An assessment of the use of Geographic Information System (GIS) in monitoring and evaluating the progress of in-situ upgrading of informal settlements: A case study of Cato Crest Informal Settlement, eThekwini Municipality.

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Abstract

As a point of departure, this study investigates the innovative use of geographic information system (GIS) as a technological tool for urban governance in South Africa used for monitoring and evaluating informal settlement upgrading projects, using the case of Cato Crest informal settlement in eThekwini municipality. In South Africa, the number of informal settlements continues to increase perpetuated by phenomena such as rapid urbanisation and poverty; notwithstanding of the goal of the Department of Human Settlements to eradicate all informal settlements by 2014. The BNG advocates for in-situ upgrading as the preferred approach for settlement upgrading as it seeks to improve settlements in their current location through the provision of services, and secured land tenure. In-situ upgrading is a holistic approach with an emphasis on eliminating social exclusion, poverty, and vulnerability. Favouring neoliberal policies has resulted in increased poverty as people are not able to compete in formal housing markets due to insufficient capital. Technological adaptation is barred by lack of support from top management and capital resources. This research adopted a qualitative research design, utilizing primary and secondary sources of data, employing semi-structured interviews, questionnaire, observation, GIS based methods of digitizing, and buffering as data collection methods. Data is analysed through thematic analysis and GIS technology, and findings presented in cartographic display. The research has found that, among other things, eThekwini municipality utilizes GIS through the ISP to inform decisions for housing projects. However, GIS continues to face barriers in monitoring and evaluating in-situ upgrading of informal settlements as spatial data is updated annually; thus unable to map spontaneous land invasions as they occur throughout a year cycle. Notwithstanding, the in-situ upgrading of Cato Crest informal settlement has impacted the community positively through the provision of services, and secured land tenure, preserve socio-economic networks, and integration of the settlement into the broader urban fabric.

Declaration

I declare that this dissertation is my own unaided work. All citations, references and borrowed ideas have been duly acknowledged. This research report has not been previously submitted to the School of Built Environment and Development Studies or any other body for any purposes.

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     Bahle Mazeka   Date

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I would like to extend my most sincere gratitude to the following people:

Acronyms

ADB: African Development Bank

ANC: African National Congress

AVSI: Voluntary Association for International Service

BNG: Breaking New Ground

CAD: Computer Aided Design

CBD: Central Business District

CCTV: Cape Town City Council

CDC: Commonwealth Development Corporation

CMDA: Cato Manor Development Association

COHRE: Centre on Housing Rights and Evictions

DA: Democratic Alliance

DBMS: Database Management Systems

DBSA: Development Bank of Southern Africa

DEM: Digital Elevation Model

DD: Decimal Degrees

DMS: Degree Minute Second

DSW: Durban Solid Waste

EU: European Union

DoH: Department of Housing

DoHS: Department of Human Settlement

GEAR: Growth Employment And Redistribution

GIS: Geographic Information System

GIT: Geo Information Technology

GPS:	Global Positioning System
IMF:	International Monetary Fund
ISP:	Informal Settlement Plan
IS:	Information System
NEMA:	National Environmental Management Act
RDP:	Reconstruction and Development Proramme
SAFs:	Structural Adjustment Frameworks
SAPs:	Structural Adjustment Programmes
SDI:	Slum Dwellers International
StatsSA:	Statistics South Africa
TAM:	Technology Acceptance Model
TRA:	Theory of Reasoned Action
TIN:	Triangulated Irregulated Network
TPB:	Theory of Planned Behaviour
UCT:	University of Cape Town
UISP:	Upgrading of Informal Settlement Programme
UNDP:	United National Development Programme
UNCHS:	United Nations Centre for Human Settlements (HABITAT), since 2002 known as UN-HABITAT
USAID:	United States Agency for International Development
UTAUT:	The Unified Theory of Acceptance and Use of Technology
UTM:	Universal Transverse Mercator
ViSP:	Visual Settlement Planning
WB:	World Bank
WHO:	World Health Organisation

Table of Contents

List of figures

List of plates

List of tables

Chapter 1: Introduction

1.1 Introduction

In South Africa, the number of informal settlements continues to increase (Tissington, 2011), despite the goal of the Department of Human Settlements to eradicate all informal settlements by 2014 (DoH, 2004). In as much as shacks are demolished and restructured in patterns that can allow for the provision of services, new shacks are being built during the process of upgrading. In light of the above, the vision of eradicating all informal settlements by 2014 will not be realised.

According to Wu and Murray (2003) the trend of urbanisation continues to escalate, over 45 per cent of the world's population resides in urban areas. Rapid urbanisation is one of the developmental challenges facing developing countries globally. The rate of urbanisation (the process through which cities and towns develop and grow, includes migrations of people from rural to urban areas, and movements among towns and cities) is higher than the rate of local authorities' capability to accommodate the former Wu and Murray (2003). The shortage of readily available housing stock in urban areas leads to people finding informal settlements as an alternative form of accommodation available within their affordability and convenience. In developing countries informal settlements are a common feature of urban growth, and land is occupied through informal practices (Zeilhofe and Topanotti, 2008), formally termed as land invasions.

In-situ upgrading is a process undertaken by local authorities to improve the housing conditions from informal to formal settlements, this is achieved by installing basic services such as water, electricity, sanitation, roads, and even formal housing top structure. During the 1950s and early 1960s the dominant approach adopted by first world countries in addressing informal settlements was one of demolition and replacement by public housing (Abbott, 2002). Furthermore, this approach was used post Second World War, and it proved to be a success. However, in reality developing countries faced an escalating rate of urbanisation, overcrowding, and growth of informal settlements.

In the late 1960s and early 1970s, seeking to address the challenges of informal settlements, John Turner and other authors concentrated on the concept of incremental housing (the process of owners controlling the expansion of their housing guided by their needs and resources) (Abbott, 2002). Moreover, they advocated for a 'shift to greater autonomy or dweller control in the

production of housing' (Abbott, 2002: 306). Their focus on incremental housing has indirectly resulted in the introduction of informal settlement upgrading as a strategy to deliver housing. In public or state owned land, in-situ upgrading is advocated as the primary instrument of addressing the challenge of informal settlements (Huchzermeyer, 2006), on the other hand; relocation is used as a last resort enforced by uncontrollable factors (such as unsuitable land for housing development) (DoH, 2004).

Primarily there are two dominant approaches used in in-situ upgrading of informal settlements. The one group originates from the Indian Sub-continent, it advocates for community-based initiatives through NGO partnerships (Huchzermeyer, 1999) cited in (Abbott, 2002: 305). On the other hand, Latin America advocates for technologically driven solutions (Abbott, 2002). This study is focused on technologically driven solutions.

The use of spatial data has been adopted in the spectrum of informal settlement upgrading. Common techniques include remote sensing, aerial photography and GIS; used mostly for change detection, land use management and planning, and database management (Zeilhofer and Topanotti, 2008). The first use of GIS as a tool for planning and integrating informal settlement upgrading into the urban fabric can be traced to the city of Belo Horizonte in Brazil in 1983 (Abbott, 2003). Spatial technology, GIS in particular has been manipulated and used simply as a management tool to provide decision makers with sound information, to a technical tool to supporting integration of informal settlements to the urban fabric through dynamic display mapping technology.

According to Abbott (2003) the experience of Belo Horizonte was acknowledged and it spread throughout Brazil, Latin America and Central America in a broader context. The ability of GIS to define complex spatial patterns found in informal settlements gives the former an advantage as a solution in in-situ upgrading. Positive experience of GIS and informal settlement upgrading was adopted in South Africa in the late 1990s. In 1998, the Urban Geographical Information System Group within the Department of Civil Engineering at the University of Cape Town (UCT) initiated a pilot project (New Rest informal settlement) of informal settlement upgrading (Abbott, 2003). This pilot project sets the precedent for GIS methods to be used in informal settlement upgrading projects in South Africa.

This study investigates the innovative use of geographic information system (GIS) as a technological tool for urban governance in South Africa used for monitoring and evaluating

informal settlement upgrading projects. This study seeks to explore the innovative ways and extent in which eThekwini municipality uses GIS as a tool to monitor and evaluate in-situ upgrading of informal settlements. Adequate information gathered by the use of GIS will enable municipal officials to take swift measures to fight the re-emergence of informal settlements. Moreover, this study is aimed at unpacking the importance of the use of GIS in monitoring and evaluating the re-emergence of informal settlements spatially. Furthermore, GIS has the ability to assist decision makers to make informed decisions about space under their jurisdiction.

1.2   Research Problem

While the conventional method of upgrading informal settlements is through in-situ, as it is encouraged by the existing housing policy (BNG), one must acknowledge that it is a complex and a challenging task. Authorities often resort to less challenging means of redress such as relocations combined with green-field developments (Misselhorn, 2008). There are many factors that contribute to the complexity of implementing in-situ upgrading programs. Many of these factors (discussed below) overlap influencing each other, and are equally important to some degree.

There is scarcity of adequately located and developable land for in-situ upgrading, and relocations (Fourie, 2001). Some informal settlements are located on land that is not suitable for human settlement, thus resorting to relocations. However, the bulk of developable land has already been developed, and new developments will be located further away from urban socio-economic centers. Developing on more peripheral land also has implications on the cost of extending the bulk services network, increased transportation costs for inhabitants, and social networks and livelihoods become disrupted (Durand-Lasserve, 1999).

Conventional informal settlement upgrading method is more appropriate as it not only responds to the former, but it also addresses poverty, vulnerability and social inclusion (Huchzermeyer, 2006). Be that as it may, there are constraints in implementing in-situ upgrading programs. Informal settlements have high population densities, and this preclude the implementation of in-situ because a large number of people will be relocated (Misselhorn, 2008). For example, Cato Crest in-situ informal settlement upgrading began in 2000, funded by the national government, and implemented by local municipality of eThekwini (Patel, 2009). Since its commencement

approximately 500 low cost (RDP) houses have been built. For installation of services (water, sewerage, electricity) and construction of five houses, an average of 20 shacks are demolished; five household's benefit from in-situ development and 15 face the possibility of being relocated further away from the city (Patel, 2009).

Furthermore, in-situ upgrading of informal settlement is a slow process, influenced by the factors mentioned above, not ignoring other constraints. The average time-frame for a project to be completed is between 7-12 years, while other projects may take longer (Smit, 2006). For example, the Bester upgrading project in eThekwini is still receiving subsidies for top structure 20 years after the project commenced. Delays are further experienced with the manner subsidy funding is channeled. According to existing housing framework (chapter 13 of the Housing Code), the first phase of funding should be released early in the project process. The second phase of funding is essential in securing "topographic work, detailed design, land acquisition and planning approval" (Misselhorn, 2008: 20). However, the way it is implemented, the second phase of funding cannot be released until such a time land is secure.

All the above mentioned factors contribute to the complexities of implementing conventional method addressing informal settlements. In Cato Crest, the in-situ upgrading program is on its implementation phase. Evidently living conditions are being improved and shacks replaced by adequate quality housing structures. However, people are continuing to occupy the land illegally, and shacks continue to be erected despite the in-situ upgrading program being implemented (Patel, 2009). Consequently, this is a result of many challenges (such as rapid urbanisation, slow implementation rate, political conflicts, and inability of people to fulfil their housing needs, just to mention a few) facing municipal officials.

The short supply of housing persists and increased despite the South African government having put in place a number of housing initiatives to help alleviate the housing backlog which was inherited from apartheid legacy (Kajimo-Shakantu & Evans, 2006). Rapid urbanisation has also escalated the complexity of redress, thus people continue to establish and occupy informal settlements as means to shelter. Rapid urbanisation accompanied by the inability of people to satisfy their housing needs results in informal settlements continuing to be seen as alternative shelter.

The growth of Informal settlements poses challenges for urban environments and authorities. Due to the illegal nature of informal settlements, they develop outside formal regulations and standards of towns and cities (UN- HABITAT, 2002). Consequently, informal settlements lack basic services, and formal land administration. Evidently human health and the environment are compromised. Most importantly the continuing growth of informal settlements poses a great challenge for sustainable human settlements.

There is compelling evidence which suggests that GIS is being used in informal settlement upgrading projects, both internationally and locally. Metropolitan municipalities in South Africa have adopted GIS technology, however; Musungu *et al* (2012) maintain that the potential of GIS has often been unrealised. This is because "*GIS development and analysis has traditionally been carried out exclusively at a technical level by various professionals without input from communities located in the actual geographical space being analysed*" (Musungu *et al,* 2012: 3).

Informal settlements cause spatial problems, on the other hand GIS is a spatial tool, thus spatial problems need spatial tools to be addressed adequately. GIS has the ability to reveal spatial relationships otherwise not visible (Chang, 2010). Informal settlement's relationships with the formal urban environment may be revealed and understood clearly through the use of spatial tools (Abbott, 2001). Informal settlements have a direct relationship with the formal city. Figure 1 illustrates conceptually the relationship between an urban cadaster and 'holes' which represent informal settlements. This diagram is an example of how relationships can be revealed using GIS. The primary issue is the linkages between the formal and informal spatial locations. Therefore, GIS should be an essential tool used to monitor and evaluate upgrading of informal settlements.
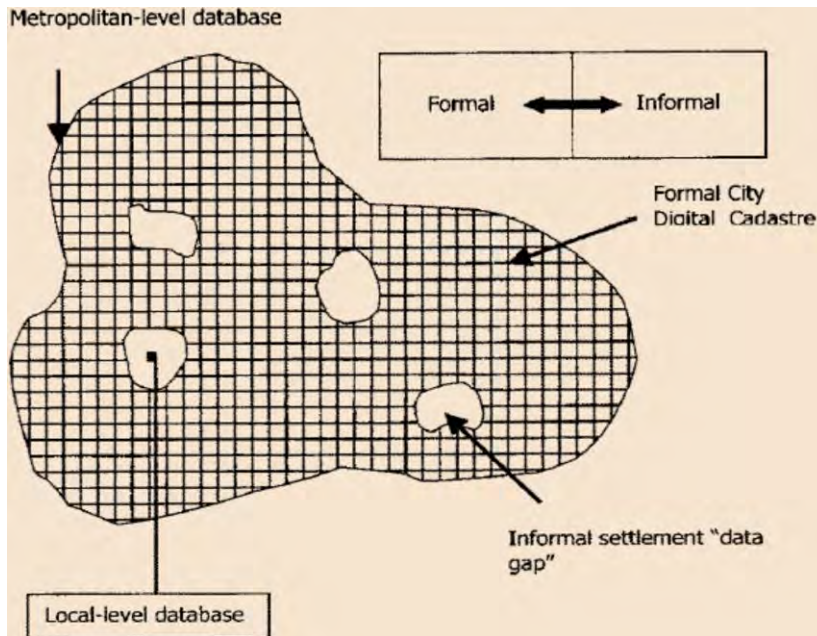
Figure 1. Image displaying informal settlements as 'holes' in the formal city (Abbott, 2003).

1.3   Justification of the study

This research is important because the eradication of informal settlement through in-situ upgrading is relatively a new phenomenon in South Africa. Informal settlements are active housing agents, they are highly successful solutions to housing problems in urban areas of developing countries (Tshikotshi, 2009). Turner (1969) adopts a positive stance advocating for upgrading of informal settlements rather than evictions and relocations. This research is important because it reinforces the creed that location of such settlements is the centre to poverty eradication as people have chosen their desirable residing area respectively. The selected location of informal settlements is by far not a coincidence, it is a people driven initiative. People choose such settlements because it favours mostly their socio-economic engagements and close to networks of transportation routes. Upgrading of informal settlements permits formal legal recognition of land parcels by authorities, thus granting tenure security which directly influences sustainable livelihoods. Improving the conditions of the urban poor in informal settlements is critical to social, economic and political stability (Barry & Ruther, 2005).This research supports the notion of the use of spatial technology to be used by officials for optimal implementation of informal settlement in-situ upgrading program.

Cato Crest is one of the many informal settlements under the administration of eThekwini Municipality. This informal settlement provides an opportunity for the application of GIS to be used for monitoring and evaluating the progress of in-situ upgrading, a venture that has not been sufficiently exploited. Furthermore, the selection of this case study is of paramount importance because Cato Crest mirrors informal settlements in a broader context. The positive experience this study has potential to assist officials strategically in positively implementing in-situ upgrading programs holistically.

GIS complements and enhances data storage and management tools because the former offers an advanced database management system which may be manipulated. GIS has the ability to interact with data in a computer. This study is significant because with the use of GIS, one has the capability of representing geographic features which is the heart of GIS (Longley et al, 2005). This research is imperative since primarily it has the potential to demonstrate the process and role GIS as a spatial tool has to offer to officials dealing with upgrading of informal settlements. GIS is an effective tool that can be manipulated to provide decision makers with sound information. Evidently GIS has been successfully implemented in informal settlements and displayed positive experiences (Abbott, 2001; Abbott, 2002; Abbott, 2003; Habitat, 2000; Karanja, 2010). This study offers the opportunity to unpack the importance of GIS and the extent to which it can be adopted for upgrading of informal settlements in a South African context.

1.4 Research Aim

The aim of this research is to ascertain the ways and extent to which GIS as a spatial tool can innovatively be used to inform eThekwini municipal officials in monitoring and evaluating the progress of in-situ upgrading of informal settlements.

1.4.1 Objectives

The objectives of the study are to:

1. Cartographically map the current in-situ upgrading of Cato Crest informal settlement.

2. Trace the progress of in-situ upgrading of informal settlements in Cato Crest using GIS tools (past and current).

3. Explore whether eThekwini municipality uses GIS to monitor and evaluate in-situ upgrading of informal settlements.

4. Analyse the relationship between informal settlement upgrading and the use of GIS.

5. Investigate the use of GIS for optimizing in-situ upgrading of informal settlements.

6. Emphasize the use of GIS as a monitoring tool to avoid the recurrence of shacks in places where formal houses have been constructed.

7. To investigate challenges faced by municipal officials for the use of GIS.

1.5   Main Research question

To what extent has GIS been effectively and innovatively used by eThekwini municipality as a spatial tool to monitor and evaluate the progress of in-situ upgrading of Cato Crest informal settlement?

1.5.1   Sub-questions

❖ Does eThekwini municipality use GIS as a spatial tool to monitor and evaluate the upgrade informal settlements?

❖ What is the eThekwini municipality Informal Settlement Plan (ISP)?

❖ How effective is the use of GIS in monitoring and evaluating in-situ upgrading of informal settlements in eThekwini municipality?

❖ Who is responsible for monitoring and evaluating in-situ upgrading of informal settlements?

❖ To what extent is the affected community involved in decision making process before and after the in-situ upgrading of informal settlements?

❖ To what extent has GIS been used in-situ upgrading in eThekwini Municipality?

❖ Has the use of GIS as a spatial tool to monitor and evaluate the upgrading program been of great importance to the municipality?

❖ Can the use of GIS assist the department of human settlements eradicate informal settlements by 2014?

❖ What are other methods used by eThekwini municipality to monitor and evaluate in-situ upgrading of informal settlements besides GIS?

❖ What are the challenges associated with the in-situ upgrading of informal settlements?

1.6   Definition of key concepts

The purpose of this section is to introduce and define important concepts used in the study. Informal settlements do not exist in a vacuum, they occur within the broader urban fabric context interacting with other various concepts, and supported by certain theories. The following concepts will be defined, and contextualized accordingly: informal settlement, in-situ upgrading, GIS, community participation, household, and land tenure.

1.6.1   Informal settlement

There is no standard definition for informal settlement, definition varies greatly from country to country and it's defining parameters. According to Srinivas (1991) informal settlements may be defined as a residential area which developed without formal legal standing or claim to land. Furthermore, because of their illegal status they develop outside the regulations of the city hence they have a common feature of inadequate services and infrastructure (Klug & Vawda, 2009).

Informal settlements may be defined by certain characteristics: physical, social and legal. Physical characteristics refer to poor services of networks (water, sanitation, electricity, and roads) and inadequate physical infrastructure constructed from a variety of materials including corrugated iron, plastic, clay, timber and metal sheeting (Marx & Charlton, 2003). Social characteristics refer to low income groups, and predominantly migrants; and legal refers to lack of legal ownership of land parcel on which a shack is constructed because of illegal occupation (Srinivas, 1991).

Informal settlements are often located at the edge of cities. Furthermore, these settlements are often better located than new housing developments that are constructed to accommodate inhabitants that are relocated from informal settlements (Tshikotshi, 2009). Informal settlements are active housing agents, they are highly successful solutions to housing problems in urban areas of

developing countries (Tshikotshi, 2009). Location of these settlements is of paramount importance for the socio-economic activities of inhabitants (Abbott, 2003).

1.6.2 In-situ upgrading

In-situ upgrading is the process undertaken to improve an informal settlement in its current location by delivering basic services and secure tenure to people (Pikholz, 1997). According to Mukhija (2002: 554 cited in Tshikotshi, 2009) informal settlement upgrading involves the recognition of three condition: "the property rights, the property values and physical attributes of the underlying assets, and their impact on each other". Furthermore, according to Cities Alliance cited in Ziblim (2013: 4) informal settlement upgrading is defined as a process whereby the former in urban environments is incrementally upgraded, formalized, and incorporated in the urban fabric. Therefore, upgrading does not only focus on the legal aspects, but seeks to improve the living conditions and services.

Upgrading of informal settlements may happen using one of two approaches: relocation or in-situ development (Del Mistro and Hensher, 2009). Relocation is the process of moving inhabitants from their settlements to another 'greenfield' site. Often these new settlement sites are further away from urban opportunities than the informal settlement, thus directly interfering with socio-economic activities. On the other hand, in-situ development reduces the number of household's that are relocated to another site; thus minimizing the extent of disruption to economic and social networks (Del Mistro and Hensher, 2009). Furthermore, settlement upgrading is more appropriate in responding to poverty, vulnerability and social inclusion (Huchzermeyer, 2006).

1.6.3 Geographic Information System

Geographic information system is a computer system used for capturing, storing, querying, analysing and representing geospatial data, which describes both location and characteristics of a spatial feature or features (Chang, 2010). Furthermore, it can be manipulated to analyse data visually and see patterns, trends, and relationships that might not be visible in written or tabular form (Li *et al,* 2005). This computer (GIS) system is made up of five main components (Chang, 2010):

1. Hardware - it is made up of all physical equipment like a computer (monitor, mouse, keyboard, tower), printers, scanners, global positioning system (GPS), just to mention a few.

2. Software - it is responsible to run the computer, includes packages such as ArchGIS for example.

3. Humans - it is people who operate the GIS system.

4. Data – it is the information to be represented.

5. Procedure – certain lines need to be established and followed to archive its objective.

The components are interrelated, function together, and are all equally important. In cases of a component not being able to be present, GIS processes cannot be applied. One might have hardware, software, procedure and humans but lacks data (input), there cannot be output. It is of paramount importance to have all five components working, as this contributes to making GIS an advanced spatial information system. The GIS system as notably been an effective tool using a global positioning system (GPS) to identify ground points accurately (Li *et al*, 2005), site selection (Corner *et al,* 2006) to the integration of decision by authorities based on GIS analysis (Sharifi *et al*, 2009), just to mention a few.

Evidently GIS can be applied across disciplines including addressing informal settlements, and it has regularly been used to facilitate decision making (Musungu and Motala, 2012). There are a number of studies focusing on the use of GIS and informal settlements in-situ upgrading (to be discussed extensively in chapter 2). GIS has been used at a technological level for planning and management for informal settlements. However, most importantly there is evidence of GIS being used to permit, encourage, and facilitate community participation (Musungu and Motala, 2012). Thus GIS can be used to integrate local communities into decision making activities concerning their own settlements. The application of GIS and community participation from a planning phase, eliminates resistance to upgrading initiatives by local authorities. Therefore, informal settlement upgrading through integrating in-situ upgrading and GIS as a spatial tool will contribute to the creation of sustainable human settlements.

1.6.4   Community participation

 According to Samuel (1986:46) community participation, in a broad sense, may be "thought of as an instrument of empowerment". Arnstein (1969) presents a typology (rungs of the ladder) of eight levels of community participation, these are: manipulation, therapy, informing, consultation, placation, partnership, delegated power, and citizen power. Furthermore, community participation

that lacks redistribution of power is a hollow and frustrating process for the powerless people. Moreover, community participation is fueled by two main objectives: one is to improve the living conditions, and to influence decisions in the political arena (Choguill, 1996). Thus, community participation is not only focused on improving living conditions, rather it should pursue power to influence political decisions, therefore permanent change to the status quo.

The current housing framework advocates for active community participation as a paramount tool in project life cycle of in-situ upgrading programs (DoH, 2004). Community participation is a concept that is often easy to use, however; in reality difficult to translate into practice. In a local context, according to Jordhus-Lier and de Wet (2013) community participation in practice often becomes "formal, legalised, and politicized". Furthermore, it is common in upgrading cases that most options and plans are meticulously defined by officials, and residents are "informed" (not engaged) at a later stage during implementation phases (Piper, 2012).

1.6.5 Household

A household is composed of related or unrelated persons residing together in a dwelling unit. Household members share living space, energy, water, and other goods, leading to potentially important economies of scale (Leiwen and O'Neill, 2004). The assumption of one household per dwelling is proven wrong in informal settlements. According to Tissington (2011) an informal settlement dwelling unit may be composed of more than one household, hence the actual figures of estimating households in informal settlements remain relatively unknown. Households are not fixed structures, their average sizes continuously vary. Average number of members in developing countries is five (Bongaarts, 2001), numbers fluctuate greatly in informal settlements because there is no accurate measuring instrument.

Informal settlements are densely populated (Misselhorn, 2008), with multiple households in a single dwelling unit (Tissington, 2011). The complexities associated with household densities consequently results in officials' being reluctant to implement conventional methods of settlement upgrading, thus causing delays. Keeping in mind the number of households in a dwelling unit, it is not possible that all members will benefit from in-situ upgrading. Inevitably, some households will be relocated temporarily or permanently (Budlender, 2003). According to Posel (2001) relocated households often come back (to the settlement that is being upgraded) and continue to erect shacks.

It is of paramount importance to note the dynamics of households in this study, primarily because informal settlements are made up by the latter. Argued in Forster (1993) in informal settlements it is common for households to be headed by children or minors, which do not meet subsidy requirements. Thus, upgrading programs need to be considerate of such, and have instruments to address special issues. Moreover, these challenges provide the basis for stronger intergovernmental partnerships.

1.6.6 Security of tenure

Informal settlements are erected and occupied without formal legal standing which directly influences land tenure. Land tenure may be defined as the legal regime in which land is owned by an individual, who is said to hold the land (Singer, 1996). Land is a crux asset for rural and urban poor, it provides an important foundation for economic and social development. Sound property rights and adequate access to land offers the potential to help empower the poor to adjust to the challenges posed by recent trends of globalisation. Regardless of initiatives aimed at reduction of poverty and safety net programmes, inhabitants living in informal settlements continue to increase; insecure tenure often discourages urban poor households from improving their sustainable livelihood survival strategies (Mahanga, 2002).

In settlement upgrading, the availability of adequate land is of paramount importance. Furthermore, where land is suitable for upgrading, the current policy (BNG) seeks to support different tenure options. It is argued in Del Mistro and Hensher (2009) the supported tenure option is freehold tittle. It provides security of tenure, and therefore the "opportunity to leverage the property values as means as a poverty alleviation" (Del Mistro and Hensher, 2009: 335). Thus security of tenure offers the urban poor the opportunity to derive sustainable livelihood survival strategies. Moreover, security of tenure provides for better socio-economic development for informal settlement residents. Inhabitants will be motivated to invest in their structures, and livelihood's knowingly their tenure is secured.

1.7 Research design and Methodology

A research design is a strategy or plan which moves from the underlying philosophical assumptions to specifying the selection of respondents, data gathering techniques to be used, data

analysis to be done, and choice of research design is based on the researcher's assumptions, research practices, research skills, and desirable information (Maree, 2007: 70). This study has adopted a qualitative research design.

According to Gillman (2000: 10) qualitative methods are 'essentially descriptive and inferential in character'. Furthermore, they permit a researcher to examine people's experiences in detail through use of certain research methods (Hennik *et al*, 2011). Moreover, qualitative methods allow subjects being studied to give much valuable responses, and reveal information that may have not being possible to obtain if other methods were used. This research employs GIS techniques to complement qualitative research design, thus these two methods are used concurrently to investigate and produce the most accurate results.

According to Matveev (2002) adopting a qualitative research design is advantageous wit strengths that include:

- Obtaining a more realistic feel of the world that cannot be experienced in the numerical data and statistical analysis,

- Flexible ways to perform data collection, subsequent analysis, and interpretation of collected information,

- Provide a holistic view of the phenomena under investigation,

- Descriptive capability based on primary and unstructured data,

- Ability to interact with research subjects in a comfortable language and their own terms.

It is upon these advantages qualitative research design is selected.

1.7.1   Justification of the Case Study

This study is designed such that it makes use of a case study as a methodology. A case study investigates a case to answer specific research questions. This research seeks to investigate the in-situ upgrading of Cato Crest informal settlement, the case study serves as the primary methodology. One source may be declared insufficient (Gillman, 2000), thus sub-methods are utilized to add value and reach sound conclusions.

Cato Crest informal settlement is the selected case study; it falls within the jurisdiction of eThekwini municipality (Durban). The selection of the case study is guided by its rich history of the eviction of settlers during the apartheid era, and resettlements from 1994 (Patel, 2009). It has been a contested space for many years occupied informally, resulting in its informal settlement status. However, in-situ upgrading commenced in 2000 funded by national government, implemented by local municipality. On the other hand, BNG advocates for the eradication of all informal settlements by 2014; which seems to be an imposable task.

This case study is of utmost importance, because primarily it offers the opportunity to investigate the ways and extent in-which GIS as a spatial tool can be innovatively used to monitor and evaluate the in-situ upgrading progress of informal settlements. Cato Crest informal settlement provides a foundation to further explore the manner GIS can be used by municipal authorities' tasked with the responsibility of implementing in-situ upgrading programs. In-situ upgrading in Cato Crest informal settlement is on its implementation phase, thus the case study selected is relevant to the study and practical. It is upon these facts that Cato Crest was selected as a case study for the research.

1.8   Sampling

As discussed in Hennink *et al* (2011) usually it is impossible to include the entire population in a study because of time, cost, and population size, consequently in such cases one will have to make use of sampling. Population (in research) does not only represent people, however; it is a group of items, objects, or individuals from which samples are taken for measure (Salant & Dillman, 1994). A sample can then be defined as a set of respondents selected for the purpose of a survey from a larger population. Therefore, sampling can be defined as the process or technique of "selecting a suitable sample, or representative part of a population for the purpose of determining parameters or characteristics of the whole population" (Patton, 1990).

For the purpose of this study, a strategy of mixed method sampling was employed which encompassed the selection of cases or units for a research study using both purposive sampling (this increased transferability) and probability (random) sampling strategies (this increased external validity) (Teddlie and Yu, 2007). Random sampling may be simply defined as a sample

in which each unit has an equal opportunity of being selected, and purposive sampling involves selecting certain units or case "based on a specific purpose rather than randomly" (Tashakkori & Teddlie, 2003: 713), and "knowledge of the population, its elements, and the nature of your research aims" (Babbie, 1990: 97). Purposive sampling was employed because this sampling method is used in special situations where the sampling is done with specific purpose in mind (Maree, 2007). The purpose of purposive sampling for this study is to identify participants to provide mainly primary data. Person(s) were identified purposefully for their relationship with the in-situ upgrading of Cato Crest informal settlement. Thus, purposive sampling was used on involved stakeholders selected as participants, these are: eThekwini Metropolitan Municipality (housing and GIS unit), the Cato Manor Development Association (CMDA), and Abahlali baseMjondolo (an NGO actively involved with informal settlements on a national scale).

On the other hand, random sampling was also employed because it permits the population to have an equal chance of being selected as participants (Mason, 2002). It is of paramount importance to use this sampling technique as it ensured the population in the study is adequately represented (Yin, 2003). According to Patel (2011) Cato Crest has a total household population of 1500. In light of the above, and dynamics centred in informal settlements (such as rapid urbanisation and land invasions), the researcher opted to estimate household population has increased by 500; bringing the total household population to 2000. As it is not feasible to include the entire household population as participants because of selective constraints (such as time). For the purpose of this research, a 10% sample was taken from the Cato Crest informal settlement household population. Therefore, a total number of 200 beneficiaries were sampled to participate in the study.

1.9   Sources of data

For the purpose of this research, two sources of data were utilized; these are primary and secondary sources of data. Moreover, the use of both sources of data serves as s strength because they complement each other. Furthermore, the two source of data assisted towards achieving the research objective.

1.9.1 Primary sources of data

Primary data is data collected by the researcher specifically to address the research problem under study, "using procedures that fit the research problem best" (Hox & Boeije, 2005: 593). Primary data is raw data (collected purposefully for the objective of the research), and it is obtainable using methods such as experiments, observation, focus groups, surveys, and interviews, just to mention a few. For the purpose of this research, primary data was in the form of interviews, questionnaire, and observation.

Advantages of primary sources of data may be summarised as follows: data collected is original and relevant to the topic; level of accuracy is very high; it can be collected from various methods (these include questionnaire, interview, and observation); data collected is reliable because it is gathered by the concerned and reliable party; and it is current thus may provide the realistic view to the researcher (Hox & Boeije, 2005).

1.9.1.1 Interviews

According to Maree (2007) an interview is a two way conversation method in which the interviewer asks the participants questions in order to collect information and to learn about ideas, beliefs, views, opinions and behaviours of the participant. Furthermore, if used correctly interviews are a valuable source of information; in cases where the person interviewed thinks the topic is important and can trust the interviewer they will give you information that you will not be able to collect in any other way (Maree, 2007).

For the purpose of this study, semi-structured interview method was employed, this allowed the participant the freedom to express and explain themselves. The participant may be in possession of valuable information, the freedom of expression permits for such information to surface. Open ended questions were designed prior to the interview in order to permit participants room to provide extra valuable information. A voice recorder was used to capture the conversation; thus avoiding disrupting.

Interviews were conducted with eThekwini municipal officials responsible for in-situ upgrading, and Abahlali baseMjondolo. The inclusion of these stakeholders was to attain a complete picture on the processes of in-situ upgrading of Cato Crest of informal settlements.

- EThekwini municipal officials, as the developer (entity that is responsible for the in-situ upgrading of Cato Crest), was interviewed in order to obtain information on how the in-situ upgrading program is carried out, what strategies are in place to monitor and evaluate such projects, and challenges experienced thus far.

- Abahlali baseMjondolo is an NGO's working closely with the Cato Crest community, interview was scheduled to be conducted to get information on the role and support they provide for the community. The inclusion of these stakeholders is to attain a complete picture on the processes of in-situ of informal settlements.

1.9.1.2 Questionnaires

In its basic form, a questionnaire is a formal set of questions for obtaining information from beneficiaries (Taylor-Powell, 1998). For the context of this study, a questionnaire was designed for residents of Cato Crest to get information on (1) how the in-situ upgrading project was introduced; (2) what was and is the level of community participation; (3) and, what are the new challenges and opportunities they experience after the project has commenced.

1.9.1.3 On-site observation

It is discussed in Maree (2007) that observation is a systematic process of recording the behavioural patterns of participants, objects and occurrences without necessarily questioning or communicating with them. An everyday exercise or activity which allow sensors (seeing, hearing, touching, smelling, etc) to be used to gather data. Furthermore, it permits the researcher to gain deeper insight and understanding of the phenomena being observed. The use this method is of utmost importance as it was used as a verifying strategy to what is on the ground.

1.9.2 Secondary sources of data

Secondary data is existing information collected by other researchers or party with a specific purpose. However, a researcher may extract certain information (from secondary sources of data) and use it to fulfil other objectives. Secondary data has already been collected, analysed, and organised for a specific purpose, available in electronic, published, and unpublished sources (Hox & Boeije, 2005). Furthermore, secondary data is used to get initial insight and understanding into the research problem. For the purpose of this study, secondary data was made up of relevant case studies, books, journal articles, internet, thesis, and municipal data.

1.9.2.1 Aerial photograph

Aerial photographs served as base maps for the research. Base maps in GIS are used as background information, not as the primary focus, however; an aid to the reader (Tyner, 2010). Two aerial photographs were compared, captured between the year 2004 and 2013. This method was used to get information, and to clearly demonstrate the changes in space over time. Through this method it was possible to visually see the developmental pattern of the settlement over time.

1.9.2.2 Digitizing

Digitizing is the process of converting data from analog to digital format, and the accuracy is determined by the quality of the base map (Chang, 2010). Digitizing was performed for extracting and manipulating relevant data from several aerial photographs serving as based maps, it was executed on ArcGIS software, version 10. Digitizing was employed to simply show the study area boundary, geographical features, and to clearly show the changes in space in Cato Crest informal settlement over time. This method was used to obtain geographic information data to be represented and analysed through GIS.

1.9.2.3 Buffering

According to Chang (2010) buffering is a concept based on proximity which creates two areas, one within a specified distance of selected features and the other beyond. Buffering was utilized mainly for creating proximity between the upgraded settlement and surroundings (this includes Umkumbaan River to adhere to the principle of environmental sustainability, settlements may not be constructed within 32meters of a river). The use of GIS and buffering as a tool clearly revealed if such a principle has been complied with. Most importantly, through buffering it was possible to get information that clearly showed the interconnections of the settlement with the urban fabric.

1.10   Data Analysis

Data analysis is a process of inspecting, cleaning, transforming and modelling data with the goal of highlighting useful information, suggesting conclusions, and supporting decision making (Huang and Wei, 2002). Data analysis requires discipline, creativity, and systematic approach (Patton, 1990). For the purpose of this research, data analysis was based on the availability of data collected by the researcher. Data was analysed using two approaches.

Data was analysed through the use of GIS as tool and technology, and thematic analysis. Results will be presented through cartographic ("art, science and technology of making maps, together with their study as scientific documents" [Tyner, 2010:3]), and pictorial representation. According to Salant and Dillman (1994) visual presentation are under-utilised but powerful sources of information. Thus, this research maximised visual representation of data through a series of maps that communicate with each other.

Secondly, qualitative data is made up from words gathered by various methods (interviews, observation, survey, etc), and the data collected must be interpreted and summarised. For the purpose of this research, data was also analysed though thematic analysis. According to Boyatzis (1998) thematic analysis emphasizes organisational and rich explanation of the data set. Thematic analysis moves yonder counting "explicit words or phrases in a text and focuses on identifying implicit and explicit ideas within the data" (Boyatzis, 1998: 35). Data with similar attributes or speaks of similar ideas was grouped together, and presented under one theme. Thematic analyses helped present data in a structured and systematic manner, making it easy to understand.

1.11   Limitations

The main limitation came from the targeted participants to be interviewed declining to participate in the study. Participation is optional and with no remunerations, or personal benefit. Furthermore, due to the nature of semi-structured interview method, participants may go beyond the scope of research. To overcome this issue, structured questions prepared prior to the interview was key in shifting the focus back to the subject at hand. Moreover, respondents may misunderstand or misinterpret questions raised. To tackle this challenge the researcher will translate questions from English to isiZulu.

1.12   Structure of dissertation

Chapter 1: Introduction and research methodology

The purpose of this chapter is to introduce the study, and to provide a sufficient background. Furthermore, this chapter provides a detailed research problem, research objectives, research questions, and conceptual framework. Research methods will be discussed to provide the reader

with the research design and approach used, data gathering techniques, the sampling method, and GIS-based methods. The last two sections to complete the chapter is data analysis, and the structure of the dissertation.

Chapter 2: Theoretical framework and literature review

This chapter provides a detailed theoretical framework by discussing theories explaining informal settlements. Furthermore, existing literature on informal settlements and GIS was discussed.

Chapter 3: Historical background of case study

The purpose of this chapter is to provide the historical background and current status of the study area (Cato Crest). Case study selection and the importance of the study is provided in this chapter. This chapter also serves to provide an understanding of challenges in the study area.

Chapter 4: Research findings, data analysis and interpretation.

This chapter presents findings from data collected. Data is analysed through thematic analysis, and cartographic display (use of GIS).

Chapter 5: Conclusion and recommendations

The final chapter provides a summary of findings and conclusion. Furthermore, recommendations based on the findings are provided.

Chapter 2: Theoretical Framework and Literature review

2. 1   Introduction

The purpose of this chapter is to introduce relevant literature review for the study conducted. This chapter departs by discussing various theories explaining informal settlements. Furthermore, the chapter unpacks GIS, and informal settlements. In light of the above, GIS and informal settlements are different fields of study with separate backgrounds, this chapter attempts to strike a balance between the two, and use pertinent case studies to support the argument. The final component of this chapter discusses the realm of informal settlement within a South Africa context. It is of paramount importance to mention, while GIS has been successfully applied in many fields (such as environmental management, transport, defense and intelligence, business, health and human services, statistics, just to mention a few), it remains limited in the field of informal settlements. A number of studies on the use of GIS and informal settlements have been carried out over a number of years. Nevertheless, the application of GIS in monitoring and evaluating in-situ upgrading projects of informal settlement remains insufficient.

2.2   Theoretical Framework

This section seeks to discuss theories explaining informal settlements and including other key concepts discussed in the conceptual framework. These theories were not conceptualized for the sole purpose of informal settlements, however; their umbrella extends to this phenomena. This section will highlight the following theories: Liberalism, Neo-liberal, and the UTUAT. Furthermore, the concept of poverty is added as part of the theoretical framework as it is vital in aiding the explaining the manifestation root of informal settlements. Lastly, the concept of sustainable development is discussed as it is one of the cornerstone principles on development.

2.2.1   Liberalism

Liberalism advocates have a common ground of believing that freedom or liberty is the key idiosyncratic and the value that every inhabitant must enjoy. Furthermore, it may be argued as a principle of justice that each individual is to have an "equal right to the most extensive basic liberty compatible with a similar liberty for others" (Rawls, 1972: 60 cited in Yengo, 2006). Freedom as

a building block of liberalism advocates for individualism, equality of opportunity, property rights, a free market economy, and a limited State role are of importance (Gerber, 1983).

Thus, in order for liberalism to prosper the state must not be directly involved or concerned with the people's welfare, however; it must seek to establish a workable society founded on values of justice. The primary responsibility of a liberal State is to simply provide and guarantee freedom of all citizens. It is upon the principle of Liberalism that has given rise to the Bill of Human Rights, which are adopted in democratic countries (Yengo, 2006).

In a liberal state, the state's role is to organize housing activities through laws that respect and promote the founding principles of freedom and justice (Rawls, 1972). Housing activities include the responsibility to provide housing finance accessible to all citizens, more especially low-income people. Furthermore, the ability for the state to organize housing activities adequately vests upon its ability to facilitate access to land for low-income people; to provide easy access to land (Payne, 1999).

Moreover, in a liberal state, it is the state's responsibility to 'planning' housing activities as a facilitator and not the primary actor (Yengo, 2006). The state is responsible for providing and actively protecting access to the elements of housing process for users, and these include; laws, land, tools, credit, building materials (Nientied et al, 1988: 11 cited in Yengo, 2006: 13). In addition, planning of housing activities must be guided by principles of fair opportunity in order to uphold the values or principles of Liberalism. Therefore, planning of housing activities should not become a tool used for injustice (such as segregation and discrimination as experienced during the apartheid regime in South Africa).

Regardless of the positive account mentioned above, liberalism is not directly concerned with the people's welfare (Osborne, 1991). People who erect and occupy informal settlements in general lack the necessary tools to formal urban land economies. Laws created by the state do not guarantee equal opportunities to housing activities for all, the rich will benefit more than the poor. Liberalism supports individualism, however; in some cases informal settlement are characterised by child headed households (Posel, 2001). Nevertheless, these children by age (minor) are not eligible to enter the formal urban land market. In relation to housing processes, the inability of poor people to satisfy housing needs is not only as a result of the lack of a house structure only. However, it is

embedded on poverty (to be discussed below). Liberalism in this regard is important to understand as it provides the foundation for Neo-liberalism.

2.2.2 Neo-liberal

This ideology is founded on the principles of liberalism. Its name suggests it is the new liberalism. It advocates for freedom, however; the main driving concept is free-market or free trade (Ntema, 2011). A market centred or driven approach which allows people to trade governed by the theory of supply and demand (Hall and Lieberman, 2004 cited in Yengo, 2006: 18). In contrast to the liberalist view which advocates for limited role in the state, neo-liberals advocate for the non-interference of the government in the economic sphere through privatisation (Colclough, 1991: 19 cited in Yengo, 2006: 18).

The role of neo–liberal state is similar to liberal State, they both maintain freedom as the starting point. However, there is a debate among the two bodies of thought, some neo-liberal suggests the State must not intervene in economic activities at all, on the other hand; some neo-liberals maintain the state should play the role of a referee and create laws (Yengo, 2006). This limited state power is formally known as laissez-faire.

Some neo-liberal defenders have argued there is room for the state, however; the latter should assume the role of being a referee. According to Turner (1972) the state must permit households to address their housing issues themselves, because no one understands real needs of individuals than individuals themselves. On the other hand, some neo-liberal argue the state's role is to create laws promoting and protecting individual's interest. Clearly, according to neo-liberals there is no common ground concerning the role of the state. However, there is consensus that the role of the state must be consistent with 'laissez-fare' principles.

In relation to the housing process, according to neo-liberals it is the state's responsibility to organise the housing process (Yengo, 2006). Nevertheless, the state is to act as a facilitator of the housing process, and not the main actor. Moreover, the process of housing finance, construction, and land acquisition should be open to the market. The state's laissez-fare is evident by the ability to encourage individuals but without forcing them to create and improve housing conditions for themselves. There are a number of global development agencies (which are briefly discussed

below) that have influence over housing policies. These agencies have neo-liberal macro-economic policies that influence the housing development in developing countries.

2.2.2.1 Development agencies

International Monetary Fund (IMF) and the World Bank (WB) are two dominant development agencies which have influenced housing policies internationally by their neo-liberal macro-economic policy (Omenya, 2006). Primarily, the WB and the IMF provide "policy advice, technical assistance and financing to members in economic difficulties as well as ensuring that developing countries achieve macroeconomic stability, caring of environment, develop individual opportunity, tend hope and reduce poverty" (Tshikotshi, 2009: 22). Other agencies (or organisations) that advance neo-liberal policies include: the United Nations Development Programme (UNDP), the UN-Habitat, the United States Agency for International Development (USAID), the European Union (EU), and the Commonwealth Development Corporation (CDC). In addition, there are also a number of African based organizations supporting the aspect of housing, these include: the Development Bank of Southern Africa (DBSA), and the African Development Bank (ADB) (Omenya, 2006).

The IMF and the WB have devices responding to the balance of payment difficulties confronting developing countries by adopting Structural Adjustment Frameworks (SAFs) and Structural Adjustment Programmes (SAPs). The SAFs and SAPs are strategic core tools to assist developing countries by providing loans conditional on the adoption of neo-liberal policies (World Health Organisation (WHO), 2009:1 cited in Tshikotshi, 2009).

Furthermore, SAFs and SAPs are planned to promote the "structural adjustment of an economy by removing excess government controls and promoting market competition as part of neoliberal agenda followed by the Bank (and the IMF)" (Tshikotshi, 2009: 23). Therefore, on a broad scale neo-liberal policies are engineered to reduce state's intervention, promote privatization of public services, social expenditure reduction, currency devaluation, and wage suppression. The development agencies are western countries in nature, and develop policies for developing countries. These policies are developed outside the context of developing countries, for developing countries. Therefore, such an approach is bound to have consequences on the ground for developing countries.

2.2.2.2 Consequence of neo-liberals and development agencies

In developing countries, the rate of inequality and poverty continues to grow as a direct consequence of neo-liberal policies. According to Yengo (2006) in neo-liberal states it is only the elite who have the capacity and potential to perform in markets of good jobs and opportunities. Furthermore, the elite individuals possess the qualities (skills, rich, goods, and services) to be competitive and contribute to the market. On the other hand, the poor lack such qualities and have little or nothing to contribute to the market. Thus, the poor will continue to grow poor.

The growth of informal settlements in developing countries may be argued to be attributed to 'accelerated globalization and structural adjustment policies' (Durand-Lasserve and Royston, 2002), these include: privatization of urban services, deregulation controls, massive state engagement in the urban and housing sector. Consequently neo-liberal policies have accelerated inefficiency, insecure tenure, inequalities, skewed wealth, and resource allocations (Tshikotshi, 2009). Furthermore, the urban poor people lack access to basic services which continues to undermine the socio-economy.

In relation to housing, a neo-liberal state where the state maintains laissez-faire (social services and distance from economic activities), the urban poor excluded from competing in the market find alternative solutions in order to satisfy their housing needs. Informal practices to satisfy the housing need has become a common practice, according to Huchzermeyer (2003) land has been acquired informally. Land invasions become a popular method to acquire land, and informal settlements become housing solutions for the urban poor.

2.2.2.3 Neo-liberal policy in South Africa housing

Historically, in South Africa the housing process was linked with reproduction along racial lines, the end product was townships for Africans, homelands, and white suburbs (Omenya, 2006). Tools used to govern and maintain racially segregated housing process where dominated by rigorous laws and legislation passed. All the laws were equally important, however; a few were absolute imperative to the nationalist with their agenda, these include: the Native Urban Areas Act of 1923, Native Bill of 1936; transfer of African housing to Department of Native Affairs, Population Registration Act No 30 of 1950, and Group Areas Act No 41 of 1950, just to mention a few.

For the purpose of this research, it is of paramount importance to note housing was arranged to facilitate reproduction of African labour in urban areas. Statically, housing was arranged in a controlled environment that would accommodate labourers, therefore; shelter was guaranteed but permanent residence and family was discouraged. This was achieved by the use of single sex hostels, single-room accommodation for domestic workers, and transit camps (Huchzermeyer, 2002).

Post-apartheid, in 1994, the first policy framework was the Reconstruction and Development Proramme (RDP), a political manifesto that "provided the overarching policy framework for subsequent development of wide ranging socio-economic policies" (Omenya, 2006: 67). RDP was employed as a redress strategy, and housing was regarded as a basic human need and right (Huchzermeyer, 2001 cited in Omenya, 2006). Evidently, housing was included in the Bill of Rights in the Constitution.

The ANC led government adopted neo-liberal macro-economic policies from 1996 with the introduction of the growth, employment and redistribution or GEAR program (Goebel, 2007), replacing RDP. Consequences of neo-liberal policies limits state funds for public welfare-oriented programs, thus low-cost housing program is not sufficiently funded (Huchzermeyer, 2003 cited in Goebel, 2007: 293). Informal settlements are a direct result of inadequate housing delivery for the poor, and their location often is of beneficiary to urban poor population socio-economic activities. The inability to enter formal housing markets leads to people finding alternative accommodation; informal settlements become a viable housing solution.

2.2.3 The Unified Theory of Acceptance and Use of Technology

The rapid developments in technology and the continuous changes in the communication channels have altered the way people work and, for many, where they work from (Alwahaishi and Snasel, 2013). The presents of information technologies and computers in today's organizations has increased vividly. According to Westland and Clark (2000 cited Venkatesh *et al*, 2003: 426) since the 1980s, estimates indicate that about "50 percent of new capital investment in organizations has been in information technology". Hitherto, in order for technologies to improve productivity, they must first be accepted and used by staff in organization. User acceptance is often the essential factor, and a vital focus of Information System (IS) implementation research in determining the accomplishment or failure of an information technology product. The availability of information

technology does not automatically lead to its acceptance. The bulk of information systems failures are a consequence of a lack of user acceptance rather than poor quality of the system (Torkzadeh and Angulo 1992, Igbaria 1993, Davis 1993 cited in Alwahaishi and Snasel, 2013).

Attempting to explain user acceptance of new technologies is frequently described as one of the supreme mature research areas in the contemporary information system (Hu *et al*, 1999). Continuous research in this area has consequently resulted in several theoretical models with backgrounds in information system, sociology, communication and psychology that characteristically elucidate over 40percent of the variance in individual intention to use technology (Venkatesh *et al*, 2003).

The Unified Theory of Acceptance and Use of Technology (UTAUT), developed by Venkatesh *et al* (2003), is a comprehensive synthesis model of individual acceptance that is compiled from eight theories or models (Tan, 2013). The eight models are: the Theory of Reasoned Action (TRA), the Technology Acceptance Model (TAM), the Motivational Model, the Theory of Planned Behaviour (TPB), the combined TAM and TPB, the model of Personal Computer Utilization, the Innovation Diffusion Theory and the Social Cognitive Theory (Venkatesh *et al*. 2003). The UTAUT maintains four constructs (performance expectancy, effort expectancy, social factors, and facilitating conditions) together with four moderators (gender, age, experience, and voluntariness of use) that explain influence on behavioral intention to use technology. Here "*Performance Expectancy* is the degree to which the individuals believe that the use of the technologies will results in performance gains. This may also be viewed as the perceived usefulness of the technologies; *Effort Expectancy* it the ease of use of the technologies; *Social Factors* it the extent to which the individuals believe that important others believe that they should use the technologies; *Facilitating Conditions* is the perceived extent to which the organisational and technical infrastructure required for the support of the technologies exist" (Thomas et al, 2013: 73). According to the UTAUT model, performance expectancy, effort expectancy, and social factors have direct effects on behavioural intention, which along with facilitating conditions have direct effects on use behaviour (Venkatesh *et al*. 2003).

In a general sense, GIS is a computer system that is used to integrate and present all geo-referenced data, attached to many operations and applications, and relates unrelated information through utilizing location as the key index variable. GIS has been accepted at an individual to

organizational level, evidently through its wide implementation or application in many disciplines (Chang, 2010). GIS has been advanced in other disciplines (such as military, transport, hydrology, climatology, etc) to an extent its application may be custom-designed intended for a particular organization (Bolstad, 2005). However, the application of GIS in informal settlements remains unsatisfactory. It is maintained in Alwahaishi and Snasel (2013) that in developing countries, it is the lack of top management support and capital resources that stand as barriers in information technology adoption and advancement. In order for GIS to extensively be adopted as a strategy to combat informal settlements (and yield improved productivity) it must be fully accepted by organizations (such as municipalities) and its employers.

2.2.4   Concept of Poverty

The concept of poverty is broad and is understood differently from different perspectives and context. For the purpose of this research, poverty is defined using the understanding of the WB. According to the World Bank Poverty is hunger, lack of shelter, being sick and not being able to see a doctor, not having access to school and not knowing how to read, not having a job, is fear for the future, living one day at a time, losing a child to illness brought about by unclean water, powerlessness, and lack of representation and freedom (http://web.worldbank.org)**.**

Different schools of thought have recognized a close connection between poverty and underdevelopment. From a liberal perspective, poverty is understood as the lack of income; Marxist perspective, poverty is understood in relation to production; dependency theory understands poverty through comparing developed and undeveloped countries, "underdeveloped countries are dependent and developed countries are autonomous"; and modernization theory understands poverty as a result of some countries lacking modern economies, institutions, cultures, and psychological traits (Yengo, 2006: 32-33).

The inability of people to satisfy their basic housing need is poverty. Lack of formal adequate income excludes poor people from the housing market. Inevitably, it should be the responsibility of the state to intervene ensuring citizens have access to the most basic housing. The South African government has attempted to provide low-cost (RDP) housing for the poor. However, because of globalization factors demand for adequate housing remains relatively high, and the state is not able to meet its targets, as approximately 15 000 houses per year are being built, and approximately 7, 35 million people continue live in informal settlements (Thomas, 2010). Consequently, people

seek alternative shelter to satisfy their basic housing need. This alternative shelter comes in the form of informal settlements through (and) land invasions (Zeilhofe and Topanotti, 2008). Thus, informal settlements are directly developed as a reaction to poverty.

2.2.5   Concept of Sustainable Development

Sustainable development is a result of a merger of two paradigms; growth and development, and environmental movement (Irurah and Boshoff, 2002). Growth and development paradigm is grounded in economic growth, on other hand; environmental movement is on the realization environmental degradation and resources are finite. Our Common Future – also known as the Brundtland Report - was published in 1987, coined and defined sustainable development as *"development that meets the needs of the present without compromising the ability of future generations to meet their own need"*. The report gathered different issues and launched a comprehensive gateway to sustainability, which includes social, economic, political and environmental criteria (pillars).

BNG introduces the principle of sustainable human settlements, it is upon this ideology that in-situ upgrading of informal settlements is founded; to create sustainable settlements. It is argued in Sowman and Urquhart (1998) in order for housing to be assigned a sustainability status it has to conform to these main requirements: environmental, economic, social, and technical sustainability. All pillars of sustainable development must be balanced, nevertheless; in some cases the environmental pillar is neglected and not given priority compared to economic pillar. Therefore, sustainable human settlements could remain a fantasy if it is not applicable in real life situations.

Ecological sustainability means developments must conserve both renewal and non-renewal resources, at the same time pollution produced must not occur at a rate faster than it can be absorbed; thus avoiding environmental degradation and damage. Economical sustainability means there must be a balance between initial capital and maintenance costs, and also it must be affordable and accessible by all stakeholders. Social sustainability refers to promoting community participation along with well-being of beneficiaries. Lastly, technical refers to technology used must be sound and not degrading to the environment (Sowman and Urquhart, 1998). Therefore, the use of GIS covers the technological aspect of sustainable development.

Community participation is a fundamental requirement concerning sustainable development (Sowman and Urquhart, 1998). It is of utmost important for people concerned to be fully involved in all stages of the development (from planning, decision making, to implementation, etc.), not just informed, however; engaged in all processes as they will be affected directly. Community participation is the crux of sustainability, prior to the pillars of sustainable development. It permits the people affected to be involved in their development and maintenance. Furthermore, participation of the all stakeholders involve improves the ratio in which sustainable development can be achieved. Community participation has a direct influence to the social pillar (Sowman and Urquhart, 1998).

In South Africa, early provisions of low-cost housing were simply bureaucratic (top-down approach) lacking the aspect of community participation (Jenkins, 1999). The authorities took decisions on behalf of people affected. Crucial decisions such as location, typology, size, etc, where decided at the top. This approach simply was concerned with the delivery of structures to the people in need of a top structure. Consequently, this bureaucratic approach proved to be unsustainable in the aspect of continuing the legacy of apartheid concerning housing delivery. Locations of new houses remain unchanged as new houses were placed in ghettos on urban peripheries, far from jobs and services (Seekings, 2000).

2.3   Historical background of Geographic Information System

According to French (1998 cited in Nour, 2011) GIS was pioneered as an environmental technology, in the 1960s (Yeh, 1991). It is only in the 1990s that GIS started to expand becoming viable for a wide range of business operators as it became available on personal computers. Early adopters of GIS were industries with geospatial needs with proper financial backing, these included transportation companies, logistics companies, and public utilities (Chrisman, 2006). Nevertheless, GIS is now adopted in a broad spectrum of disciplines. Furthermore, it is different from information systems as it has the ability for cataloguing spatially referenced objects in the context of a map (Obermeyer and Pinto, 1994). According to Nour (2011: 284) it is argued GIS has long been valuable technology for communication and collaborating in decision making for "effectively managing resources and assets, for enhancing the efficiency of workflows, for improving the accessibility of information, and generally offering tangible cost savings to

organizations both large and small". Furthermore, GIS may be manufactured and presented in the form of three idiosyncratic but overlapping views; these are map (emphasis on cartographic aspects), database management systems (DBMS) (emphasis on the importance of an adequately designed and implemented database), and spatial analysis views (emphasis on spatial analysis) (Maguire and Raper, 1990). This empowers GIS to be an advance technological tool capable of answering spatial queries. The followed section is structured in a manner to enable the reader to better understand GIS and the components which make it function at an optimal level. GIS functional tools will are discussed, and the importance of the former. Then after, GIS will be contextualized into the subject at hand.

2.3.1 Data Models

According to Longley *et al* (2011) a data model is the core of GIS, is it a set of constructs for representing, describing selected aspects of real world in a computer and processes. The representation of geographic features in a GIS is crucial as it permits the earth to be studies and various analysis implemented. GIS models have been developed for the past half-century, all based in some way on the conceptual discrete object/field and logical vector/raster geographic data models (Longley *et al*, 2011). Several main data models can be identified: computer aided design (CAD), computer cartography, image processing, raster, and vector.

CAD is an earliest data model used in a GIS (Robinson, 1995). It used simple graphic symbols to represent real world features as points, lines and polygons. However, this model had major problems to be used widely in GIS; features did not have unique identifiers thus not easy to have attributes, it only used a local coordinate system instead of world coordinate system, and lastly it did not offer storage for relationships because it focused primarily on graphic representation. With all the above mentioned, CAD is still widely used today in engineering, computer design, survey and architecture (Bagron and Skelton, 2010).

Cartography, 'the art, science and technology of making maps, together with their study as scientific documents and work of art" (Tyner, 2010: 3), fused with computers gave birth to computer cartography. This model used in a GIS focused on the reproduction of maps in-which paper maps were digitized, converting data from analog to digital format (Chang, 2010). Furthermore, computer cartography had the ability to store entities as point, line and polygons (Longley *et al*, 2005). However, computer cartography had the same disability as CAD; it did not

have a requirement to have attributes. Relationships and information about features on the map could not be identified and compared to each other. The last data model developed in the early phases of GIS is image processing. Aerial images and digital satellite images were scanned, and represented by a grid system; in addition these real world features could be from photographs and (or) pictures (Longley *et al,* 2005). This meant a GIS user could now work with images, and having a sense of attribute dealing with real-world photographs.

2.3.2   Raster

According to Esri (2008) a raster data model consists of a matrix of cells, also known as pixels (figure 1, pp 33). They are organised into rows and columns, properly known as a grid, each cell containing a value that corresponds to the characteristics of a spatial phenomenon at the cell location; with rows functioning as y-coordinates and columns as x-coordinates (Chang, 2010: 65-66). Furthermore, raster data works best with spatial phenomena that vary continuously over space (for example elevation and precipitation). A large quantity of data is coded in raster proving the possibility of performing a number of analysis; this includes satellite images, digital orthophotos, graphic files, digital elevation data and scanned maps. Lastly, raster data demands large amounts of storage, a user must have the proper adequate hardware, and software to meet the required storage capacity (Chang, 2010). Data is stored by dividing a raster into rows, columns, and cells; solving a problem earlier data models struggled addressing the issue of storage.
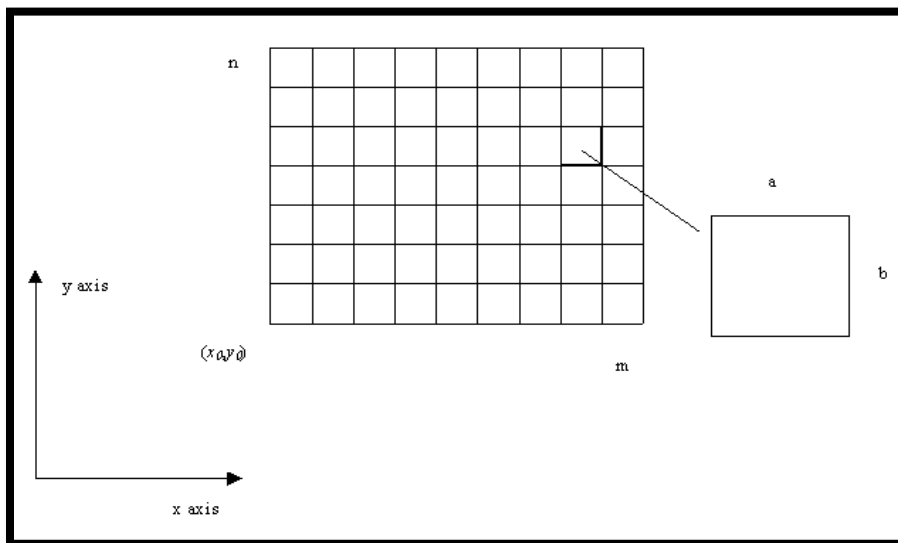

Fig 1. Rasta grid (source: Esri, 2008)

Early data models primarily focused on graphic representation of objects, neglecting to store details about relationships between represented objects. Raster data has the capacity to store represented objects, with their metadata (information about information). Metadata provides information about geospatial data, typically includes the projection, geographic coordinates, cell size, number of rows and columns; just to mention a few. Most importantly raster data provides the platform to establish relationships between objects represented, crucial analysis with the ability to reveal unforeseen relationships and patterns (Longley *et al,* 2011).

Raster data may be represented as a point, line and polygon (figure 2, pp 35). A point is represented by a single cell, line is represented by a sequence of neighbouring cells, and polygon is represented by a collection of contiguous cells (Chang, 2010). Furthermore, a cell contains a value that corresponds to the characteristics of a spatial phenomenon, there are two types of raster cells; integer and floating point (Chang, 2010: 66-67).

'Integer cell values usually represent categorical data, which may or may not be ordered. A land cover raster may use 1 for urban land use, 2 for forested land, 3 for water body, and so on. A wildlife habitat raster on the other hand, may use the same integer number to represent ordered categorical data of optimal, marginal, and unsustainable habitats. Floating-point cell values represent continuous, numeric data. For example, a precipitation raster may have precipitation values of 20.15, 12.23, and so forth'.

Raster is a cell based model, and the size of an individual cell is of utmost important as it determines the resolution. A small cell has a fine spatial resolution, the potential of representing the precise location of spatial features (Chang, 2010). Moreover, it is also imperative for raster data to be spatially referenced. Data must be based on the same coordinate system so it can align spatially with other data sets. Lastly, a processed raster to match a projected coordinate system is called a georeferenced raster (Chang, 2010: 68).

Data stored in a raster can be represented in a thematic or continuous format and pictures. Thematic data, also known as discrete, discontinuous, categorical data represents objects with known and definable boundaries; for example a lake, building, and road. On the other hand, continuous data, also known as non-discrete or surface represents "phenomena in which each location on the surface is a measure of the concentrate level or its relationship from a fixed point in a space or from an

emitting source" (Esri, 2008), for example temperature. Lastly, the nature of a raster is most suitable for representing continuous data, instead of discrete.

According to Chang (2010: 65) raster require large amounts of memory, simply because data storage and retrieval are important to a raster user. In some cases a user is forced to store as a raster for example, imagery may only be stored as raster. However, it is useful storing as a raster for a number of reasons, these include: the aptitude to represent continuous surfaces and perform surface analysis; the ability to uniformly store points, lines, polygons, and surfaces; the capability to perform fast overlays with complex datasets; a powerful format for advanced spatial and statistical analysis; a simple data structure, a matrix of cells with values representing a coordinate and sometimes linked to an attribute table (Esri, 2008).
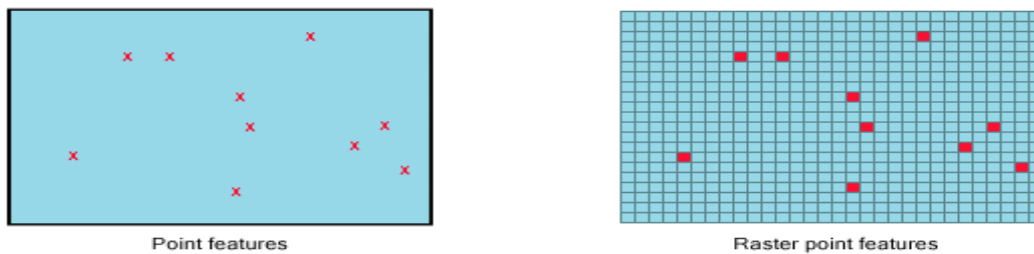
Fig 2.a. Raster point features (Source: ESRI, 2008)
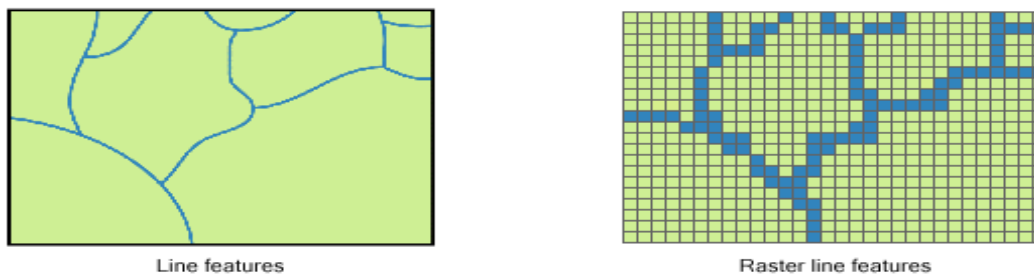
Fig 2.b. Raster line features (Source: Esri, 2008)
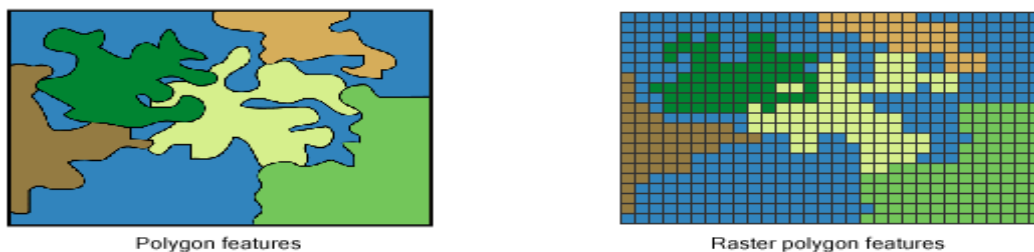
Fig 2.c. Raster polygon feature (Source: Esri, 2008)

2.3.3 Digital Elevation Model

Digital elevation model (DEM) (as represented by figure 3, pp 36) is the digital representation of the topography, input data model, with a grid or raster structure normally consisting of a matrix of square grid cells with the mean cell elevation stored in a two dimensional array (Garbrecht, 1999). Moreover, DEM is less subjective, faster and provides more reproducible measurements than traditional manual techniques applied to topographic maps. Lastly, a DEM is important because it can be readily imported and analysed by a GIS.

DEM data captured consists of an array of uniformly spaced elevation; it is point based, and must be converted into a raster prior to analysis. Furthermore, there are several techniques used to capture data; sources for capture include satellites, radar data, LIDAR (Chang, 2010: 269). LiDAR data in terrain mapping have high quality resolution providing DEMs with a spatial resolution of 0.5 to 2 meters and a vertical accuracy estimated around 15 centimetres (Chang, 2010: 269). In addition, LiDAR provide detailed topographic data suitable for a number of studies; water resource, ecosystem, forest structure, telecommunications, just to mention a few. Output in a GIS is as good as input, thus high quality detailed data will provide sound analysis.
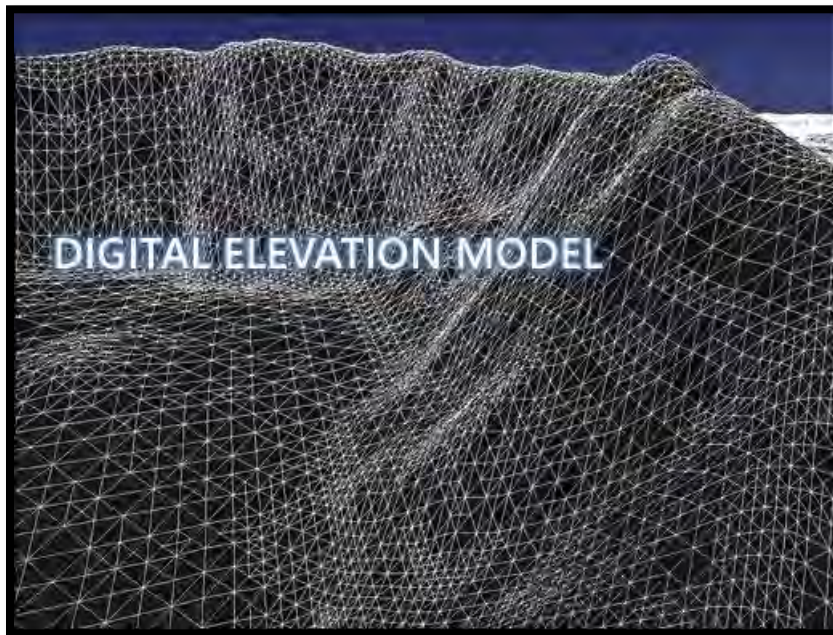
Fig 3. Digital Elevation Model (source: www.microsoft.com)

2.3.4 Vector

According to Longley *et al* (2011: 214) vector data model are the mostly widely implemented in GIS, furthermore; because vector data is closely linked with the discrete object view it provides the foundation for a number operations. Vector data uses points and their x- and y- coordinates to represent spatial features precisely (Chang, 2010:41). Spatial features are represented as simple points, lines, and polygons (figure 4, pp 38). A point can represent a town hall, and is recoded as single coordinate pairs; a line represents linear features, a road for example, and it recoded as a series of ordered coordinate pairs; polygon represents closed body feature, country for example, and recoded as one or more segments that close (Campbell, 1991).

Spatial features in a vector are represented x-y coordinates, suggesting it is two dimensional. However, a z- value may be added to a vector, used to represents height. Moreover, an m-value may also be added, used to represents time or other properties needed to be represented in a data set (Longley *et al*, 2011). Spatial features in a vector may be represented in simple features, as already mentioned a point feature may be used to represent a building, or a country on a large scale map. A point is zero dimensional with only the property of location, on the one hand; a line is one dimensional with the property of length in addition to location, used to represents road, rail line, stream, just to mention a few . Lastly, a polygon is 2-dimensional with the property of area and perimeter in addition to location, a closed connected line segment to represent features such as a political boundary (Chang, 2010).

Simple features can also be topological or non-topological, the science and mathematics of relationships (Longley *et al*, 2011). Furthermore, topology is used to 'validate the geometry of vector datasets, and for certain types of operations'. In Chang (2010) it is discusses topology as a study of those properties of geometric objects that remain invariant under certain transformations such as bending or stretching. In GIS it is clear that topology focuses on geometric objects, such as checking if polygons close. Made possible by the graph theory (see Chang, 2011: 43) making vector data model as diagraphs which includes points called nodes, and lines called arcs; arcs are joined at nodes. Topology is advantageous on the aspects that it ensures data quality and integrity, and it has the ability to enhance analysis in a GIS (Chang, 2011).
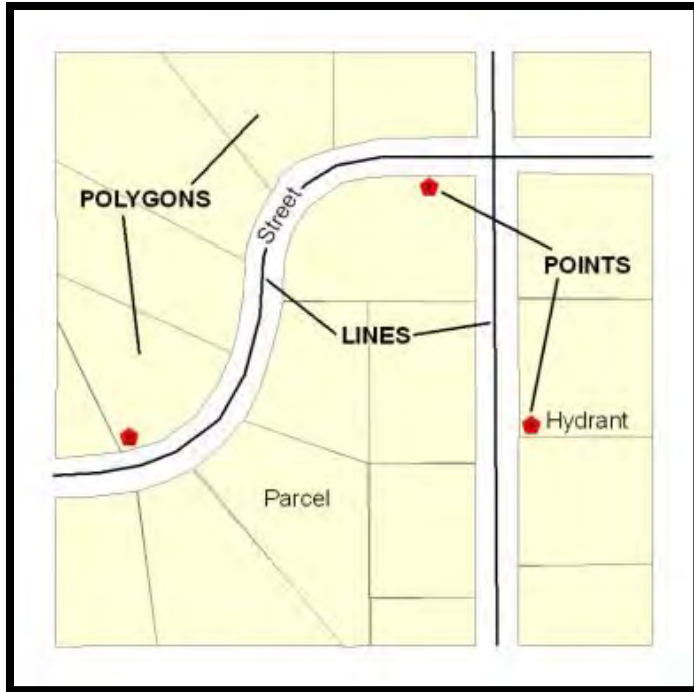
Fig 4. Vector data model (source: gisedu.colostate.edu)

Storage in a GIS is of utmost importance, vector data is mostly used also because it provides better efficient, and less demanding storage. Vector data model employs the georelational data model which stores geometries and attributes separately in a split system (Chang, 2010: 46). Geometries are held in graphic files, on the other hand; attributes in a relational database, using a feature ID to link the two components. Lastly, geometries and attributes must be synchronised to be able to be queried, analysed, and displayed together; offering the ability to be used for a large number of purposes (Chang, 2010).

2.3.5 Network

Longley *et al* (2011) identify a network data models as a special type of topological feature model. Networks are used for a wide variety of applications, for example; to represent the 'flow of goods and services'. Furthermore, two types of networks are introduced, radical and looped. Radical network have a flow pattern which has an upstream and downstream (Longley *et al*, 2005), thus flowing to a certain direction depending on variables determining flow; storm drainage system is an example. On the other hand, looped network has intersections; an example would be a street network with streets joined at intersections. In addition, in a GIS networks are represented as points

and lines. Points could be used to identify intersections, on the other hand; lines representing streets.

Network data model is also important in route or linear networks, which are features such as a road, stream, or bus route. However, a route network is different from other networks because it has a measurement system that allows linear measures to be used on a projected coordinate system (Chang, 2010). A transport agency might prefer route network as it has the ability to measure from a known point, such as a road; thus possible to calculate time to a desired destination. Lastly, network is commonly used in shortest path analysis used to find the shortest route between an origin and destination, used mainly in navigation for example. Connected by topology arcs do not break or just end, they are joined at nodes.

2.3.6 Triangulated Irregular Network

Triangulated irregular network (TIN) is a data model which depicts geographic surfaces as a contiguous no-overlapping triangles, created from a number of points which are x, y, and z coordinate values (Longley *et al*, 2005). This then suggests a topographic surface is represented by several triangles joined at nodes only (figure 5, pp 39). Moreover, TIN is used to achieve a true 3-dimention; such as elevation for example. TIN approximates the land surface with its triangles, using irregular distribution of elevation (z-value) points (Chang, 2010). Primary data source for TIN is a DEM, however; there are various other techniques used to capture data. They can be listed as follows; global positioning system (GPS), contour lines, breaks lines, survey elevation points and LIDAR data.
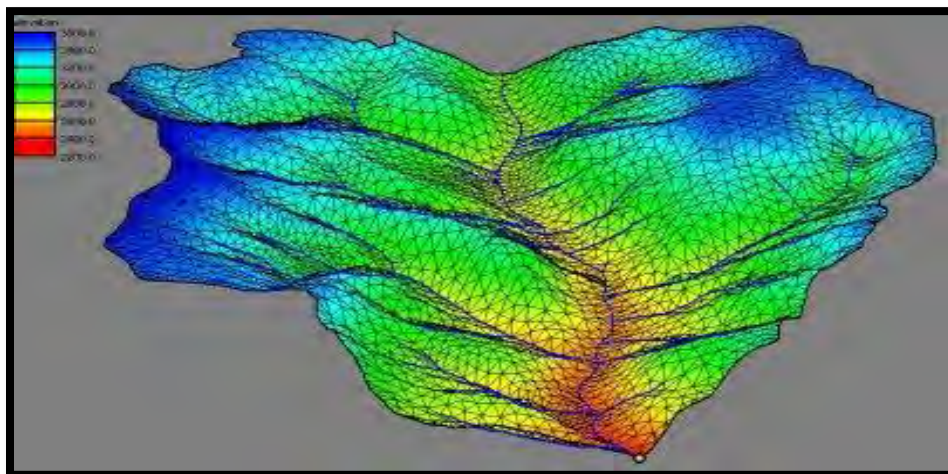
Fig 5. An oblique view of a TIN (source: www.xmswiki.com)

TIN is a useful model, contributing much to GIS. Linear features, stream, ridge, roads, shorelines for example; are more accurately represented using TIN. Furthermore, only points needed to represent the terrain are selected, with fewer points needed to represent the topography; thus less storing space. In addition, accuracy is achieved through-out, points are concentrated on important areas or where details are required (Chang, 2010). TIN may only be used in a vector, which spatial features are represented as point, line, and polygons; x-y coordinates, latitude and longitude are assigned to locate features. Thus data is two dimensional, however; a z-value can be added to identify height or elevation, making data 3 dimensional (Longley *et al*, 2005). Lastly, the structure allows for easy elevation calculations.

Important selected points to be represented are generated through algorithms, very important points (VIP) in ArcInfo; and the most popular, maximum z-tolerance (Chang, 2010). Furthermore, points are selected from an *"elevation raster to construct a TIN such that, for every point in the elevation raster, the difference between the original elevation and estimated elevation from the TIN is within the specified maximum z-tolerance"* (Chang, 2010: 270). In other words; a maximum z-value is set, any smaller z-value is acceptable.

2.3.7 Location

The ability to show location accurately on the earth's surface is the heart of a GIS. Geographic location is the primary distinguishing variable of GIS compared to other information systems; it provides the grounds to map, to tie different kinds of information together because they refer to the same place, the ability to measure distances and area, and the process of assigning location to information is georeference (Longley *et al*, 2011: 124). There are several techniques used to identify location, simple techniques such as place names, postal address, IP addresses, just to mention a few; on the other hand, techniques can be based on various kinds of measurements and are named metric reference, most common being longitude and latitude (Longley *et al*, 2011). Lastly, is it discussed in Chang 2010) latitude and longitude serve as the baselines of geographic coordinate system, which is a location reference system for spatial features on the earth's surface.

2.3.8 Longitude

Longitude is an angular line, and a line joining places at equal longitude is a meridian, collections of these lines are known as meridians. The prime meridian passes through Greenwich, England; at

this point it is given the value of zero degrees, ranging from 180 degrees west to 180 degrees east. Thus possible to measure the earth; identify a location point as 0 – 180 degrees east or west of the prime meridian (Chang, 2010). In a GIS longitude values are equivalent to x-values, it is suggested in Longley *et al* (2011) because computers are designed to handle numbers ranging from very large and negative, to very large and positive. Longitude values are represented with positive signs in the eastern hemisphere, and negative in the western hemisphere.

2.3.9   Latitude

The equator is an angular line known as a parallel, showing places of equal latitude. There are more lines of equal latitude, known as parallels. The equator is given the value of zero in degrees, thus one can measure the latitude value of a point from 0 - 90 degrees north or south of the equator (Chang, 2010: 19). Furthermore, in a GIS latitude values are equivalent to y-values. Lastly, latitude values are represented with positive signs in the northern hemisphere, and negative in the southern hemisphere.

2.3.10 Map Projection

Map projection is the process of transforming the spherical earth's surface resulting in a systematic arrangement of meridians and parallels on a plane surface representing the geographic coordinate system (Chang, 2010: 23), as demonstrated in figure 6, pp 42) . A necessary process in order to represent spatial features, because the earth's size and shape in reality is enormous it must be approximated to be modelled in a GIS for a number of applications. The transformation from the earth's surface to a plane has distortion which cannot be avoided. One might simply choose the property to preserve.
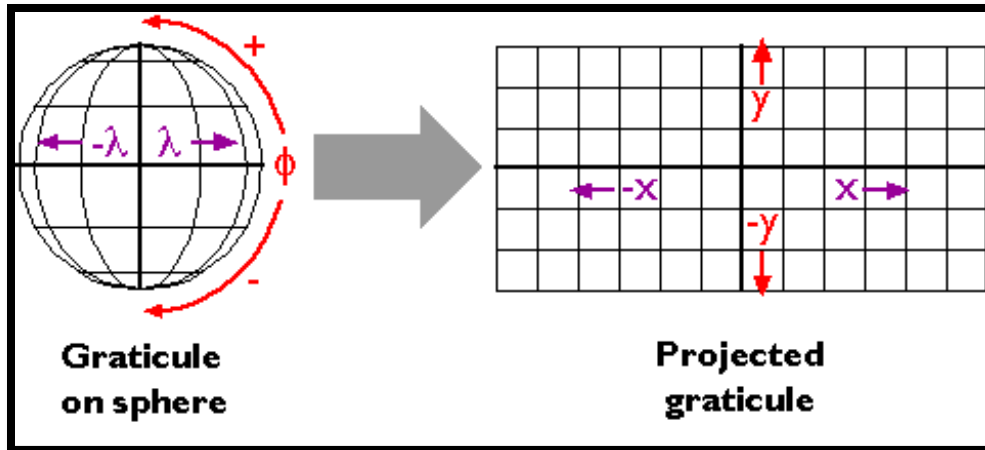
Fig 6. Map projections are mathematical transformations between geographic coordinates and plane coordinates (Source: www.e-education.psu.edu)

Map projections may be grouped according to the property they preserve; conformal, equal area or equivalent, equidistant, and Azimuthal (Chang, 2010:23-24). Conformal preserves local angles and shapes, equal area preserves area in correct relative size, equidistant preserves distance along certain lines, and Azimuthal preserves direction accurately (figure 7, pp 42). Moreover, map projections may also be classified by "analogy to a physical model of how positions on the map's flat surface are related to positions on the curved earth" (Longley *et al*, 2011). The popular identified classifications are cylindrical, conic, and planar projection surface. The most popular used projection is the Universal Transverse Mercator (UTM) (figure 8, pp 43).
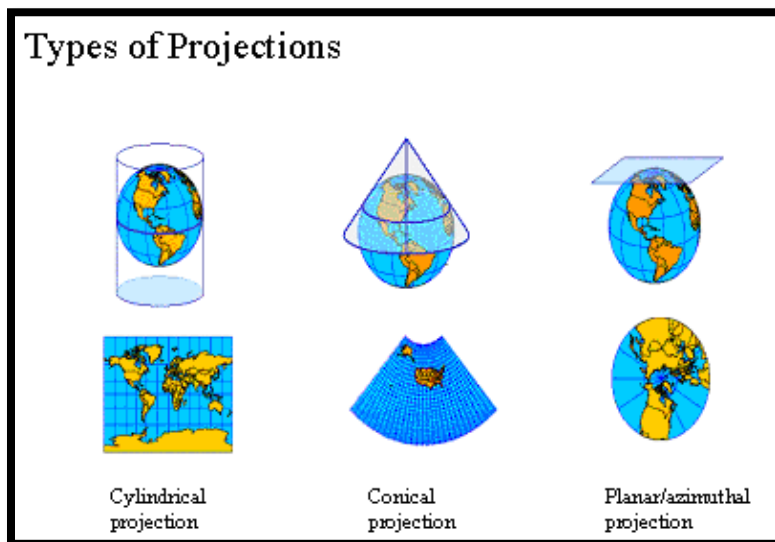
Fig 7. The different types of map projection (source: www.naarm.ernet.in)
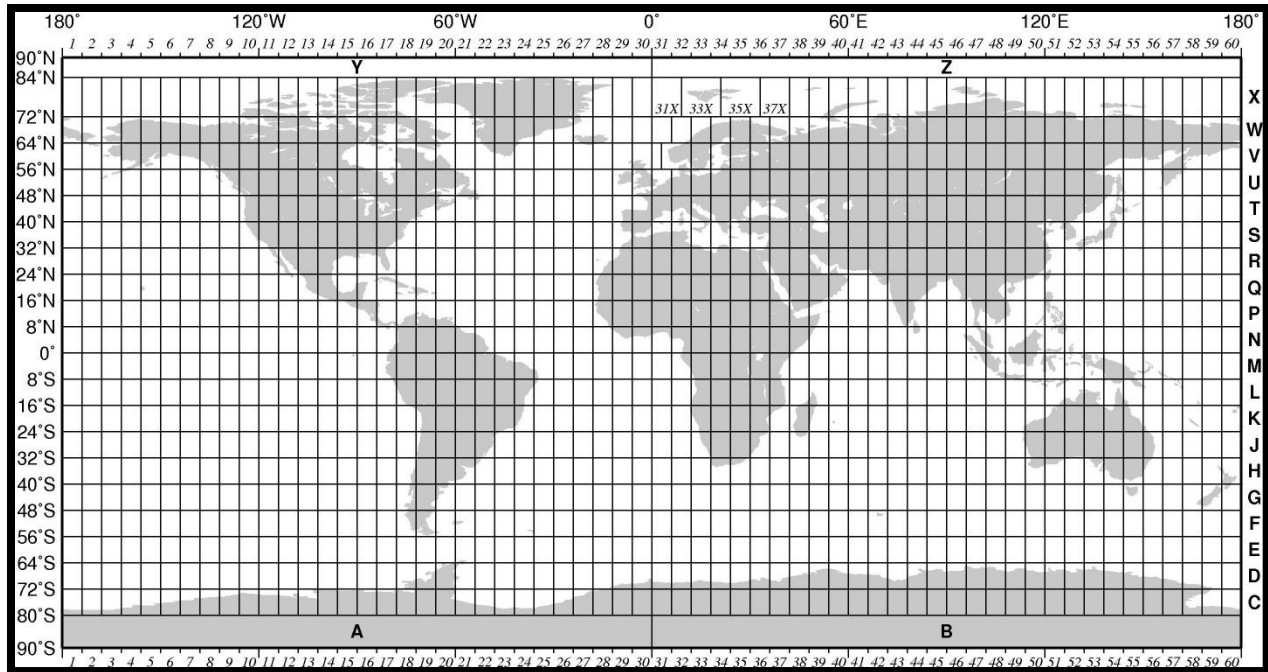
Fig 8. Universal Transverse Mercator zone layout (source: www.beamreach.org)

2.3.11 Spatial analysis

Spatial analysis (a set of methods whose result change when locations of the objects being analysis change) is the crux of GIS, it includes all the 'transformations, manipulations, and methods that can be applied to geographic data to add value, support decisions, and to reveal patterns not immediately obvious'. Additionally, it includes the processes of turning raw data into useful information which can be used for various applications (Robinson, 1995). Spatial analysis can be categorized into six types: queries and reasoning, measurements, transformations, descriptive summaries optimizing, and hypothesis testing (see Longley *et al*, 2001).

2.3.12 GIS application

All the above mentioned elements combined enables GIS users to capture, store, analyse, manage spatially referenced, and present data. Data can be collected in vast quantities using various methods such as topographic surveys, remote sensing satellites, transection loggers, population and market surveys, and other methods. Most of the data has explicit (this could be a latitude/longitude coordinate) or implicit (this could be the name of a town, or a physical feature such as a lake) geographical reference allied with them. In most cases, it is possible to stem an explicit reference from an implicit reference. This geographical reference has proven as an

effective means of linking data sets composed (Maguire and Raper, 1990). This attribute of being able to link multiple datasets, link geographic data with descriptive information, and reveal relationships, perhaps is one of the leading reasons that make GIS a successful tool.

GIS is a tool that can be applied to different type of questions. According to Rhind (1990) there are types of generic questions which GIS are habitually used to investigate, these are: location, condition, trend, routing, pattern, and modelling. This permits GIS to be applied in many disciplines. There is no shortage in literature documenting successful GIS application in many disciplines for similar to different reasons. GIS is commonly used in environmental management.

In the case of Tavares *et al* (2008) GIS is used to optimize the routes used for solid waste management, consequently; this reduces carbon dioxide ($CO2$) emissions and financial resources (such as fuel). In the case of Wilson (2007) GIS is used by analysts and law enforcement agencies in crime mapping to visualize crime incident patterns. It is an important policing strategy which permits authorities to identify crime hot spots, and patterns and trends are revealed. Another case is in Harris and Elmes (1993) successfully using GIS in urban and regional planning. GIS is also successfully used to process remote sensing data (see Jensen, 2007). In the case of Girish Kumar *et al* (2009) is it clearly articulated GIS has become an important tool in hydrology and management of water sources. In this case, GIS is further used to manage surface and groundwater levels through the use of DEM data models. GIS is also used by financial institutions to enhance understanding of risks, customer communication, economic conditions through the use of spatial models, improve lucrativeness and operational performance by sharing knowledge based decisions across departments (www.esri.com). This study has demonstrated with a handful of cases that GIS is a successful tool applicable in multi disciplines. It enables better decision making platforms for relevant authorities through its ability to link geographic information with evocative information.

2.4   Informal Settlements

During the 19th century industrialization in Britain, there was rapid urban change coupled with class formation which resulted in inequalities in residential conditions. Early factories were situated in low-lying locations adjacent to canals, and housing for workers was often situated nearby waterlogged land (Cowie, 1996 cited in Huchzermeyer, 2011). These settlements were

characterized by damp, overcrowding, dark, unhealthy and cramped accommodation conditions. Therefore, the word 'slum' comes from the 1820s, derived from the word 'slump', which was used to refer to these inadequate housing conditions (as mentioned above) (Huchzermeyer, 2011).

Be that as it may, today the term 'slum' is defined differently with different meanings according to different contexts. For example, in Kenya the term is used to characterize "unplanned settlements that accommodate the urban poor" (Huchzermeyer, 2011). In the city of Nairobi, 'slums' are commercialized, predominantly residents are tenants, whereas, owners of structures are rich person(s) connected politically who do not reside in these settlements (COHRE, 2005). In Kisumu (city in Kenya), 'slum' refers to settlements that contain a mixture of tenants and structure owners, landlords tend to be residents themselves (Huchzermeyer, 2011). In India, 'slums' refer to highly populated shack settlements that are occupied by owners with little prevalence of rental tenure. In Abuja (capital city of Nigeria), 'slum' refer to "informal expansion of indigenous villages that preceded the formally planned city" (Huchzermeyer, 2011: 6).

For the purpose of this research, it is of paramount importance to differentiate between 'slum' and 'informal settlement', even though there is substantial overlap between the two terms, they have different meanings. Simply put, 'slum' refers to the physical housing condition, and 'informal settlement' refers to the legal standing of the settlement (Ley, 2009). It is further stated in Tredoux (2009), informal settlements may also be characterized by crime and social stress. According to Abbott (2003, 2), informal settlements are characterized by people who reside on a portion of land without legal tenure and the settlement is outside formal planning processes, consequently such settlements lack basic services such as sanitation, water, and are constructed from basic materials Furthermore, it is stated in Jenkins (2006) informality may be defined by activities that are not regulated by government in any form. The term 'slum' has negative connotations on an international and academic sought to move away from the former (Massey, 2013). In a South African context, a clear departure from apartheid terminology, conscious and policy was strongly advocated for in 1994. Consequently, this included the term 'slum' and 'squatter camps' to be replaced by 'informal settlement' (Huchzermeyer, 2011).

2.4.1   Approaches to Informal Settlement Upgrading

Informal settlement upgrading is rather a complex process which may unfold through different approaches. The first approach is 'relocation', it involves the demolishing of the existing informal

settlement and the residents are relocated to a suitable greenfield location. This approach originates from the 19th century in Britain and continued to be the central methodology right up until the late 1970s (Maylam & Edwards 1996 cited in Massey, 2013: 14). According to Abbott (2002) this approach was used in developed countries, and it proved to be a successful solution. Notwithstanding, there is historical evidence, in a South African context of the demolition and relocation approach during the apartheid era. While there are many cases, the most commemorated are District Six in Cape, demolished between 1968 and 1980, residents relocated to the Cape Flats; Sophiatown in Johannesburg, demolished between 1955 and 1968, residents relocated to Diepkloof and Meadowlands in Soweto (Brodie, 2008 cited Huchzermeyer, 2011: 8); and Cato Manor in Durban, demolished between 1958 and 1960, residents relocated to Chesterville, Umlazi, Kwamashu Merebank, Phoenix, Chatsworth, (Maylam and Edwards, 1996 cited in Cele, 2010: 10). This approach is best utilized when the settlement location is not suitable for development or habitable.

The demolition and relocation approach implemented in developed countries was successful in their own context. On the other hand, developing countries faced an escalating rate of urbanization, overcrowding, and growth of informal settlements. Thus, the demolition of informal settlements and replacement by public housing approach was not fit to be adopted in developing countries. Seeking to find an adequate approach to address the challenge of informal settlements, during the late 1960's and early 1970's John Turner and other authors focus on the concept of incremental housing (Abbott, 2002), and autonomy (Turner, 1976). They argued, and advocated for 'dweller control', stating that when residents are part of major decision making processes and at liberty to make contributions to the development of their housing, this environment enables the stimulation of individual and social well-being (Fichter *et al*, 1972).

The second approach is 'in-situ upgrading', it is the process undertaken to improve an informal settlement in its current location through the provision of access to basic services and secure tenure to people (Pikholz, 1997). It also involves the recognition of three condition: "the property rights, the property values and physical attributes of the underlying assets, and their impact on each other" (Mukhija 2002 cited in Tshikotshi, 2009: 33). Therefore, in-situ upgrading is a holistic approach that focuses on legal aspects, and improving living conditions and services. Furthermore, settlement upgrading is more appropriate in responding to poverty, vulnerability and social

inclusion (Huchzermeyer, 2006). In-situ upgrading of informal settlements is a people driven initiative, the people have chosen their desirable location for housing which favours mostly their socio-economic engagements and close to transportation networks.

There is evidence that in-situ upgrading of informal settlement approach does not only focus on the physical attributes of a settlement, it also has positive implications on the social well-being. In a study conducted in India, through the provision of piped water, the incidence of Cholera diseases affecting children witnessed a reduction (Jalan and Ravallion, 2003). In Mexico, settlement upgrading through the provision of cement floors helped to reduce sicknesses related to dirty floors that were once found on the settlement (Cattaneo *et al*, 2007). The provision of legal tenure status in Peru through a property titling programme provided households with emotional and mental stability, and encouraged investments in their livelihood ventures (Field, 2007). This is to display a significant connection between in-situ upgrading of informal settlements and socio-economic development (and well-being) of informal settlement dwellers.

2.4.2 Methods to In-situ Upgrading of Informal Settlements

On a global scale, there are dominantly two methods into upgrading of informal settlements: community-based and technological solutions. The one group originates from the Indian Sub-continent, it advocates for community-based initiatives through NGO partnerships (Huchzermeyer, 1999 cited in Abbott, 2002: 305). This method unfolds through active community participation and private-public partnerships. It has the ability to place power in the communities that are to be upgraded. Communities are built by its residents, thus it is imperative that people are included in the planning processes in order to make decisions about their settlement, as they are directly affected (Fyhr, 2012).

In 2008 in Pune, a city in India, Yerwada slum (informal) settlement was upgraded through intensive community participation, and fruitful private-public partnerships. To uphold the principle of community participation, NGOs distributed documentation to residents to be signed, the community had to give consent to the upgrading of their settlement. Most importantly, community members were actively involved in decision making process, notably from the planning (design) phase (Fyhr, 2012). In Mathare 4A, an informal settlement in the City of Nairobi, Kenya, was upgraded through a people-centered and holistic approach instead of the traditional top-down approach. The upgrading commenced in 1993 as a pilot project through public-private

partnerships with emphasis on community participation (Diang, 2012). While there are many cases of informal settlement upgrading through community based initiatives, the above examples merely serve as an illustration that this method to some extent can be applied successfully.

The second method, the technological solution originates from South America, and is dominantly used and supported in Latin America (Abbott, 2002). Common techniques include remote sensing, aerial photography and geographic information system (GIS); used mostly for change detection, land use management and planning, and database management (Zeilhofer and Topanotti, 2008).

The two methods have proved to be a success on a small scale, however; on a large scale they are insufficient because they are not duplicable. In the case of community-based initiatives, communities are not the same (Abbott, 2002). They may share certain characteristics (such as poverty) but are made up by different individuals with different needs and desires. On the other hand, technological approach is centered exclusively at a technical level without input from affected communities (Musungu *et al*, 2012). Informal settlement communities are complex and diverse entities (Smit, 2006), thus a method used to upgrade settlements should takes into account and understand the complexities of individual cases. Nevertheless, a new approach which seeks to mosaic or integrate the two dominant approaches is evident, and has been successfully used on an international and local level (Abbott, 2001; Abbott, 2002; Abbott, 2003; Musungu *et al*, 2012).

2.5   Informal settlement upgrading and the application of GIS

The focus of this study is the use of GIS technology as a tool in in-situ upgrading of informal settlement. It is of utmost importance to state that the application of GIS in informal settlements is poorly documented, or has not been carried out extensively as it is a relatively new phenomenon. However, there is evidence of successful use of GIS in informal settlements. GIS in informal settlements has been used as a planning tool, enhancing community participation, evaluation of environmental impacts, integrating data for decision maker (Abbott, 2002), just to mention a few. Using GIS technology purely for monitoring and evaluation in-situ upgrading process of informal settlements remains insufficient in literature, often it is combined with other technologies and approaches.

The city of Belo Horizonte in Brazil is the pioneer of using GIS as a planning tool for upgrading informal settlements. In 1983, the city of Belo Horizonte Pro-favela (informal settlement) Law was passed resulting in a new dimension of upgrading of the favelas (Habitat, 2000). The Voluntary Association for International Service (AVSI) was invited to provide technical support to the upgrading program. AVSI realized the structure of favelas was similar to Italian historical town, thus established links with the Italian University of Bologna, which had developed GIS applications in the upgrading of historical centers in Italy (Abbott, 2003).

Furthermore, the use of GIS for favela upgrading at the University of Bologna concurred with 'the development of the ViSP (Visual Settlement Planning) approach by UNCHS (Habitat)' (Abbott & Douglas, 2001) cited in (Abbott, 2003). At the same time Habitat was developing a methodology for low resolution data captured through the use of aerial photographs. In 1991, the University of Bologna mosaicked the ViSP and GIS technology. These attempts lead to sound decision making, and planning.

The Belo Horizonte experience proved to be a success, they achieved upgrading informal settlements in-situ through creating a master plan on a large scale. Evidently, success of the Belo Horizonte experience is highlighted by being adopted in other cities in Brazil and Latin America (Abbott, 2003). This study is important because it sets precedents for GIS technology to be used in the spectrum of informal settlements. It paves the way in which GIS can be innovatively used in in-situ upgrading programs of informal settlements.

Nevertheless, despite the success of the Belo Horizonte experience, its methodology has proven not to be duplicable in other contexts. Primarily, it was a strategy responding to a Brazilian challenge that existed at that time, and the Profavela law produced a unique planning framework for upgrading (Abbott, 2003). Furthermore, the methodology was that of a masterplan, and it was not incremental. This is problematic because informal settlements are very poor, in-situ upgrading is likely to unfold in an incremental manner. Lastly, the methodology had little community consideration, it was purely a technological approach. As a result, the masterplan demanded rapid implementation and large scale investments.

One of the fundamental objectives of the informal settlements in-situ upgrading program is the socio-economic development of communities (DoH, 2004; Huchzermeyer, 2006). Thus, if GIS as a tool is to be utilized adequately, it must support the process of socio-economic development of

communities (Abbott, 2003). In 2005 and 2006, a study was conducted in an informal settlement in Kisumu, Kenya. This study focused in establishing partnerships within the local community, an NGO (Pamoja Trust) and a savings group the Kenyan Homeless People's Federation (Muungano wa Wanvijiji). The primary purpose of the study was asking household information for upgrading, provision of secure tenure, 'designing and implementing an upgrading programme within the Kisumu Cities' (Karanja, 2010: 223).

Two main methodologies were employed in the study. Firstly, demographic data was collected through questionnaires from households and linked with maps of the existing house structures that had been extracted from satellite imagery. Secondly, updated maps were digitized into a GIS database (Karanja, 2010). Most importantly, at the end of data collection and analysis information was presented to the community and its stakeholders for sound decisions to be made. The importance of the study is its ability to integrate GIS and community participation. Its success is highlighted by providing a platform for communities to engage the GIS from the inventory to verify data, and spark debate within the community concerning their needs.

In South Africa, there hasn't been extensive use of GIS in informal settlement upgrading, therefore there is no single method used to address the latter. However, there is an understanding that GIS must be used to promote socio-economic development, and enhance community participation (Musungu and Motala, 2012). A study was conducted in the informal settlement of New Rest in Cape Town. The purpose of the study was to explore the extent GIS can possibly include community gathered data for in-situ upgrading of the informal settlements (Abbott, 2000).

Furthermore, in order to integrate community participation and GIS for the informal settlement in-situ upgrading, two methodologies were used and combined into one meaningful dataset. Questionnaires were used for gathering demographic information about community members, and was subsequently integrated into a GIS system that contained spatial data that includes existing roads, foot paths, shack outline, and geological data (Abbott, 2000). The most critical exercise is the integration of the two data sets into a GIS, in order to perform GIS analysis techniques of buffer and queries (Abbott, 2000). Data analysis resulted in statistical reports and thematic maps that indicated areas prone to disasters and vulnerable. Moreover, focusing on socio-economic activities, thematic maps facilitated the planning to provide even access for the community to transportation hubs and locate areas suitable for business prospects (Abbott, 2000).

Another study was conducted in Cape Town with the objective of improving flood risk management in informal settlements. This study takes a detour from investigating the extent of community participation integrated into a GIS. GIS data from the Cape Town City Council (CCTC) was used to examine trends in rainfall and flooding in informal settlements, to study biophysical vulnerability (Bouchard *et al*, 2007). Furthermore, interviews were conducted collect data about mitigation and coping strategies from the community.

This study is different on the grounds that even though there was community participation in the initial stages, data analysis was exclusively done by expects. Thus, maps produced did not particularly represent the views of the community, however; one may ague disaster and flood mapping is best done by expects. This study is important for more than just using GIS for in-situ upgrading of informal settlements. It represents a dimension of environmental mapping to informal settlement upgrading programs. Environmental mapping can be carried out at a planning phase to investigate the suitability of the land to be upgraded (Li *et al*, 2005). GIS is the perfect tool to execute such tasks because it is equipped with proximity techniques for any desired calculations.

A study was conducted in Langrug informal settlement under the jurisdiction of Stellenbosch Municipality. Several issues were raised by the community concerning the settlement, the in-situ upgrading objectives was to respond to the urgent needs of the community which included: accessible streets in the settlement, and extension of services such as water taps, toilets and electricity (Musungu and Motala, 2012). Community participation proved to be the heart of in-situ upgrading projects.

The methodology used for data collection consisted of two main parts, collecting of demographic data from communities and capturing spatial data using GIS. Demographic data was captured by using questionnaires through a partnership between the Slum Dwellers International (SDI), Stellenbosch municipality, and NGOs (Musungu and Motala, 2012). Furthermore, partnerships were initially formed with the community to reach a consensus concerning the outcomes of the study. On the other hand, aerial photographs were printed and data collectors marked every shack (and added demographic data). This data was capture into a GIS and digitized. In order to meet the needs of the community, the shacks were restructured using GIS to enable creation of streets and services. A new layout was created that can be used by municipal planners for planning purposes.

The importance of the case studies above is to demonstrate the successful use of GIS in informal settlement upgrading programs. GIS can be manipulated to suit the needs of any in-situ upgrading project. It can be exclusively used at a technical level, or be integrated with community participation to promote socio-economic development. The use of GIS in informal settlement upgrading projects represents a paradigm shift towards an era of using spatial technology to assist decision makers in eradication of all informal settlements.

2.6   Informal Settlements in South Africa

South Africa has a long history of informal settlements, the latter have marked the urban landscape for at least half a century (Huchzermeyer et al, 2006). Present day informal settlement and housing challenges are a footprint inherited from the apartheid legacy, however; the former received little attention in national policy (Charlton, 2006). Nevertheless, attempts by the democratic government, and commitment to address the housing backlog is evident. The White Paper on Housing of 1994 (legislated by the Housing Act 107 of 1997) detailed the right of people to adequate housing (Massey, 2013), prioritised the needs of the poor and promised to deliver 1 million houses in 5 years, community participation and the private sector were employed as chief architects ensuring such promise (Goebel, 2007). The Reconstruction and Development Programme (RDP), adopted by the African National Congress as part of its 1994 election manifesto, promised about 15 000 houses per year (Thomas, 2010). Furthermore, South Africa is one of 30 countries "that has included the right to housing in its constitution" (UN Committee on Economic, Culture and Social Rights, 2001 cited in Aigbavboa and Thwala, 2010: 233).

Despite various attempts by the South African government to address housing challenges through a number of initiatives, the lack of housing has persisted (Kajimo-Shakantu & Evans, 2006). Irrespective of the delivery of over two million housing units since 1994 (Mthembu, 2009), the housing backlog has continued to grow, and approximately 7, 35 million people still live in shacks (Thomas, 2010). The inability to fulfil the promises of the White Paper and RDP, the inadequacy of people to satisfy their housing needs, the failure of government subsidised housing to accommodate the urban poor (UNCHS, 1999), taking into account rapid urbanisation which has escalated to the complexity of redress, people continue to erect and occupy informal settlements

as a viable housing solution. Consequently, in 2004, the South African government responded to the housing challenges with a new National Housing Policy.

2.6.1 Legislative framework towards dealing with informal settlements

In 2004, after a being side-lined for decades informal settlements earned their recognition. This was through the introduction of a new National Housing Policy in the form of a document titled *Breaking New Ground: A Comprehensive Plan for the Development of Sustainable Human Settlements* (BNG). The Department of Human Settlement (former Department of Housing) through the BNG are devoted to satisfy specific objectives, these include: (a) fast-track the delivery of housing as a key strategy for poverty alleviation, (b) using the delivery of housing as a chief job creation strategy, (c) Ensuring property can be accessed as an asset for wealth creation and empowerment, (d) stimulating economic growth, (e) Combating crime, encouraging social cohesion and improving living standards for the poor, (f) Supporting the functioning of the entire single residential property market to reduce duality within the sector, and (g) achieve sustainable human settlements and spatial restructuring through housing (DoH, 2004). Furthermore, it is explicitly outlined in the BNG informal settlements must be integrated into the broader urban fabric, this will thus assist to overcome economic, spatial, and social exclusion.

The introduction of the BNG framework resulted in the development of an Upgrading of Informal Settlement Programme (UISP), "with a dedicated subsidy mechanism" (Huchzermeyer, 2011:41). The UISP advocates for a paradigm shift in the spectrum of informal settlement intervention. Upgrading of informal settlements must be advanced from a pragmatic dimension in the face of changing realities and many uncertainties (DoHS, 2009). The challenge of informal settlements must not be viewed as merely a 'housing problem' which requires a 'housing solution', rather; it must be perceived as a manifestation of mechanical social change. A solution of which requires a "multi-sectoral partnership, long-term commitment and political endurance" (DoH, 2004: 4).

The new instrument, UISP supports eradication of informal settlements by 2014. The proposed method for eradicating informal settlements is through a phased in-situ upgrading approach in desired locations that is in line with international standards, and relocation as the last resort in cases where development is not feasible (DoH, 2004). The UISP offers grants to accredited municipalities to implement sustainable housing development, thus enabling municipalities to be chief architects on the ground (Ziblim, 2013). Moreover, the UISP supports and encourages a wide

range of tenure options and typologies (DoH, 2004). Within the context of this instrument, community participation and social inclusion are encouraged and supported as mechanism that enable in-situ upgrading (Angignu and Huchzermeyer, 2009). Therefore, the UISP strives to be a multifaceted and interconnected policy that aims to achieve security of tenure, safety, health, social capital, and empowerment (social and economic development) (Aigbavboa and Thwala, 2010).

According to Godehart and Vaughan (2008) settlement upgrading phases can be categorized into three stages: Project Initiation, Project Implementation, and Housing Consolidation. It is argued in Tshikotshi (2009: 34) the first two stages "deal with whole areas of informal settlements, and all families living there". Moreover, project initiation phase echoes the emphasis on community participation. Lastly, housing consolidation phase (which is not funded under the UISP) deals with special conditions to those families who do not qualify for housing subsidies. Therefore, the phased in-situ settlement upgrading is incremental or progressive in nature.

2.6.1.1 KwaZulu-Natal Slum Act

The escalating rate of informal settlements in the urban space of South Africa poses a challenge for the government. A greater concern is that if this challenge is not adequately addressed, the number of informal settlement inhabitants if predicted to double by 2030 (Aigbavboa and Thwala, 2010). Part of government response in an attempt to address informal settlements is a tone that suggests that it is dealing with an undesirable, pathological and menacing process. This is demonstrated by the use of terminology that is often used to life-threatening epidemics and vicious crimes such as: 'elimination', 'zero tolerance', and 'eradication' (Huchzermeyer, 2009). This approach is evident through the instruction of the KwaZulu-Natal Elimination and Prevention of Re-emergence of Slum Act of 2007 (KZN Slum Act). In a nutshell, the KZN Slum Act purpose was to eliminate substandard housing conditions by authorizing the provincial Human Settlement MEC (Member of the Executive Council) to advocate a time in which it would be mandatory for municipalities to evict illegal occupiers of 'slums' when landowners have failed to do so.

The KZN Slum Act led to a Durban-based shackdweller movement Abahlali baseMjondolo approaching the Durban High Court in November 2008 challenging the constitutionality of the Act. The main concern was that the KZN Slum Act aimed to eliminate slums by *de facto* enabling and encouraging evictions to occur without meaningful engagements. After the unsuccessful court application, abalali baseMjondolo appealed direct to the Constitutional Court in 2009. On 14 May

2009, the Court heard arguments relating to the KZN Slum Act, more specifically to section 16 which stated that "municipalities must start proceedings for the evictions of unlawful occupiers if the owner or person in charge of the land fails to do so within the time period prescribed by the MEC" (Tissington, 2011). The Court held the KZN Slum Act was unconstitutional, section 16 of the Act was unconstitutional because it violated section 26(2) of the constitution, gave the MEC too much power, and violates the Prevention of Illegal Evictions Act and Unlawful Occupation of Land Act (PIE Act) 19 of 1998 (Tissington, 2011). In light of the above, GIS is a viable tool to assist municipalities to upgrade informal settlements via in-situ strategy.

2.7   Adequate housing

In its basic form a house may be defined as shelter which is identified as an indispensable need for human survival and progression (Tredoux, 2009). Moreover, there needs to be a clear distinction between formal and informal housing. There are many definitions for informal housing, however; for the purpose of this paper similar characteristics will be outlined. Informal housing in general have characteristics of poor or no access to water, poor or no access to sanitation facilities, overcrowding, poor quality of the structure and durability, insecure tenure, poor or dangerous location of settlements, inadequate environment, and exclusion (Tredoux, 2009). For the purpose of this paper, it is of paramount importance to make a clear distinction about the subject matter. The challenge of adequate housing may include a shift from informal housing to formal housing

The importance of adequate housing is evident because it is recognize by the constitution, and a number of international human rights instruments and treaties. According to the Universal Declaration of Human Rights, it is stated that "everyone has a right to a standard of living that is adequate to the health and well-being of himself [herself] and his [her] family, including housing". On the other hand, The Committee on Economic, Social and Cultural Rights uses a criteria to clarify the meaning of adequate housing, it features seven characteristics: legal security of tenure, affordability, availability of services, habitability, accessibility, location, and cultural acceptability (Tissington, 2011).

Therefore, adequate housing extent beyond the quality of a dwelling structure, it also features and considers variables of adequate location, security of tenure, sound habitable environments, access

to services, and access to socio-economic opportunities and benefits. A physical structure upholds the right of human dignity in section 10 of the Constitution, and security of tenure is consistent with section 26(3) which promotes social development. Variables of location, availability of services, and access are important for the development of individuals to the greater community at large.

2.7.1 In-situ upgrading contribution to adequate housing

In South Africa, informal settlements are a common phenomenon perpetuated by globalization and high levels of urbanisation. In-situ upgrading of informal settlements program seeks to improve the living conditions of people by providing access to services (like water, electricity, sanitation and roads), secure tenure, and top structure. In-situ upgrading of informal settlements contributes to the progressive notion of adequate housing. The program does not only seek to provide a product (structure), however; it seeks to achieve a sustainable human settlement. That is why South African government has begun to value the conversion of informal settlements to formal settlements as one of the tools to deliver housing and therefore fighting against the growing number of housing backlog.

2.7.1.1 Intergovernmental cooperation

In terms of the Constitution sections 41 and 42, it advocates for cooperative governance. In-situ upgrading program requires a multi-departmental partnership, it provides a platform for various departments to work collectively towards achieving the purpose of adequate housing. Local municipalities play the role of chief architects or developers. It is the responsibility of the local municipality to identify informal settlements needing to be upgraded within its area of jurisdiction, and apply for funding from the Provincial Department (DoHS, 2009).

Furthermore, in order for the in-situ upgrading program to be fully implemented it demands partnerships of cooperative governance between the National (DoHS), Provincial, and municipalities. Most importantly, the program requires the support of other government Departments: Basic Education, Home Affairs, Cooperative Governance and Traditional Affairs, Public Works, Water and Environmental Affairs, and Health (DoHS, 2009). The cooperation and integration of different government Departments ensures housing is not only focused, on the structure, however; it focuses on creating adequate housing and sustainable human settlements.

2.7.1.2 Security of tenure

Informal settlements occur through land invasions, without formal legal standing, and outside the regulations of towns and cities. Principles of adequate housing emphasize on the importance of tenure security. According to the BNG, in-situ upgrade program supports a wide range of tenure options as part of the program (DoH, 2004). Experience has shown that housing with secure tenure "provides a springboard to households to improve their social and economic circumstances" (DoSH, 2009: 16). In-situ upgrading will grant residents of informal settlements secured tenure, thus offer the capability for residents to invest in their livelihoods, contributes to achieving adequate housing, and sustainable human settlements.

2.7.1.3 Location

Historically, the South African spatial urban landscape has enforced radically unjust and uneven distribution of space, opportunities, and resources according to a hierarchical and arbitrary system of racial groupings (Kellett *et al*, 2002). Africans were displaced and subjected to reside in township (Roberts, 1994), furthest from socio-economic opportunities. Informal settlements are better located than old and new housing developments for the poor. However, due to the nature of informality residents of informal settlements are excluded from formal practices (Huchzermeyer, 2004).

Formalizing informal settlements through in-situ upgrading grants the opportunity for spatial reconstruction, and integration (both racially and economically), moving towards achieving the vision of the BNG (DoH, 2004) and inclusion (Huchzermeyer, 2006). The urban poor (and previously discriminated Africans) may now reside in strategic locations which facilitate changing, or reshaping the urban spatial arrangement. Areas close to the central business district (CBD) were occupied by the middle to upper class. Nevertheless, the location of informal settlements to be upgraded is an agent into recreating a new urban space free of segregation.

2.7.1.4 Bulk services

In-situ upgrading of informal settlements happens through a phased approach (DoH, 2004). Installation of services may take place during the 1st and, or 2nd phase, these service include water, electricity, and sanitation (Abbott, 2003). The provision of services helps to improve the social status, health, and prevents environmental degradation on the urban sphere. Furthermore,

providing access to basic services (including security of tenure, and housing) on these settlements is a "necessary step towards more equitable and liveable cities" (Tshikotshi, 2009: 35).

2.7.1.5 Accessibility

Characteristics discussed in the paper thus far are all important and interlinked, they revolve around the key characteristic of access (ability). Upgrading of informal settlements provides access to secure tenure, adequate location, basic services, and access to socio-economic opportunities; of which is of paramount importance for individual development, household, and family developments (Tshikotshi, 2009). Location of informal settlements has a direct relationship with socio-economic activities of inhabitants. Thus formalizing these settlements offers sustainable access to socio-economic activities of people.

The in-situ upgrading of informal settlements program conforms and is consist with the principles of adequate housing. Adequate housing characteristics (legal security of tenure, affordability, availability of services, habitability, accessibility, location, and cultural acceptability) and in-situ upgrading program cannot be divorced. Through implementing in-situ upgrading, access to all characteristics is made possible.

2.8   Conclusion

This chapter has indicated that neo-liberalism (which stem from liberalist ideologies) advocated for freedom in the markets, while there are two branches of neo-liberal philosophies on the role of the state, the common principle is one of laissez-faire. This theory enables people with necessary resources to compete in the housing market. One must be objective of the fact that developing countries are faced with high levels of urbanization, thus; neo-liberal principles are not ideal as people are poor with insufficient capabilities to compete in the formal housing sector. Consequently, people resort to alternative means of satisfying their housing needs through land invasions and informal settlements. A successful solution to eradicating informal settlements demands a radical shift from focusing on the provision of top structure, to a holistic approach that will tackle or address poverty. Furthermore, this chapter has revealed literature on the use of GIS in informal settlements remains insufficient. Nevertheless, there is evidence of successful application of GIS in the field of informal settlement. These handful of cases should be used as

positive experience to encourage the acceptance of technological solutions into addressing informal settlements. Informal settlements are upgraded using two methods, relocation, and in-situ upgrading which is desirable for socio-economic activities. In light of the above, even in in-situ upgrading projects some people will be subjected into relocation as resources (such as insufficient habitable land) are limited. Lastly, in order to realize the vision of sustainable human settlements, in-situ upgrading needs to be accompanied by meaningful community participation.

Chapter 3: Background of case study area

3.1   Introduction

The purpose of this chapter is to present a detailed account of Cato Crest as the case study in which the study is conducted, which is one out of six informal settlements that make up the greater Cato Manor Township. It is of importance to explore the complex historical background of the case study area, it reveals factors contributing to the current state of the settlement. Furthermore, Cato Crest mirrors informal settlements in South Africa, therefore; making it an important case study to understand the multifaceted dynamics of such settlements. Most importantly, the case study area offers the opportunity to continuously investigate the extent and innovative use of GIS in the upgrading of informal settlements. This chapter will: provide a brief history of Cato Manor; provide a profile of Cato Crest informal settlement; and provide the status of in-situ upgrading informal settlement.

3.2   Historical background of Cato Manor

Cato Manor inherits its name from the 1st Mayor of Durban, Mr. George Cato. In 1845, George Cato was granted 1800 hectares of land in Cato Manor as compensation for his beachfront property that was expropriated for military purposes (Maylam, 1983). The Mayor and his descendants farmed the hilly and fertile soil of Cato Manor until the turn of the century. Land was then subdivided into a number of smaller farms and sold to white land owners (Leclerlec-Madlala, 2004).

Between the period of 1900 and 1930s, most of the land was sold or rented to Indians who decided to remain in South Africa post completing their indenture service (Makhatini, 1994). The land was used to grow vegetables and fruits for market sale. Furthermore, this period experienced a steady influx of African migrants from rural areas seeking employment opportunities in Durban. Landowners of Cato Manor responded by renting land to Africans, on the other hand; some Africans started to erect shacks alongside Umkhumbane River which meanders through the area. Under the Union of South Africa's laws, Africans were prohibited from owning land and constructing homes in urban areas, thus they were regarded as the renting class (Popke, 1997).

In 1932, Cato Manor was integrated into the Durban Municipality, and shack dwellers were declared illegal settlers. Despite the passing of National Influx Control laws, the steady influx of African migrants continued to increase. However, according to Cele (2010) the authorities turned a blind eye or relaxed implementation of Influx Control laws. Be that as it may, Indian landowners discovered that shack letting had more profits than vegetable and fruit farming for the market. Thus, shops and bus stops were set up by Indian businessmen.

During the 1940s, the estimated population of people residing in the Cato Manor area was 50 000 (Makhathini and Xaba 1995 cited in Leclerlec-Madlala, 2004: 3). Living conditions typically reflected an urban slum, with much overcrowding and lacking basic services like electricity, water, and proper sanitation. These conditions contributed to pressures which led to the eruption of conflict between the Indian and African populations of Cato Manor in 1949. This resulted in the known Cato Manor Riots, allegedly sparked by an Indian man assaulting a 14 year old African boy near the Durban's Indian market (Maylam, 1983).

The anti-Indian violence lasted for two days resulting in one white, 50 Indians, and 87 Africans killed; more than 100 people got injured, and destruction of property also took place (Maylam, 1983). Consequently, the riots triggered many Indians to flee the area. Moreover, the neighboring white residents put pressure on city officials to implement the Native's Urban Areas Act 21 of 1923, advocating for the removal of remaining illegal inhabitant from Cato Manor to designated areas.

During the 1950s, the Indian landlords who had left the area because of riots returned to collect rent. Some landowners continued letting entire plots to Africans, and this resulted in more shacks being erected and also sub-letting them (Cele, 2010). At the time of shacks rapidly increasing in Cato Manor, the National law of Group Areas Act 41 of 1950 was passed. Landowners and tenants were forcefully removed from the Cato Manor area, Indians were relocated in Merebank, Phoenix, and Chatsworth, while Africans were relocated in Chesterville, Umlazi, and Kwamashu (Maylam and Edwards, 1996 cited in Cele, 2010: 10). Evictions were militantly opposed, often resulting in conflict between residents and officials, and the loss of lives (Pithouse, 2006).

From the late 1960s, Cato Manor was largely vacant, all that remained was a few houses, the beerhall, few Hindu temples amongst numerous avocado, litchi, and mango trees once the pride of Indian market gardeners (Popke, 1997; Leclerlec-Madlala, 2004). Furthermore, evidence of

African informal settlement was erased from the landscape. The few remaining residents started the Cato Manor Residents' Association to resist forced removals and housing developments that were racially motivated.

From the 1980s, two important phases of development occurred in Cato Manor. Formal houses were constructed at Wiggins (Singh, 2012). On the other hand, African people slowly started to move back in the area, reclaiming land and establishing informal dwellings. An informal settlement re-emerged in the area that today in known as Cato Crest (Leclerlec-Madlala, 2004). The abolishment of influx control and apartheid laws escalated the migration of previous and new inhabitants.

Post 1994, Cato Manor continued to attract a big number of informal settlement dwellers and continuous land invasions. The formation of the CMDA was perpetuated by the need to deliver infrastructure on the area. In 1995, Cato Manor was selected to be one of the largest lead projects, reflecting its significance and importance (Cato Manor Social Development Strategy Review, 2005 cited in Cele, 2010: 10). Cato Manor was thus targeted as a strategic area for integrated community and housing development on an area formerly reserved for 'white' people.

Cato Crest settlement is shaped by the rich history of Cato Manor that includes forced removals and relocations. Consequently, this rich history has left a legacy of competing land claims, land invasions, and settlement rights in the area. Through various legislation (including Group Areas Act 41 of 1950) "the apartheid government intensified influx control, embarked on mass removals and enforced stricter residential control on blacks and subsequently enforced residential segregation (Motladi, 1995: 57).

Currently, a large percentage of landlords in Cato Crest participate in practices of giving out illegal subdivided sites, and renting shacks or rooms to people (Motladi, 1995). Thus, for the majority of residents access to land, and land markets is through informal practices. Due to the inability to participate in formal land markets and satisfy their housing needs, people resort to informal settlements. Cato Crest offers people shelter despite being accessed mainly through informal practices. Therefore, Cato Crest is faced with a challenge of continuous growth as an informal settlement.

3.3   Cato Crest

Out of the 1800 hectares of Cato Manor, Cato Crest is a settlement made up of 97 hectares (Patel, 2009), spreads over two constituencies (ward 30 and 101), and is further dived into 12 'areas' (Community leader, 2014). Moreover, each 'area' is well represented through an Area Committee that forms part of the Community Development Committee, better known as the 'Ward Committee' or 'committee' by residents. The existence of such structures is of utmost importance because they are a 'life line' (first contact, a source of information, and direct channel) between residents and ward counselor. It is a densely populated area which is home to an estimated population of 17 856 people (StatsSA, 2010), however; due to trends of globalization the total number of people can be argued to have increased. Inhabitants of the settlement consists of diverse ethnic groups mainly of Africans dominated by Zulu speakers, Xhosa, Ndebele, and Sotho, amongst others. Moreover, refugees and immigrants from other countries such as Zimbabwe, Burundi, Malawi, just to mention a few, are also residents in Cato Crest. The dominant spoken language is isiZulu, the language of the province (Leclerlec-Madlala, 2004).

According to Patel (2009) Cato Crest is predominantly made up of three housing types: RDP (low cost housing from the Reconstruction and Development Programme, constructed by the municipality of eThekwini), shacks, and transit camps to accommodate people temporarily while waiting for their formal houses to be completed. Furthermore, inhabitants in Cato Crest range from tenants, landlords, owner-occupiers, and squatters of shacks and low cost houses. Therefore, Cato Crest has a multitude of tenure options with irregular degrees of tenure security and insecurity.

Furthermore, in Cato Crest, people opt to reside in the informal settlement motivated by various reasons. Predominantly, the most favorable reason is access to economic activities. The location of Cato Crest is of paramount importance (it is nucleus) as it offers access to job opportunities, and close to the CBD. Some people are residents of Cato Crest because they were born and grew up in the settlement. Other residents opted to reside in the study area because it offers very cheap rentals. Moreover, some people reside in Cato Crest because they came to stay with family member(s), and as inheritance from family. On the other hand, there's a portion of people who currently reside in the study area because they were promised housing, and some saw the opportunity of the latter.

Politically, the geographical location of Cato Crest is of importance to the study. According to Patel (2011) Cato Crest is surrounded by the traditionally white middle class areas which have people who have consistently voted for the Democratic Alliance (DA) since 1994. On the other hand, the vast majority of African residents in Cato Crest have consistently voted for the African National Congress (ANC). Furthermore, it can be argued that politics have influenced the redrawing of ward boundaries to assist political representation. Between 2006 and 2011, the settlement was divided into ward 30 and 31. As already mentioned, Cato Crest is influenced and shaped by years of people competing for some minimum resources (mostly land). The primary factor that influences such competitions can be argued that they are related to the desirable location of Cato Crest.

3.3.1 Location

Cato Crest is one of six informal settlements, and is located on the ridge of Cato Manor between Vusi Mzimela Road (former Bellaire Road) and Mary Thiphe Street (former Cato Manor Drive) (Leclerlec-Madlala, 2004). Figure 9 (pp 65) is a visual cartographic representation (map) of the study area, its neighboring communities, and surrounding in general. Its primary objective is to provide a clear understanding of the study area location. The red line represents the boundary or buffer of the study area, the main focus is Cato Crest which is situated within the buffer.

The popularity of Cato Crest is attributable to its location about five kilometers from the CBD of Durban. Figure 10 (pp 66) is a locality map with a purpose to highlight relationships between the study area surrounding elements. The red area represents Cato Crest which is under the jurisdiction of eThekwini metropolitan municipality, represented as the grey area. It is strategically located close to national roads, N2 runs north east-south west, and N3 runs north-west from the study area. Thus making Cato Crest permeable, accessible from all directions. Moreover, industries and the CBD are easily accessible. Evidently Cato Crest is walking distance to employment opportunities in the city, schools, health facilities and shops (Patel, 2009). Furthermore, it is strategically located to enable inhabitants to use cheap modes of transport including walking, bicycle, and access to public transport that takes less than 10minutes to reach the CBD.

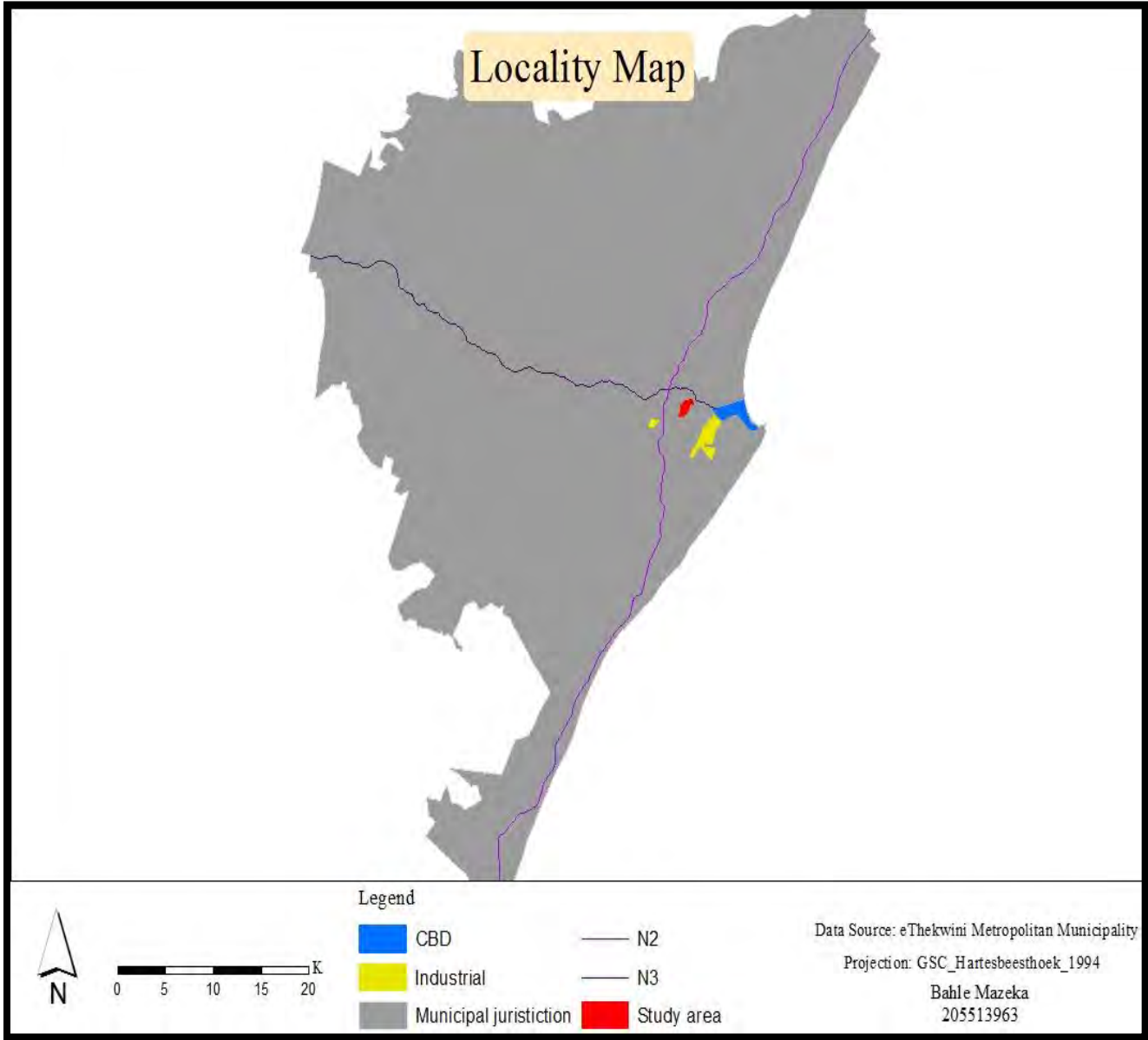Fig 9. Map displaying the study area and its surroundings.

Fig 10. Displaying Locality map

3.3.2   Social character of Cato Crest community

According to StatsSA (2010) the majority residents of Cato Crest are youth, approximately 77% of the population is below 35 years. Furthermore, 24% of the economically active inhabitants are formally employed. Education levels is low with 0.07% of the residents had a post-matric qualification, 45% educated between 8 and grade 12, and 34% educated between Grades 5 and 7. Lastly, unemployment is very high with estimates as high as 45%. High levels of unemployment imply there is poverty that contributes to the people not to have the ability and capacity to satisfy their housing needs.

Cato Crest settlement is strategically located offering access to a number of social amenities, within the settlement and surroundings at walking distance (fig 11, pp68). Social amenities available with ease to Cato Crest inhabitants include a community hall, cultural and historical sites, educational facilities (which include two multipurpose centers consisting of a school, library, community hall, and sports field), health facilities, libraries, municipal offices, religious institutions, police station, sport fields, shopping center, Bellair Market, and recently constructed Intuthukho junction.
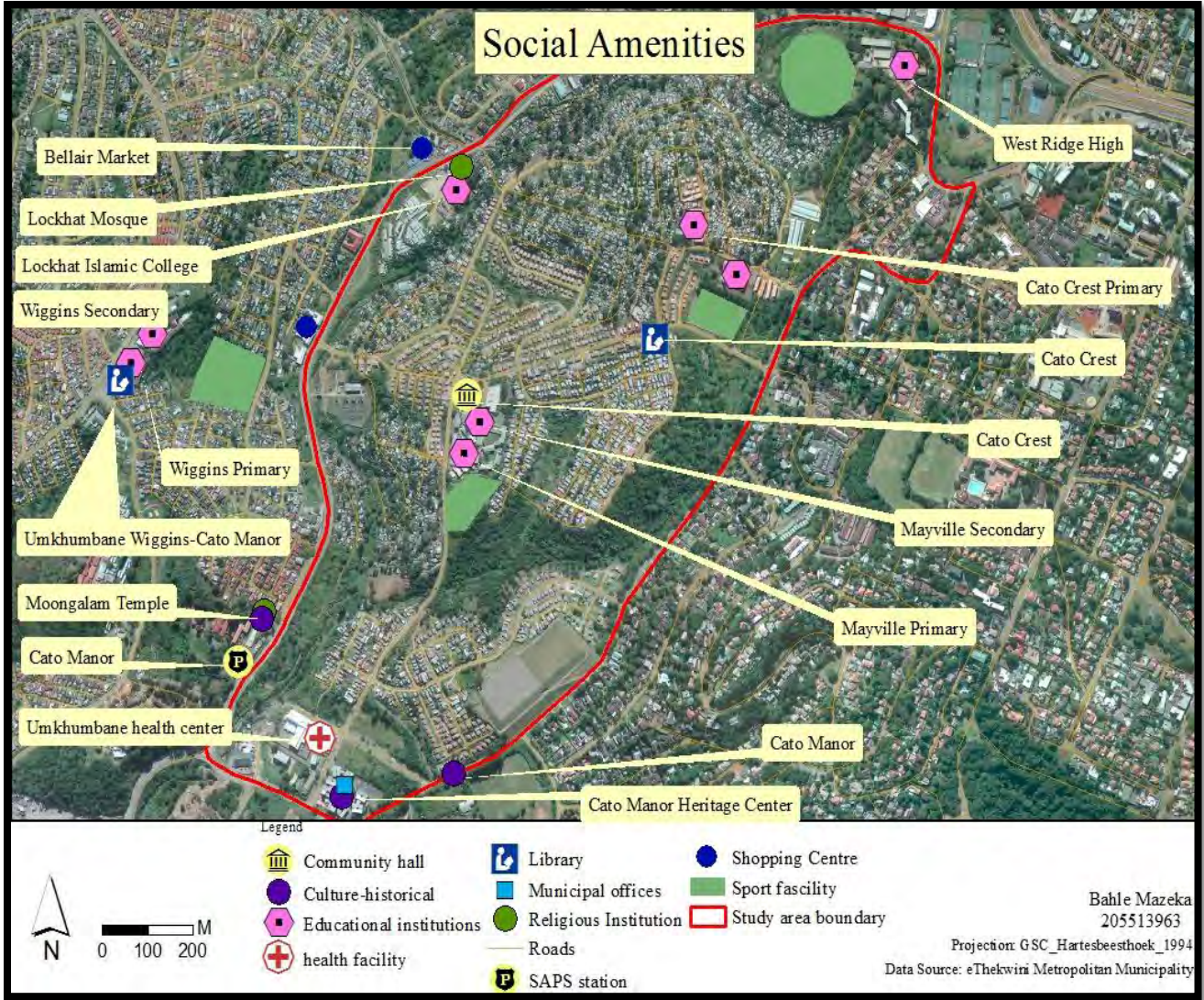
Fig 11. Map displaying social amenities within and surrounding Cato Crest

3.3.3 Basic services and infrastructure of Cato Crest

The strategic location of Cato Crest settlement permits opportunistic access to municipal services. Water is supplied by EThekwini municipality to the whole of Cato Manor area. According to (www.cmda.co.za), Durban Metro Water has utilised three water service levels for the area in an attempt to overcome affordability constraints. A full pressure system gives unlimited water supply at greater pressures than 250kPa and is the most expensive system. A semi-pressure system makes use of a water tank installed in the roof space of the house and is supplied directly from the water main. Water within the building is supplied solely from the tank. The pressure is not greater than 30 kPa, allowing for waterborne sewerage but at greatly reduced costs. In the informal settlements standpipes (plate 1, pp 70) or 200 litre tanks situated next to the houses are provided as a temporary measure.

Sewage is catered for through a system of flush toilets used by more formal developments like shops, schools, formal residential properties. Pit latrines are used and built by residents. Chemical toilets (plate 2, pp 70) are also used and cleaned every week; these toilets are government initiative (www.cmda.org.za).

Electricity in the area is supplied by EThekwini municipality. Some residents, more especially shack dwellers have illegal connections. Adequate street lighting is provided to ensure safety and access to public facilities in the evenings and early mornings. Business premises and higher income houses are provided with electricity in the normal manner, whilst smaller emerging enterprises and low income households are serviced on a pre-paid system (www.cmda.org.za).

Solid waste is collected by Durban Solid Waste (DSW) from the area. Every Thursday DSW delivers refuse bags to residents and collects it twice a week. However, there is waste along and in the banks of Umkhumbane River (plate 3, pp 71).

Road hierarchy system of the study area comprise of 4 types of roads, namely primary distributor, district distributor, local distributor and residential access road. Rick Turner road and Jan Smuts Highway are primary distributor; these roads are for distribution of traffic to, from and within the city. Jan Smuts Highway and Rick Turner road collects traffic for Vusi Mzimela Road from the city and freeways. On the other hand, Vusi Mzimela road is a district distributor, therefore it distributes traffic between neighbourhoods, residential area, industrial area, commercial, and

public transport. Access roads have direct access to properties, used by people for various activities.

Plate 1. Picture displaying a communal standpipe (source: researcher)

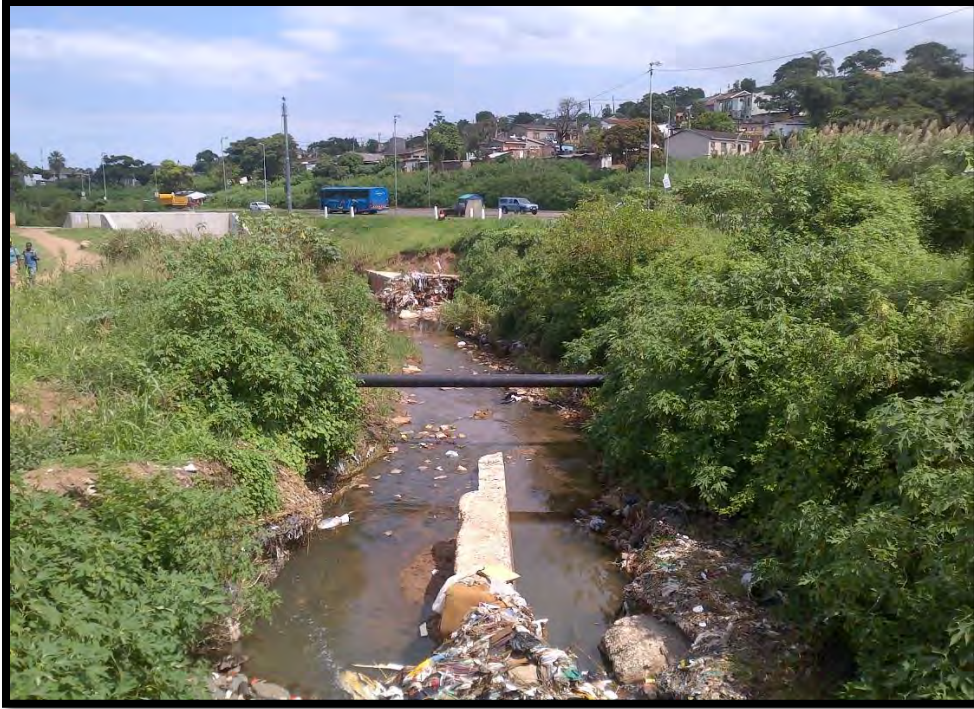Plate 2. Chemical toilet onsite (source: researcher)

Plate 3. Picture showing waste along the Umkhumbane River (source: researcher)

3.3.4   Income group integration

Cato Crest settlement provides the perfect opportunity for spatial restructuring and integration of different income groups. Historically low income group was found on the periphery in townships. Nevertheless, this project has challenged the traditional norm of spatial location. Consequently the greater area of Cato Manor and surrounding areas is made up of integrated income groups. Cato Crest and Chesterville are predominantly made up from the low-middle income group. Manor Gardens, Sherwood, and Mayville are made up of high to middle income.

3.4   In-situ upgrading of Cato Crest

In 1992, the CMDA was established and initially tasked to undertake the upgrading of Cato Manor, including Cato Crest. The objective was to develop Cato Manor as an all-inclusive urban environment and integrated within the urban fabric of Durban. Moreover, CMDA was to address housing and social needs of the poor (CMDA, 2002). Post 1994, Cato Manor was declared a Presidential Lead Project (Leclerlec-Madlala, 2004). This permitted development to be fast tracked

through provisions of financial support. Consequently, three schools were constructed in Cato Crest, a high school and two primary schools. Furthermore, a multi-purpose center was developed that consists of a public library, pre-school, primary school, community all, and sports field. In 1997, the construction of Ekuphileni Clinic was completed, and it offers primary health services to the community. A container park was established to assist and encourage entrepreneurship. 22 large metal containers were refurbished and are used for offices, workshops, and market outlets for aspiring businessmen/businesswomen of the study area (Leclerlec-Madlala, 2004).

The state policies towards addressing informal settlements favors a phased in-situ upgrading instrument to improve living conditions and formalize tenure status for residents. According to Patel (2012) in-situ upgrading of Cato Crest commenced in 2000 and is ongoing. In 2004, the BNG was introduced adopting and formalizing the in-situ upgrading instrument. Eradicating informal settlements through in-situ upgrading is implemented by local municipalities. Therefore, eThekwini Municipality are the chief architects with the responsibility of transforming Cato Crest from its informal to formal status.

3.5   Conclusion

Cato Crest which is located within the Greater Cato Manor community was selected as a suitable community for the study conducted. Amongst the historical relevance of the community, the strategic location of Cato Crest is of utmost importance as it attributes, and enables the settlement to be integrated into the urban fabric. In the context of housing development, Cato Crest is a low-cost housing development that is surrounded by affluent settlements such as Manor Gardens, Westville, Morning Side, just to mention a few. The in-situ upgrading of Cato Crest breaks down the traditional norm of spatial location, placing low-income settlements in the periphery of cities and towns. Furthermore, Cato Crest also offer economic integration as people in the low class now leave with well-off people in the same geographical space. The location of Cato Crest offers important socio-economic relations with easy access to employment opportunities and amenities.

Chapter 4: Data Analysis

4.1   Introduction

The purpose of this research is to ascertain the ways and extent to which GIS can be used to inform local officials in monitoring and evaluating the progress of in-situ upgrading of informal settlements, using the case of Cato Crest informal settlement in eThekwini municipality. This study seeks to trace the progress of the in-situ upgrade of Cato Crest informal settlement using cartographic and GIS tools. Furthermore, this study seeks to understand the Informal Settlement Plan (ISP) (and its obligations), analyse the relationship between informal settlement upgrading and the use of GIS, explore the extent of community participation, and investigate the challenges encompassed in in-situ upgrading of informal settlements. This chapter presents and provides analysis of data collected from informants. This data analysis is based on availability of primary and secondary data collected through different methods; interviews from municipal officials, and community leaders, community questionnaire, field observation, documentation and manipulation of base maps (and spatial data) through digitizing. Findings are presented systematically using themes and tables where necessary. Spatial data will be analysed through the use of GIS as tool and technology. Results will be presented through themes, cartographic, and pictorial representation.

4.2   eThekwini Municipality Informal Settlement Plan

As a point of departure, the study has established that eThekwini metropolitan municipality has a GIS unit which is under the photogrammetric department that manages spatial data. This enables programs such as the Informal Settlement Plan (ISP) (under the department of Human Settlements) to thrive and function adequately. The ISP is a program which is used to work with spatial data, identify new informal settlement through land monitors, or any member of community concerned, investigate the extent of the informal settlement, gather the number of structures, identify available services, and determine whether the land occupied is developable or not. Furthermore, ISP officials may embark on a site visit as a necessary verifying strategy to the claim. This is of utmost importance because GIS data may be a few months old, thus unable to fully depend on the former.

Therefore, the ISP makes recommendations of a housing project that needs to be undertaken (in-situ upgrading or relocation).

The ISP is the initial step of housing development, this is achieved through collecting information that is used to prioritize housing projects, stores and managing (spatial) data, and perform (desktop) analysis to inform other line departments. This includes water and sanitation department, they depend on the ISP to provide adequate service and information. Most importantly, the ISP aids various departments that are involved in housing projects. For example, projects department (within Human Settlements) depend on the ISP to plan for in-situ upgrading project. They depend on information (such as the spatial layout of the settlement, number of structures) that is gathered and analyzed by the ISP.

Once an informal settlement has been identified, and the project recommended, it has to go through an extensive prescreening process. This process demands other departments to go through the project and make comments and recommendations. For example, Water and Sanitation department are expects in their field, therefore their contribution at a planning phase is important. The recommended project is circulated within relevant departments, and only when their recommendations are approved, the ISP may proceed to purchase the land and pass it to projects department who are responsible for implementation.

4.2.1   The use of GIS in housing projects

EThekwini municipality uses GIS extensively to inform housing development projects and decisions. GIS is used from the beginning of housing projects. It is used from desktop study and prescreening processes. According to eThekwini municipal official GIS is also used to inform other various decisions, such as identifying and buying land. Services that are provided by line departments are informed by GIS. Base maps that are used in detailed planning by planners such as land surveyors on site all depend of GIS. Therefore, GIS is used extensively in housing projects from the planning phases, also keeping in mind ISP is predominantly a desktop study which depends on GIS.

4.3   In-situ upgrading of Cato Crest informal Settlement

According to eThekwini municipal official, the in-situ upgrading of Cato Crest informal settlement was initiated in 1992, as part of the Cato Manor development that was to be an all-inclusive urban environment and integrated within the urban fabric of Durban. Consequently, Cato Crest benefited extensively through the construction of education facilities, multi-purpose facility (which consists of a library and community hall), road network (in 2003) and a health facility (fig 12, pp 75). National policy that strongly advocates for in-situ upgrading of informal settlements was introduced in 2004, and municipalities tasked to be developer in implementing relevant housing projects. However, according to eThekwini municipal official the municipality became in charge of the Cato Crest project in year 2000. At the time eThekwini metropolitan municipality took over to the upgrading project, Cato Crest had already achieved accomplishments. Nevertheless, the local authority were faced with a difficult challenges successfully implementing the project.
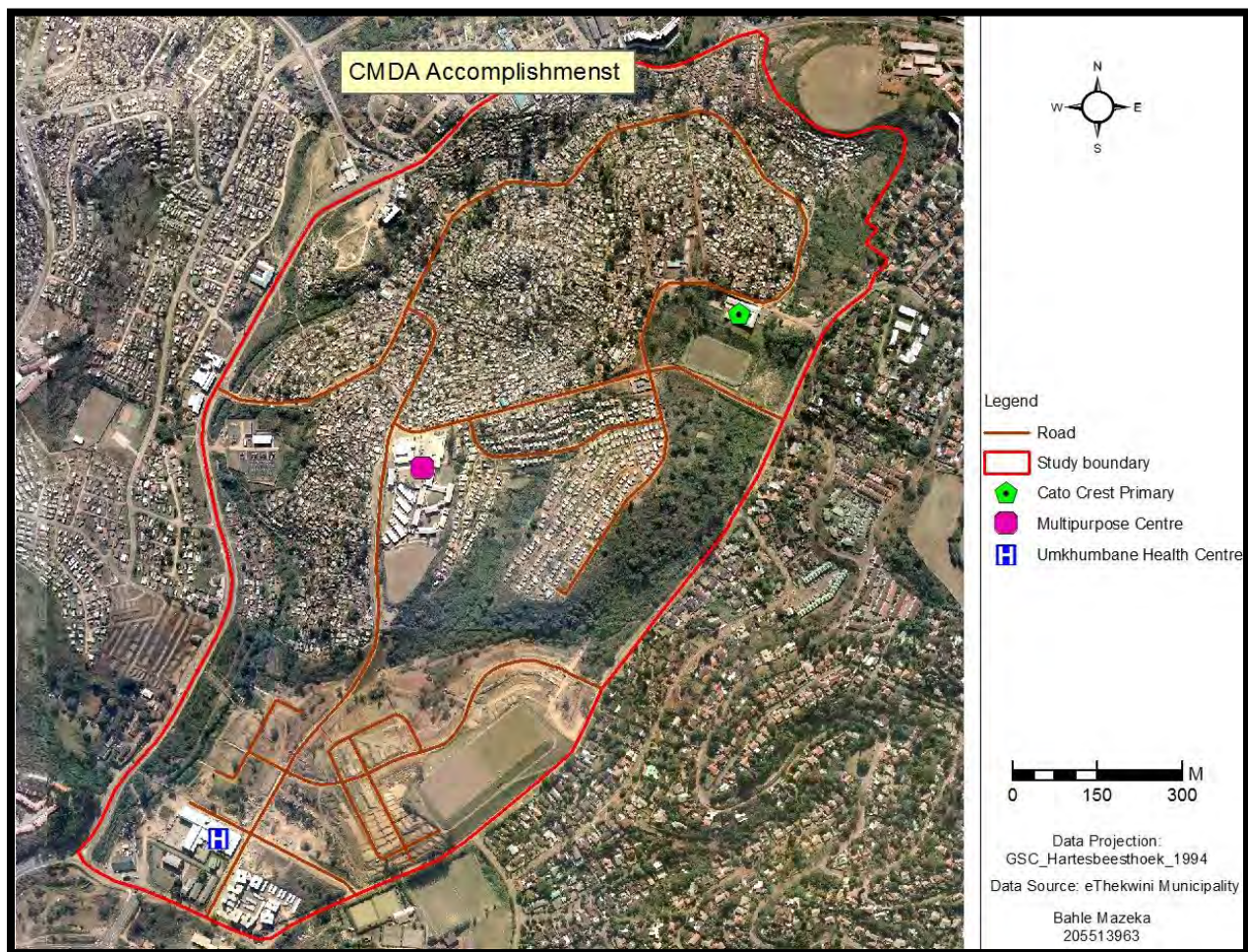

Fig 12. Some of the benefits of the Cato Manor development project in Cato Crest

4.3.1   In-situ upgrading implementation phases

According to municipal spatial (aerial photograph) data, figure 13 is a simple illustration of changes in space over time, figure (13.a. pp 76) is a 2004 aerial photograph and figure (13.b. pp 77) is the latest available aerial photograph (2013).
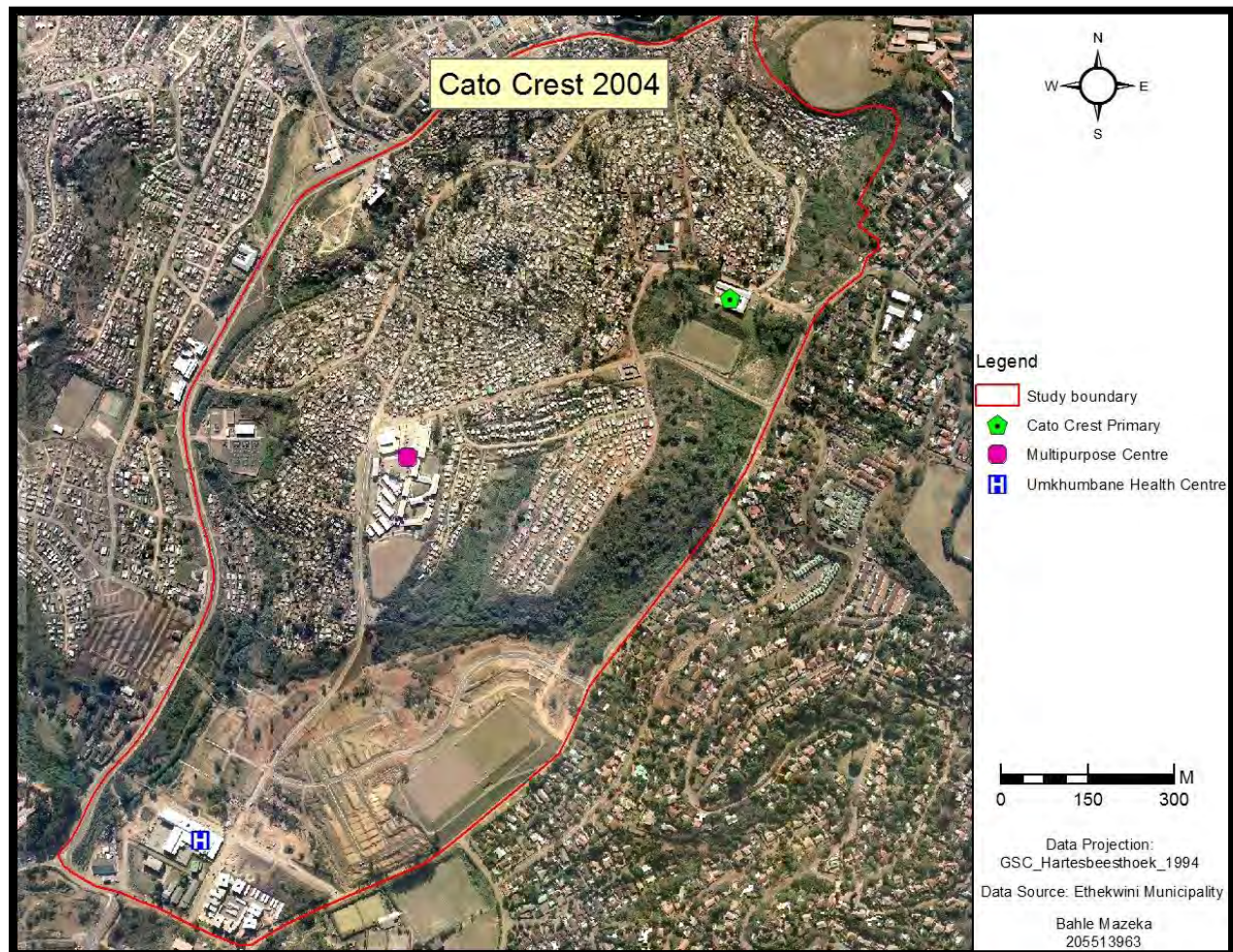

Fig 13.a. The state of Cato Crest in 2004

The municipality has indicated that Cato Crest in-situ upgrade is implemented through different phases which are Cato Crest Greenfield north, central, and in-situ upgrade (fig 14, pp 78). Cato Crest Greenfield north and central phases have been completed. Cato Crest in-situ upgrade phase is currently on its implementation phase. Thus far, there are three structures associated with the in-situ upgrading; (i) detached house (plate 4.1. pp 80), (ii) duplex (plate 4.2. pp 80), and (iii) transit camp (plate 4.3. pp 80). Furthermore, simultaneously to the construction of housing phases, the

road network continues to increase. Figure (15.a. pp 81) clearly demonstrates the current existing road network. On the other hand, figure (15.b. pp 82) shows the planned road network that has not yet been constructed. Figure (15.c. pp 83) shows the future (combination of what is already on the ground, and what is to be constructed) road network of Cato Crest. Lastly, figure (15.d. pp 84) displays the complete futuristic cadastral for the in-situ upgrade phase together with its road network.

Fig 13.b. The state of Cato Crest in 2013
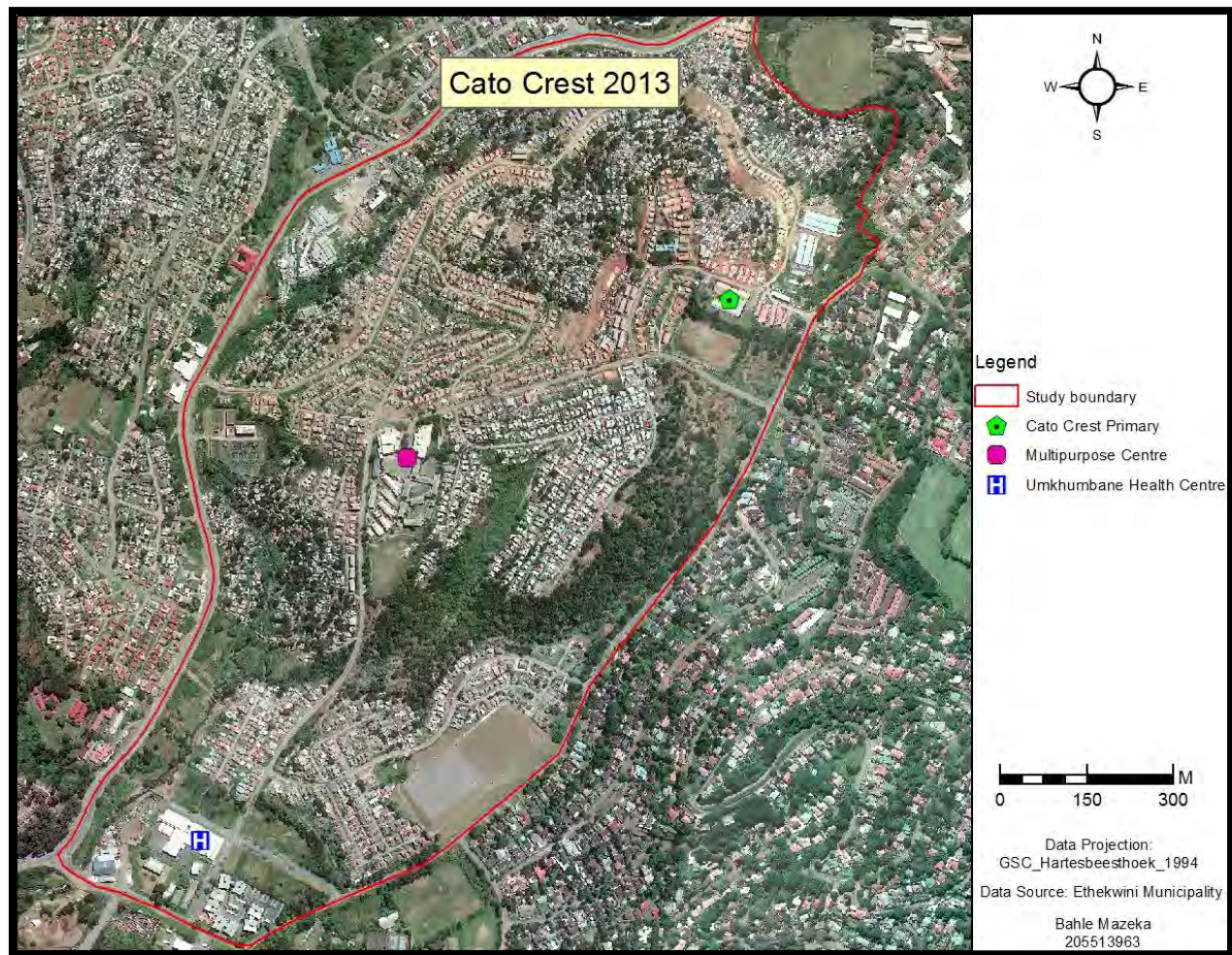
While it is evidently clear from simple observations (and referring to fig 13), infrastructure development in Cato Crest has grown substantially. It is without question efforts of the municipality in implementing the in-situ upgrade project thus far is commended. Notwithstanding, housing development should not be judge on the presence of physical structure; rather it should be

reviewed holistically. It should also focus on social, economic and environmental sustainable development.
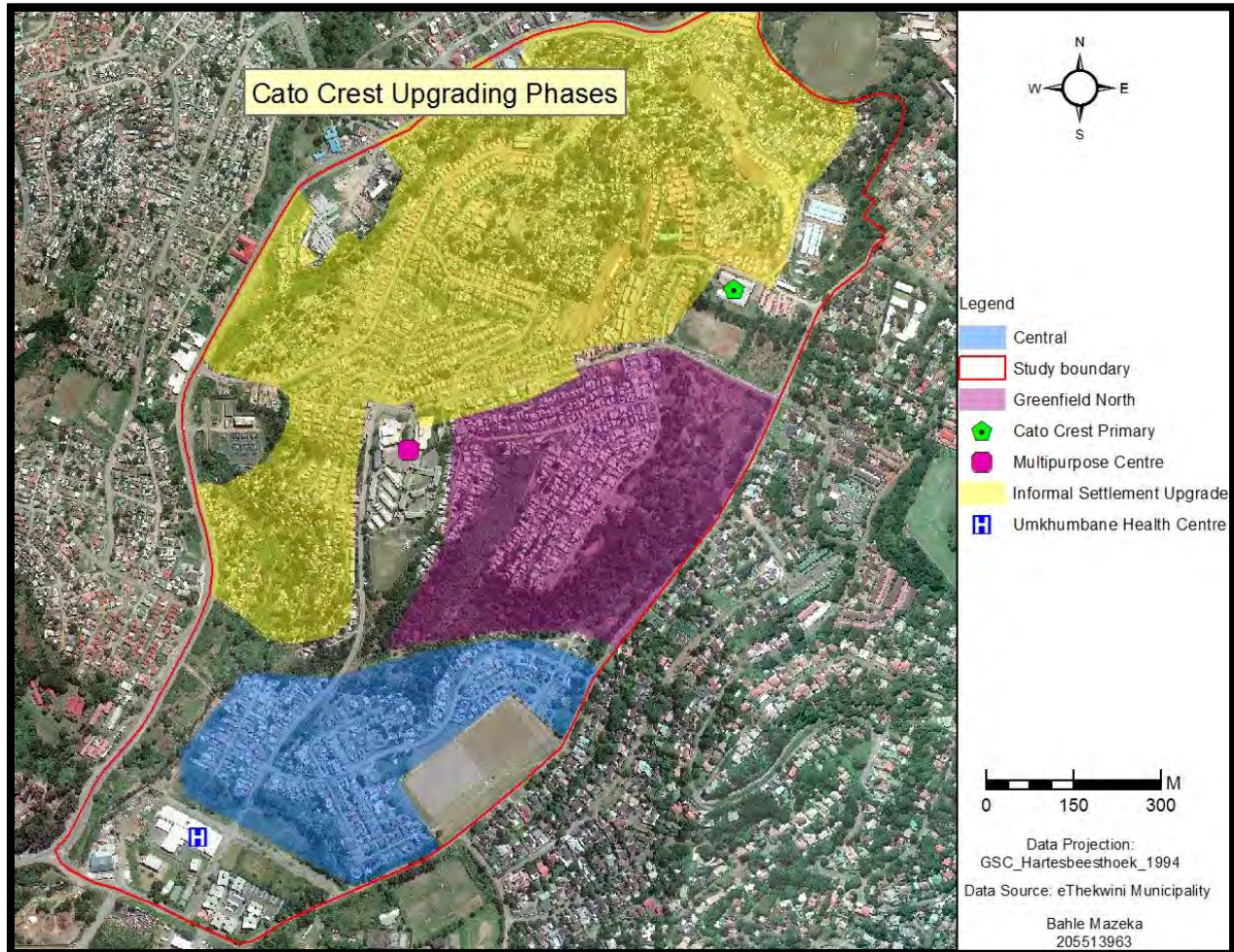

Fig 14. Map showing the 3 phases of Cato Crest upgrading project

Cato Crest residents are in two fold concerning benefits of the in-situ upgrading project as articulated in table 1 (pp 79). While the dominant perspective (73.5 %) is that in-situ upgrading has improved living conditions on the settlement, there is counter view that the former has no advantages. The greater majority of Cato Crest residents are of the impression the in-situ upgrade is advantageous to the well-being of the settlement and individuals. Residents of Cato Crest concur in-situ upgrading project has improved living condition citing "the provision of infrastructure", "people have received adequate housing structures", crime has drastically declined and one is able to installed security measures (such as burglar guards) in adequate structures previously not

feasible; thus the settlement is now a safer environment. Furthermore, because of the in-situ upgrading project, there is less soil erosion, better clean and hygiene environment, more aesthetic environment, better access to social facilities and services, better access to economic opportunities, reduced fire risk, "community unity", "improved roads", access to water, access to legal electricity, secure tenure status, and the size of the newly constructed houses are more spacious than shacks.

Nevertheless, a proportion (26.5 %) of Cato Crest residents feel the in-situ upgrading project has had no impact improving living conditions. This view is subjective because these residents continue leaving in shacks. Until their informal status has changed, they do not recognize the in-situ upgrade project and its benefits. Furthermore, the majority of the people who share this view are relatively new in the settlement. They may be aware of the previous condition of the settlement from word of mouth, however; did not physically experienced the hardship of older Cato Crest residents. People who have been residing in the settlement the longest have testified in-situ upgrading has drastically improved conditions on the settlement, acknowledge its advantages (and benefits), and are grateful.

Table 1: Improved living condition as a consequence of the in-situ upgrading project

Response	Number	Percentage
Yes	147	73.5
No	53	26.5
Total	200	100

Source: Researcher

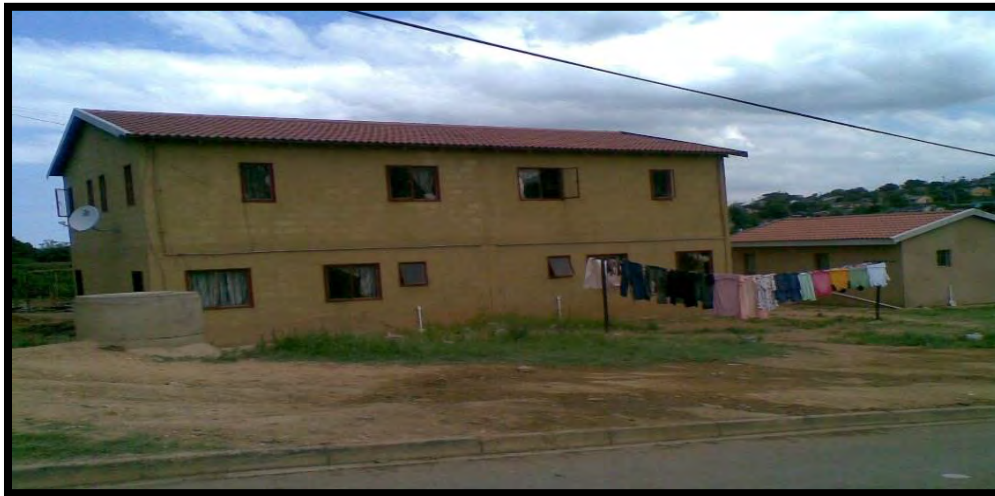Plate 4.1. Detached house (source: researcher)

Plate 4.2. Duplex house (source: researcher)

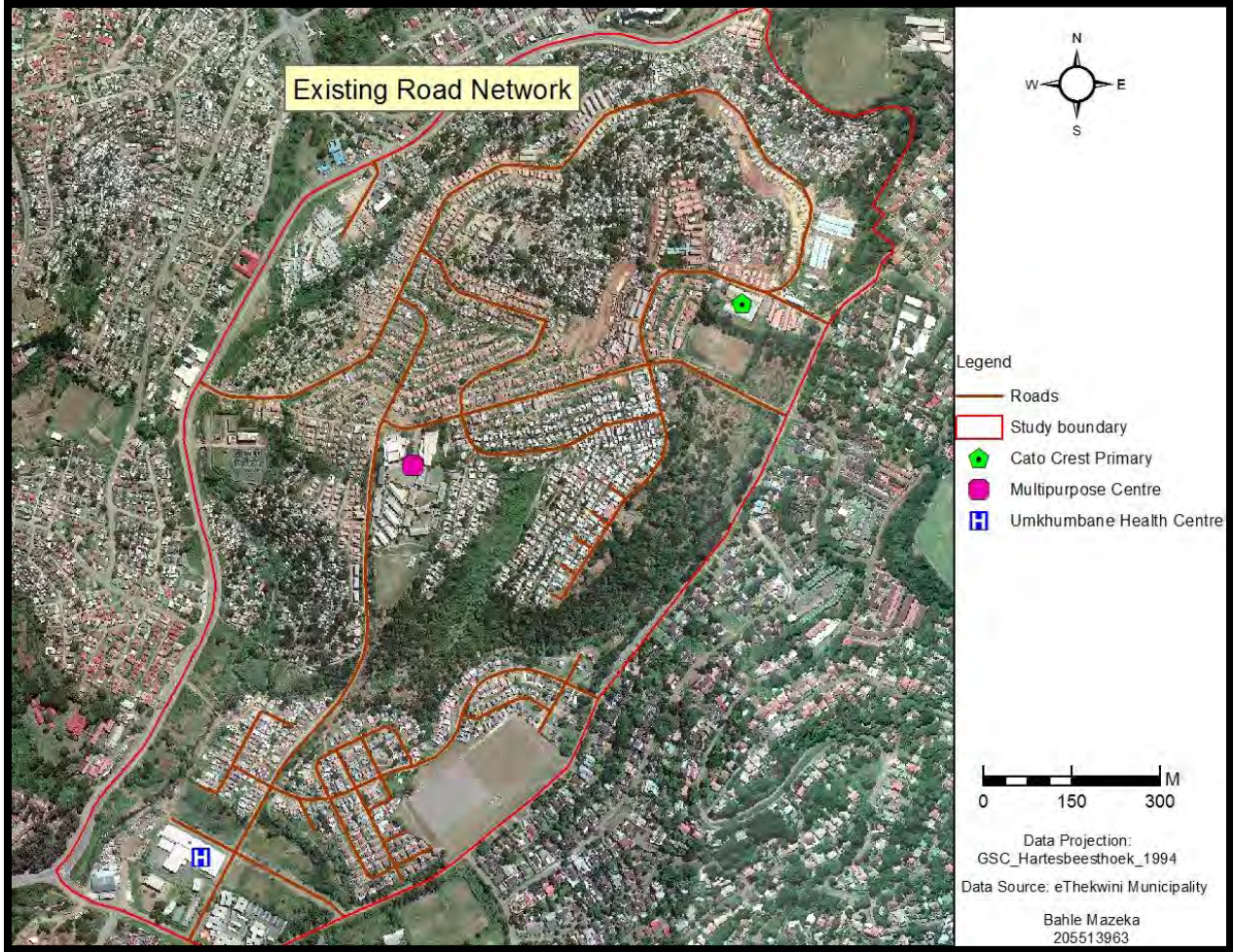Plate 4.3. Picture showing transit camp (source: researcher)

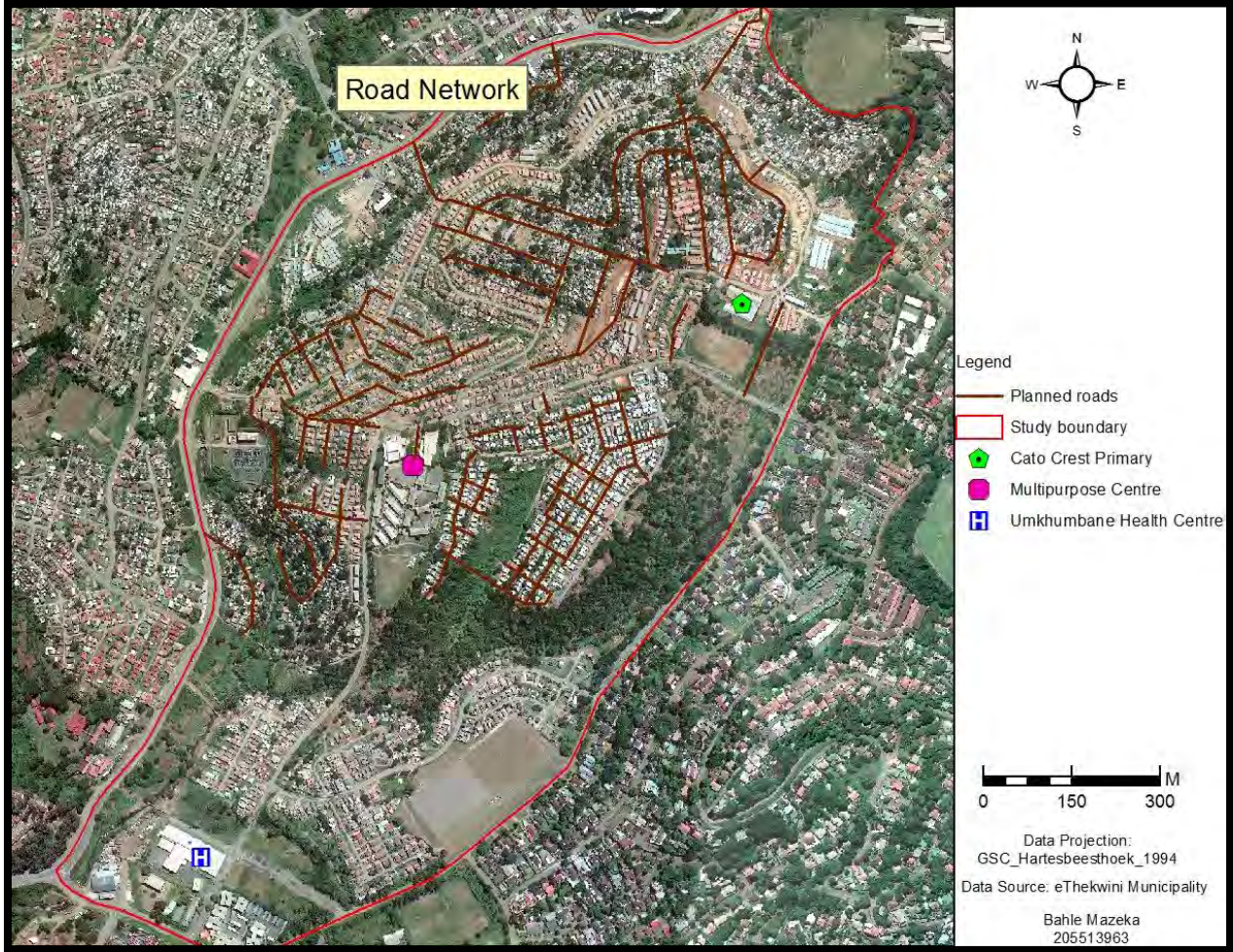Fig 15.a. Current road status of Cato Crest
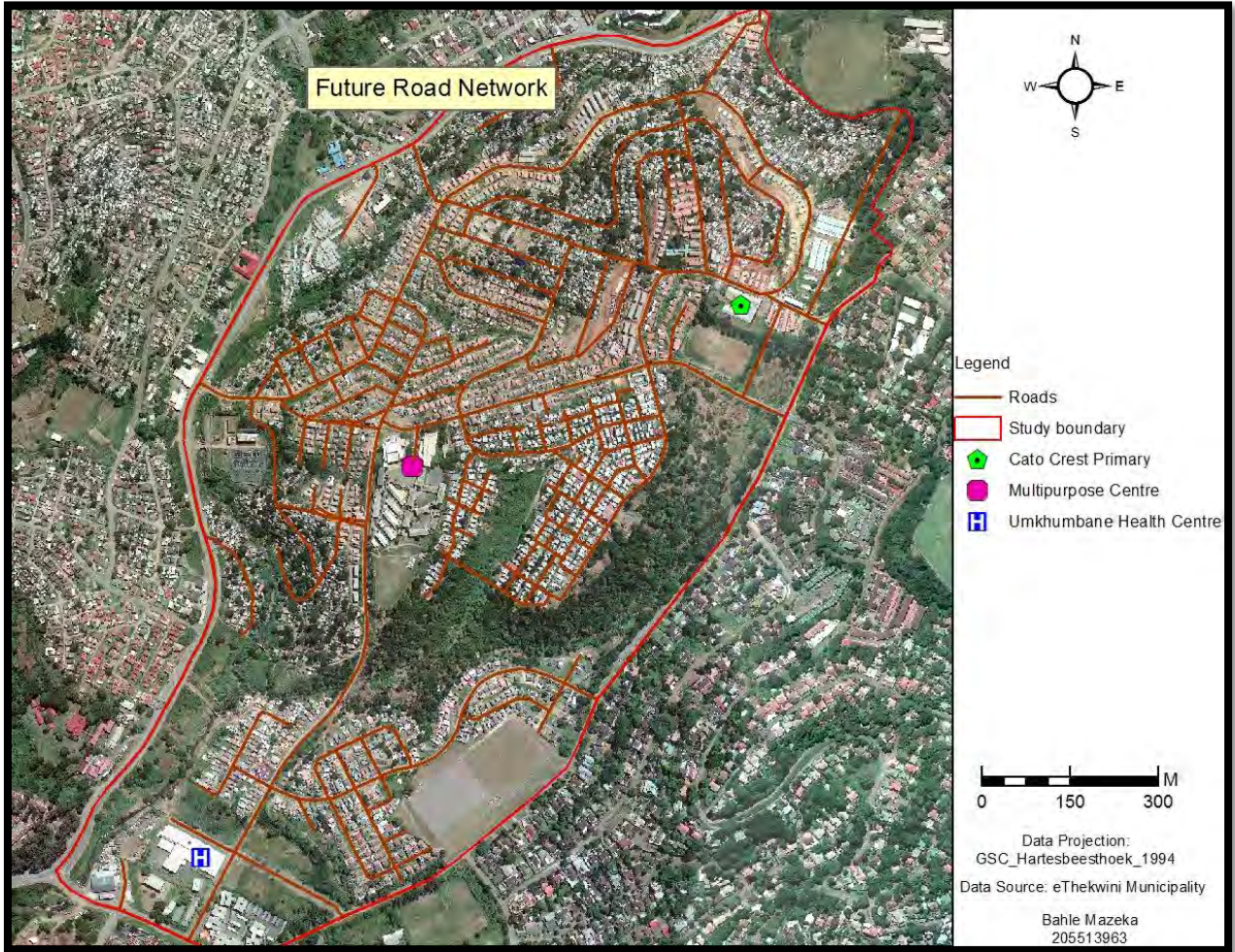
Fig 15.b. Planned roads of Cato Crest
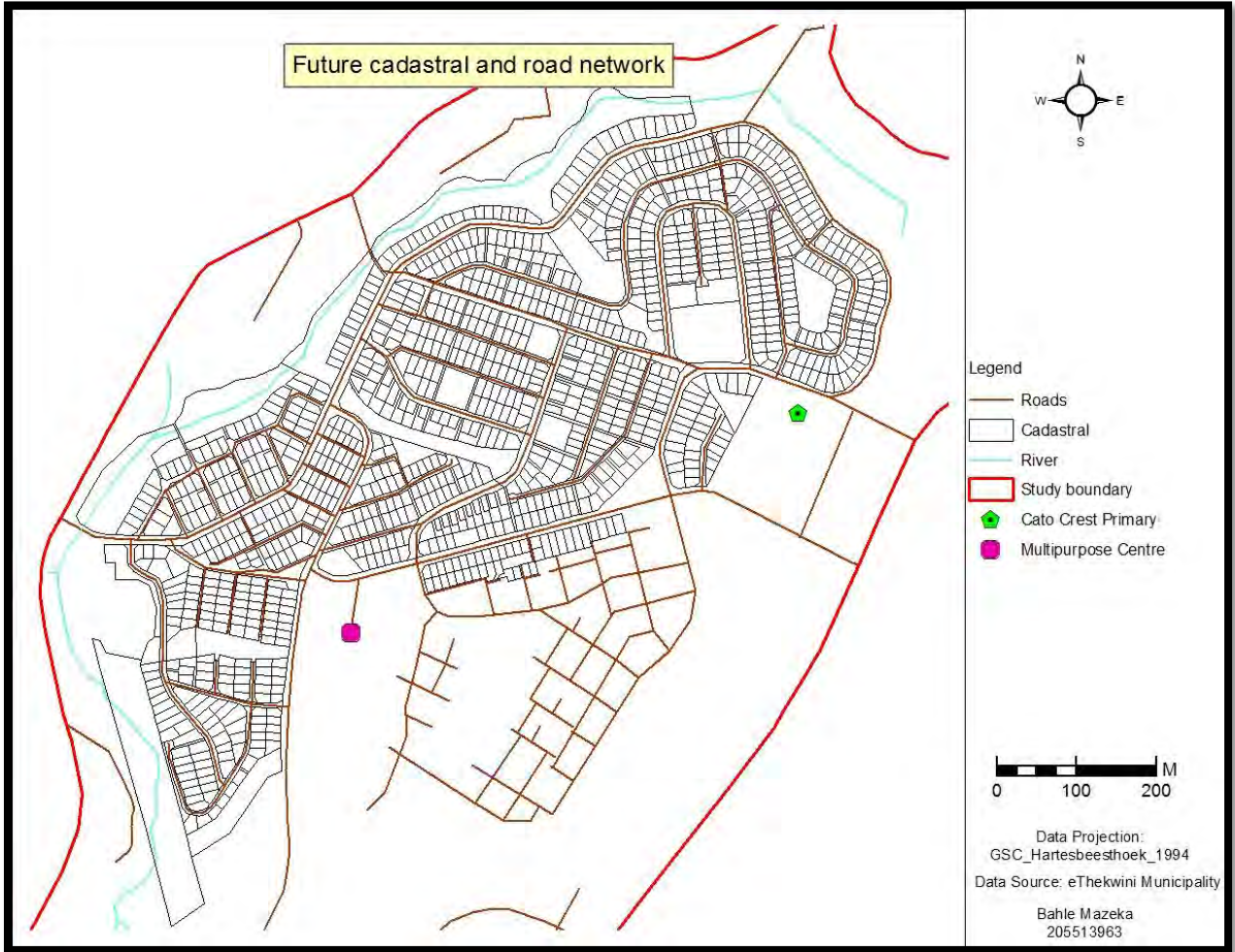
Fig 15.c. Complete futuristic Cato Crest road network

Fig 15.d. The future cadastral and road network of Cato Crest

4.3.2 Beneficiary identification criteria

In order for the municipality to identify beneficiaries, the primary criteria used to accommodate people is the duration of stay. People who have been in the informal settlement the longest were first to become beneficiaries. A system developed by the CMDA gave people approval numbers, better known as the "cc number". People who arrived at a later stage after 'cc numbers' where issued, the municipality has a criteria to identify beneficiaries, with priority given to people with disabilities, and individuals who were moved into transit camps because of services. Thus far, over 920 (and counting) adequate structures have been completed. The rest of the population are benefiting from various services (such as roads, installation of water, sanitation facilities, etc.) that are part and parcel of the in-situ upgrade.

4.3.3 Monitoring and evaluating

For the purpose of monitoring and evaluating the progress of the in-situ upgrade, eThekwini municipality use two strategies; ground 'monitors' (people tasked to observe any illegal activities, and report land invasions to authorities) and GIS. Keeping in mind land invasions occur overnight, the municipality has developed a healthy sustainable community participation relationship with Cato Crest residents. For the purpose of monitoring and evaluating day to day activities, local authorities depend heavily on ground monitors that are the form of community members, and municipal officials. Local authorities have advocated for community members to take responsibility in their settlement and report any illegal activities to relevant community leaders. This is because when land is invaded, the entire community is affected as implementation processes are interrupted.

On the other hand, GIS is used to monitor and evaluate the in-situ upgrade over a longer period. This is primarily because spatial data is updated annually, thus local authorities are able to use GIS to check the progress of implementation over a long period. Housing development projects takes a number of years to complete. GIS technology is still very much relevant and an important tool to use to monitor and evaluate in-situ upgrading. Additionally, information from ground monitors can be used to update the GIS data, and be able to influence decisions.

4.4   Community participation

According to eThekwini municipality, they have managed to create a strong sense of community participation that is sustainable with Cato Crest residents. This has been achieved through vigorous engagement processes over the years. To an extent, the municipality has managed in encouraging residents to be active agents concerning activities in their settlement. As a result, the ward committee is partially responsible for monitoring and evaluating purposes. This is because unauthorized activities interrupt implementation processes, consequently; the residents suffer the most. Furthermore, municipal authorities state the community is empowered (through representation by its leadership) that participates in decision making platforms.

Residents of Cato Crest, through democratic processes, have selected a Ward Councilor and Ward committee (also known as 'Community Development Committee' or informally 'committee'). One of the primary objectives for a Ward Committee is to be voice of the community throughout the in-situ upgrading project. The community has contrasting views concerning the extent and efficiency of community participation as indicated in table 2 (pp 87). The dominant view (83%) is not only do residents believe there is adequate community participation, rather acknowledges as community members they are involved in decision making processes. The foundation of this perspective lies on the attribute that as community members they gave consent for the settlement to be upgraded. The community could have refused, however; as a collective they agreed or permitted the municipality to be chief architects of the in-situ upgrading. Communication platforms with community leaders are through committee meetings. Such gatherings permit direct engagement processes with community leaders, and municipal authorities (in some meetings). Through these platforms decisions are made, and suggestions are taken into account for further scrutiny.

Evidently, community members of Cato Crest decided against being relocated into transit camps prior to being allocated a house. As a community, they felt its best people find their own temporary shelter, and move into the newly constructed house(s) upon its completion. Moreover, as a community they decided to be pro-actively involved in monitoring and evaluating the in-situ upgrade process. Primarily, this is because when land is invaded, or other technicalities arise, it is the community that suffers due to delays in in-situ upgrade processes. Thus, a collective decision to assist the municipality was reached through community forums. Cato Crest community

members tasked Community Development Committee to be major agents for monitoring and implementation purposes.

On the other hand, the other perspective that is less popular believe community participation is inadequate (13%) to non-existent (4 %). This view is largely motivated by the opinion as community members they are not involved in decision making processes. Secondly, there are divisions in the community, and those members that have ties with leadership receive special treatment. Some of the residents who share this perspective were subjects of forceful removals. One may feel this expression owes its roots to the experience of harsh treatment by authorities. A sub-portion of residents who share this perspective believe community participation is there but ineffective. They feel community participation processes occur sometimes when it's going to benefit authorities.

Table 2. Perspective on community participation

Community participation	Number	Percentage
Efficient	83	83
Inadequate	26	13
Does not exist	8	4
Total	200	100

Source: Researcher

4.5   Constraints and challenges

According to the eThekwini metropolitan municipality they are faced with various challenges and constrains daily implementing the in-situ upgrade in Cato Crest. These challenges come in the form of politics, beneficiary issues, residents refusing to move, and people who rent versus ownership. One of the biggest challenges revolves around which individual or household will receive a house, and who has to move. The reason for this is that one detached house occupies land that previously accommodated an average of five households. It then becomes problematic for the households that will not be receiving a house, thus; they opt to interrupt the implementation process by refusing to relocate, and (or) resort to land invasions. Another primary challenge comes in the form of 'shack-lords' (these are shack owning individuals who lease their properties to tenants).

When shack-lords are instructed by municipal authorities to demolish their properties in order to receive a house. Consequently, land-lords chase their tenants, who also resort to land invasions. Figure (16, pp 88) shows an area that has been largely invaded, and recently lead to forceful removals. Currently, the municipality is in court as people opened a lawsuit as a result of being evacuated because of land invasions. This interrupts the implementation process as land that has been set aside for development is invaded. Construction is thus halted till such a time land has been cleared.
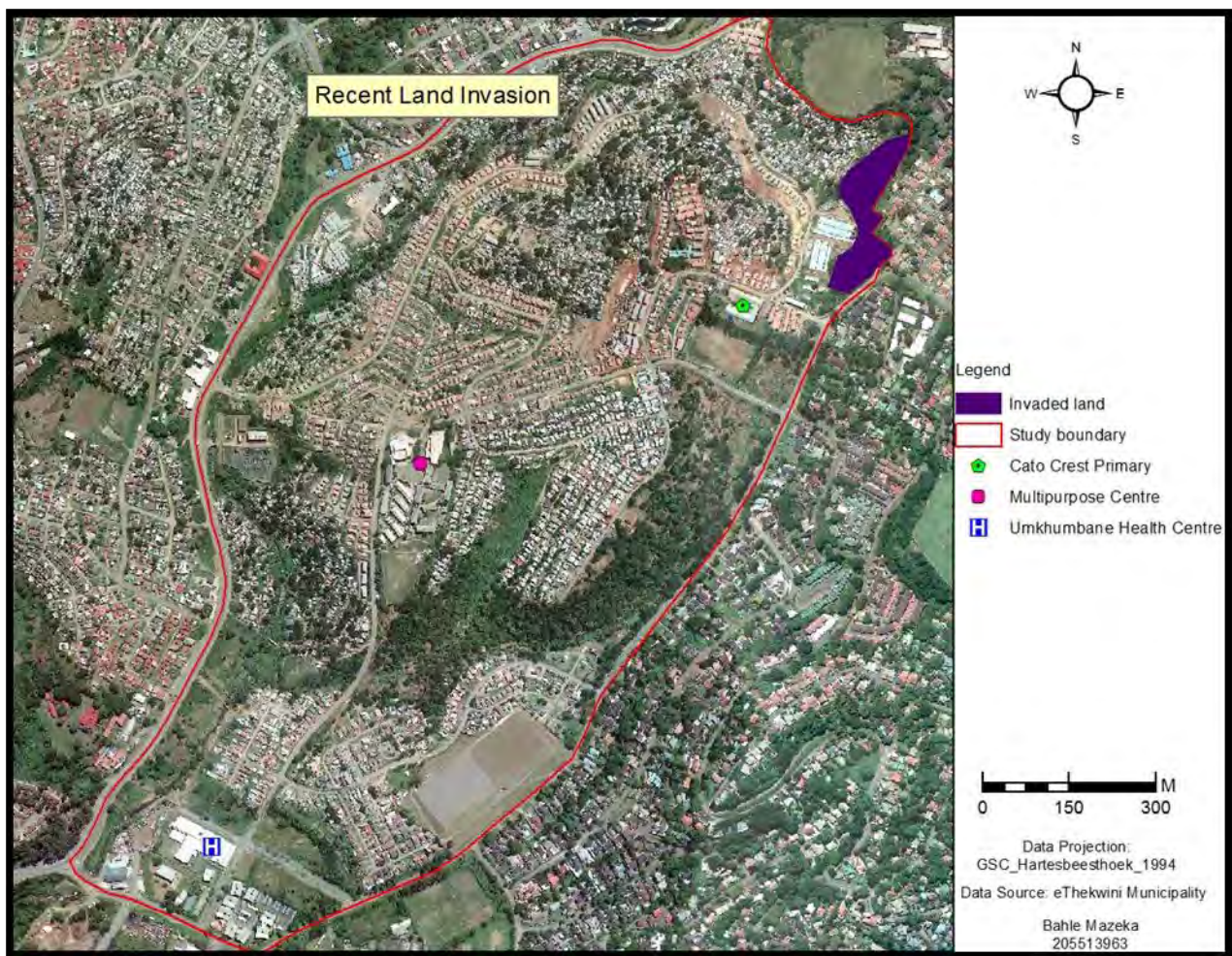

Fig 16. Land that was invaded by a group of people

During implementation stages of housing projects, it is a challenge for the municipality to monitor and evaluate in-situ upgrading projects. The primary challenge comes in the form of updating spatial data, and local authorities depend on images that are a year old. Images are captured in April annually, and published in November. Images that local authorities rely on in 2014 were captured in April 2013, therefore; data is always behind. It becomes an almost close to impossible task to monitor and evaluate housing projects using GIS alone, spatial changes on the image may not be accurate to what is currently on the ground. Primarily, this is because informal settlements grow rapidly and are spontaneous. Shacks are erected overnight, and if one has to rely on an annual image, that technology alone is not sufficient. As a result, the municipality strongly depend on ground monitors for updated status on the settlements. However, images are an adequate technology to monitor spatial changes over time during implementation stage because housing projects take years to complete.

Land, as a valuable resource is scarce and limited. The sad reality is that Cato Crest currently accommodates more people beyond its capacity, inevitably some individuals will be relocated. To combat this constraint, the municipality has resorted to maximize land in a manner that some houses and roads are constructed within the 100 year flood line, and on portions of land that were declared to have unstable soils (fig 17, pp 90). In an event of flooding, the areas that fall within the flood plain will experience extreme flooding conditions, and human life will be threatened. Moreover, a buffer zone is displayed (in figure 18, pp 91) which clearly demonstrate and reveals cadastral is planned on an environmental hazardous zone. Environmentally this is a risk, however; the pressing issue is that people need to be accommodated irrespective of a few minor environmental risks. Figure (19.a. pp 92 and 19.b. pp 93) displays the cadastral, roads, buffer zone, and the 100 year flood line. It clearly depicts some land pockets are planned on areas that are vulnerable to 'environmental risk'. Furthermore, instead of the traditional detached house, local authorities have also resorted into constructing duplexes (high-rise) structures. This practice is executed in order to maximize land by increasing density (population and housing), subsequently; more people accommodated.
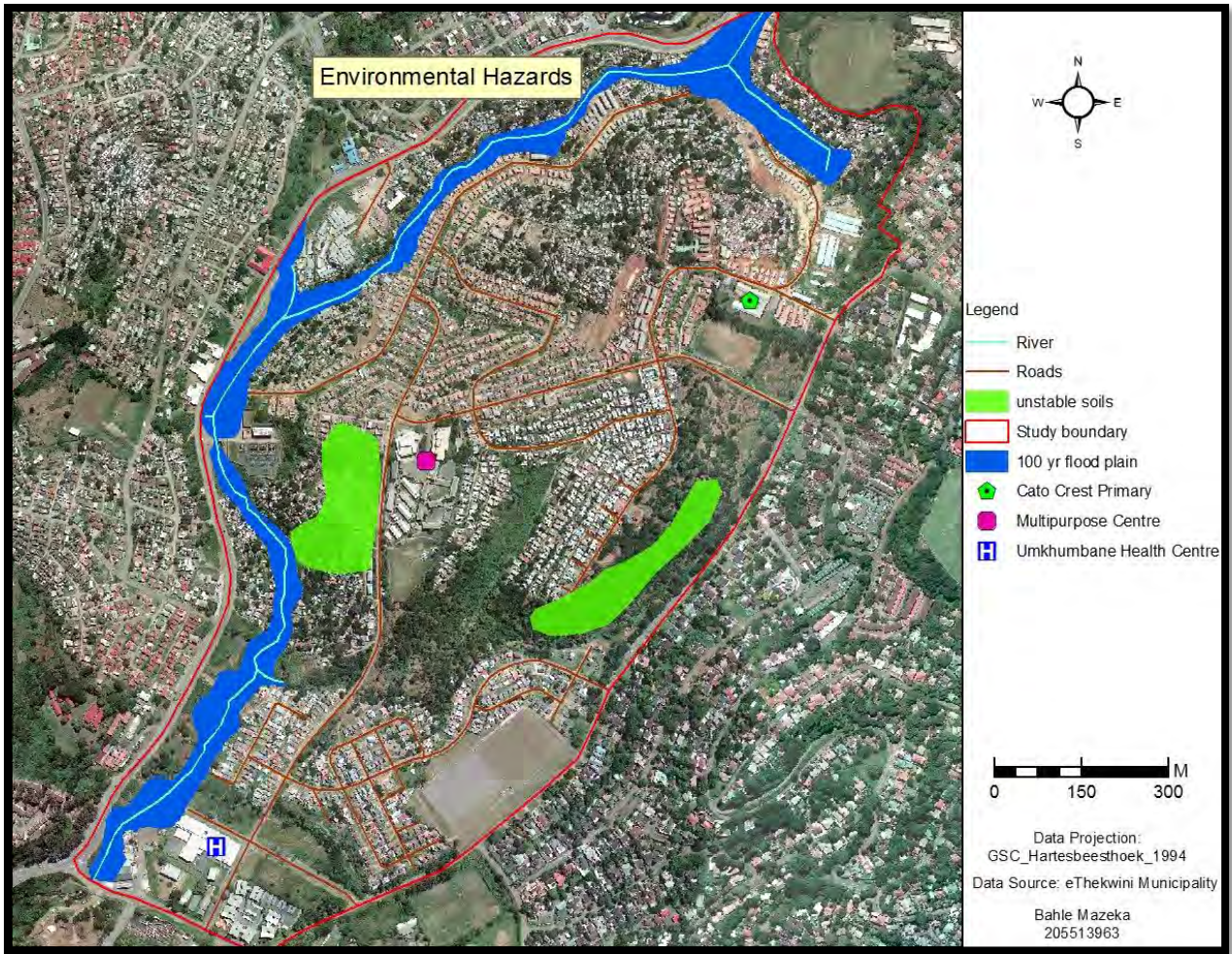
Fig 17. Map showing portions that are under environmental risk
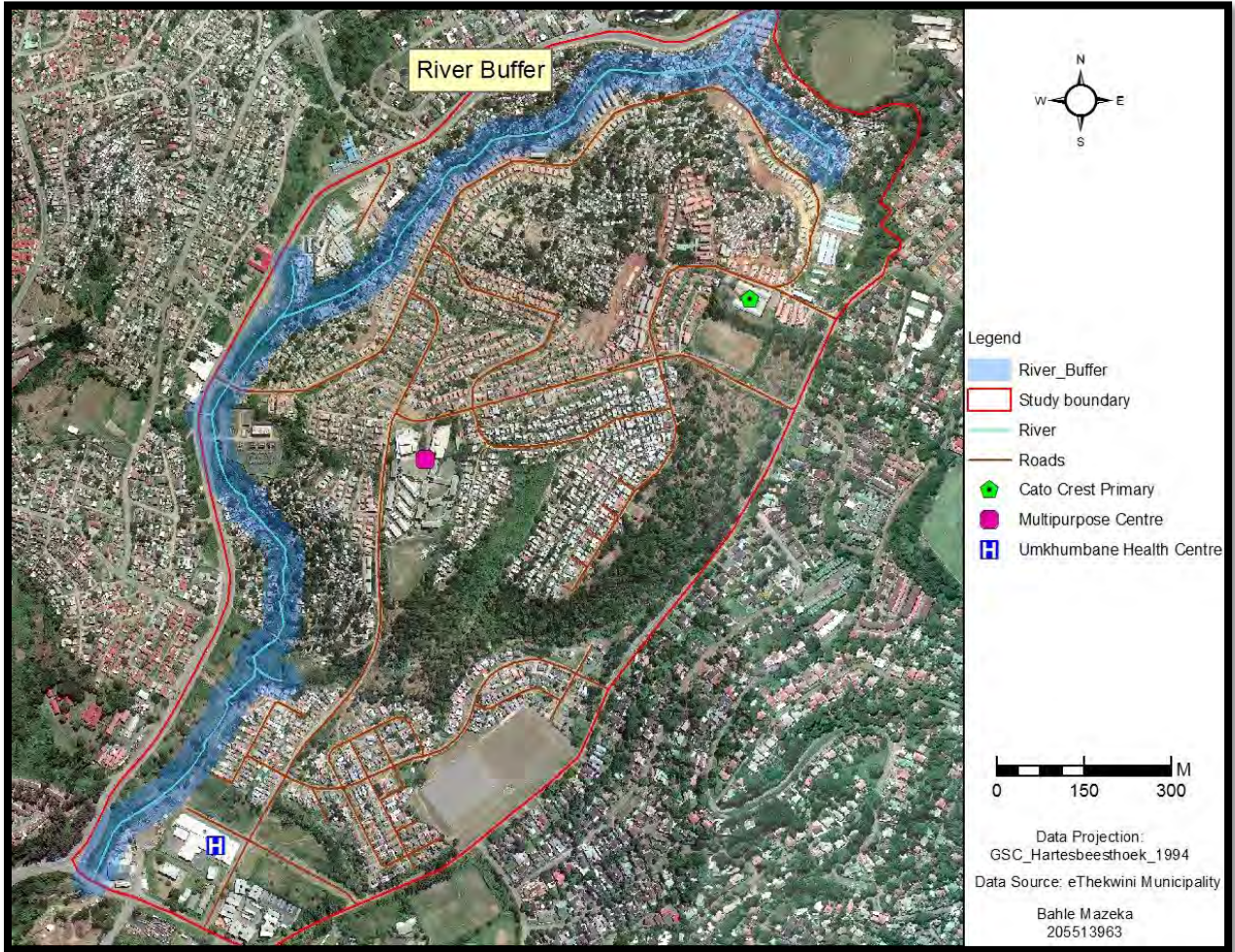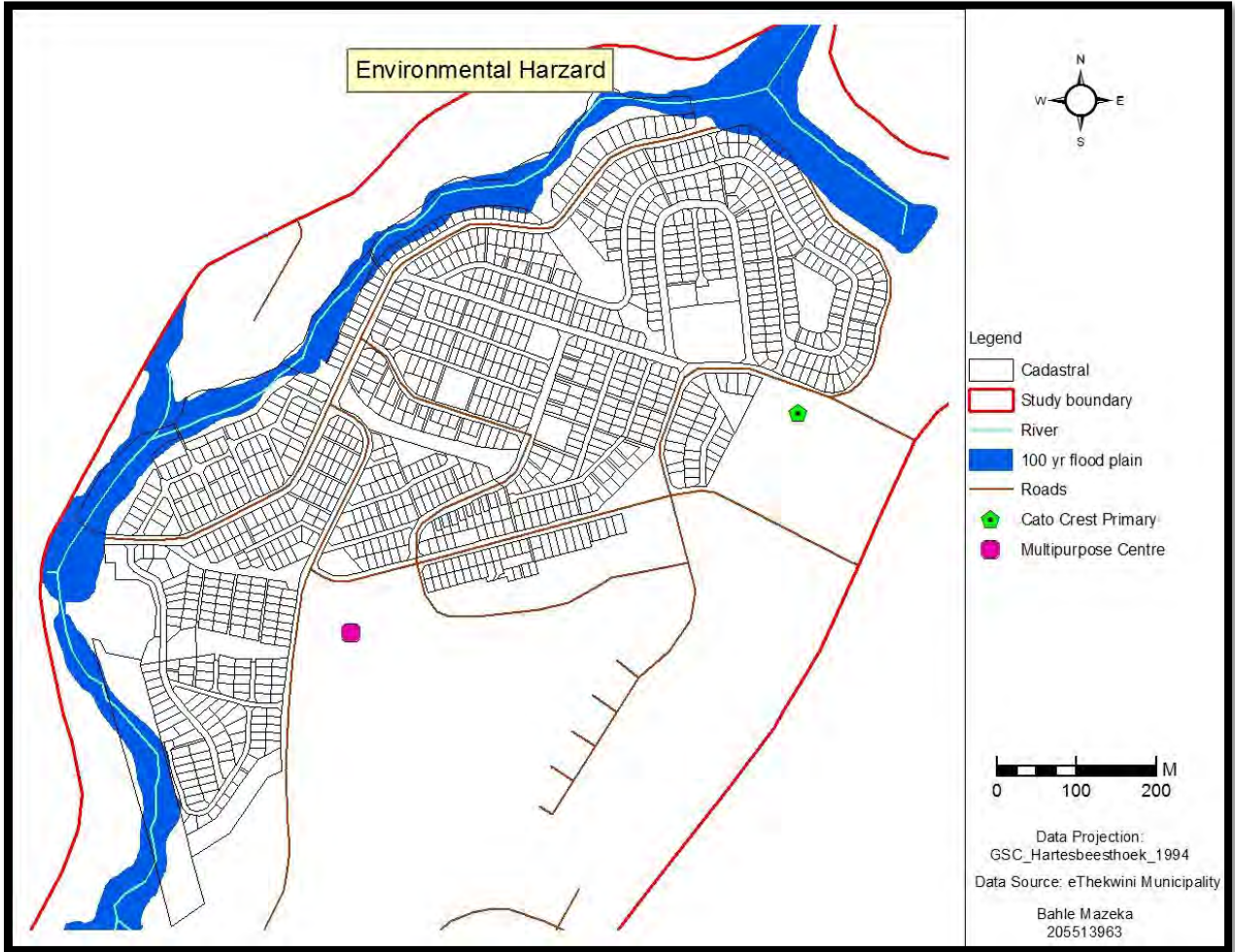
Fig 18. Buffer zone

Fig 19.a. Cadastral and road planned within the 100 year flood plain
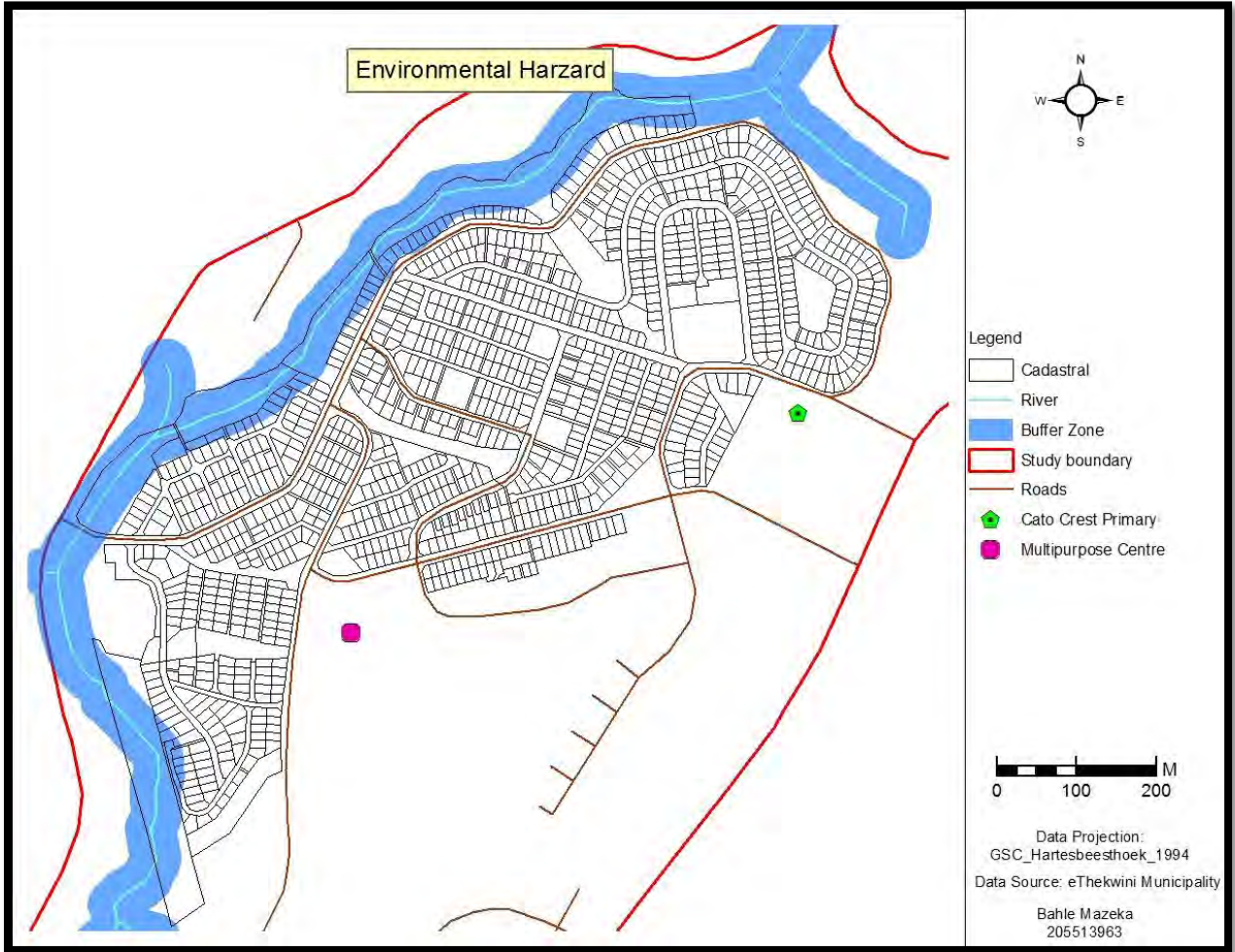
Fig 19.b. Cadastral and road planed within the river buffer zone

Nonetheless, improved living conditions associated with the in-situ upgrading project are not without challenges the community is facing and has to endure. Cato Crest residents experience communal and (or) different challenges. This is because the in-situ upgrading project is still in its implementation phase, thus people are affected differently due to the nature of their upgrade status. People in transit camps are faced with challenges such as "the unit is too small for family", and in corrugated iron structures weather conditions are drastic (in summer the unit are extremely hot, and in winter the winter is extremely cold), there was no electricity, dump site, and adequate sanitation facilities. Some residents were instructed to relocate into the transit camps for a few months, however; they still find themselves in these units after a number of years.

The study has found that common problems for people who continue to occupy shacks include inadequacy of their structure to cope with extreme weather condition. During heavy rains, shacks are often flooded. Consequently, such conditions assisted by poor waste management strategies leads to abundance of rats, health hazards, soil erosion, and collapsing of structures. Additionally, roads are constructed on the edge of shacks, this results in accidents as cars crash into the units. On the other hand, people in adequate structure are experiencing challenges correlated to poorly constructed units. The structures are not safe because a few have collapsed before. Moreover, contractors divert to using cheap construction materials in order to maximize their profits. This practice is a hazard to beneficiaries as structures are weak, evidently with huge cracks on the walls of structures. Be that as it may, communal challenges include poor waste management, pollution which leads to health vulnerabilities, insufficient land to accommodate all residents while population grows daily, slow implementation pace, inadequate sanitation facilities, shortage of water, crime, limited patience as residence continue to fight over tittle deeds, political conflicts, and incomplete structures.

This research has also found that land invasions is the crux of community challenges associated with the in-situ upgrading project. A group of delinquent residents (popularly known as 'marikana') are largely responsible for such activities. This groups blatantly refuses to abide by community authority and rules onto accessing services. They demand services (such as a house) and retaliate through rebellious behavior. Moreover, this group is said to be responsible for the vandalism and burning of the community hall in 2013. Contrary, some residents are of the perspective they are not experiencing any challenges. This view owes its origin on the fact that

they have been residents in the settlement for more than two decades. For them, conditions have improved, and continue to improve. Thus, living conditions on the settlement have dramatically improved as compared to a decade (and counting backwards).

4.6   Conclusion

This chapter has presented the results and analyses of the data collected from respondents of Cato Crest. Data was collected using interviews, questionnaire, GIS techniques, and observation. This chapter has indicated eThekwini municipality extensively uses GIS for housing development projects. This is achieved through the informal settlement plan (ISP) unit which performs desktop studies to inform decision makers. However, due to the challenge of updating municipal data, GIS remains ineffective in monitoring and evaluating day to day activities. Thus, the municipality resorts to ground monitors. The chapter also indicates there is a tangible relationship between informal settlements upgrading and the use of GIS. It is through the use of GIS an approach (relocation or information) to upgrade an informal settlement is decided, to planning phases, and long term monitoring and evaluating purposes. This research report has unpacked, to some extent, there is meaning community participation. This chapter witnessed eThekwini municipality and residents of Cato Crest experience challenges. Some Challenges are common, such as land invasion, which result in construction delays. Lastly, this research found that the in-situ upgrading has improved living conditions on the settlements.

Chapter 5: Conclusion and Recommendations

5.1 Introduction

This research is carried out in order to establish the ways and extent to which GIS is used in monitoring and evaluating the in-situ upgrading of informal settlements, using a case study of Cato Crest informal settlement under the jurisdiction of eThekwini metropolitan municipality. While in-situ upgrading remains the favourable method for eradicating informal settlements, implementation processes face challenges, this includes continuous land invasions and the re-emergence of shacks. EThekwini municipality has adopted a systematic approach of using human capital and spatial tool (in the form of GIS) to monitor and evaluate the progress of in-situ upgrading projects. This study has also unveiled the emphasis on active community participation to yield a comprehensive environment that optimizes implementing in-situ upgrading projects. In order to satisfy the objectives of this study, data was collected using various methods; interviews with municipal officials, community questionnaire, and manipulation of spatial data. The purpose of this chapter is to provide a summary of findings from data collection and analysis, conclude, and recommendations.

5.2 Summary of research findings

The study found out that eThekwini metropolitan municipality utilizes the technology of GIS for a wide array of activities. GIS data is updated annually to better assist decision makers. In the month of April, annually, an aerial photograph representing the municipal jurisdiction is captured. During the course of the year, data is processed, cleaned, analyzed, and updated (including existing and new shapefiles); and in November of every year updated municipal data is published. This enables municipal authorities to have access to the latest available data in order to provide services efficiently. Nevertheless, because data is only updated in November, this means municipal officials rely on data that is months old. Geographical features that are static (such as roads, rivers, and buildings, just to mention a few) offer little challenges or none at all. Some geographical features (such as informal settlements) are spontaneous, and may spread overnight. Thus spatial data (GIS) unsupported by other methods is insufficient to efficiently address rapid changes in space over

time. Be that as it may, the use of GIS by the municipality positively aids authorities to make sound decisions.

The Informal Settlement Plan (ISP) is a program that thrives because of the presence of GIS within the municipality. The ISP is predominantly a 'desktop study' that focusses on identifying informal settlements to recommending the method (in-situ upgrading or greenfield relocation) for eradicating the settlement and land acquisition for development. This is achieved through a vigorous prescreening process that is multi departmental. Housing projects involve not only Human Settlements department, but other departments (such as water and sanitation). At a planning stage, the ISP involves other line departments through circulating the desktop analysis concerning a particular settlement for comments and recommendations. This is of paramount importance because all involved departments are expects in their fields, this permits them to make valuable contributions at a planning level. In return, this aids the ISP to plan better for projects.

Once an informal settlement is identified, ISP officials are responsible for identifying available services in/or close to the site. Through a slope analysis (which is performed in a GIS) the ISP makes a recommendation on the type of development to be undertaken. Once land has been purchased, a project is handed over to the 'Projects' department for implementation. Therefore, the ISP is involves GIS with housing projects as early as the planning stage. Once a project is on its implementation phase, it is important to monitor and evaluate the former.

ISP officials assist projects with the use of GIS for monitoring and evaluating purposes. One reaches a conclusion that the ISP is no doubt a valuable component in the municipality. It assists projects from planning phases, and continues to assist even in monitoring and evaluating developments. However, the ISP heavily depends on spatial data. As already mentioned, spatial data may not be sufficient to display real time changes on the ground as it behind. Moreover, the ISP is a highly technical practice which requires sound knowledge individuals to ensure the program runs at its optimum. However, shortage of adequately qualified individuals in the field of GIS (and spatial technology at large) remains a concern. Nevertheless, within the limited resource available, the ISP aids the eradication of informal settlements.

It is evidently clear there is a relationship between informal settlement eradication, and the use of GIS at large, and for monitoring and evaluating purposes. Prior to making a decision to upgrade a settlement, a slope analysis (part of the desktop study) is performed on a GIS to inform decision

makers about the topography in which the settlement is in. Through the availability of spatial data one is able to create maps to track the progress on the projects, and to make further recommendations to decision makers. For example, one may create a map to show a portion of land that is invaded, this will inform decision makers effectively because through cartographic representation, information is communicated efficaciously. For the Cato Crest in-situ upgrading project, municipal officials utilize GIS to monitor and evaluate the progress of the project over a longer period of time instead of day to day challenges. Because of limitations associated with spatial data, they resort to other measures to monitor and evaluate activities that cause rapid change in space over time. Local authority has resorted to used ground monitors in the form of community members, and municipal officials as part of monitoring and evaluating strategy. Community members report incidences such as land invasions to relevant authorities to be addressed efficiently.

In 2004, the BNG advocated for the eradication of informal settlements through a phases approach that supports in-situ upgrading as the primary method, and tasking local municipalities to be chief architects. Cato Crest in-situ upgrading project commenced in 1992, spearheaded by the CMDA, and it achieved iconic geographical features such roads, multipurpose center (consisting of a community hall, library, and school), and a primary school. The local municipality inherited the burden of implementing the project and oversee its completion. The project is implemented in three different phases (Greenfield north, central, and in-situ upgrade), the first two phases are complete. Thus far, the municipality has been faced with challenges (such as lawsuits) implementing the project, however; they have achievements of their own of which they must be commended for. Infrastructure development has tremendously grown in the settlements, the availability of bulk services, permeability of the settlement through an improved road network, robust, and visual appropriateness. Up to date, over 920 (and counting) structures have been constructed, each structure translates into a household. The sad reality is that not every Cato Crest resident will benefit positively because of the in-situ upgrading project. Land is vital resource, and adequately located land it is scarce and limited. Consequently, some residence will fall victim to relocations to greenfield projects, or existing developments located further away from the CBD.

The local authority and the residents of Cato Crest, over the years, have managed to forge a sound sustainable community participation, and partnership. To some extent, community members are

not merely informed, rather they are active agents concerning their settlements. Nevertheless, one should not be under the impression the in-situ upgrading has been flawless. Challenges arise, but, the most important aspect is that stakeholders are able to sort out their differences through vigorous engagement platforms to find common ground. The ability to address challenges, and yet continue to share the common attribute of achieving the ultimate goal (eradicating of informal settlement) is a bonus for stakeholders. The capability of community members to request the municipality not to relocate residents to transit camps, and to be part and parcel of monitoring and evaluating strategy, is evidence enough there is a partnership that enables residents to feel they are part of decision making processes. Nevertheless, there is still much work needed as some community members do not feel part of decision making platforms. Logically, residents who arrived in the settlement during the in-situ upgrading implementation phase tend to feel they are excluded from community participation activities. Moreover, some residents who have not yet been beneficiaries do not recognize community participation, understandable so to some degree; they have witnessed other people benefiting. It is the responsibility of community participation to inspire confidence on these residents, because; housing projects take a number of years to complete. It is thus the responsibility of community participation forums to convince all residents to have faith and trust in the in-situ upgrading process.

The in-situ upgrading has impacted the Cato Crest positively, from physical attributes (such as roads, bulk services, adequate housing structures, just to mention a few) to inspiring sustainable livelihood strategies. One of the outstanding benefits of in-situ upgrading is secured tenure status for residents. Consequently, residents are able to invest in their properties through incremental practices. Furthermore, secure tenure provides a platform for inhabitants to better access and engage with economic activities.

As already mentioned, one should not be under the impression the in-situ upgrading of Cato Crest is without challenges. These arise in different forms that needs unambiguous solutions. There is often conflict when shack-lords remove people in order to receive a house. The evacuated people are left stranded, and often resort to land invasions. Some inhabitants have been in transit camps for more than a decade, keeping in mind these are supposed to be transitional facilities from a shack to a house. Land invasions continue to slow down implementation processes. People in transit camps are not able to make a smooth transition because land is invaded, thus interrupts the

implementation phase. Inevitably, some residents will be victims of relocation which will interrupt their livelihood strategies. Land is limited, and the topography of the settlement does not permit to utilize the entire site as there are land pockets that are undevelopable. As a result of ongoing problems, it is not possible to meet the BNGs target of eradicating informal settlements by 2014.

5.3   Challenges experienced during the study

The study departed wanting to include all involved stakeholders with in order to paint a full picture vis-à-vis the in-situ upgrading of Cato Crest informal settlement. This was to enable one to have a clear understanding of different stakeholders and their contributions to the upgrading processes. It goes without say, when one looks at Cato Crest (even Cato Manor) CMDA comes to mind first, because of their prolific role in the area. Unfortunately, the CMDA is no longer in existence, its name survives (and will continue to survive) through its undisputed legacy. Therefore, one was not able to make them respondents as initially planned. As initiators of Cato Crest in-situ upgrading, their contribution would have of paramount importance to some degree.

Furthermore, after approaching Abahlali Basemjondol offices in Durban, it was requested I send an email to legitimize my interest for the NGO to be participants in the study. However, efforts to communicate with the NGO were futile as the response was disappointing. Therefore, the study had to continue without Abahlali Basemjondol.

The use of GIS in the field of informal settlements remains limited. Thus, relevant literature is scarce and difficult to find, and access if it does exists.

Lastly, because municipal spatial data is updated and released in November of each year, one had to work with data that was published in 2013. One must note, this gave a small challenge as static geographical features are unchanged.

5.4   Recommendations

This research concludes by results that explicitly indicates GIS is an important tool in the whole spectrum of in-situ upgrading of informal settlements, from a planning stages to monitoring and evaluating projects. One of the objectives of this study is to influence adequate measures to be

used in addressing spatial issues of informal settlements. Guided by the findings of this study, recommendations are provided in order to optimize the use of GIS in monitoring and evaluating of informal settlements in-situ upgrading.

- The study recommends that the municipality invest (and acceptance) in spatial technology and its use. This starts with investment on human capital that is adequately skilled in the field of GIS. This should be followed by the will and support from top management to venture on new technology that produces positive results in fields it is used on. The ISP is able to perform a marvel spectacle at planning phases using GIS, this performance needs to be extended to monitoring and evaluating purposes. This will be achieved through an increase of competent staff and supporting technology.

- The study has found that there is a gap in having spatial data that is updated on a daily basis. Therefore, it is recommended that the municipality maintains a spatial database and exploit the venture of the use of GIS in informal settlements through the use of global positioning system (GPS), a process used to establish ones exact location (latitude, longitude and height) accurately within a range of 10m to 1mm or position at any point on the globe and the precise time (Bagron and Skelton, 2010). Through the use of GIS, local authority will be able to maintain a spatial database system that will influence informed decision. A GPS can be used to accurately assist in mapping land invasions as they happen, and to monitor them efficiently. A GPS record ground points accurately, data obtained from a field survey will be integrated in a database management system. In order to fully maximise the use of such technology depends on the competence of human capital. The use of this strategy will adequately bridge the gap created by updating data with its shapefiles before it releasing in November of every year.

- This research has discovered that while there is some sense of community participation, there is a problem with residents not being aware of such processes. It is recommended the local authority enhances community participation through hosting educational seminars for residents in order to better understand upgrading projects and their dynamics. Moreover, they must transfer the skill of managing a spatial database to community structures responsible for monitoring and evaluating strategies. Instead of reporting problems, community will be better engaged if they are able to update their own maps. This will

enable a better stronger community ties as residents will feel they contribute to their settlement more effectively.

- The study has found out that there is problem of land invasions as informal settlements are located in strategic pockets offering socio-economic benefits. Thus, it is recommended that local authorities be more proactive in finding well located land for low-cost housing developments as oppose to being reactionary.

- It is recommended the power of GIS should continuously be investigated to improve in-situ upgrading of informal settlements.

- The study recommends that government have a duty to ensure in-situ upgrading projects create employment opportunity to improve the lives of informal settlement inhabitants. The upgraded landscape may soon become another environment to be upgraded again.

Incorporating GIS into all the phases of in-situ upgrading projects will optimize the implementation process as decision makers will make informed decisions throughout project life cycle. However, the approach must not only be techno-centric, a viable active community participation must exist. There is a need for the local authority to encourage inhabitants to be involved, not only as participants, but as decision makers in in-situ upgrading projects. Informal settlements may be eradicated using a techno-human approach that will ensure a sustainable human settlement.

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Questions for eThekwini municipal officials

- What is the ISP and its objectives?

- Who is responsible for the monitoring and evaluation in-situ upgrading of informal settlements?

- Does this unit use GIS and other spatial tools to monitor and evaluate in-situ upgrading of informal settlements?

- Would you recommend GIS as a spatial tool to be the crux of monitoring and evaluation processes?

- What is the level of community participation during the in-situ upgrading of informal settlement process?

- To what extent is the community involved in the decision making process?

- Which other tools that are available to the municipality, and are used to monitor and evaluate in-situ upgrading of informal settlements?

- Is it important to monitoring and evaluating in-situ upgrading of informal settlements?

- What are the challenges facing the unit concerning upgrading of informal settlements?

- What are the challenges facing the unit with regards to monitoring and evaluating in-situ upgrading of informal settlements?

- Any solutions? Or ideas, recommendations concerning the entire informal settlement upgrading plan, and the use of GIS?

- Which other organs (institutions, people, etc.) are involved in upgrading of informal settlements?

- Will Cato Crest informal settlement be eradicated by 2014?

Questionnaire for Cato Crest informal settlement beneficiaries

1. Age of respondent | 18-29 | | 30-39 | | 40-49 | | 50-59 | | Over 60 |

2. Gender | Male | | Female |

3. Nationality   ………………………………………………………………………….

4. Home language | IsiZulu | | IsiXhosa | | Other |

5. How many years have you been a resident in Cato Crest informal settlement?

| 0-5 | | 6-14 | | 15-30 | | Over 31 |

6. What motivated you to reside in Cato Crest?

7. What is the in-situ upgrading of informal settlements?

8. How did you find out the settlement was going to be upgraded?

9. What is the extent of community involvement in the in-situ upgrading process?

10. Is the community involved in decision making processes?

11. Is the community informed or engaged or participants in the municipality plan of eradicating informal settlements?

12. Which tools are used to control the in-situ upgrading of informal settlements?

13. Were you involved in decision making processes about the upgrading? If yes, please elaborate.

14. Were you relocated during the upgrading process? If yes, were to?

15. What are the challenges the community is experiencing concerning in-situ upgrade?

16. Has the upgrading improved living conditions on the settlement?