tenure Domain Model

UML: Unified Modelling Language

LA: Land Administration

GL: Government Land

KISIP: Kenya Informal Settlement Improvement Project

KENSUP: Kenya Slum Upgrading Programme

NGOs: Non- Governmental Organisations

LP: Land Policy

NSUPP: National Slum Upgrading and Prevention Policy

WB: World Bank

AfDB: Africa Development Bank

CHAPTER 1: INTRODUCTION

1.1 Background Information

One of the reasons which make people live in informal settlements is as a result of the government's inability to place a regularity framework to construct affordable houses or provide land for development of such houses. Due to this, these people usually squat on unoccupied lands including road, railway, pipeline, power line or riparian reserves. Nairobi for example is home of approximate 200 informal settlements constituting 55% of total inhabitants covering only 5% of the occupied land (UN-Habitat, 2010).

Availability of land has been the major impediment towards formalization of slum areas since most informal settlements in Kenya sits on land whose tenure status has not been ear marked for settlement (Figure 4). In the conventional practice, informal settlements are mapped as un-occupied parcels of land from the survey plans usually marked as Government land (GL) for land that were acquired by government after independence, Public utility land, Reserves among others depending on the original designated use of such land with or without any knowledge of occupation of the residents. Proliferation of slums has often increased due to uncontrolled and/or unplanned construction of structures.

Most informal settlements in Kenya are typically located in the neighbourhood of affluent estates (Figure 1). Such estates include Muthaiga, neighbouring Mathare and Woodley estate which neighbours Kibera among others. A proper database of informal settlements together with the inhabitants is crucial for improved land administration. To address land administration in informal settlements, the Government of Kenya initiated land regularization program so as to bring some of the informal settlements into the formal systems. Informal settlements in Kenya are in dire need of such regularization since previously the response of the government through evictions at one point and exclusion from planning at another has not been successful.

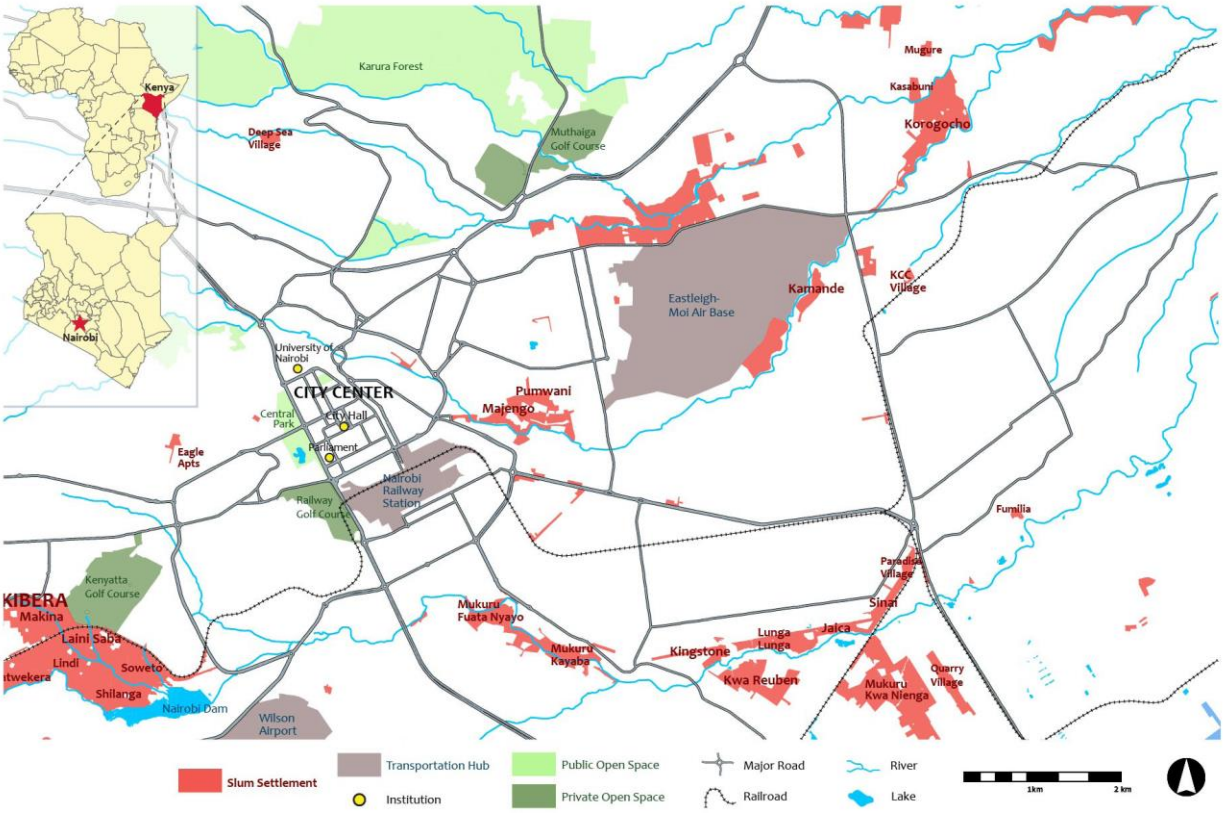

Figure 1: Distribution of informal settlements in Nairobi (Source-Nairobi Zonal Plan 2012)

Similarly, in Mombasa City, informal settlements constitute close to 65% of the city's population (Mombasa County inventory report, 2014) and are well distributed throughout the county (Figure 2). The characteristic of the informal settlements in Mombasa are slightly different from the ones in Nairobi since most of the building materials are permanent in nature though tenure insecurity is common across board.

The distribution follows the pattern of the separation of Mombasa into Island, Main Land North, Main Land South and Mombasa West by the Indian Ocean and its Gulfs as depicted in the map (Figure 2).

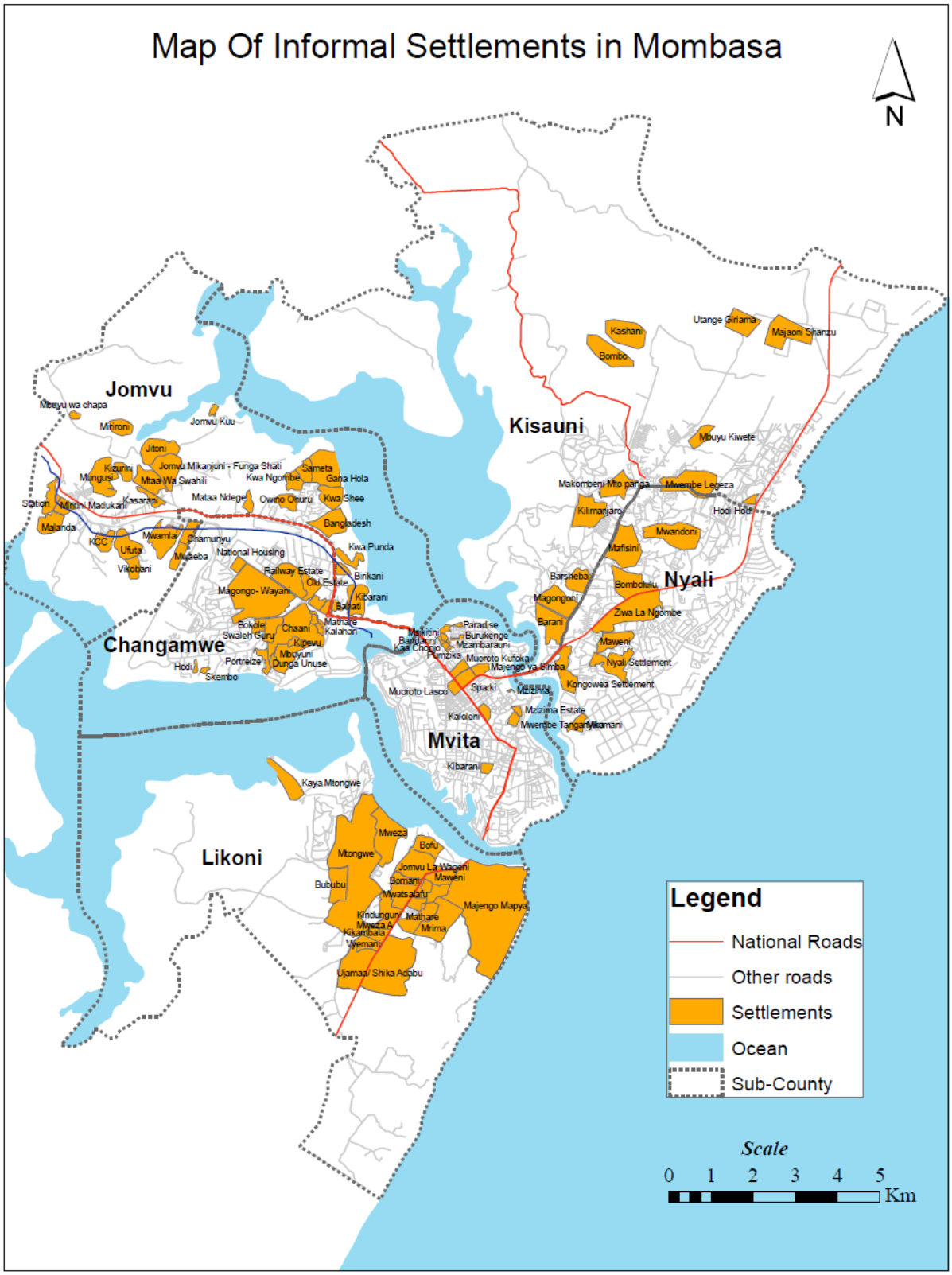

Figure 2: Informal settlement in Mombasa (Source-inventory report)

Finally, the city of Kisumu consist of a belt of informal settlements around the formally planned city centre in a semi-circular pattern around Lake Victoria (Figure 3) with a concentration on the eastern side where developments occurred without proper planning. Unlike Nairobi and Mombasa, here the informal settlements other than experiencing lack of planning, tenure security is not a major issue because the settlements are located in a peri-urban areas predominantly on ancestral land (Un-Habitat, 2005)

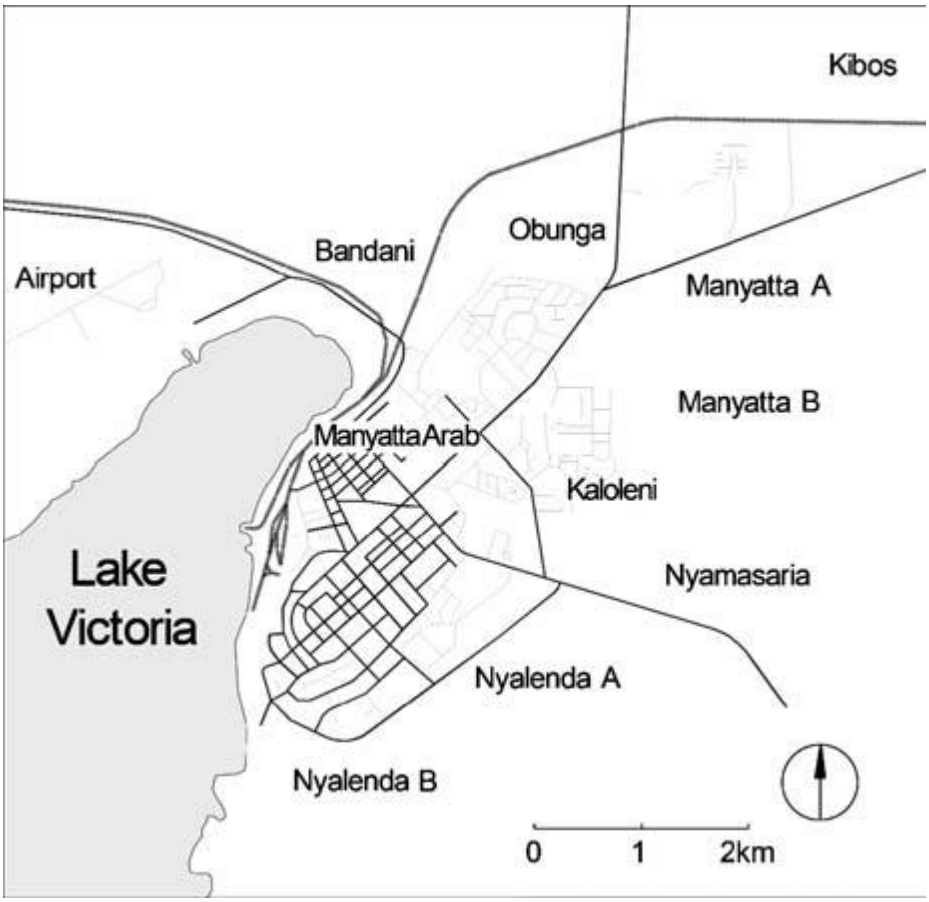

Figure 3: The belt of informal settlements in Kisumu (Source-Un-Habitat 2005)

Other informal settlements across the country more or less follow the pattern of the three cities especially around the current county headquarters and the former municipal towns (Draft National Slum Upgrading and Prevention Policy, 2017). Therefore, the government had put several measures to curb development of new informal settlements as well as improve the conditions of the existing ones, key among them happened after the promulgation of the Kenyan Constitution 2010, when the government established the Kenya Informal Settlement Improvement Program (KISIP) with a mandate of improving the living conditions in informal

settlements in 14 selected Counties in Kenya. It is on this premise that serious attention has been given towards addressing pertinent issues affecting informal settlements ranging from security of tenure, infrastructure improvement, capacity development and planning for their future.

1.2 Problem Statement

The complexity of tenure claims in the informal settlements has been difficult to incorporate into the formal systems owing to their dynamic and continuously changing nature; innovative tools are therefore required to capture these claims. This necessitates the development of an informal cadastral model that would document such interests to make it easier to manage informal land tenure situations as well as prepare for possible future formalization processes such as regularization or relocation. Land regularization refers to the process of planning and surveying of an informal settlement which had initially been occupied without adhering to the standards and regulations of planning and development control while relocation on the other hand is the resettlement from their current location to a new location.

Conventional processes of adjudication have been tried to regularize such informal settlements but with little success due to the complex nature of informal settlements such small land sizes which could not be incorporated in the formal system as well as the continuous changing nature of the residents. Additionally, the processes have been long, expensive and marred with corruption making the genuine beneficiaries to miss out in the final list of allotees.

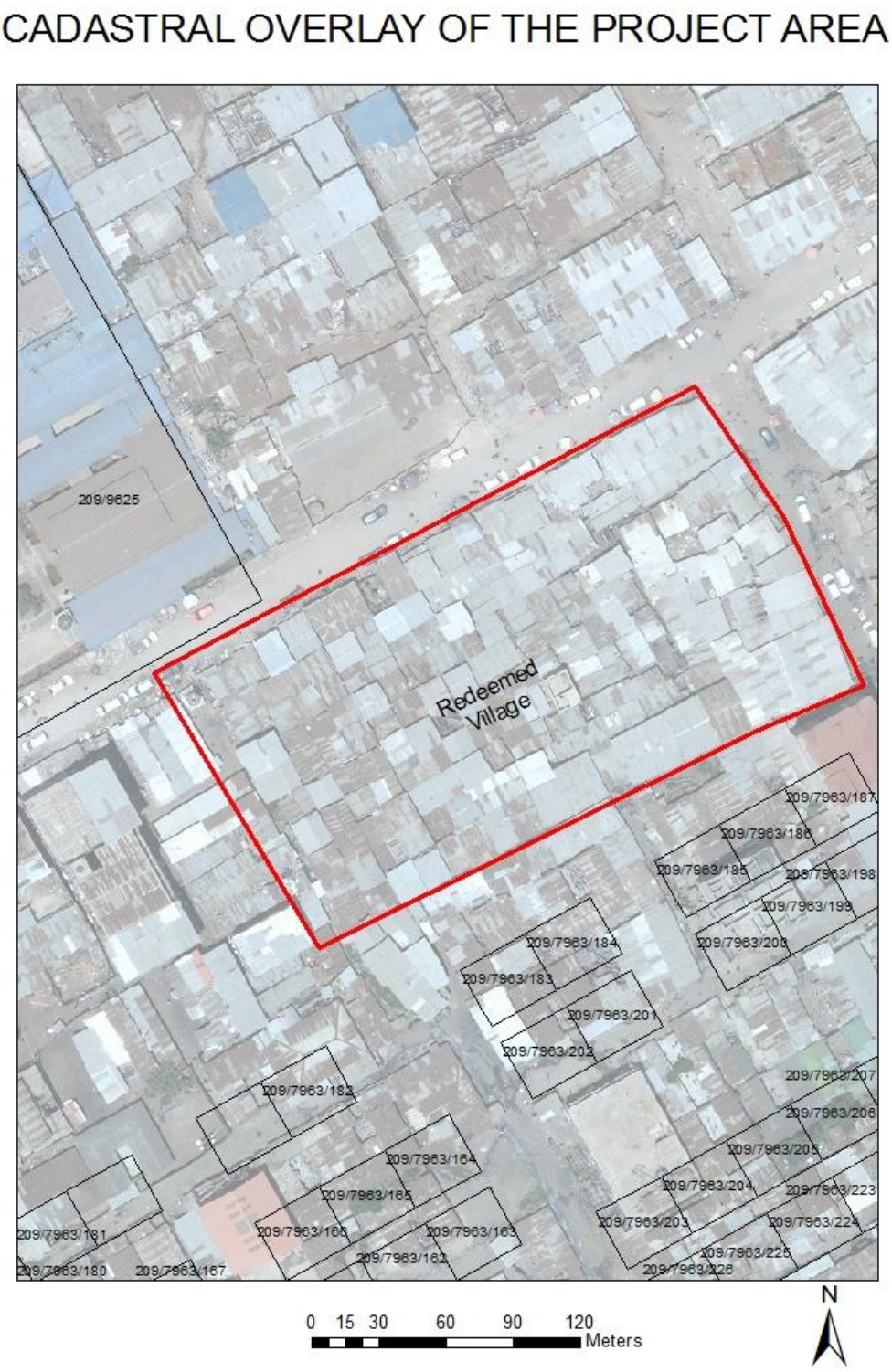

Figure 4: Cadastral overlay of the formal parcels and the informal settlement (Source-Own)

Therefore suitability of the land habited by the residents forms the first step of enhancing tenure security as recommended in the National Land Policy. Of course some informal settlements are on un-conducive environment such as railway, power line and riparian reserves hence unsuitable for habitation and such could be planned for relocation. Additionally, areas occupied by informal settlements have not yet been recognized and registered as so, but remain un-accounted for, hence prone to grabbing by well-connected developers. It is on this basis that a holistic cadastral model is recommended for informal settlements.

1.3 Objectives

The main objective of this study was to develop and test a cadastral model for informal settlements in Kenya, based on Open Source Geo-solutions.

Specific objectives were:

(i) To characterize the Informal settlements in Kenya

(ii) To develop a cadastral model for the study area

(iii)To test the cadastral model

1.4 Justification for the Study

This study will inform the basis for informal settlement regularization options that could be adopted by the Government's informal settlements upgrading programs since a comprehensive database of all the interest will be documented and an up to date cadastre achieved for day to day land administration in the informal settlements.

It will further cap the perennial squatters who usually move from one informal settlement to another since their details will be tracked from the database and can easily be traced and appropriate action taken. The database could also be used for service delivery in the informal settlement including supporting planning and surveying processes because the required data sets will be available.

It also provides an alternative to forced evictions, and a framework for negotiations. It ensures that only concerned parties are involved in a process and can be used to eliminate non genuine from the genuine interest holders.

1.5 Scope of work

The study was focused on structures as spatial units as opposed to the land parcels. The project was limited to the relationship between people and structures only. Even though the methodology could be applied to the entire Huruma informal settlements, Redeemed village represents the predominant characteristic of the other informal settlements.

CHAPTER 2: LITERATURE REVIEW

2.1 Cadastre

A cadastre conventionally refers to a land based land information system register of land interests such as rights, responsibilities and restrictions plus a description of such land parcels combined with other attribute information highlighting interest nature, ownership status and sometimes the value of land parcels (FIG, 1995). An "informal cadastre "definition can therefore be defined as one that considers informal interest (RRR) that is conventionally not recognised and in formal cadastre.

Demand for land record management in informal settlements is for the secure land tenure and improvement of services where scarcity of land as well as tenure insecurity has made it difficult to develop appropriate model that could capture these complexities. Social tenures of the inhabitants need to be documented, recognised and protected. Pro-poor approaches involving the people themselves to adjudicate their land and capture the socio-cultural tenure arrangements might require not very accurate forms of data (Zevenbergen, 2011).

With such a database in place, formalization of such informal settlements could be easier because a current register of the inhabitants is available and a reliable base map capturing their structures of interest equally drawn. The records could also be managed and updated from the grassroots' level and the updated database shared with government institutions.

Slum dwellers currently number one billion in the entire globe forming 60% of most cities (UN-Habitat, 2008). Many countries in the world have both formal and informal land tenure systems covering 30% and 70% respectively with the former mainly in Africa since the colonial masters left while the latter do not have even frameworks for land recordation (Okoth-Ogendo, 1999) and during transfers such as sale, this is often informal and the land register is often out of date. Additionally, the inhabitants often transact their land matters informally when moving or inheriting, and do not follow formal procedures of registration, especially when it is expensive, complex or out of reach (Payne et al, 2008). This is the trend in most of the third world countries (Barnes and Griffith-Charles, 2007).

In Kenya, the cadastral coverage is estimated at 25% but still consisting of disjointed datasets emerging from different projections used, multiple application of many registration statutes and the existence of both general and fixed boundary systems (Siriba, Voss and Mulaku, 2011).The remainder is largely consisting of customary and informal tenure in which the former has been legally recognised in law while the latter is under conceptualization in various policy documents.

The government through the department of land adjudication has taken some steps of increasing the cadastral coverage by systematically registering customary lands to individual members and establishment of settlement schemes for regularization of informal settlements. The processes have been slow, expensive and limited to budgetary allocations hence have not changed much the existing situation.

Informality has in many cases filled the gap of the land coverage left out by the formal ones, which makes the poor to get shelter and continue with their livelihood. Such informalities need to be registered and recognised though the establishment of the database.

2.2 Cadastral Modelling

Cadastral modelling is an instrument for establishment of a digital cadastre, (Lemmen et al, 2003) and facilitates appropriate system development used for inter-communication amongst different components. So far there has been development of generic cadastral models such as Land Administration Domain Model (LADM) which was developed by the Technical Committee 211 (TC211) of the International organization for Standardization (ISO) and identified as ISO 191152.

It is based on this model, that a prototype version known as Social Tenure Domain Model (STDM) have been developed by Global Land Tool Network (GLTN) to bridge the gap between the formal and the informal cadastres. STDM captures the registration of full range of possible tenures and shows them as could be observed on the ground in collaboration with local communities.

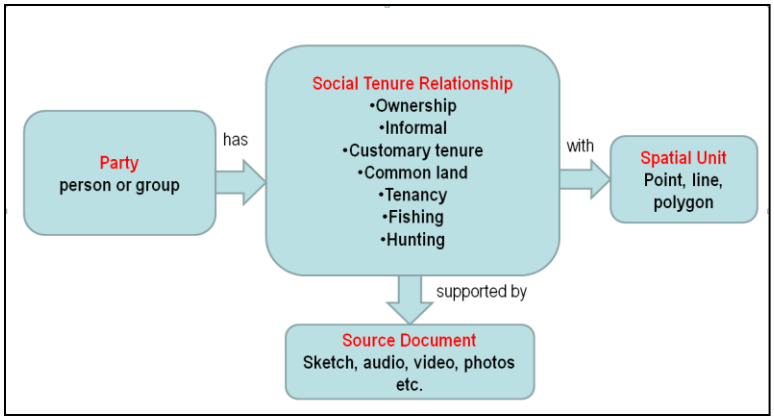

Figure 5: Generic STDM (Source-GLTN, 2003)

Under the model, the relationship between people and land could be considered to consist of tenure arrangements of different tenure types of ownership, access such as hunting, fishing, and tenancy, informal, customarily amongst others (Figure 5). It is a subset of ISO certified LADM thus considered to capture tenure security for all (Lemmen et al, 2003).The model has been tested in Ethiopia, Uganda and piloted in one of the informal settlements in Kenya known as Mashimoni village in Mathare slums (Wayumba et al, 2014).

STDM concept proposes a continuum of land rights in which tenure types can be registered from the basic level and gradually improved with time to the statutory formal level (Figure 6). Initially there could be informal rights which could be captured and registered and with time, more recognised tenures such as customary, occupancy, leases could be given.

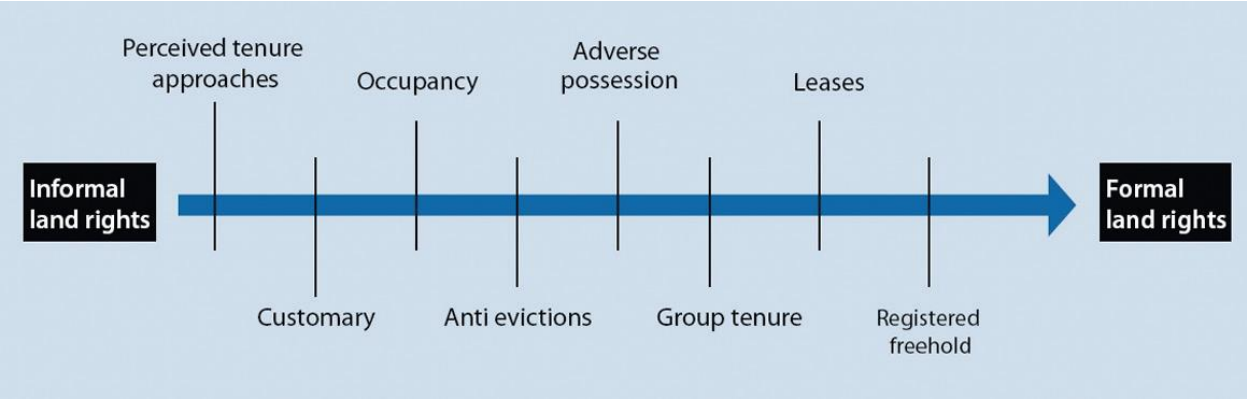

Figure 6: Continuum of tenure (Source-GLTN, 2003)

2.3 Informal Settlements in Kenya

According to the National Land Policy Sessional Paper no. 3 of 2009, informal settlements are defined as areas which lack security of tenure and planning and do occur on all categories of land ranging from government, private of community. These settlements therefore experience problems of non-existent plans as well as development control.

Population pressure and rural-urban migration are the major causes for the proliferation of informal settlements especially in the capital Nairobi. This has also been witnessed in satellite towns such Mombasa, Nakuru, Kisumu and Eldoret. They are characterised by irregular and unplanned structures, poor road network and lack of basic facilities including water, sanitation etc. Most houses are of temporary nature made of mud walls and corrugated iron sheets for walls and roofs respectively.

The residents usually own the structures but not the land on which their structures are built on thus do not have any legal claim. Some have informal letters of authorization to construct temporary structures given by provincial administration such as chiefs, village elders amongst others. These constitute temporary occupation licences (ToL) which guarantees one to construct (and rent out) a housing unit provided it is not a permanent structure.

Table 1, shows the theoretical framework classification of informal settlements based on the broad categories of land in Kenya (Land Act, 2012). Scenarios 1 and 2 in the table illustrate the Nairobi's situation. Because the land has not been bought legally and the structures do not conform to planning standards and by laws, the settlements are not yet been recognised by the government.

Land in Kenya is broadly classified into public, private and Community lands. Informal settlements occupy all these categories with the public category having a unique sub-categories consisting of the pure government land meant for usage by government entities and the registered government lands that was bought from the colonial governments after independence, the latter are commonly referred to as government lands (G.L)

Table 1: Theoretical Framework for classification of informal settlements based on land Categories

Scenarios	General Category	Specific Category	Occupier
1	Public	G.L	Tenants and structure owners
2	Public	Public	Owner occupier and tenants
3	Private	Individual/Company	Tenants and structure owners
4	Community	Clan/Family/Tribe	Owner occupier and tenants

2.4 Case Studies

Case study countries were selected with a representation from West Africa (Nigeria), Central Africa (Zambia), Southern Africa (Namibia) and East Africa (Tanzania) in order to have a homogenous coverage across the entire continent of Africa. In each country, various attempts by their respective governments were analysed and their scenarios put in context of the Kenyan situations.

2.4.1 Regularization in Zambia (Lusaka-Chaisa Informal Settlement)

Informal settlements in the city of Lusaka has been brought to some level of registration with the introduction of Land Occupancy Rights which were given out the city council. It was found to be simple but it improved the tenure security in general since the occupants were issued with come form of recognition by the relevant authority.

Aerial imagery in the form of orthophotos were used to generates maps through digitization using ArcView GIS software where polygons constituting the existing structures on the ground were captured. A database was then created in which structure numbers were used as unique identifiers for each house and were link to other personal information of the residents. The attribute information was collected using questionnaire which was then incorporated into the digital map. This dataset was used for adjudication process with the involvement of community members who were informed through public awareness forums.

2.4.2 Flexible Land Tenure in Namibia

Informal settlers in Namibia commonly referred to as shack dwellers were classified as tenants to the local town boards and they were required to pay rent. This also applied to the customary lands. The local board therefore only recognised those people living under temporary structures made of iron sheets and majority were vulnerable to evictions (Fjeldstad et al, 2005). Cohre (2006) reported on the at least 30 evictions in Windhoek during the period 2005/2006.

Christensen (2005) describes informal settlements in Namibia to possess the following characteristics (amongst others): deficiency of serviced land, supply of residential plots by government did not meet the demand, slow processing and provision freehold titles. The government thus came up with an alternative second level registration system which would ran alongside the formal registration system though could be cheap, secure, simple and could be upgraded to the level of formal registration. Two concepts emerged

1. Starter title: which could register a block of land;

2. Landhold title: a lesser tenure with similar conditions as freehold but with no ownership;

The significant difference is that the starter title is issued within a block, without demarcating individual plot. The block parcel may owned by a government body, community group or even private entity. Bylaws are then set up by the organization holding the starter titles and members within the block could transfer rights though it could not be used as collateral. In contrary, the land hold title could be used as collateral for credit.

2.4.3 Certificates of Occupancy in Tanzania

Certificates of occupancy were issued to informal settlement settlers except in areas that were considered to be environmentally sensitive. The inhabitants registered their interests under a government regulated statutory tenure as provided in the Tanzania's Land Act of 1999. The registration comprises of occupancy rights for 33 or 66 or 99 years depending on the usage of the land. The project was implemented by the Ministry of Lands, Housing and Human settlements.

This was in response to the big informal property market where informal transactions are conducted based on some written papers possibly drafted by lawyers and witnessed by friends of relatives. In most case the local leaders such as chiefs facilitated the transactions even stamping them (Wairimu Wanjohi, 2007). These documents could be used in local courts. This informal system as a result of registration proved to be more secure than the customary tenure because of reduced disputes.

According to (Ramadhani, 2007), there was also a residential license that was given for a duration of two years. The license could be upgraded into a Certificate of Occupancy and registered at the local authority and may be used as a collateral. The piloting of these licenses was tested in 2004 when the government wanted to establish a complete register of all unplanned settlements in Dar es Salaam.

2.4.4 Special District Programme in Nigeria

The special category for title registration for the informal settlements has been implemented by the Nigeria's Ministry of Physical Planning and Urban Development in collaboration with the Community Development Associations. It is an upgrading programme aimed at improving the living conditions of people living in such areas. The government usually acquires those lands from the registered owners through compensation of the affected families and once the government takes possession, it is later regularized and allocated to the occupants

Across all the four case studies, the resultant informal database provided the first step of registration which could be upgraded with time to some formal registration status following the existing laws and regulation in the specific countries. Some still existed in paper form while majority were hosted on GIS platforms.

Table 2: Summary of case studies

Case Study	Ownership status	Recognition documents	Comments
Zambia	City council of Lusaka	Community database	Ensures up to date records and minimizes illegal entry into the city
Namibia	Customarily	Block title	Can not be used as a collateral
Tanzania	Municipal council of Dar es Salam	Certificate of occupancy	It is more recognised than the customary tenure
Nigeria	Government	Certificate of title	Because of limited land, only few beneficiaries are covered

From (Table 2), it emerged that informal settlements is a common problem across Africa with the Namibian case where block title concept was used register individuals in a flexible manner to take care of the small houses often experienced in such settlements, this is then followed by Zambia where customary land was registered under a community database using non-conventional methods of satellite imagery and certificates of rights of occupancy were used.

Nigeria presented the conventional approaches of regularization in which government purchased some land which was then surveyed and certificate of titles issued to the beneficiaries while in Tanzania, upgradable residential licences could be changed into certificates of occupancy as a second level registration for the residents of informal settlements.

CHAPTER 3: METHODOLOGY

3.0 Study Area

Nairobi City owes its origin from the construction of Kenya-Uganda railway which started in Mombasa in 1896 under the colonial government. When the rail reached Nairobi in 1899, the railway headquarters was moved from Mombasa to Nairobi which resulted to the emergence of settlements around it. Nairobi was then zoned into Central Business District (CBD), industrial area, commercial, residential and undeveloped land (Mitullah, 2003). With population pressure especially from the rural areas coming into the city to look for employment yet there were no provision for such class of the population in the zoning, some were hosted by the relatives while majority occupied informal settlements which were built on the undeveloped land. A study by UN-Habitat reported that 95% of new arrivals from rural areas find their home in informal settlements (UNHSP, 2003a).

Under the colonial government zoning (Figure 7), areas with large parcels such as Kilimani and Muthaiga were considered low density residential areas preserved for the Whites while areas such as Parklands of middle density reserved for Asian community and lastly the Shauri Moyo and the entire Eastlands were left for Africans which comprised of very high densities.

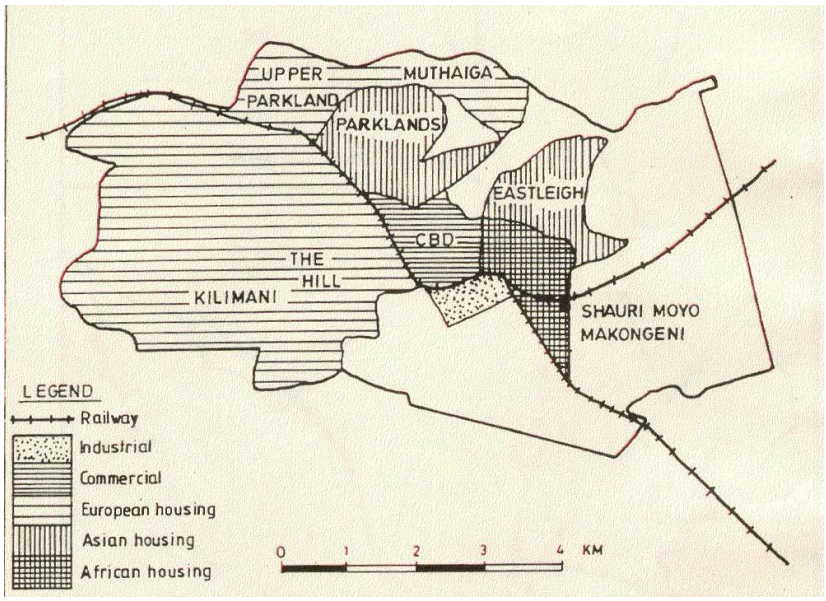

Figure 7: Colonial Zoning of Nairobi (Source-Nairobi inventory 2005)

From the research carried out by Matrix consultants in 1998, close to half of Nairobi's inhabitants occupy approximately 5% of the total inhabited land which unfortunately represents only 1% of the land coverage. This could be traced from the segregation patterns perpetuated by the colonial masters who even after leaving in 1963, their management style continued in operation with the post independence government where by the segregations was now based on economic status rather than race. Therefore at the CBD and the former high class residential areas initially occupied by the white settlers, planning and service standards were maintained while the remaining areas were sprouting with informal developments.

The natives reserves were majorly affected because the initial ban of coming into the city was abolished and so many people migrated from their rural areas to look for opportunities in the city. Some came to visit their relatives but they did not go back. Life in the city was deemed to be good and better than the rural life and it attracted many people to come and experience this new life.

The new government's efforts to settle the new arrivals to areas such as Kariobang could not match the huge demand for landless inhabitants through land adjudication as previously implemented. The population pressure continued to grow rapidly by mid 1970s hence the available services were strained especially housing which was being provided solely the Nairobi City Council. Private developers tried to fill that gap but with limitation of insufficient planning resulting to haphard construction of houses and informal settlements such as Redeemed village emerged in Huruma.

Redeemed village was founded in 1978 after the residents were evicted to pave way for construction of Kiamaiko market. Some of the inhabitants benefited from the government's land allocation process in Kariobangi while other were left out. Their political leaders by then who was the major of the city migrated them to their present location. In 1986, Redeemed village formally known as Post, caught fire and the pastor from Redeemed Gospel Church assisted them with reconstruction efforts hence it was renamed 'Redeemed'.

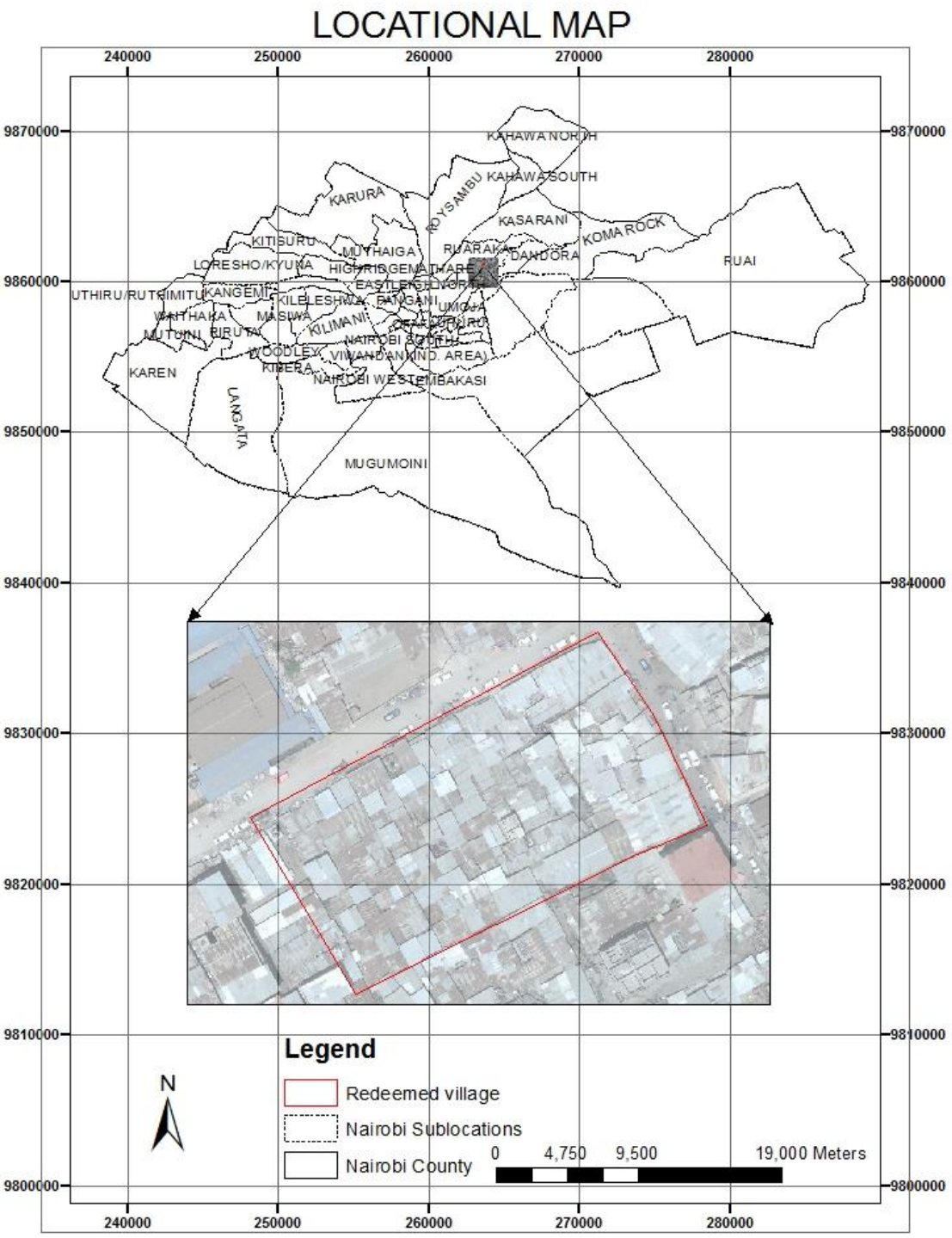

Figure 8: Study Area (Source-own)

Redeemed village measures approximately 0.8 acres in size and is enclosed between Kariobangi road and Mathare North road adjacent to Kiamaiko slaughter. It is located in Kiamaiko ward, in Mathare constituency, Nairobi City County. It is accessed through Kariobangi road, off Juja road approximately 3km from the CBD (Figure 8).

Table 3: Summary of Methodology

Objective	Research Question	Methods	Output
Characterize informal settlements in Kenya	What is the tenure status of land occupied by informal settlements?	Desktop Review Interviews	Informal Settlements Typologies
Developing the model	What is the appropriate model for informal settlement?	External modeling/User Needs Assessment Conceptual Modelling Logical Modelling Physical Modelling	User needs assessment report Unified Modelling Language (UML) diagram
Testing the model	Can the model accommodate all typologies?	Digitization of the structures Editing and numbering of the structures Creation of the dummy register Importation of the numbered structures and the dummy register into the customized STDM	Database

3.1 Characterization of Informal settlements in Kenya

Several documents were reviewed including the National Land Policy, National Slum Upgrading and Prevention Policy, KISIP Project Appraisal documents as well as other reports on informal settlements.

In each document, special attention was dedicated to the sections addressing informal settlement regularization and options for upgrading of such settlements. Characterization of informal settlements was established with emphasis on tenure status of the land occupied categorised into public land, private land and community land as theoretical framework for development of the informal settlement typologies. A Focused Group Discussion (FGD) was held with the leaders of the selected informal settlement where specific characterization was discussed and evaluated against the broad typologies already identified from the literature review. The FGD tool used is attached in the appendices

3.2 Development of the model

The four stages of modelling were undertaken as follows:

3.2.1 External Modelling/ User Needs Assessment

This involved identification of the users/stakeholders involved in informal settlement regularization program. They were mapped based on the previous attempts that have been tested by both government interventions and Community self-driven initiatives.

Two previous government intervention programs of Kenya Slum Upgrading Program (KENSUP) and Kenya Informal Settlements Improvement Project (KISIP) were visited and their views captured in an in-depth interview with key staff.

The interviews were held separately so as to get independent opinions as well as validate the findings of the detailed synthesis of their programs. Their views were captured based in past experience plus the critical information requirements that inform their strategy. In some cases, success stories were elaborated alongside challenges and lessons learnt.

Discussions were then held with the community village leaders so as to get their view having captured the government's strategy and interventions. The tools used were different with the community one being simplified for better understanding and more of open ended while the one used for the government staff on the other hand being more specific and detail cross-examination in-depth interview (Appendix 1)

The outcome and synthesis is outlined in Chapter 4.

3.2.2 Conceptual Modelling

Based on the external model, different classes were identified and their associations established in a Unified Modelling Language (UML) diagram. Some classes were found to be aggregates of others hence were classified as sub-classes. Relevant associated attributes, methods plus their multiplicities were well defined and designed using Dia drafting software which is open source software for drawing UML diagram, Entity-Relationship (ER) diagrams as well as flow charts in a user friendly and in already designed template. It has a limitation of migrating from one notation to another, therefore creating incompatibility between UML and ER modelling methods. Each attribute data item was described to specify the data values that will go into the database and primary keys identified. Classes such as structures were given structure code as the primary key.

3.2.3 Logical Modelling

Skeleton tables were generated from the conceptual model based on the attributes of the classes using pgADMIN which is an open source database management software integrating both the spatial and non-spatial tables. The tables were normalized to conform the First, Second and Third Normal Forms. Other non-spatial data items such as name was broken into first, and other names, likewise the associating class linking structures and the people was set to be either structure owner or a tenant. Multiple structure owners were also taken into consideration.

3.2.4 Physical Modelling

This was the resultant database management system that was customized from the generic Social Tenure Domain Model (STDM) developed by UN-Habitat. The generic model considered so many tenure relationships ranging from leasehold, freehold, individual owner among others and the spatial unit as a land parcel whereas the developed model only had two tenure relationship of structure owner and tenant while the spatial unit was the structure. The customization involved the introduction of the classes modelled, their correlation and specification of the data values that would be instantiated. Each data field must have the same data type as the ones captured in the classes and the configuration completed so as to adapt to the new changes.

3.3 Testing the cadastral model

Aerial Imagery of 15cm resolution covering the project area was acquired. All the structures were digitized into vector format using QGIS as open source GIS software. The reference datum was set to ARC Datum, 1960 commonly known as EPSG 21037(CRS in QGIS) so as to conform to the formal land parcels. All GIS functionalities of creating layers, editing and attribute key in were done in a QGIS environment.

Under participatory GIS (pGIS), community leaders were able to identify the digitized structures overlaid on the imagery printed at enlarged scale of 1:500. Therefore it was used to number all the digitized structures. The numbers were then written on the print out created by preparing overlapping sheets drawn at a much larger scale of 1:200. These were edited in QGIS environment and a structure number created to be used as the unique identifier. This will constitute the structure class as captured in the conceptual model.

A dummy register consisting of structure owners as well as tenants was keyed in as a spread sheet in excel constituting the party class in the conceptual model.
The structures and the dummy register were imported into the database PostGIS and Postgres respectively under the customised STDM.
The resultant database was developed where changes to the database could be done, quick reports of the beneficiaries extracted and certificates auto generated after creating social tenure relationship between the structure and the party.

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CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 Characterization of informal settlements in Kenya

The phenomenon of informal settlements in Kenya can be associated with reasons that are both historical as well as current. Historically, the colonial model of land tenure displaced many Africans which created landlessness alongside the colonial urban policy that excluded the Africans from urban settlements. There was no room for Africans in cities like Nairobi. Later on, the colonial administration allowed Africans access to urban areas through Kipande system (a pass). Those coming to the urban areas would either be accommodated in the shelter provided by their employer through the trusteeship policy that required employers to provide housing for their employees or in the "Native Settlements" where the municipal authority then built houses for the Africans. But when the number of Africans coming to the urban area grew beyond the capacity of the designed "Native Settlements", those who could not find housing moved to the fringes of Nairobi such as today's Mathare valley informal settlements.

After independence in 1963, the new administration deployed a mixed and varying policy which at one stage consisted of the call for the Africans to return to their rural "homes" while other times there were forced evictions of those who had resided in makeshift structures that were mainly built on public land. Between the 1970s and the late 1990s, the government attempted various initiatives which did not reverse the trend. The increased growth and expansion of informal settlements in almost all counties in Kenya can be associated to both continuity of some colonial modes of exclusion as well as the inattention of policy makers to policies, budget priorities and housing needs of the low income population.

Critical characteristics of Kenyan informal settlements include lack of tenure security, poor housing conditions, high rates of unemployment, high population densities, non functional infrastructure and high rates of environmental pollution through poor management of waste.

Lack of security of tenure is perhaps the greatest challenge since informal settlements emerge on public, community and private land. Due to tenure insecurity most informal settlement residents live under constant fear of evictions which in turn make development initiatives difficult.

There are competing land interests in such areas. There are the tenants, the structure owners (both resident and absentee) and the land title holders in case of private lands. Therefore the following typologies characterize the tenure arrangement for informal settlements in Kenya.

Table 4: Typologies of informal settlements in Kenya

Land Category	Typology	Informal settlement Category	Examples
Public land	1	Government land	Mathare, Huruma, Kibera,(Nairobi) Maweni (Mombasa)
	2	Reserves(Roads, Riparian, Pipeline)	Gitathuru, Mukuru, Deep Sea, Mitumba (Nairobi)
Private land	3	Individual	Embakasi village(Nairobi), LikoniMisufini (Mombasa)
	4	Company/Group	Kisii village (Nairobi)
Community land	5	Ancestral	Manyatta, Nyalenda (Kisumu)

Land tenure and administration in informal settlements are quite complex. Lack of security of tenure is perhaps the greatest challenge amongst all the typologies except the fifth typology where the greatest challenge is the subsequent updating of the formal cadastre, making it difficult to manage almost up to four generations outside the register.

The first four typologies have a similar characteristic of tenure insecurity with most residents living under constant fear of evictions which in turn make development initiatives difficult. Under typology one which forms the lion's share, the national land policy had recommended for regularization with no proper framework of how it should be done other than applying the conventional approaches which have been tried in some places such as Mombasa, Mkomani informal settlement and the end result was gentrification and currently the settlement is a home for both the middle and upper middle class while the genuine beneficiaries have been displaced

to other neighbouring informal settlements of Mnazi Moja and ShauriYako informal settlements (Mombasa County Inventory Report 2014, unpublished)

Where this typology appeared to be the easiest to formalize and government's interventions have been revolving around this typology, specifically among the criteria for selection under KISIP is that the informal settlement must fall under this typology, therefore infrastructure priorities have been implemented to this typology. Examples include Kayole Soweto, KCC village which again in spite of huge infrastructure investments by the World Bank, gentrification pushed the beneficiaries to the neighbouring Matopeni informal settlement since the land value had increased as a result of infrastructure improvements hence with the idea of willing buyer willing seller, the genuine beneficiaries sold their allocation letters even before their titles were out (Pamoja Trust inventory Report, 2005).

Additionally, with the establishment of the National Land Commission under the National Land Commission Act, 2012, administration of public land was vested to the commission hence alienation of such lands to the informal settlements on leaseholds may jeopardize availability of land banks for future developments especially owing to the trend that in actual fact the genuine beneficiaries would still sell out their allocated land and again look for another government land which they will in turn request for allocation.

The second typology represents a very unique category, majority of which came as a result of a previous eviction from another land. Such cases are witnessed in Mathare where the residents were pushed to occupy the Mathare valley which is a riparian reserve yet they were settled there as a temporary measure to take care of the immediate need. Also in the same category is the Kibera informal settlement where the better part falls along the railway reserve and they were issued with temporary occupation licences by the Kenya Railway though they settled on very dangerous positions with respect to the railway line (World Bank RAP report, 2010).

Under this typology, the national land policy recommended relocation because their area of settlement was found to be dangerous or environmentally sensitive thus they could not be settled where they are. Attempts by government to relocate them have been resisted and apart from a

negotiated relocation by Kenya Railway in Kibera, majority still occupy these reserves and are prone to hazards such as floods, derailment of the railway among others.

The third typology is very interesting and has been a subject of debate in national TV stations. The recent case has been the famous Waitiki farm in Likoni Mombasa that was raided by informal settlements (Kenyan Daily Nation, 23rd August 2015) who then deliberately refused to leave even after a court order was issued. Similar cases were also found in Embakasi village, Nairobi where informal settlements invaded private properties and the owners have not accessed their land to date while the occupiers have since been selling parts of that land to unsuspecting buyers (KISIP report, 2015)

This typology requires a lot of negotiations with the owners before any regularization could commence and in most cases, it might involve buy off by either the informal settlement residents or the government. Without such negotiations, very little could be done other than letting the status quo to remain.

The fourth typology occurs where a legal entity such as companies or cooperatives are the legal owners of the land occupied by informal settlements. In such cases, very little negotiations have been experienced but rather evictions which occurred in some two informal settlements of Kalahare and Mathare in Mombasa (HakiYetu report, 2014) and Kisii village in Nairobi which are still battling it out with a company that is the legal owner of the land they occupy and is even paying land rates on their behalf.

This typology is usually marked with accusations of who occupied the land first and contestation of the acquisition of such land by the purported companies. The informal settlements often accuse the companies of irregular acquisition of such lands hence they have been reluctant to concede the request by the companies to leave but have decided to stay put unless they are forcefully evicted by the companies.

4.2 External Model/User needs Assessment

Based on the five typologies, the following classes were identified and found to be common across all the informal settlements categories;

1. Structure/house which represented a fabric framework of material parts put together and used as a dwelling or a house in an informal settlement
2. Structure owner which constituted the person who builds or owns the structure and uses if for occupation or renting. The structure owner is not the legal owner of the land except in the last category of community land.
3. Tenant which represents the person who uses the structure as a dwelling and pays rent to the structure owner

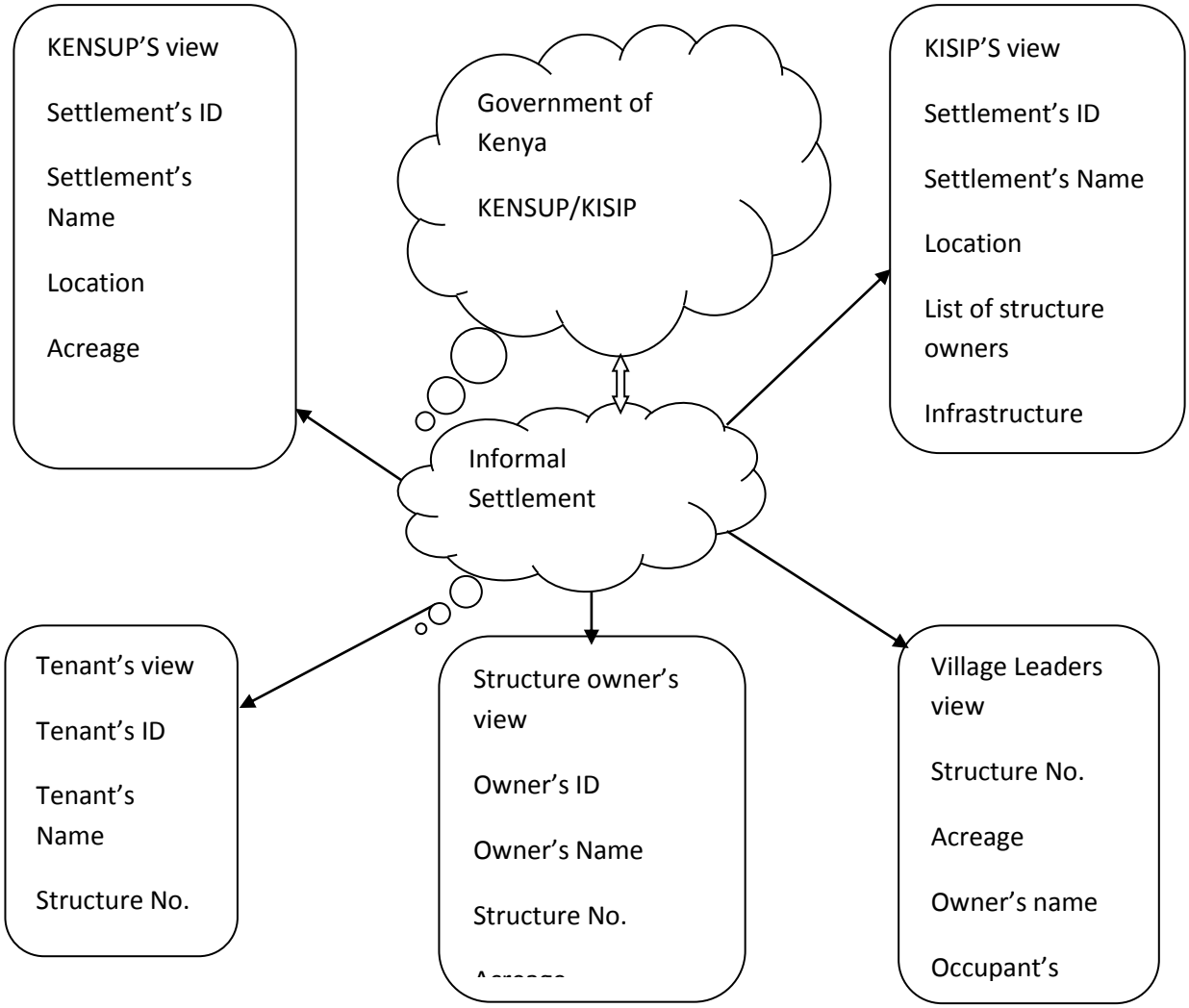

Figure 9: External model

Based on the literature review and the user needs assessment interview with KENSUP, KISIP and Community Village leaders, the critical issues that emerged was the list of beneficiaries which appeared to be mirage both to the government and the community at large. In some past experiences, the government introduced new criteria which made the bonafide beneficiaries exchange their proofs with non bonafide beneficiaries resulting to other middle class benefitting from government programs aimed at the lower class.

Additionally, community leaders also changed the list depending on their interests and sometimes demanded payments for the bonafide beneficiaries to be included in the list. Therefore the list from the community kept on changing and causing a lot of conflicts within the community. Community leaders devised a paper based register that could be used to document the beneficiaries. It was also important to both the government and the community leaders to know the extent of the structure so as to ascertain the level of compensation or allocation.

Therefore the schematic diagram above captured the key data items that each view thought that would be of paramount importance and should not be missed. They also highlighted the need for some inter-mediate proof for those beneficiaries since it emerged that processes of tenure security might take a bit of time and cheaper methods of addressing those processes would be recommended.

4.3 Conceptual Modelling

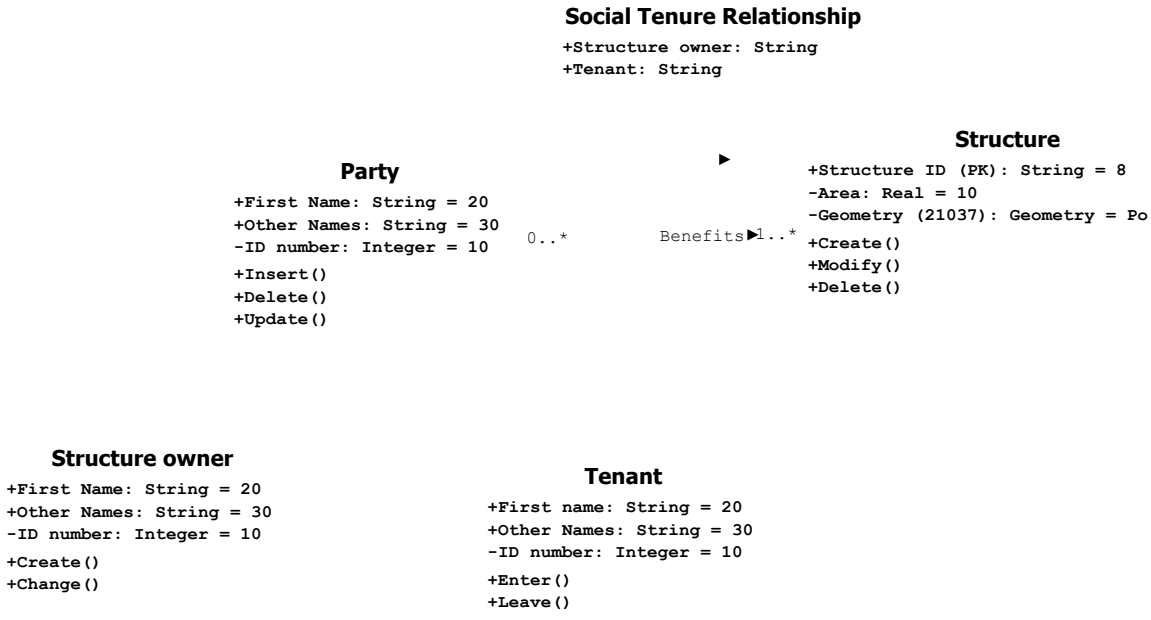

Figure 10: UML Diagram of the model

The Unified Modelling Language (UML) was used to develop the various classes as identified in the external model. The classes, their attributes and behaviours/methods were drafted in a UML diagram as shown above. Classes that share common attributes were aggregated so as to reduce redundancies as well as explore inheritance characteristics of the super-class.

The key beneficiaries of the informal settlement was agreed to be structure owners and tenants hence they constituted the class Party through aggregation of the Tenant and Structure owner sub-classes. They inherited all the attributes of the party class although the methods applied to each were slightly different, e.g. the structure owners subclass had some permanency while the tenant subclass was dynamic and easily changing.

An associating class linking the party and the structure was developed and called the social tenure relationship. It picked the attributes of the tenure status of both structure owners and tenants to differentiate their relationship with the class called structure. A structure was mandatory class without which no party can be linked.

The degree of multiplicity was specified where at least a structure must exist first before a party could be attached to it while a party could be attached to at least one structure or more.

4.4 Logical Model

Based on the conceptual model, relevant data fields were developed that were of primary importance to both the government departments as well as the community leaders. It is these skeleton tables that data values would be entered and tested as per the parameters that had been defined.

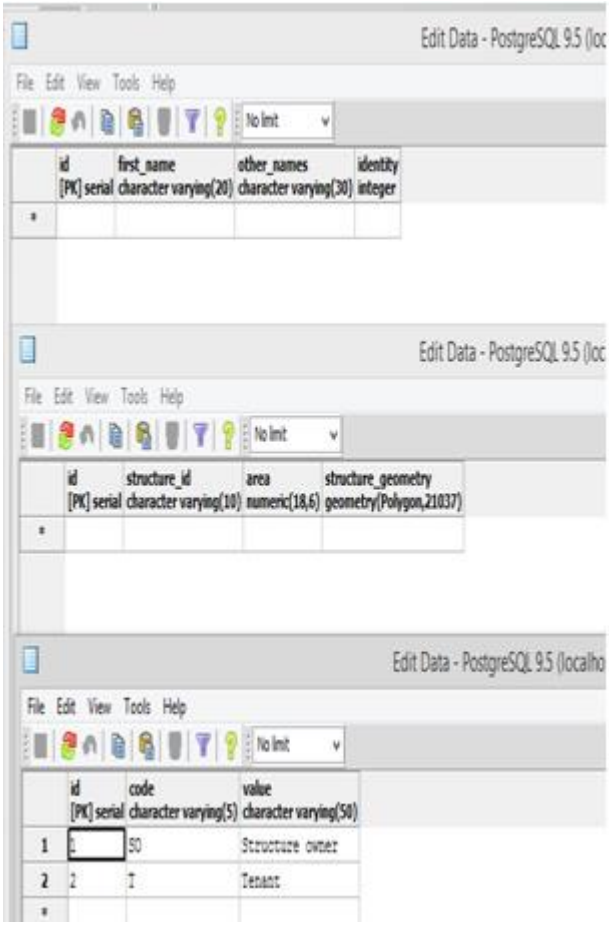

Figure11: Skeleton Tables

As shown in Figure 11, three tables were developed together with their corresponding attributes each with its unique identifier as the id which was used in the association of class table. The association class was then pre-determined to be the prevailing tenure situation of structure owners and tenants as the predominant tenure types in the informal settlement.

4.5 Physical Model

The generic STDM model was configured to be able to capture the three main classes and their attributes as in the logical model.

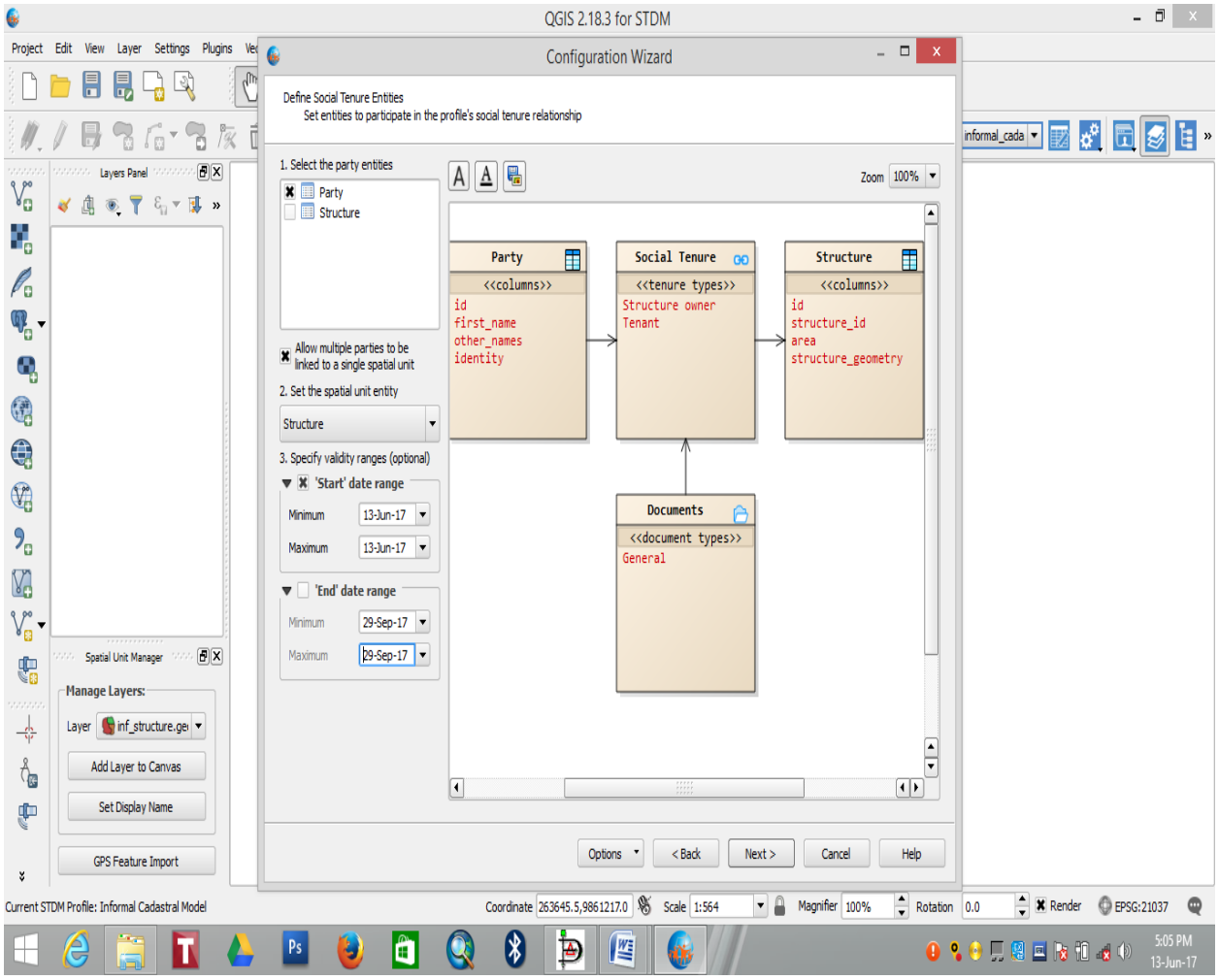

Figure 12: Customized STDM

The database that would host the spatial and attribute data was configured (Figure 12) to reflect the data items already captured in the logical model and the relationship between the party which includes both structure owners and tenants, and the structure defined under the social tenure. Supporting documents such as letter from the chief, photos could also be attached as evidence of the existing party.

4.6 Testing the cadastral model

The spatial data generated from digitization of the aerial imagery (Figure 13) captured the structures constructed by structure owners and are been rented by the tenants hence forms the spatial unit. It is the object that must first exist before any tenure arrangement could be defined.

Figure 13: Digitized structures

Each structure given the unique identifier by numbering (Figure 14) created a code through which the party could be linked to it. The code was participatorily agreed upon by community leaders hence could also act as an address system for identification of each structure.

Figure 14: Numbered structures

The resultant model was tested by importing data into the database. The prototype database could handle both the spatial data as well as the attribute data, all in one inter phase (Figure 15).

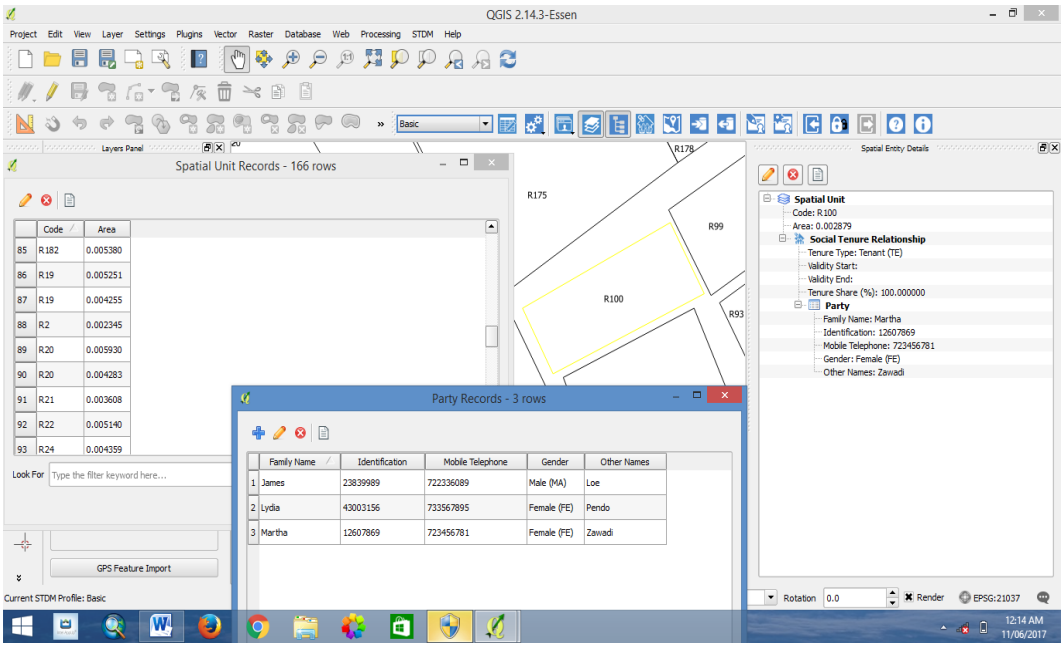

Figure 15: Populated database

The inter phase was user friendly and could allow any designated person to either add a new record or update the existing records. Such changes could only be effected after a login credentials have been put hence information and data security, and integrity well taken care of (Figure 16).

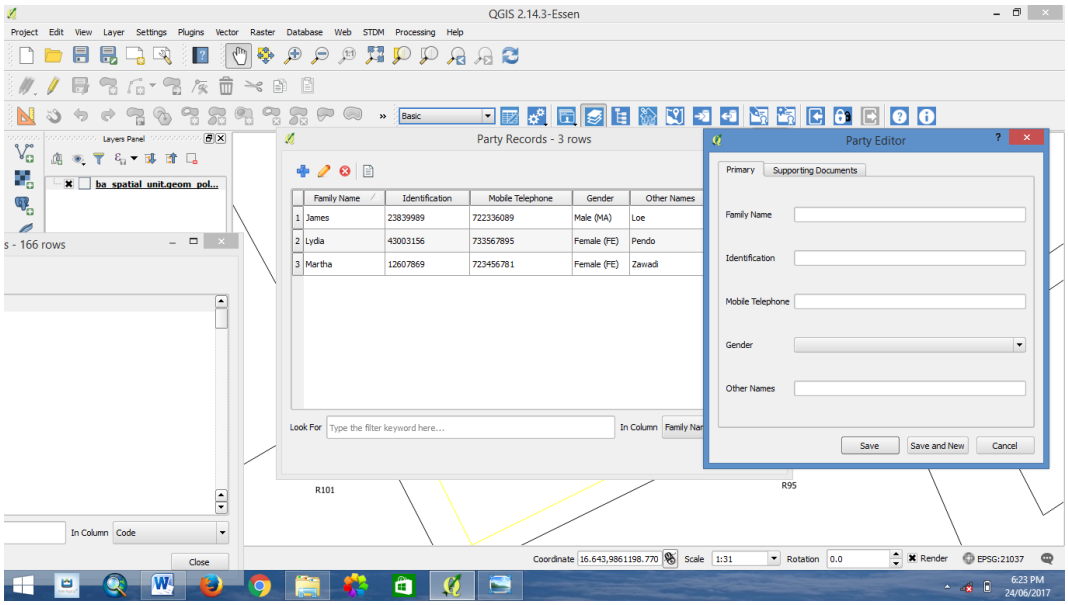

Figure 16: Record addition

The model constrained the data entry such that a structure must first exist before any tenant or structure owner could be linked to it under the social tenure relationship. This was important to sieve the problem where beneficiaries were being added yet never attached to any existing structure, thus constituting ghost beneficiaries. Likewise one structure could have a structure owner and also occupied by a tenant, therefore different tenure status could exist for the same structure. This was a key factor that highlighted the bundle of rights that often exist in informal settlements that could be captured under one database.

Since it was also observed that it was a common trend for one structure owner to have multiple structures, the model allowed linkage of many structures to one structure owner enabling one to many relationships. This could very vital during negotiations for way leaves because give and take scenarios could be discussed with facts on the table. Previously structure owners introduced their family members including the under aged and allocated them some structure rooms so as to benefit in double portion.

Digital proof documents were then designed which could aid extraction of vital information from the database such as the structure and the personal details of the beneficiaries coupled with other static design features such as logos, signatures which

ensured that counterfeits proofs were prevented and could easily be noticed because they will not be from the database. Other support documents such as letters from the chief or photos of the beneficiaries could also be added (Figure 17).

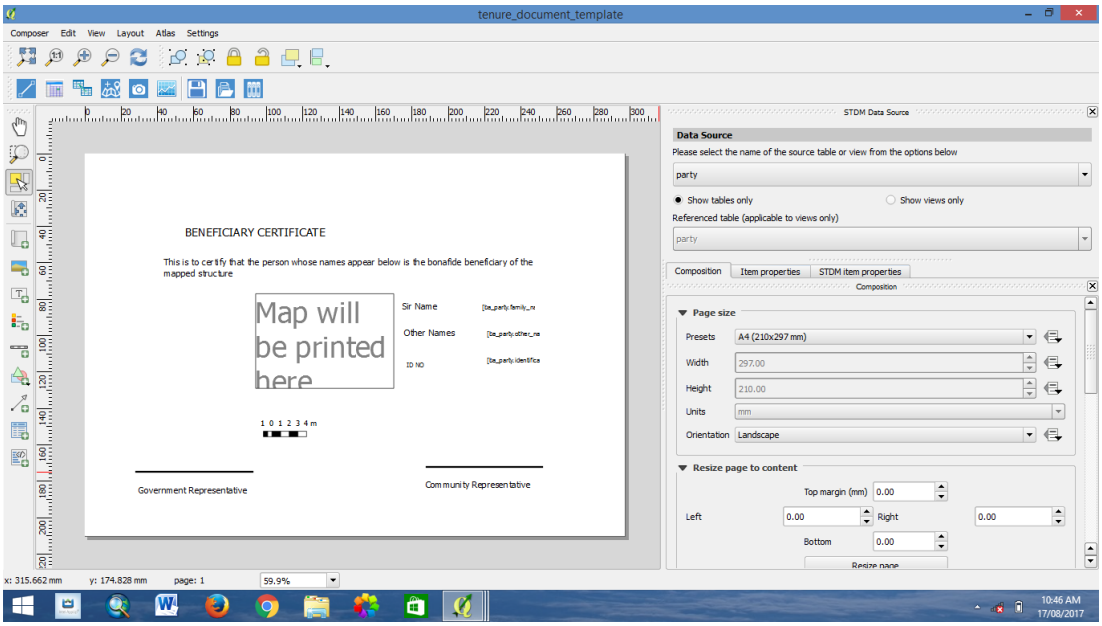

Figure 17: Certificate design

Once the template have been designed, then any party information as well as the structure in which social relationship exist was generated and printed as a pdf document or a jpeg (Figure 18) which could be manually signed off by the relevant authority and a copy left for the beneficiary. This was meant for dealing for the issue of perennial squatters who keep from moving from one informal settlement to another in anticipation of getting assistance in both cases.

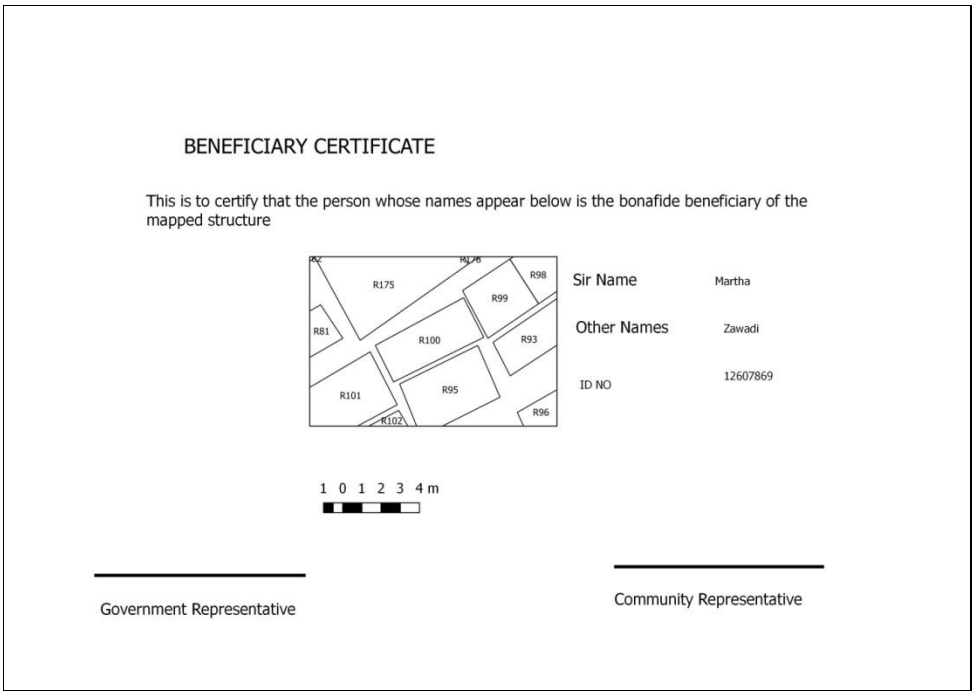

Figure 18: Sample Digital Certificate

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Based on the study, informal settlements in Kenya are categorised in five broad typologies which emanates from both colonial and post-colonial times. Various attempts have been made by the Kenyan government to try and reverse this trend by improving the existing informal settlements and also preventing the occurrence of new ones though the methodology and strategy adopted have been laborious, time consuming, expensive and not suitable to the immediate needs of the informal settlements

A holistic approach to addressing the pertinent issue of tenure security which emerged to be the underlying issues across all the typologies except typology five, can be solved by this model while typology five, the model could be modified by introduction of super class of land parcels but structure maintained as the unit of social tenure and the children of the parcel owner as the party class.

The tenure document auto-generated from the database could be a digital proof of tenure security that could authenticate the genuine beneficiaries of the informal settlements in which government could plan for and their tenure status improved in a continuum framework under the existing laws and regulation. This would limit and put a cut-off date to the number of people currently occupying informal settlements and bar influx of new arrivals after establishing necessary mechanisms of stopping perennial squatters.

The bureaucratic formal land administration procedures make the system expensive and prone to corruption coupled with the lack of clear land administration systems for regularization of informal settlements. Space allocation in such areas has been done in a haphazard manner by various actors ranging from local administration to politicians with no regard to existing laws. There are competing land rights: There are the tenants, the structure owners (both resident and absentee) and the land title holders which could be a government body, private entities or ancestral, hence a continuum approach based on this model can suite enhancement of tenure security in informal settlements.

Land tenure system in Kenya is predominantly based on individual titling which makes it very difficult to undertake meaningful tenure regularization for informal settlements owing to the small land sizes and the complex relationship between structure owners and tenants. The process is also laborious, expensive and time consuming while the inhabitants are poor and living one day at a time hence open source tools would suffice under these prevailing circumstances.

The critical issue for the residents of the informal settlements was found to be recognition of their presence as an immediate need; therefore the model would form the first tire of the continuum with the introduction of user rights that would deal with the finite nature of the land use for both tenants and structure owners. The database would thus cover the holders of the differentiated rights of access, transfer, inheritance amongst others and would be updated accordingly within the validity period.

5.2 Recommendations

National programmes such as, the Kenya Slum Upgrading Programme (KENSUP) and the Kenya Informal Settlement Improvement Project (KISIP), are some of the measures put in place to respond to this evolving scenario of informal settlements. However, the two programmes are inadequate in addressing the problem of tenure security unless proper and tested models are recommended coupled with a comprehensive legal and institutional framework. The national land policy, sessional paper no. 3 of 2009, had laid the foundations for addressing the tenure security where this model could apply, which included;

(a) Take an inventory of genuine squatters and people who live in informal settlements;

(b) Facilitate planning of land found to be suitable for human settlement;
(c) Facilitate negotiation between private owners and squatters in cases of squatter settlements found on private land;
(d) Facilitate the regularization of existing squatter settlements found on public and community land for purposes of upgrading or development;
(e) Develop, in consultation with affected communities, a slum upgrading and resettlement programme under specified flexible tenure systems;
(f) Put in place measures to prevent further slum development; and
(g) Regulate the disposal of land allocated to squatters and informal settlers;

A holistic approach to addressing these pertinent issue of tenure security across all the informal settlement typologies in line with the above guidelines can be solved by this cadastral modelling because the findings could be replicated in the four typologies while the fifth typology would require some slight modification of the class structure which could be replace by a super class of the ancestral parcel, followed by sub classes of the informal allocations to the family members and the party to be retained as family members themselves.

Policy documents such as the National Land Policy and the Slum Upgrading and Prevention Policy have given frameworks for addressing the tenure security which the model could be applicable in the identification of the genuine beneficiaries as well as provision of acceptable documents for their recognition.

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APPENDICES

Appendix 1: In-Depth-Interview Tool

INDEPTH INTERVIEW WITH GOVERNMENT DEPARTMENTS DEALING WITH INFORMAL SETTLEMNT UPGRADING

Interview Questions

A. GOVERNMENT'S STRATEGY/KENSUP AND KISIP

I. What is the government's strategy for regularization of informal settlements?
II. What are the critical information needs that would facilitate such strategy?
III. What are the foreseeable challenges in getting that critical information?

B. PAST EXPERIENCE

I. In your opinion, how has been the success of previous regularization programs
II. What does it require to undertake a complete regularization program
III. Other than regularization , what other programs do you undertake to improve informal settlements
IV. How do informal settlements respond to these interventions

C. LESSONS LEARNT

I. What are the main stages when undertaking informal settlement improvement?
II. During the stages, does the link of potential beneficiaries change?
III. If there are in (II), what are the mitigate measures
IV. Overally, what is your assessment of the government's intervention towards improving tenure security?

Appendix 2: FGD Tool for community leaders

Interview Questions

A. Settlement history

1. Describe briefly the background of the settlement i.e. when it was started , how it was started and background of the settlers
2. Any memorable moment in the history
3. Settlement characterization (In what category of typology)

B. Land and Tenure Status

1. What is the land status of the area occupied by the village?
2. Are there cases of eviction or eviction threats
3. Any challenges to your own initiatives to secure the land

C. Land administration

1. Who allocates spaces for building structures
2. How are the issues of sale, inheritance addressed?
3. What is the general relationship between structure owners and tenants
4. Which tenancy documents do people possess?

D. Tenure security

1. How secure is your land?
2. Are you aware of government's regularization efforts? Does government regularization effort constitute this security?
3. If not, what are your thoughts?