# UNDERSTANDING THE SPATIAL DYNAMICS OF INFORMAL SETTLEMENTS

## A SPATIAL ANALYSIS CASE STUDY OF OOHAMBO DHA NEHALE IN THE CITY OF WINDHOEK

A THESIS SUBMITTED IN PARTIAL FULFILMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS (GEOGRAPHY)

OF

THE UNIVERSITY OF NAMIBIA

BY

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JULY 2016

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## ABSTRACT

Informal settlements expansion and development continues to be a problem for the government and urban planners. Understanding spatial dynamics of informal settlements may therefore be a key for future success in their effective management. This research explores the possibilities offered by the advancement in Geo-Information science and spatial analysis to improve the understanding of informal settlement spatial dynamics. A geographical information system (GIS) was used to analyse the spatial distribution and expansion of the Oohambo Dha Nehale informal settlement. GIS techniques were applied to aerial photographs taken in 2005, 2008, and 2011 in order to map the distribution of dwellings and spatial patterns, as well as to estimate the spatial expansion. Terrain data was used to determine the suitability of land for building residential purposes. Results show that the number of dwellings in Oohambo Dha Nehale increased from 465 in 2005 to 2,496 in 2011 as did its population, which grew from 1,628 to 8,729 inhabitants. During the same period, the area increased from 226,127 m² to 515,686 m². Additionally, dwellings found along the edge of the area exhibited a linear pattern, while those in the interior exhibited a cluster pattern. Slope analysis indicated that 70% of dwellings were built on unsuitable land, most of which were built on extremely sloping land. Oohambo Dha Nehale informal settlement continues to expand further into the mountains, northeast of Windhoek, despite efforts by the municipality to halt its expansion. With the expansion of the area, dwellings continue to be built on unsuitable land without adhering to the physical building regulations of the Windhoek municipality. The results of this study can assist the municipality, the government, urban planners, and policy makers to make informed decisions with regard to informal settlement.

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## LIST OF ACRONYMS

| | |
|---|---|
| CoW | City of Windhoek |
| DEM | Digital Elevation Model |
| EC | European Commission |
| GIS | Geographical Information System |
| GN | Government of Namibia |
| ISG | Informal Settlement Growth |
| LR | Logistic Regression |
| LRO | Land Rights Offices |
| LSA | Land Survey |
| MDGs | Millennium Development Goals |
| MLRR | Ministry of Lands, Resettlement and Rehabilitation |
| MRLGH | Ministry of Regional, Local Government, Housing and Rural Development |
| NPC | National Planning Commission |
| NSA | Namibia Statistic Agency |
| ODH | Oohambo Dha Nehale |
| PSBO | Planning, Service, Building and Occupation |
| SG | Surveyor General |
| TIN | Triangulated Irregular Network |
| UK | United Kingdom |
| UKODPM | United Kingdom Office of the Deputy Prime Minister |
| UNCHS | United Nations Centre for Human Settlement |

| | |
|---|---|
| UNDP | United Nations Development Program |
| UNECE | United Nations Economic Commission for Europe |
| WB | World Bank |
| WHO | World Health Organisation |

## ACKNOWLEDGEMENTS

The completion of this thesis would not have been possible without the guidance and support of relatives, friends, advisors and mentors.

Firstly, I would like to express my deepest gratitude to my supervisors Dr Simon Angombe and Mr Alex Mudabeti for their guidance, encouragement, and academic advice in ensuring the finalisation of this study. Secondly, I would like to thank Linda-Ann Bonny for improving the quality of this paper through her editing skills. Special thanks go to the City of Windhoek, Department of Planning, Urbanisation and Environment, especially Mr F. Maanda for his contribution and provision of detailed information and existing documents on informal settlements in Windhoek, and to Mr Edwin Kotjinjo for the provision of orthophoto maps of Windhoek. I would also like to thank Mr Nevel Ngahahe from the Namibia Statistic Agency for the provision of census data, and Mr P. Lisho for his scientific advice when I started my research. Lastly, I would like to thank my family for their constant support and word of encouragement during the period of my studies.

## DECLARATIONS

I, Mukando Mountain, declare hereby that this study is a true reflection of my own research, and that this work, or any part thereof has not been submitted for a degree in any other institution of higher education.



_____ _____

Mukando Mountain 18 July 2016

# 1. INTRODUCTION

In developing countries, rural-urban migration and poverty are some of the problems that have not been dealt with successfully (Njamwea, 2003). Rural-urban migration and poverty have led to the growth of informal settlements, which are urban areas that develop and grow without planning, and in which basic facilities are mostly lacking (Beckers, Flacke & Retsios, 2011). According to Abbott (2002), informal settlements are usually built on land without legal tenure, and tend not to follow established building and planning regulations. It is estimated that 30 to 70 % of urban growth in developing countries is informal (UN-Habitat, 2005a).

This research aims to explore the possibilities of using a geographical information system to improve the understanding of informal settlement through spatial analysis. The research determines the spatial distribution and expansion of Oohambo Dha Nehale informal settlement by mapping the distribution of dwellings, estimating the spatial expansion and spatial pattern exhibited by the dwellings. Furthermore, it determines the suitability of land in slope analysis for residential building purposes and how spatial analysis can assist in managing, controlling and improving informal settlemets. The results obtained will allow better understanding of the spatial dynamics for Oohambo Dha Nehale informal settlement and assist authorities, planners and other stakeholders in managing current and future informal settlements in a more structured and sustainable way.

## 1.2. BACKGROUND OF THE STUDY

The informal settlement is the prime option for land seekers in most developing countries where the authority fails to manage urban growth according to its legal norms (Kironde, 2006). Similarly, the growth and development of informal settlements has been the main problem associated with the expansion of Windhoek, the capital city of Namibia, where informal settlements are home to 30 to 40 % of its residents (City of Windhoek, 2012).

According to the World Health Organisation (2013) and the National Planning Commission (2013), the City of Windhoek is growing at a rate of approximately 4.4 % per annum, whereas informal settlement population is growing at a much higher rate of 9.5 % per annum. These settlements are built at the periphery of the city where the land is cheap and neglected, and they are characterised by low quality houses, absent or insufficient basic services such as water, waste removal, and inadequate infrastructure (Godehart & Vaughan, 2008). Maanda (2012) stated that these settlements continue expanding further into the mountains, to the north and northeast of Windhoek because of rural-urban migration.

The City of Windhoek recognises that the existence of informal settlements is a serious problem as they accommodate a large proportion of the urban population. These people live in poor living conditions in which basic facilities are mostly lacking (Abbott, 2002a). When planning a response to informal settlement growth and development, paucity of spatial data is one of the fundamental difficulties that

authorities face in developing countries. The spatial data would assist in recognising and quantifying the understanding of settlement morphology and emerging settlement pattern (Sliuzas, 2003).

The Millennium Development Goals (MDGs) (United Nations, 2009) emphasize the need to ensure environmental sustainability and to achieve a significant improvement in the lives of informal settlement dwellers. For that goal to be achieved, spatial analysis of informal settlement is one of the methods that can be done to manage, control and improve informal settlements in a more structured and sustainable way.

## 1.3. PROBLEM STATEMENT

In many developing countries of the world, policies and approaches have been devised and implemented to contain the rapid expansion of informal settlements with limited success (World Bank, 2002). Informal settlements continue to grow and new ones being formed on land that is not legally obtained from the City of Windhoek. Recently, authority's response to informal settlement expansion and development was to evict and demolish buildings found on land occupied illegally. This approach however, has not succeeded in stopping the expansion and development of informal settlement, but aggravated the situation, leading to further expansion and formation of new informal settlements.

Therefore, there is a need to have appropriate approaches to identify and monitor the spatial dynamics of informal settlements in a systematic reliable way. One of the possible solutions is to analyse these settlements spatially with the aid of a geographical information system; a computer-based tool that has become a key factor in handling spatial data (Eldrandaly, 2007). GIS techniques are widely used for mapping (to understand the pattern), monitor (to understand the process) and modelling (to simulate) the urban growth land-use, and sprawl. The physical expressions and patterns of urban growth and sprawl on landscapes can be detected, mapped, and analysed by using GIS techniques (Kumar, Pathan & Bhanderi, 2007).

The use of GIS technology within the City of Windhoek is underutilised because it is only used for mapping settlements. A GIS however, is not just a tool that can be used in mapping of settlements, but can be explored further to assist in revealing hidden patterns that could otherwise be difficult to see with our eyes (La Rusa, 2012). A GIS can also be used to relate the inter-relationships among social and geophysical characteristics of settlement, assist represent and project, where possible, a prospective picture of the spatial pattern of unplanned development within an area (ESRI, 2010). By monitoring the spatial dynamics of informal settlements, authorities, urban planners and other stakeholders would be assisted in their proactive management of the current and future expansion of informal settlements.

## 1.4. RESEARCH OBJECTIVES

This research aims to explore the possibilities offered by Geo-Information science and spatial analysis to improve the understanding of spatial dynamics of Oohambo Dha Nehale informal settlement. The main objectives are to:

- Examine and estimate the expansion of Oohambo Dha Nehale informal settlement.

- Determine the distribution and spatial pattern exhibited by the dwellings in the area

- Evaluate the suitability for building residential purposes and forecast dwellings found on suitable and unsuitable land in the area.

## 1.5. SIGNIFICANCE OF THE STUDY

The purpose of the study is to assist authorities improve their understanding of informal settlements through spatial analysis. The study is significant in a sense that it will further contribute to better understanding of informal settlements by authorities in Windhoek. By comprehending the spatial dynamics of these settlements, authorities will be able to make well-informed decisions in their quest to improve the conditions, management and planning of informal settlements.

## 1.6. OUTLINE OF THE THESIS

This section presents the chronological order of the thesis, from introduction to the conclusion and recommendations. The thesis is, therefore, divided into the following subsections:

### CHAPTER 1: INTRODUCTION

This chapter provides an introduction and background information on informal settlements and their characteristics. It also outlines the problem statement on which the study is centred as well as the research objectives and significance of the study. Lastly, the chapter defines some key terms used in the study.

### CHAPTER 2: LITERATURE REVIEW

This chapter gives a summary of the new Flexible Land Tenure System in Namibia, which was amended in 2012. It presents a theoretical general discussion about informal settlements, as well as the historical background of informal settlements in Namibia. Furthermore, the chapter discusses informal settlements in Windhoek and reviews the intervention programmes and policies put in place to manage their development and expansion. Lastly, the chapter provides the significance of spatial planning and GIS in spatial analysis, as well as a case study on how GIS technology is used as a tool in spatial analysis.

## CHAPTER 3: METHODOLOGY

This chapter presents an overview of the study area and the methods used in the research to meet the research objectives. It also points out the approach taken, the data collection, source, and data quality requirements. The chapter describes methods of determining the expansion, spatial pattern and slope analysis are.

## CHAPTER 4: RESULTS

This chapter presents the results obtained from the methodological analysis executed in Chapter 3, regarding the research objectives, in the form of statistical tables, maps and graphs. It also provides a comparison between the CoWSC and the ZSC.

## CHAPTER 5: DISCUSSION

This chapter examines and analyses the findings from Chapter 4 regarding the distribution of dwellings, the spatial expansion and pattern and slope analysis in the study area. The chapter also reflects on the results acquired to see if they are representative regarding spatial analysis.

## CHAPTER 6: CONCLUSION AND RECOMMENDATION

This chapter makes conclusions based on the analysis in the previous chapter, and aligns them with the research objectives. It also makes recommendations concerning the study findings and suggests areas for further research.

# 2. LITERATURE REVIEW

## 2.1. INTRODUCTION

This chapter briefly provides information on the new Flexible Land Tenure system in Namibia, which was amended in 2012 in comparison with the old tenure system (Freehold and Leasehold). A general discussion on informal settlement is also provided in this chapter, as well as tracing the historical background of informal settlement in Namibia at large. Furthermore, there is a discussion on informal settlements in Windhoek and the intervention programs and policies put in place to avert the growth of these settlements. A review on the significance of spatial planning and GIS in spatial analysis is also discussed. Lastly, the chapter presents a case study were GIS technology was used in spatial analysis as a planning tool for informal settlements in Dar es Salaam, Tanzania.

## 2.2. DEFINING LAND TENURE AND TENURE SECURITY

Land tenure (formal is the set of rules that determines how land is used, possessed, leveraged, sold, or in other ways disposed of within societies. These rules may be established by the state or by custom, and rights may accrue to individuals, families, communities or organisations. Land tenure is also referred to as formal, permanent or secure tenure. Rules of tenure define how access is granted to rights to use, control, and transfer land, as well as associated responsibilities and restraints. In

simple terms, land tenure systems determine who can use what resources for how long, and under what conditions (CSIS, 2012).

Security of tenure on the other hand, is the certainty that a person's rights to land will be recognised by others and protected in cases of specific challenges. People with insecure tenure face the risk that their rights to land will be threatened by competing claims, and even lost as a result of eviction. Without security of tenure, households are significantly impaired in their ability to secure sufficient food and to enjoy sustainable rural livelihood (FAO, 2002).

## 2.3. THE LAND TENURE SYSTEM IN NAMIBIA

Namibia has two main land tenure systems, freehold in declared urban areas and commercial farms and customary tenure on communal land, all of which is rural. White people originally reserved commercial farms for private ownership during the colonial period, while homelands or tribal lands for non-whites were re-designated as commercial land at Independence in 1990. Nowadays, about half of Namibians leave on commercial land and the other on freehold property, largely in towns (Mendelsohn, Shixwameni & Nakamela, 2012).

Land tenure in Namibia has been regulated by a number of Acts and Regulation. The oldest Act, which is still in effect, is the Deeds Registries Act of 1937. This Acts states that all land in Namibia must be surveyed before it can be registered. Any transactions resulting in change of ownership of land, including long-term leases

and servitudes, requires a survey by a professional land surveyor, an approval by the Surveyor General (SG), and registration in the Deeds office. Of more recent date is the Land Survey Act of 1993 (de Vries & Lewis, 2009).

Cadastral surveying of land follows the terms of the Land Survey Act. The Act, however, is almost the same as the old Land Survey Act of 1927 of South Africa. The Act of 1927 states that, before land can be surveyed, an elaborate process of approval should be required, involving the use of professional consultants such as town planners and a series of intermediate approvals by various individuals and committees (de Vries & Lewis, 2009).

Christensen and Hoygaard (1997) and Fourie (2000) argued that these formal land registration systems – defined in a broad sense, including planning, surveying and registration – have been effective in terms of accuracy and security, but wholly ineffective in terms of cost, fitness for purpose, and equitability.

Odendaal (2006) argued that the system is undeniably slow and expensive, and mostly serves a small percentage of the population. In Windhoek, less than half of its residents benefit from the formal land tenure system. Approximately 18,000 families (at least 25 % of the city population) live in informal settlements without any permanent tenure (CoW, 2006). In order to respond to the demand for securing land tenure within the City of Windhoek, a number of new acts were developed (Christensen, 2005). The terms land tenure and security tenure have different meaning.

A consultative three-year pilot program was implemented by the Ministry of Lands and Resettlements (MLS) in conjunction with the Danish agency IBIS, where various alternatives were considered, which culminated in a parallel affordable Land Registration System, proposed in the Flexible Land Tenure Bill Act of 2003. In turn, this enacted a legal framework for the Flexible Land Tenure System in order to benefit the urban poor who reside mostly in urban informal settlements (Republic of Namibia, 1997).

The new Flexible Tenure System was proposed because the previous tenure system (freehold and leasehold) were costly and not affordable to the poor, the disadvantaged, and the majority (UN-HABITAT, 2005b). The main goal of the proposed Flexible Land Tenure System (FLTS) is to provide simpler, more affordable, and faster forms of secure tenure to low income communities and to informal settlers in particular (Christensen, 2005). The FLTS focuses on providing security of tenure rights for urban dwellers living in urban informal areas.

The objective of the Flexible Land Tenure Act is to:

- Create alternative forms of land title that are simpler and less costly to administer.

- Provide security of title for persons who live in informal settlements or who are provided with low-income housing.

- Empower persons concerned economically by means of rights.

All of the above objectives suggest that the provision of property rights to inhabitants of informal settlement are seen as a means to the end of improving their economic welfare.

### 2.3.1. Legal framework for the Flexible Land Tenure System

The system would operate parallel to the existing registration system in the sense that parallel institutions would be responsible for the registration of different tenure types, meaning that the same land parcel would be the subject of registration in both the starter and land hold title registry, and the Windhoek Deed Registry. However, the deeds registry would only reflect the ownership of the whole block erf of land, since a starter and land hold title registry already exists.

Individual starter title and land hold title rights within that block erf would not be visible in the main registry, but only in the starter and land hold title registry (Christensen, 2004). The system would be interchangeable in the sense that the different tenure types catered for in the parallel registries could be upgraded over time from an initial base that offers basic security, to individual full ownership or freehold title. The concept is illustrated graphically in Figure 1.

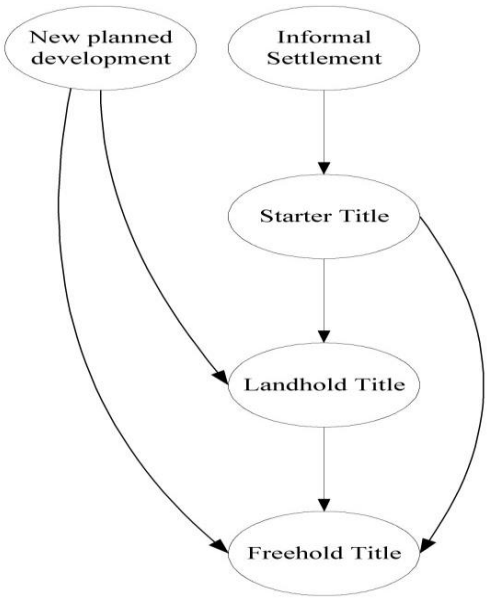


*Figure 1.* Schematic illustrations for upgrading informal settlements

Source: Ministry of Lands, Resettlement and Rehabilitation, 1997.

The Flexible Land Tenure System recommended two new types of tenure, namely:

a) The Starter Title is a form of tenure registered in respect to a block of land. It provides the holder with the right to occupy a site within a block. The occupant's freedom to transfer this right is subject to a group constitution requiring group consent. As the individual household's site is not yet defined, the right cannot be mortgaged.

b) The land hold title is a statutory form of tenure with a limited range of transactions to which it is associated . The most important aspects of ownership, including mortgages, are allowed without the full range of

transactions (with resulting complexities) that might arise in freehold ownership.

The two pieces of legislation have in common a shared commitment to informal settlement regulation through the creation of local level registries, in which people are able to acquire rights in informally surveyed land or unsurveyed (but readily identifiable) plots. The intention in both cases is to provide an adequate level of tenure security capable of supporting municipal infrastructure investment, without incurring the cost of formal surveying (UN-HABITAT, 2005b). Furthermore, both the Starter and Land hold titles are interchangeable.

A Starter Title can be upgraded to Land Hold Title or to a Freehold Title. A block is obtained by a saving scheme group, which forms an association after it has drawn up a constitution. The group can obtain Freehold Title provided it is situated in an approved urban area. Once tenure security is obtained, it is envisaged that the occupants will build their own houses and the local authority will provide services.

There are almost eight zones within the City of Windhoek and none of the informal settlements falls into them. The new Flexible Tenure System passed by the cabinet is aimed at formalizing the situation such that informal settlements in Windhoek can fall under one of the zones.

### 2.3.2. Land rights offices

Under the FLTS, Land Rights Offices (LRO) are established close to communities in order to speed up the delivery of land and bring cadastral services closer to the people. LROs will typically be staffed with registration and surveying offices, who will not only register starter and land hold titles, but also assist the communities with queries and disputes regarding land ownership (de Vries et al, 2009).

LROs will be located where pressure for land registration is high. Decisions on establishing Land Rights Offices must be carried out in cooperation with the Ministry of Regional, Local Government, Housing and Rural Development (Government of Namibia, 2006). Appointment of staff of the Rights Offices is handled by the Ministry of Lands and Resettlement. A Land Rights Office consists of a land rights register responsible for the operation of the office, a land measurer, and registration officer who are under the control of the Land Rights Registrar, will perform anything, which may be done under the Act (Government of Namibia, 2006).

## 2.4. INFORMAL SETTLEMENTS

Rapid growth of informal settlements is one of the largest problems of cities in developing countries. These settlements are common and are typically the product of an urgent need for shelter by the urban poor. Its reported that 78.2 % of the urban population in developing countries live in informal settlements. Moreover, they are growing at least twice the rate of planned settlements (UN-Habitat, 2010). Names for

informal settlements vary ranging from slums, to *favelas* in Brazil, *aashw'i* in Egypt, *cindades perdidas* (lost cities) in Spanish, *mukhukhu* in South Africa, and *ghetto* in Namibia (Kramer, 2006).

The term informal refers to the fact that these settlements are usually built without legal tenure and do not follow established building and planning regulations (Abbott, 2002a). Reasons for informal settlement growth include the weakness of statutory planning and a strong rural-urban migration that lead to substantial urban population growth. Although informal settlement growth is predominantly spontaneous, houses in these settlements usually exhibit particular growth patterns.

Sliuzas (1988) states that the growth of a settlement is clearly not a random process and is likely to be influenced by a number of physical, cultural, and economic factors. Sobreira and Gomes (2001) argue that the geometry of informal settlements does not consist of irregularly distributed dwellings, but in fact displays a complex structure that can be defined by spatial pattern.

Definitions of informal settlement vary widely from country to country and depend on a variety of defining parameters such as economic, socio and environmental factors. Another important issue in defining an informal settlement is the distinction between formality and informality, the borderline between formality and informality when applied to economic activities, employment and human settlements remain blurred (Vincent, 2009). Informality is associated with the term "illegality", however references to illegality in human settlement pertain mainly to conformity with planning

and construction norms, and more importantly to tenure situations (Durand-Lasserve, 2006).

Informal settlements are characterised by a large diversity according to different regions of the world, and can be defined in various ways depending on the planning and legal framework of the region where they exist. For Abbott (2002b), informal settlements are defined as residential areas of the urban poor, which are more often found in cities of developing countries.

This study adopts the definition by Sietchiping (2004) that states that an informal settlement is any human establishment or use of land in an urban area that is not suitable for, and/or is in opposition to, the expected standard and regulation. In his definition, informal settlements do not only include urban slums that are comprise of deteriorating and decaying areas of the city, but also poor housing near the city centre, within the city, and those that develop at the periphery of the city where the land is accessible at a relatively cheap price.

He associated informal settlements with overcrowded houses, an absence, or insufficient provision of basic infrastructure or amenities, unsanitary environmental conditions, and deteriorating housing and land environment. An important phrase in all the definitions of informal settlements is the lack of requisite permit or legal title for the use of land. However, the regional diversity of urbanisation has to be taken into consideration in forming an adequate definition of what is termed *informal settlements*, especially in developing countries (Vincent, 2009).

### 2.4.1. Stages of informal settlement development

Informal settlements development goes through various stages during its growth. These stages include *infancy*, where a piece of land that is vacant and mostly found at the periphery of city is occupied by informal dwellers. *Consolidation*, which is the stage between infancy and saturation. It is characterised by increased outward expansion, subdivision, construction and tenancy (Sliuzas, 2008). At *saturation* stage, the expansion stops and empty spaces get filled up with new structure. This stage is mostly characterised by high overcrowding which exacerbate living conditions of informal dwellers (Sori, 2012).

Abebe (2011) notes that, informal settlement growth is affected in three distinct but overlapping means, which is expansion, densification and intensification. Informal settlement expansion can be either inward, outward or independent from a known boundary of an existing settlement. The main function of the expansion process is that the settlement size increases in size. Densification refers to the infilling of empty spaces by building structures built within the realm of existing settlement (Timothy, 1995). Population and residential density describes the densification process. Intensification is the vertical increment of built up structures and is considered to be one form of the internal growth along with densification.

### 2.4.2. Historical background of informal settlements

The rapid growth of urban areas in the developing world has prompted the challenge of creating innovative approaches to sustainable development. In Namibia and other developing countries around the world, urbanisation has led to the rise of informal settlements. These settlements are often characterised by residents with low income profiles, who live under extreme poverty conditions, and lack the proper financial means and urban infrastructure to cover their basic needs (World Bank, 2005).

Informal settlements have a historical background that dates back from the colonial era. During the German colonial period, Namibia (then named German South West Africa), was divided into two parts: the police zone, and the northern and northeastern areas. The police zone was cleared for white settlement, whereas the northern and northeastern areas had reserves or homelands created for the indigenous population. Movement outside these areas was restricted (UN-HABITAT, 2005a).

After German armed forces surrendered on the 9$^{th}$ of July 1915, Namibia became a British protectorate, with the British King's mandate held by South Africa. Land held by the German colonial administration became Crown or state land of South Africa (Adams, Werner & Vale, 1990). The urban policy of both the German and the South African colonial administrations was to create exclusively white towns and cities.

Throughout the colonial era, both public and private investments were concentrated in these urban centres. Blacks were allowed to move in, mainly as contract labourers and lived in separate areas or townships with inferior social services. Permanent urbanisation was discouraged, while a number of discriminatory laws, such as pass laws and the prohibition of urban land ownership, controlled most aspects of black residents' lives (Christensen, Wolfgand & Hojgaard, 1999).

The development of informal settlements was also strictly regulated by apartheid policies. For example, residential growth in Katutura, one of Windhoek's only black townships at the time, was prohibited. Consequently, formal low-cost houses in Katutura became heavily overcrowded prior to independence (Gold, Muller & Mithn, 2001).

With Namibia's independence in March 1990 came the abolishment of apartheid policies, and the Namibian Constitution introduced the right of all Namibians to freely reside and settle in any part of the country. The change drastically reformed the Namibian Government (Gold et al, 2001), as young citizens began to migrate freely from rural to urban areas in search of employment, better paying jobs, and a better standard of living. As a result of this continuous migration from rural to urban areas, a number of informal settlements were established on vacant land around the city (City of Windhoek, 2003).

A dramatic increase of informal settlements in Windhoek resulted, mostly around Katutura. Many of those who lived in overcrowded conditions in Katutura

moved onto vacant land nearby, and many others migrated in from impoverished rural areas. Newly settled urban residents lived in unhygienic conditions, with no easily accessible water or sewage facilities (NPC, 2005).

### 2.4.3. Informal settlements in Windhoek

According to the World Bank's (2002) Country Assessment Report, informal settlements came into being between 1991 and 1998, when the Windhoek City Council, now the City of Windhoek formed up three Reception Areas. These areas were intended to be temporary places, until people could be resettled in accordance with squatter policies that were in place. In 1992 the first Reception Area, Big Bend, today known as Havana was established, followed by Okuryangava Extension 6, locally referred to as Babylon and Kilimanjaro. In 1998 a third Reception Area, consisting of 4 erf blocks in Goreangab, was developed.

The World Bank (2002, p. 2) further points out that these areas consisted of tracks of land where earth roads were cut to a rudimentary layout, a lifeline water supply was provided, and in some cases communal toilet facilities were also provided. People settled in shacks of corrugated metal sheeting on plots of 300 square meters, set out in the blocks. Currently, informal settlements in Windhoek are found in the townships of Goreangab, Hakahana, Havana, Okuryangava, and Otjomuise. The locations of informal settlements and low-income land in these townships are evenly distributed in order to form a uniform land development. Figure 2 shows the Windhoek Informal Settlement Townships.

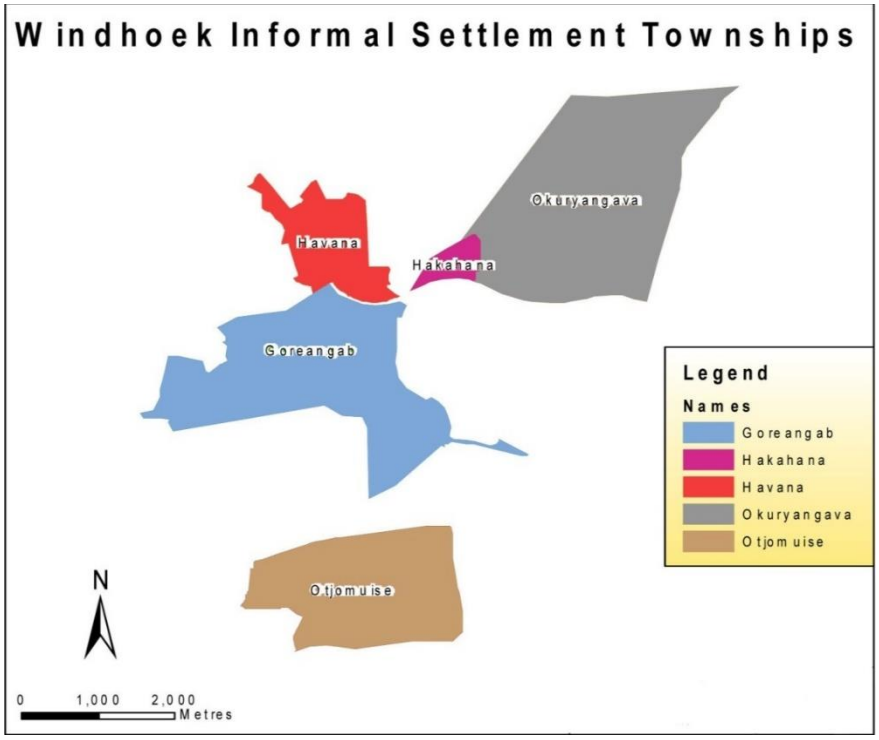


*Figure 2*. Windhoek informal settlement townships

Source: City of Windhoek.

### 2.4.4. Growth of informal settlement and household dynamics in Windhoek

Since independence, the population of Windhoek has increased dramatically, which has led to a profound impact on the growth of informal settlements in the city. The population increase is due to the flow of people to the city in search of employment and better living conditions, as stated earlier. The City of Windhoek (2006, p. 2) reveals that the population of Windhoek is estimated to be over 227,000 since 2001. However, the population is currently estimated to be above 300,000. At independence

in 1990, there were only 300 squatter households in Windhoek, but by 1995, the number had increased to approximately 7,000 such households (City of Windhoek, 2002).

Since independence, the increase has been 5.4 % per year resulting in Windhoek's population increasing from 97,000 in 1988 to 182,000 in 1995, and it had been estimated that Windhoek's population would reach 450,000 by the year 2010 (City of Windhoek, 2001). Windhoek's overall population growth rate has been more than 5 % per annum since 1991. Between 1995 and 2001, Windhoek's informal settlement population grew by more than 30,000 inhabitants. That represented an annual average increase of more than 3,300 people, representing more than 800 households per annum with an average household size of four people (World Bank, 2002).

The annual growth rate of informal settlements is about twice that of the entire city, which indicates that informal settlements have a higher population than in formal areas. As a result of high growth rate of informal settlement population, the proportion of informal settlement structures has grown from 15% in 1995 to 25% in 2001, representing a proportionate increase of 1.6% per annum growth in informal settlement structures (Simon, 2006). Table 1 shows population comparisons between urban and informal settlements between 2001 and 2011.

Table 1

*Population Growth between Urban and Informal Settlements.*

| Population | Windhoek | Informal Settlement |
|---|---|---|
| 2001 | 233,529 | 48,183 |
| 2011 | 325,858 | 102,643 |
| Absolute growth over 10 years | 92,329 | 54,457 |
| Average population growth per annum | 9,232 | 5,445 |
| Annual growth rate | 4-5 % | 10 % |

*Note*: Adopted from Namibia population and housing census 2011

Communities in urban informal settlements are diverse as are their environmental conditions. These settlements are characterised by inadequate access to safe water and sanitation, a lack of electricity, poor housing quality, overcrowding, and insecure residential status (Osrin, Das, Bapat, Alcock, Josh & More, 2011). Informal settlements in Windhoek are home to the majority of the urban poor and the unemployed. Statistics from the 2011 census data indicate that Windhoek's population stands at 350,000 residents, 100,000 of which dwell in informal settlements.

People in these settlements live in extreme poverty and hardship, mostly in houses that are congested and poorly built on land occupied illegally. The houses known as shacks or shanties are constructed from various parts of retired motor vehicles, including corrugated iron and plastic boards. Most of these shacks house three or more people in them, and do not have electricity, running water, or toilets.

## 2.5. INTERVENTION PROGRAMS AND POLICIES ON INFORMAL SETTLEMENTS

Rapid growth of informal settlements is one of the biggest problems of cities in developing countries. Many actions have been taken by city authorities to mitigate the socioeconomic, physical, and political consequences of these settlements. They range from passively ignoring or actively harassing informal settlement dwellers, to interventions aimed at protecting the rights of informal settlement dwellers and helping them improve their income and living environment (Huchzermeyer, 2008).

We are beginning to see more comprehensive forms of policy intervention that seek slum upgrading or the regularisation of illegal settlements, including the incorporation of these areas, within the formal services and infrastructure systems. Such approaches are now being promoted in many developing countries of the world and have been relatively successful in normalising squatter settlements and providing residents with access to minimum standards of service provision, including drinking water supplies, sanitation, and street paving (Mooya & Cloete, 2007).

### 2.5.1. Eviction

In the beginning, public authorities viewed informal settlements as undesirable, which led to eviction and demolition. Eviction was common in the period between the 1920s and the 1950s. Laws supported eviction and demolition because settlements were built without legal tenure from the authorities (Payne, 1984). In Windhoek, land

invasion has been practiced since independence, and continues to increase in some informal settlements, leading to the growth of existing informal settlements and the development of new ones. However, the city authority's reaction to these settlements was to evict residents and destroy their homes (UNDP, 2012).

In 2008, illegal shacks were erected in Havana, Otjomuise, and 7 de Laan. Due to the fact that land invasion increased without permission from the authorities, the City of Windhoek began to demolish illegal shacks. In June 2009, city police destroyed illegal shacks at Agste Laan in Otjomuise following directives given by the City of Windhoek. The same process occurred in 2012 when city police destroyed illegal shacks at Goreangab Dam informal settlement (Ikela, 2012).

Demolition and eviction however, have not succeeded in halting or preventing the development and growth of informal settlements, as growth continues to increase and house the majority of the urban poor.

### 2.5.2. Site and service schemes

In the mid-1960s to the early 1970s, sites and service schemes were advocated, financed, and implemented by international institutions such as the United Nations Center for Human Settlements (UNCHS) and the World Bank (Fekade, 2000). The aim was to provide better housing to the poor in addition to offering an opportunity for home ownership with a form of legal tenure. Site and service approaches recognized the ability of the poor to build their own housing when provided with a site and basic facilities (Srinivas, 2002).

According to the UNCHS (1999) the scheme advocated three main objectives:

- To address the imbalance between planned development and unplanned expansion.

- To improve the socioeconomic and physical environmental conditions in deteriorated urban areas.

- To achieve cost recovering with the participation of the beneficiaries.

Even though the approach improved informal settlements in terms of standards, implementation of the programs experienced many shortfalls and criticism. Dwellings were inadequate and insufficient for low-income groups, and the number of beneficiaries was low. The role of the private sector and the location of the serviced lands were ignored by the government, and did little to change the low or non-existent standards applied to purchase such land. The programme culminated in failure to achieve cost recovery, and the assumption was made that such initiatives were generally unsuccessful (Jacobsen, Khan & Amis, 2002).

### 2.5.3. Upgrading

Upgrading of settlements came into being in the 1970s. As the term *informal settlement upgrading* does not have a clear and concise definition, it applies to any

sector-based intervention in the settlement that results in a quantifiable improvement in the quality of life of the residents affected (Abbott, 2002a).

Upgrading is the improvement of informal settlements without the total relocation of existing population (Abbot & Douglas, 2002). According to the World Bank (1996), upgrading at its most basic level involves improving the physical environment of informal settlements. It includes the improvement and installation of basic services such as water, sanitation, waste collection, access roads, storm water drainage, lighting, public telephones, and land regularisation.

The City alliance, which is a global partnership for urban poverty reduction and the promotion of the role of cities in sustainable development, defines upgrading differently. According to them, upgrading consists of physical, social, economic, organisational, and environmental improvements undertaken cooperatively and locally among citizens, community groups, and local authorities to ensure improvements in quality of life for individuals (City Alliance, 2002).

Since the time when upgrading was accepted as a solution to the situation of informal settlements, several methods have been used in various international projects. However, there is no one upgrading approach that is uniformly applicable to all the settlements (Abbot & Douglas, 2001).

Some of the most applied methods of upgrading include:

- a sanitation and water supply;
- community choice project;
- housing improvements;
- formal tenure provision;
- infrastructure improvements; and
- an integrated approach to planning.

Upgrading of informal settlements is therefore the latest effort put forth by respective governments and donor countries. It recognizes the need for individual households to access basic services, infrastructures, and in some cases, the right of ownership of the properties each household owns by giving secure tenure (Njamwea, 2003).

The Development and Upgrading Strategy of Windhoek Municipality Council defines informal settlements upgrading as an action whereby an existing formal or informal settlement is regularised to provide a form of security of tenure or where new or additional municipal services are installed, or a combination of these is pursued. An upgrading programme may comprise of various combinations, depending on the target community's needs, priorities, and affordability levels (DUS, 1999).

The City of Windhoek is trying to upgrade informal settlements within the city. At present, some informal settlement areas have been service upgraded or are in the process of being upgraded. Informal settlements such as Onyika, Onghuwo Yepongo, Okahandja Park D, Greenwell Matongo D and C, and Freedom Land A and B have been upgraded, with 1,371 households representing 5,484 people benefiting (City of Windhoek, 2003).

However, upgrading programmes have not lived up to their promise as they had some shortcomings as well. The programmes did not do much to secure the tenure of land for informal settlement dwellers, as its vision was short and ineffective (Palmer, Fricska & Wehrman, 2009). Eventually, urban policies and strategies generated artificial land shortages in the formal sector, resulting in creating a breeding ground for insecurity of tenure, illegality, non-serviced settlements, decreasing urban land value, all of which contributed to a vicious circle of poverty (UN-HABITAT, 2007).

### 2.5.4. Housing programmes

Because the number of informal settlements was increasing and poor urban dwellers were struggling with housing, the government of Namibia decided to start some housing programmes. The aim of housing programmes was to replace earlier eviction and demolition programmes, but to build enough dwellings requires considerable resources such as money and skills, which are typically in short supply in developing countries that have informal settlements.

In addition, most developing countries have not had housing policies with clear and effective measures to deal with major housing constraints (Payne, 1984). Payne (1984) further stated that most governments of developing countries cannot afford to house a large percentage of the urban poor. The current level of investment in housing is inadequate in relation to the demand and private housing agencies are building very slowly (Asiama & Acquaye, 1986).

## 2.6. SPATIAL PLANNING

Over the past few decades, innovative approaches to spatial planning have spawned new ideas, space and place, as well as the role of spatial strategies in contemporary governance contexts. Spatial planning is a key instrument for establishing long-term, sustainable frameworks for social, territorial, and economic development both within and between countries (United Nations, 2008).

Various definitions of spatial planning exist. For example, Nichersa and Iacoboaea (2011) define spatial planning as the change of the distribution of activities in space, and the change of the links between them by converting forms of land use and property. They note that systematic spatial planning is the most advanced level in the hierarchy from data to information and knowledge, collected on each level of territorial holarchy.

On the other hand, the Compendium of European Spatial Planning defines spatial planning as methods used largely by the public sector to influence the future

distribution of activities in space (European Commission, 1997). The Compendium states that spatial planning is undertaken with the aim of creating a more rational territorial organisation of land uses and the linkages between them. The link is there to balance demands for development with the need to protect the environment and to achieve social and economic development objectives.

In the United Kingdom, the government defines spatial planning as going beyond traditional land-use planning to integrate policies for the development and use of land with other policies and programmes that influence both the nature and function of places. This includes policies that can impact land use, but are not capable of being delivered solely or mainly through the granting or refusal of planning permission, and which may be implemented by other means (UKODPM, 2005).

Spatial planning is critical for delivering economic, social, and environmental benefits by creating more stable and predictable conditions for investment and development, and by promoting productive use of land and natural resources for development. Spatial planning presumes to anticipate and prepare, to make preparations and supplies for the future. That involves preparing for future land use by residents and strengthens the preparations through regulation and promotion of changes in land use and building (HIS Romania, 2001). Given the definitions above, the researcher is of the opinion that spatial planning is an important lever for promoting sustainable development and improving the quality of life.

### 2.6.1. Spatial planning in cities

In urban areas, land use is regulated through site planning. Planning determines what should take place and where. Spatial planning mainly aims at economic use of land, orderly settlements, and permanent safeguarding and maintenance of physical environment (Van Lier, Jaarsma & De Buck, 1994). Planning covers all activities of man in spatial aspect (Schmid, 1994), which is precisely what planning professionals wish to fulfil through zoning plans, master plans, and land use plans.

Formal cities have a development sequence as per planning and building regulations. As stated by Baross (1991), the sequence is: planning, service provision, building, and occupation (PSBO). However, implementation of plans has not been easy as seen through the phenomenon of informal settlements. The aspect of economy to land means that land goes to its most profitable use while zoning limits some activities to certain areas.

Cost limits the poor from accessing land for housing. High rents in the public and private sectors makes developed houses unaffordable. Access to land for housing by the poor is through invasion of public and private land, and construction of unauthorised houses. The process of development in the informal settlements is by occupation, building, and servicing, with planning at the end (OBSP) (Baross & Linden, 1990).

### 2.6.2. Common requirements for spatial planning

Studies within the UNECE (United Nations Economic Commission for Europe) region have highlighted several common requirements of the planning system in those countries, which may also be applicable to developing countries in Africa and Latin America (UNECE, 2003). They include:

- To achieve a greater mix of land uses and densities in the urban structure that provide a full range of urban functions, housing, employment, and services in a pattern that minimizes the need to travel great distances to work, shop, or conduct business. The efficient use of land needs to be compatible with the social well-being and healthy environment objectives.

- To enhance and support regeneration of housing estates through innovative financing, technological and regulatory initiatives, and demonstration projects. Focusing on the elimination of barriers towards investment will facilitate small-scale urban renewal through cooperative efforts and self-help.

- To enhance broad participation, improve community involvement and build support for sustainable planning policies and programmes.

- To promote community identity through creation of meeting places, public spaces, pedestrian networks, preservation of historic buildings and attractive streetscapes.

- To provide water and sewage infrastructure that accommodates the needs of the local community, while meeting the healthy environment objectives; to undertake considerable improvement of existing infrastructure in order to reduce the amount of untreated urban runoff and waste water discharge; to increase the capacity of the existing infrastructure to accommodate urban growth and intensification.

- To improve and expand the transport system to meet the challenges of readjustment in the urban economy and to sustain the competitiveness of public transport. To maximise efficiency, supplement conventional public transit with specialised services directed at specific market segments; to promote energy efficiency and alternative modes of transport.

### 2.6.3. Planning tools

All countries need a minimum set of planning tools that enable effective and fair management of spatial development based on agreed criteria. In most countries, previous approaches to planning are now thought to be excessively detailed and prescriptive, choosing to use a top-down comprehensive approach that assumes an

unrealistic degree of public control over private action (United Nations, 2008). The rigid plans are both difficult to prepare and to keep up to date. They require intensive inputs, and inhibit planning authorities from responding appropriately to opportunities as they arise.

Thus planning tools should fit the purpose. The key is to achieve an appropriate balance between commitment and flexibility, knowing which needs must be addressed immediately and which needs could be met over a longer timeline (Koresawa & Konvitz, 2001). The tools must work in a complementary and consistent way to ensure both a proactive and a coordinated approach to managing development and fairness, as well as accountability and transparency in the decision-making process.

## 2.7. THE USE OF GIS IN SPATIAL ANALYSIS

Centuries ago, before geographical information system came into existence, maps were an important cultural achievement and served to demonstrate the spatial distribution of a range of different phenomena. With advances in technology, maps could be combined with computer graphics and databases to create geographical information system (Adams, 2011). During the past decade, geographical information systems have become the key computer-based technology for handling spatial data, spatial analysis, and modelling (Burrough, 1992). GIS definitions exist and continue to change as technology and applications develop further (Heywood, Cornelius & Carver, 1998).

The Chorley Report for the UK defines geographical information systems as a system of capturing, storing, checking, manipulating, analysing, and displaying data that are spatially referenced to the Earth (Department of the Environment, 1987). GIS has come to symbolise a technology, an industry, and a way of doing work. To some it has come to promise a new world of disciplinary and professional renewal, flowing from the expansion of information technology (Chrisman, 1999). Traditionally, geographical information systems are considered to perform four basic functions on spatial data; input, storage, analysis and output (Goodchild, 1987).

According to Anselin and Getis (1992), the analysis functions of geographical information systems are divided into four components that consist of selection (sampling of data from the database), manipulation (partitioning, aggregation, overlay, buffering, and interpolation), exploration, and confirmation. The first two are typical features of existing GIS, while the exploratory and confirmatory analysis functions are very limited.

A linkage between geographical information systems and spatial data analysis is considered an important aspect in the development of a GIS into a research tool to explore and analyse spatial relationships. A definition of spatial analysis (of which spatial data analysis is one element) is that it represents a collection of techniques and models that explicitly use the spatial referencing of each data case. Spatial analysis needs to make assumptions about or draw on data describing spatial relationships or spatial interactions between cases (Chorley, 1972; Haining 1994).

The power of a GIS as an aid in spatial data analysis lies in its georelational database structure, i.e., in the combination of value information and locational information. The link allows for fast computation of various characteristics of the spatial arrangement of the data, such as the contiguity structure between observations, which are essential inputs into spatial data analysis (Anselin, 1990). The use of a GIS facilitates easier, quicker solutions for technically complicated, time-absorbing geographical problems (Ospina, 2002, as cited in Teefelen, Gustavson & Verkoren, 1992).

A GIS provides a flexible means to create new data, i.e., to transform data between different spatial scales of observation, and to carry out aggregation, partitioning, interpolation, overlay, and buffering operations. Of course, such data is nothing but the results of computations, which are themselves, based on particular algorithms that often use parameter estimates and model calibrations obtained by statistical means (Bailey, 1992). The powerful display capabilities contained in a GIS also provides excellent tools for the visualization of statistical analysis results.

The GIS has a variety of software available, and is equipped with specific features for solving specific tasks in a given application context or designed as an all-in-one solution with all-encompassing capabilities regarding data formats, analysis, modelling, and output capabilities (Burrough, 1992, as cited in Davis, 2000). Data may be derived from various sources including surveying or remote sensing, such as satellite or aerial imagery, photogrammetry, global positioning systems (GPS), public census, manual digitizing, and scanning. Once the necessary GIS data for a certain

task are acquired, appropriately processed, and stored in a database, spatial analysis can be performed and desired information can be extracted and visualised (Kainz, de By & Ellis, 2000).

Ottens (1992) notes that geographical information systems have rapidly become a key technology for the automated capture, management, analysis, and presentation of location-referred data all over the world. GIS has the ability to store and retrieve data on special aspects of the earth and the way people live on it. The data can be used in models of environmental and socio economic processes in order to learn more about the possible outcomes of natural trends or planning decisions (Burrough, 1992).

There are many actual and potential applications for geographical information systems in developing countries, ranging from resource inventory and monitoring, through land-use planning, land evaluation, social and economic planning, and disaster avoidance and management (Burrough, 1992). Figure 3 by the GIS Associates (2015) shows the role of a GIS in the general planning process for site selection, environmental management, and other geographically-dependent applications in the diagram.

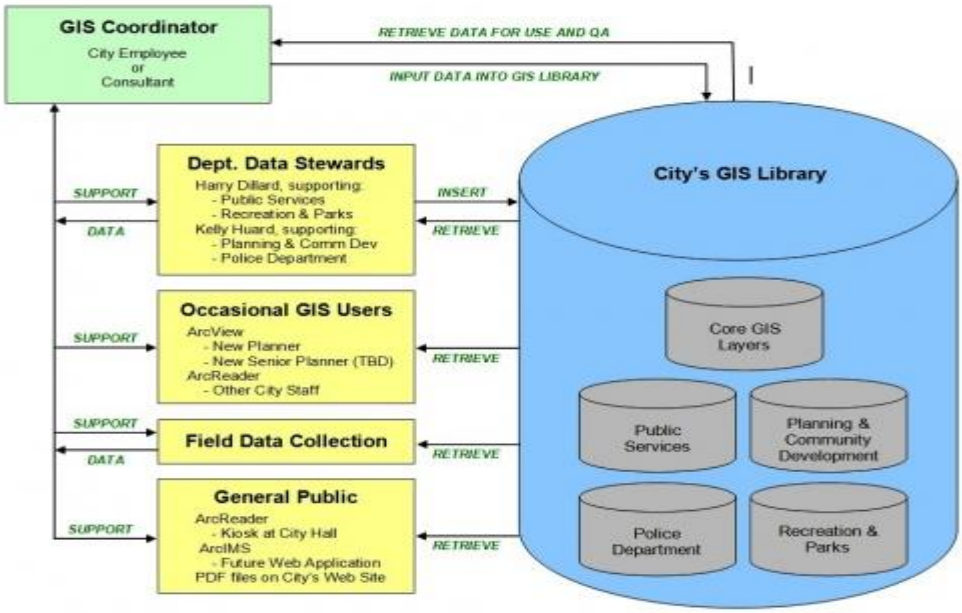


*Figure 3*. A GIS in the planning process

Source: GIS Associates (2015). Retrieved from

http://www.gis-associates.com/images/28.jpg

The use of a GIS in analysing the spatial behaviour of settlements is common in many developed countries and some developing countries. However, it is limited in most developing countries. Thus, the use of a GIS is not an end in itself, but a tool to understand urban dynamics better, and eventually to support decision-making in urban planning (Torrens & O'Sullivan, 2001).

## 2.8. CASE STUDY

Dar es Salaam, the capital city of Tanzania, has witnessed rapid urbanisation abreast many challenges that informal settlements have become inevitable manifestation of it. Tanzania is one of the countries in Sub-Sahara Africa within which

the highest population of its urban population lives in informal settlements. The proportion ranges between 50% and 80 %, and informal housing shares more than 50 % of the entire urban housing stock. Informal settlements have covered most of the urban landscape, and have been proliferating both in terms of density and of expansion.

Kombe (2005) reveals that in Dar es Salaam, the number of informal settlements increased from 40 in 1985 to over 150 in 2003, while the population nearly doubled in the same time span. Briggs and Mwamfupe (2000) reveal that due to the rapid increase in the number of informal settlements, local planning authorities within the city of Dar es Salaam were barely able to respond to the enormous settlement pressure.

Because informal settlements were increasing at such an alarming rate, different approaches, policies, strategies, and programmes were devised and put into place by authorities to solve the housing problem that was, and still is, the main breeding platform for informal settlements. Approaches or programmes that were put in place include public housing programmes, site and service programmes, and area upgrading among others.

However, policies and practices that supported the approaches contributed less to the overall urban quality of life and failed to stop further proliferation of informal settlement in the city. As a result, there was a need for proactive and defining approaches that would mitigate losses encountered by informal settlements and put a halt on their sustained proliferation.

In 2011, Abebe carried out a research study aimed at modelling informal settlement growth in Dar es Salaam, by coupling the potential of a GIS with logistic regression modelling techniques in order to explore the spatial behaviour of informal settlements. By using a GIS as a tool, integrated with spatial data accessed from ITC's data archives, land cover vector maps, and a digital elevation model (DEM), Abebe was able to:

- come up with conceptual models of informal settlement in Dar es Salaam;
- build a logistic regression (LR) model for informal settlement growth(ISG) in Dar es Salaam;
- and determine future informal settlement growth in Dar es Salaam.

The predicted models of his research study were so important in understanding the intrinsic nature of informal settlements, and would support policy makers and planners in making informed decisions and devising proactive measures in the future. In addition, the results contributed to the body of knowledge and theories of informal settlements, and demonstrated the importance of prediction and animation in unplanned settlement managements.

The problem of informal settlements in Dar es Salaam is almost similar to the one experienced in Windhoek because, in both cities, urbanisation led to the development

and expansion of informal settlements. Some of the programs and policies put in place in the two cities did not assist in managing these settlements.

# 3. DATA, METHODS AND PROCEDURES

## 3.1. INTRODUCTION

This chapter explores the methodological approach undertook in this study to meet the research objectives. It starts by discussing the research approach, followed by a flow chat that illustrates the methodology used. An overview of the study area, Oohambo Dha Nehale is also presented in this chapter. The data collection and source, data quality requirements and methods on expansion, spatial pattern and slope analysis have been discussed as well in the subsequent sections.

## 3.2. RESEARCH APPROACH

This case study applied both qualitative and quantitative methodology approaches. Qualitative approach is defined as the use of non-numerical information such as conversations, artifacts, visual images, and entails a wide range of research approaches such as content analysis, ethnography and shared beliefs in grounded theory (Leichenko, 2004). Quantitative approach on the other hand is the application of numerical analytical techniques to address geographic research questions of all types. In short and brief, it is the collection of data, analysis and presentation (Fitzpatrick. 2013).

A qualitative approach was used on spatial data such as aerial photographs, satellite images, dwelling units, and census data. Firstly, it was applied on aerial

photographs and satellite images taken in 2005, 2008, and 2011 to map the expansion of the area during that time. Secondly, it was applied on dwelling units to determine the spatial patterns of buildings (dwellings) within the area. Thirdly, dwellings within the area were mapped out in relation to the population of the area. Quantitative analysis was made on terrain data obtained from the City of Windhoek to calculate the degree of slope, and determine if they correlate with municipal regulations on where to build and construct dwellings. In addition, statistical analyses were performed to calculate how much the area had increased over the years in relation to the population.

## 3.3. ADOPTED METHODOLOGY

The adopted methodology used in this study to meet the research objectives are illustrated by the flowchart in Figure 4.

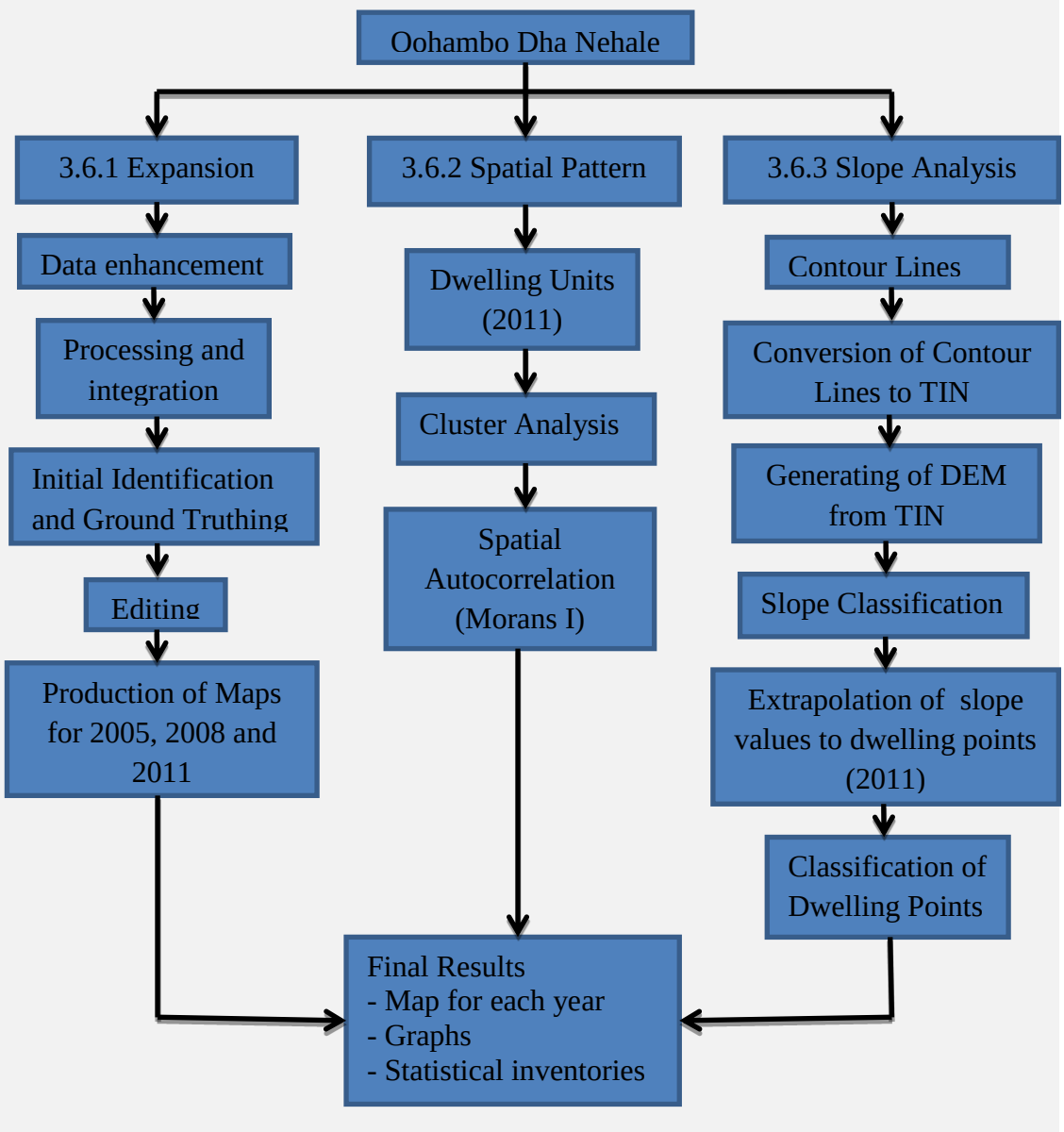


*Figure 4.* Research Methodology

## 3.4. STUDY AREA

The study area is located in the Khomas Region of Namibia on the outskirts of Katutura which is a black township created in 1961 following the forced removal of Windhoek's black population from the old location, which afterwards developed into the suburb Hochland Park (Namibia Tourism Board, 2013). Oohambo Dha Nehale informal settlement was selected for this study as it is a typical new, predominantly informally developed area that emerged in 2001 because of the city's expansion. It is located 3-5 km northwest of the city centre and covers an area of approximately 226,127 $m^2$ with a population of about 1628 inhabitants. The area is characterised by occurrence of irregular slopes, river courses and other landforms. Internal roads in the area have been created by the community for access to their plots.

Most of the dwellings, known as *Kambashos* in the local language, are constructed from corrugated iron and serve not only as resident for the urban dwellers, but many household also augment their income through selling basic commodities from home. Figure 5 shows the dwellings found in Oohambo Dha Nehale informal settlement. It is observed that many of the dwellings serve as both residence and business. The land pattern and character has been shaped as informal settlers improvise to meet their basic needs in terms of shelter, food, infrastructure, and social services (Begu, 2003). The area has water taps (few of them) and toilets. Figure 6 shows the location of the study area.

*Figure 5.* Dwellings in Oohambo Dha Nehale

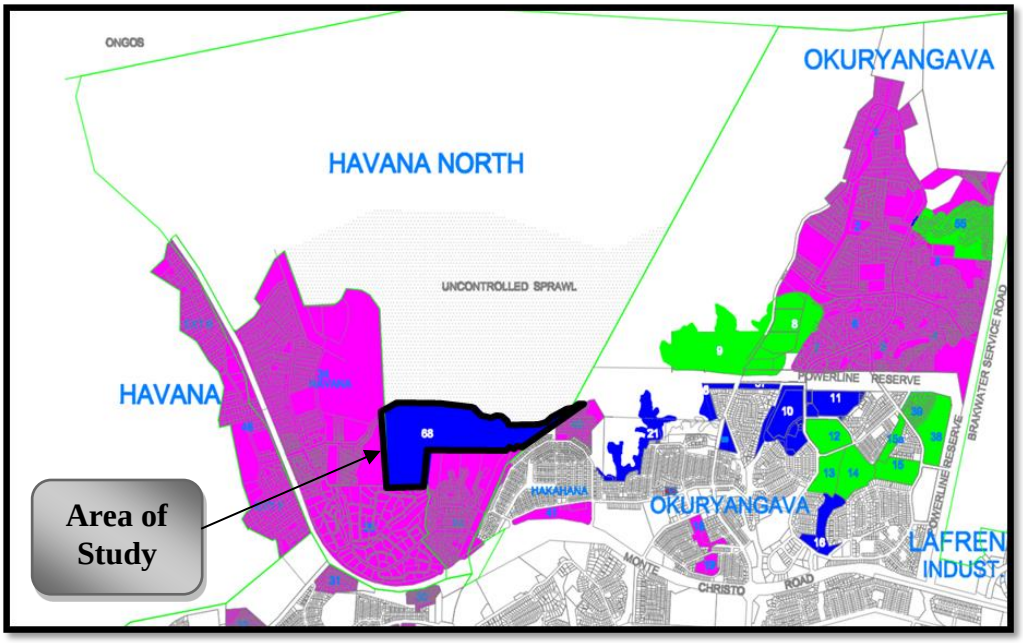


*Figure 6.* Location of Oohambo Dha Nehale

Source: City of Windhoek

## 3.5. DATA COLLECTION AND SOURCE

The data sets used in this study were obtained from both the City of Windhoek (Geomatic Department) and the National Statistics Agency of Namibia. The data obtained from the City of Windhoek included:

- aerial photographs of the study area captured in 2005and 2008;
- boundaries and contours of the study area.

Data obtained from the National Statistics Agency of Namibia includes:

- aerial photographs captured in 2011;
- census information (population size, household numbers); and
- dwelling units.

## 3.6. DATA QUALITY REQUIREMENTS

A suitable aerial photograph or satellite image for urban studies should show features in detail for the required analysis. The data used in this research were of high quality; natural phenomena such as trees, small shrubs, hills, and walking traits could be identified on aerial photographs and satellite images. Man-made features such as dwellings (*Kambashus*), water taps and toilets could also be observed.

## 3.7. METHOD

In order to meet the research objectives of the study, the following methods were used in expansion, spatial pattern and slope analysis.

### 3.7.1. Structure increase, population and area expansion

The most accurate method used to determine the expansion of an area is by using the total population of structures (number of dwellings) within a contiguous built-up area (PST, 2005). In this study, dwellings found in Oohambo Dha Nehale were used to determine how the area has expanded from 2005 to 2011. By using the dwellings found on the edge, polygons were digitized on the aerial photographs of 2008 and 2011 to represent the boundaries of the area. That was done because the area has no official boundaries since it is an informal settlement. The boundaries of the study area shown in the introduction section are not official, but are boundaries demarcated for planning purposes by the City of Windhoek. With the newly implemented flexible land tenure, the government is in the process of creating official boundaries for informal settlements all over the country.

The aerial photographs of 2005 and 2011 had a high spatial resolution of about 1 meter, which helped classification to be a straightforward task. Individual dwellings, footpaths, river channels, and gravel roads were all distinguishable and subsequently categorized. The photograph of 2008 did not have a high spatial resolution compared to the other two aerial photograph, but features such as footpath, gravel roads and

individual dwellings could be identified easily. Before digitizing, all images were rectified to the new Namibian coordinate system. The images were then displayed in ArcGIS so that digitizing of dwellings and gravel roads could be done. Figure 7 shows part of the study area with dwellings for 2011.

*Figure 7.* Part of study area (2011)

Digitizing was done manually whereby points were put on top of buildings to represent dwellings, as seen in Figure 8. Boundaries were also manually digitized by assigning lines to represent them. Visual screen digitization technique was used to calculate the area of Oohambo Dha Nehale for the period 2005 to 2011. Aerial photographs were overlayed as an expansion detection method using ArcGIS 10.2 software in order to detect the stages of growth.

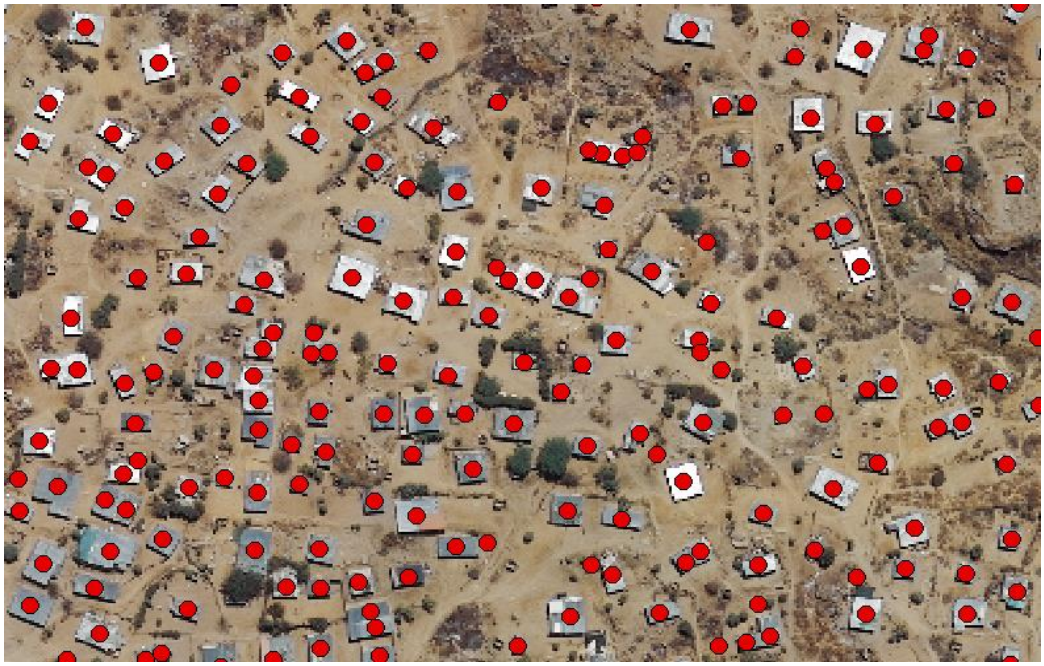

*Figure 8.* Dwellings with assigned points (2011)

Calculations were carried out in order to obtain the dwellings increase, population and area expansion in percentage. The following formulas were used in obtaining values for structure increase, population size and area expansion:

Dwelling Increase: $DI = X_n - X_{n-3}$

Where: $DI$ = Structure increase

$X$= Dwellings for each year (2005, 2008 and 2011)

$\pi$ = Years (2005, 2008 and 2011)

3 = Interval between years

Example: Dwelling increase for the period from 2005 to 2008 would be:

$$SI = X_n - X_{n-3}$$

$$SI = 1642_{\ 2008} - 455_{\ 2008-3}$$

The population size of Oohambo Dha Nehale informal settlement for 2005, 2008 and 2011 was estimated using the average household size obtained from the Namibia Population and Housing Census main report of 2001 and 2011, with the number of dwellings for each of the three years. According to NSA (2011), the average household size for 2001 was 4.2 and 3.7 for 2011. The housing and population survey in Namibia is carried out after ten years, therefore, the average household size for 2005 and 2008 would be 4.2 and for 2011 would be 3.7.

The formulas below were used to determine the population size for 2005, 2008, 2011 and the population increase for the two-time period (2005-2008 and 2008-2011).

Population size for each year was calculated using the formula below:

$$PS = AHS_x \times ND_y$$

Where: PS = Population size

$AHS_{x1}$ = Average household size for 2001

$AHS_{x2}$ = Average household size for 2011

$ND_y$ = Years ($ND_{y1} = 2005$, $ND_{y1} = 2008$ and $ND_{y1} = 2011$)

Population increase for the two time period was calculated using the formal:

$$PI = \frac{Z_n - Z_{n-3}}{Z_{n-3}} \times 100$$

Where: $PI$ = Population increase

$\mathfrak{n}$ = Years (2005, 2008, and 2011)

$Z$ = Population for each year (2005, 2008, and 2011)

3 = Interval between years

100 = Percent

Area expansion in percentage:

$$AE = \frac{Y_n - Y_{n-3}}{Y_{n-3}} \times 100$$

Where: $AE$ = Area Expansion

$\mathfrak{n}$ = Years (2005, 2008, and 2011)

$Y$ = Area for each year in m² (2005, 2008, and 2011)

3 = Interval between years

100 = Percent

### 3.7.2. Spatial pattern

A cluster analysis was conducted on dwelling points for 2011 to determine the spatial pattern of the dwellings in the area. Clusters are areas with feature attributes that are clustered together, and share some common attributes. Under the spatial statistic tool, the spatial autocorrelation (Morans I) tool was used to measure the spatial autocorrelation based on both feature locations and feature values simultaneously. It evaluated whether the patterns expressed were clustered, dispersed, or random, based on a set of features and associated attributes.

The tool calculated the Moran I index value, and both the *z*-score and *p*-values to evaluate the significance of the index. A *p*-value is a numerical approximation of

the area under the curve for a known distribution, limited by test statistics. The *z*-score and *p*-value indicate whether or not the difference between the expected and observed index values are statistically significant.

### 3.7.3. Slope analysis

Digital data of contours representing part of Windhoek's informal settlement areas were obtained from the City of Windhoek's Geomatic Department. The data set were then entered into ArcGIS 10.2 for analysis and processing. In ArcGIS, a contour submap covering the study area was extracted by using the snipping tool. This map is shown in Figure 9.

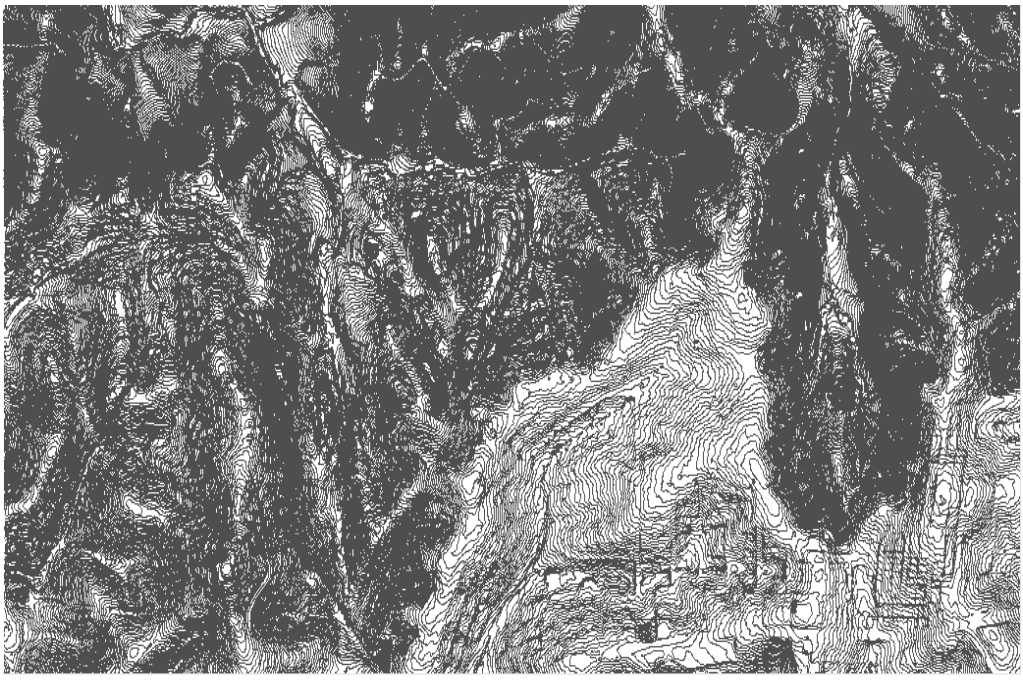

*Figure 9.* Contour sub-map of Oohambo Dha Nehale

The extracted contour submap of the study area was then converted to Triangulated Irregular Network (TIN) using *ArcToolbox* in ArcGIS. The TIN had a resolution of about 1 meter. A Digital Elevation Model (DEM) was then generated from the TIN, as shown in Figure 10. With the capabilities of ArcGIS, the slope was created from the DEM, and subsequently classified. Figure 11 shows the slope while Figure 12 shows the classified slope. The classified slope was then analysed and reclassified in degrees based on the classes recommended by Van Zuidam (1986). The classes of slope are indicated in Table 2. The Zuidam slope classification was used because it is recognised and used in slope analysis in most countries. Instead of using a single slope classification, there was a need for another slope classification, in order to have a fair and reasonable comparison.

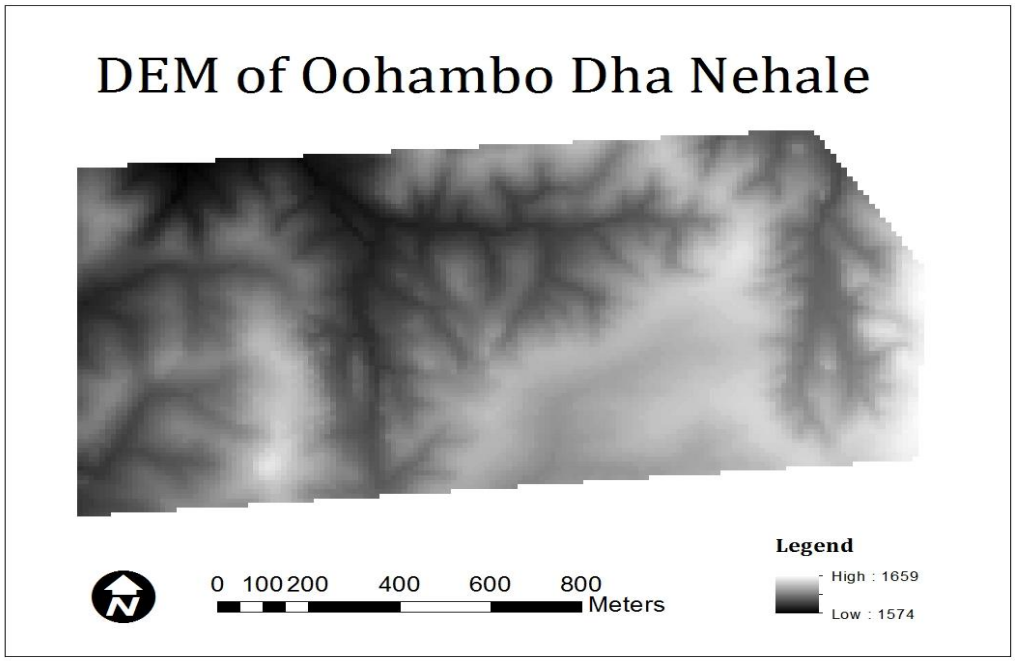


*Figure 10.* Digital Elevation Model of Oohambo Dha Nehale

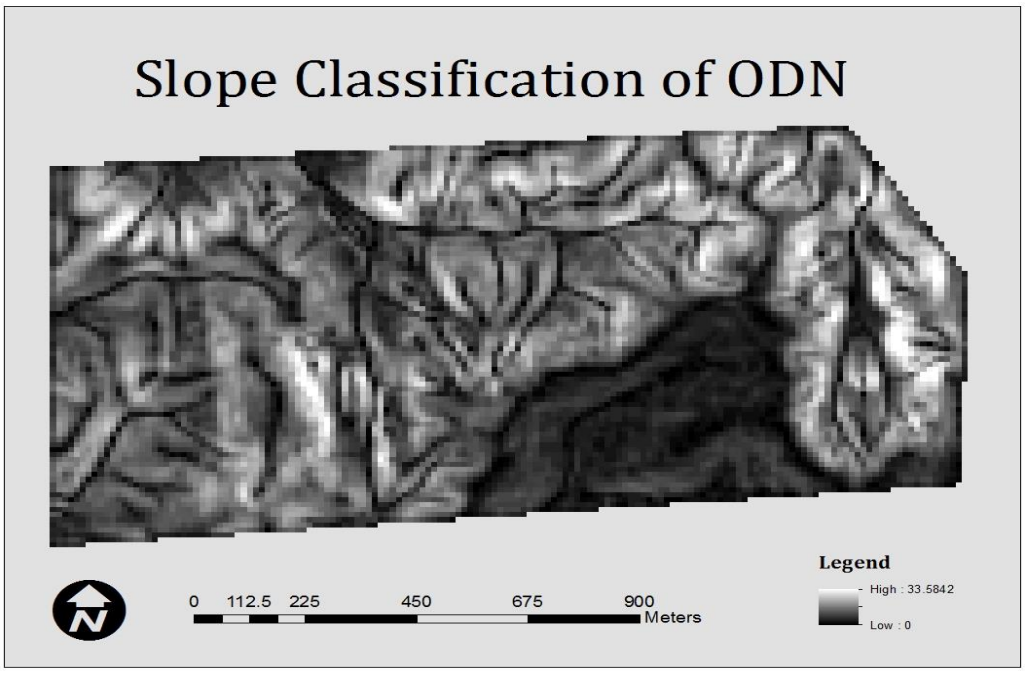


*Figure 11.* Slope of Oohambo Dha Nehale

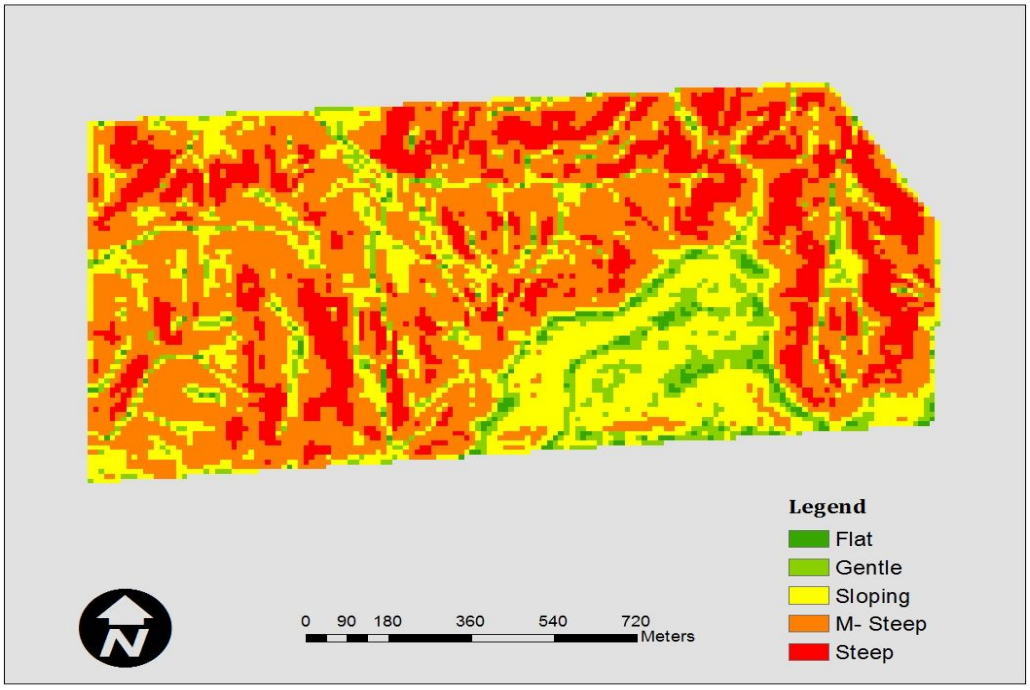


*Figure 12.* Classified slope of Oohambo Dha Nehale

Table 2

*Zuidam's Slope Classification*

| Slope Code | Degree Range | Label |
|---|---|---|
| 1 | $0^o - 2^o$ | Flat or Almost Flat |
| 2 | $2^o - 4^o$ | Gently Sloping |
| 3 | $4^o - 8^o$ | Sloping |
| 4 | $8^o - 16^o$ | Moderately Steep |
| 5 | $16^o - 33^o$ | Steep |

Source: v. Zuidam's slope classification, 1986

To determine the number of dwellings per slope class, the dwelling points for 2011 were converted from shape-file to raster data with a pixel size of 12 meters, similar to the one for the slope. The conversion was done in order for the dwelling points and slope to be in the same data model. Extraction of slope values to dwelling points followed after the conversion. The extraction was not absolute, but it was interpolated from the surrounding pixels, using the Natural Neighbor Interpolation (NNI). The NNI finds the closest subset of input samples to query point and applies weights to them based on proportional areas to interpolate values (Sibson, 1981). The allocation of slope values to the dwellings, using the NNI introduces an error in the results. This will be discussed in chapter 4.

The dwelling points were then classified based on the slope classification recommended by Zuidam. The slope was again reclassified based on the slope classes

recommended by the City of Windhoek in 2000 for low and ultra-low cost housing in Windhoek. To determine how many dwellings fall under a slope class recommended by the City of Windhoek, the dwelling points for 2011 had to be converted to the same class as the slope. Table 3 illustrates the slope classes recommended by the City of Windhoek.

Table 3

*City of Windhoek's Slope Classifications*

| Slope Code | Degree Range | Label |
|---|---|---|
| 1 | $0^o$ –$3^o$ | Very Suitable |
| 2 | $3^o$ – $6^o$ | Moderately Suitable |
| 3 | $6^o$ – $8^o$ | Less suitable |
| 4 | $8^o$ – $11^o$ | Unsuitable |
| 5 | $11^o$ – $33^o$ | Extremely Unsuitable |

Source: City of Windhoek Internal Memo, 2001

## 3.8. ETHICAL CONSIDERATIONS

Marshall (1998) defines research ethics "as the application of moral rules and professional codes of conduct to the collection, analysis, reporting and publication of information about research subjects, in particular active acceptance of subjects' right to privacy, confidentiality, and informed consent". The principle of research ethics applies to all types of research. In this study, the researcher ensured that the study was

conducted in an ethical manner. The following research ethics were considered during the study:

### 3.8.1. Confidentiality

Confidentiality pertains to the treatment of information that an individual has disclosed in a relationship of trust and with the expectation that it will not be divulged to others without permission in ways that are inconsistent with the understanding of the original disclosure (University of California, 2015). The researcher, therefore, ensured that the data collected from the City of Windhoek and the Namibia Statistics Agency were not made available to outsiders, and were only used for research purposes.

### 3.8.2. Professional integrity and responsibility

Integrity and responsibility may be defined as active adherence to the ethical principles and professional standards essential for the responsible practices of research. Active adherence means the adoption of principles and practices as a personal credo, not simply accepting them as impositions by rule makers. Ethical principles refer to honesty, the golden rule, trustworthiness and high regard for scientific record (Stanley & Karenman, 2006).

In this study, the researcher acknowledged the contribution of other academics and sources of data used, followed all relevant laws on privacy and disclosure and worked towards the best possible data quality and integrity. In addition, the researcher adhered to appropriate data security.

### 3.8.3. The right to privacy

Protecting research participants' right to privacy requires respect for their autonomy, their right to self-determination, as well as their general welfare. The evaluation of privacy involves consideration of how the researcher accesses information from or about potential participants (Talerico, 2012). It is against this background that the researcher ensured that the privacy of the respondents, who provided spatial data to the researcher, was respected in such a way that data were only collected during the day - from 08:00-17:00.

# 4. RESULTS

## 4.1. INTRODUCTION

This section describes the results obtained in response to the main research objectives of the study. It is structured to address the spatial distribution of dwellings, the spatial expansion, and spatial pattern in Oohambo Dha Nehale. Furthermore, this section examines the suitability of land for residential building purposes in the study area.

## 4.2. STRUCTURE, POPULATION AND AREA EXPANSION

Because many people are migrating from different parts (towns) of the country to its capital city (Windhoek) in search of employment and better living conditions, Oohambo Dha Nehale has become one of the informal settlements with the highest growth in the number of dwellings, population, and area size. The dwellings, the population and the area size were high during the six year study period. Maps depicting the aerial photograph of Oohambo Dha Nehale for 2005, 2008 and 2011 are shown in Figures 13 to 18. Results of the number of dwellings and the population size for 2005, 2008, and 2011 are shown in Table 4, Figure 18, and Figure 19.

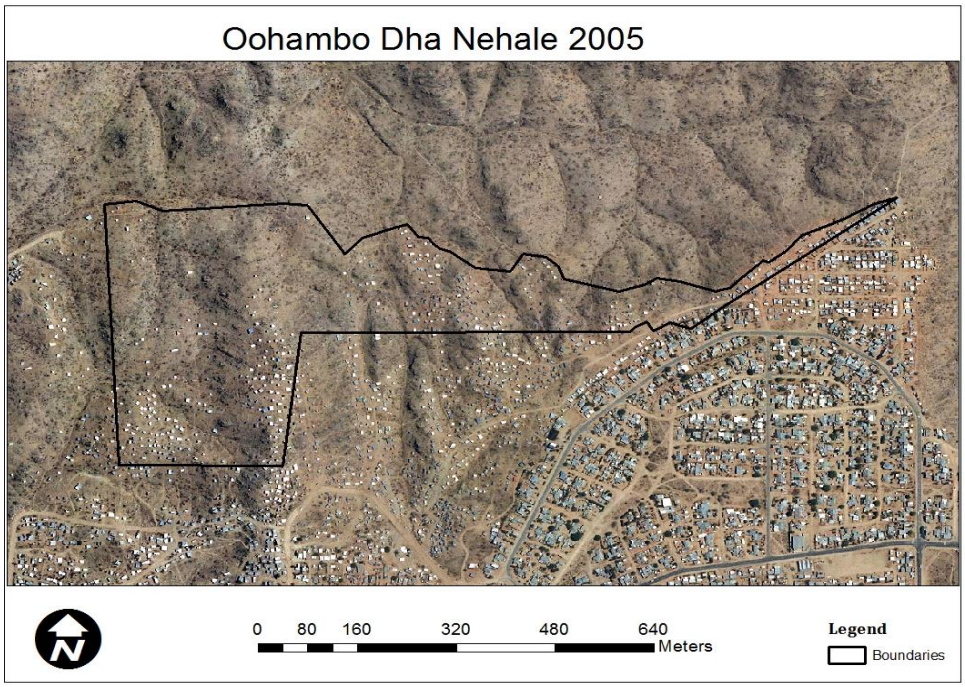


*Figure 13.* Aerial photograph of Oohambo Dha Nehale

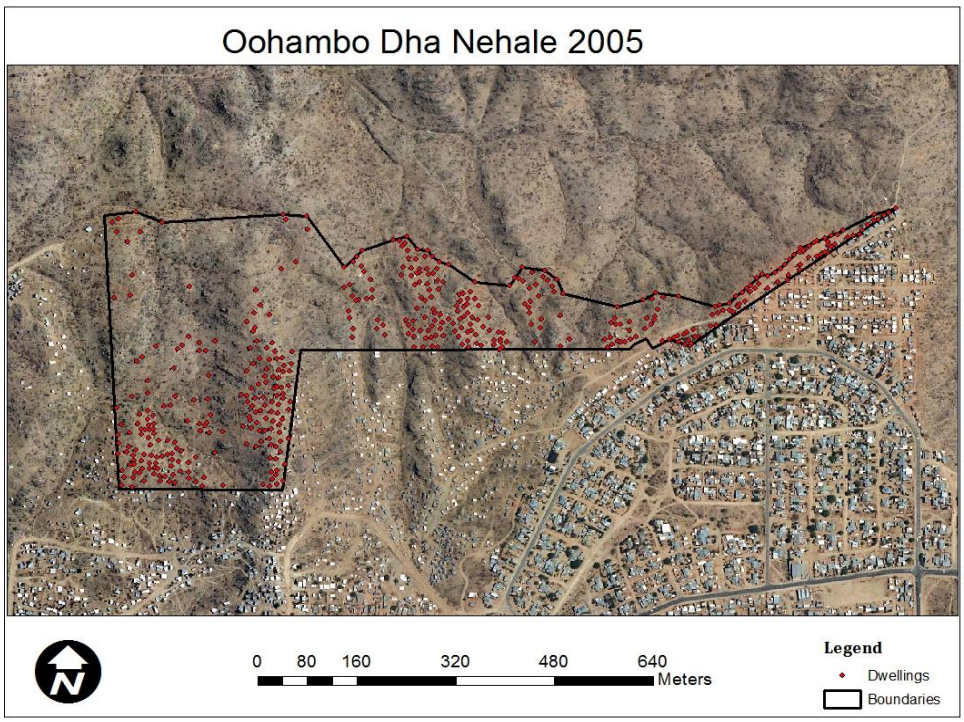


*Figure 14.* Dwelling points of Oohambo Dha Nehale

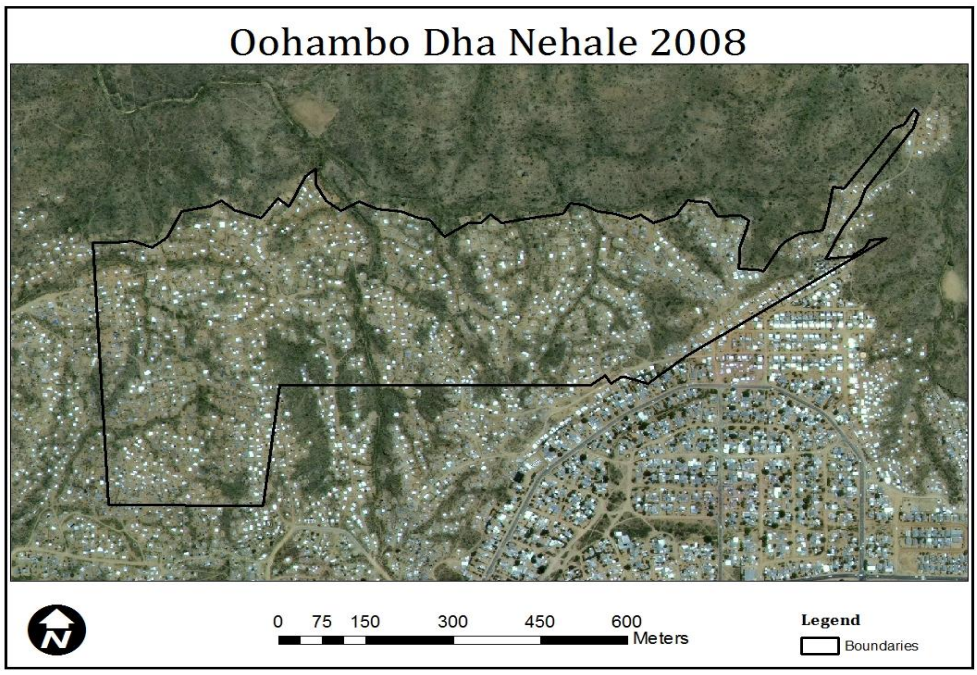


*Figure 15.* Aerial photograph of Oohambo Dha Nehale

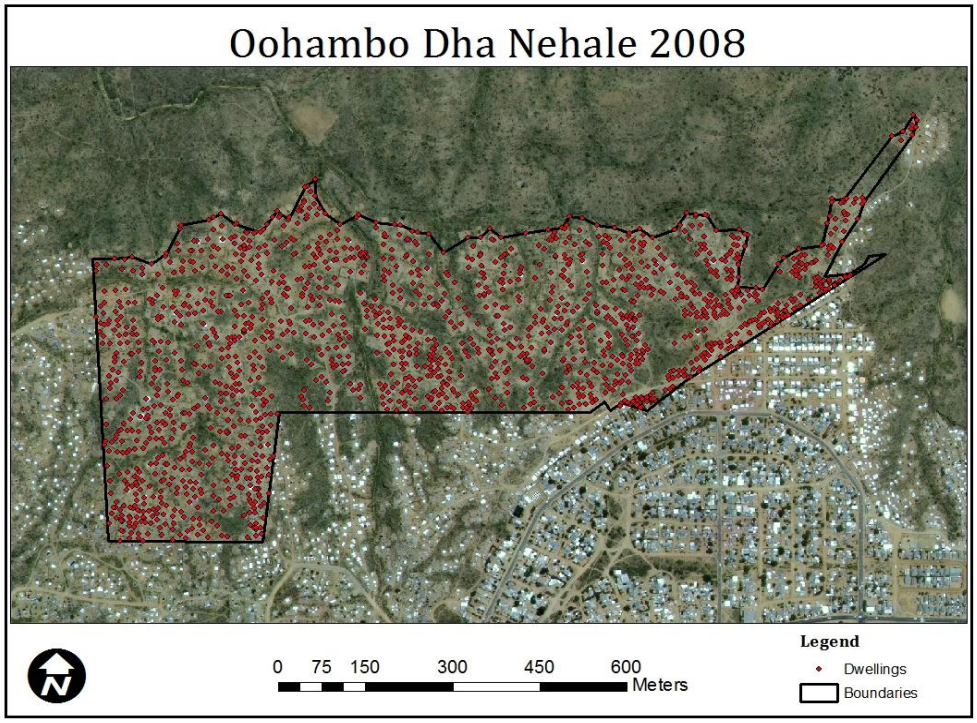


*Figure 16.* Dwelling points of Oohambo Dha Nehale

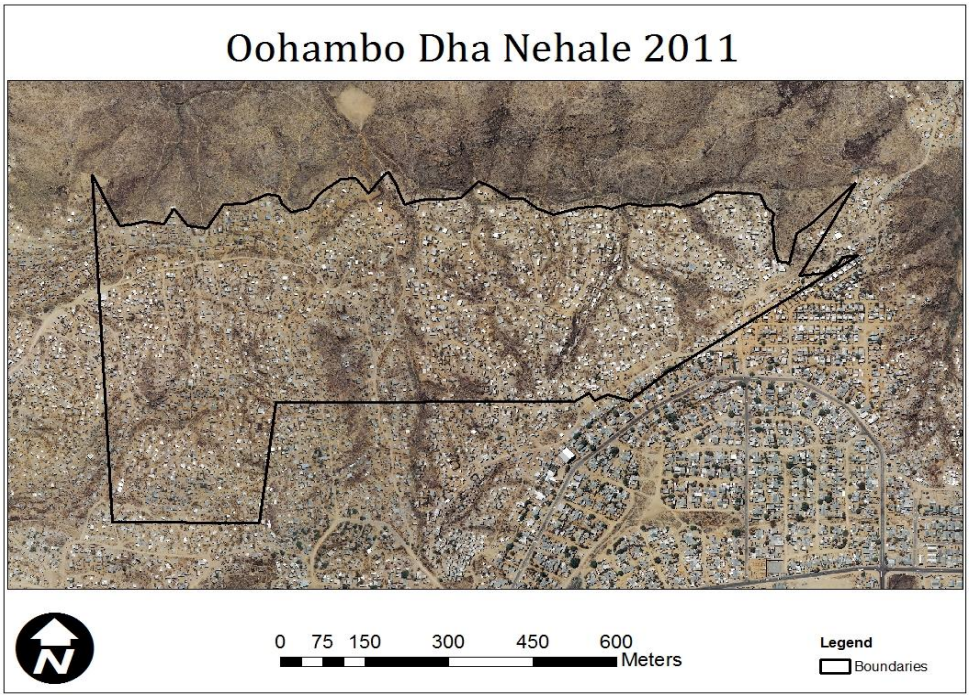


*Figure 17.* Aerial photograph of Oohambo Dha Nehale

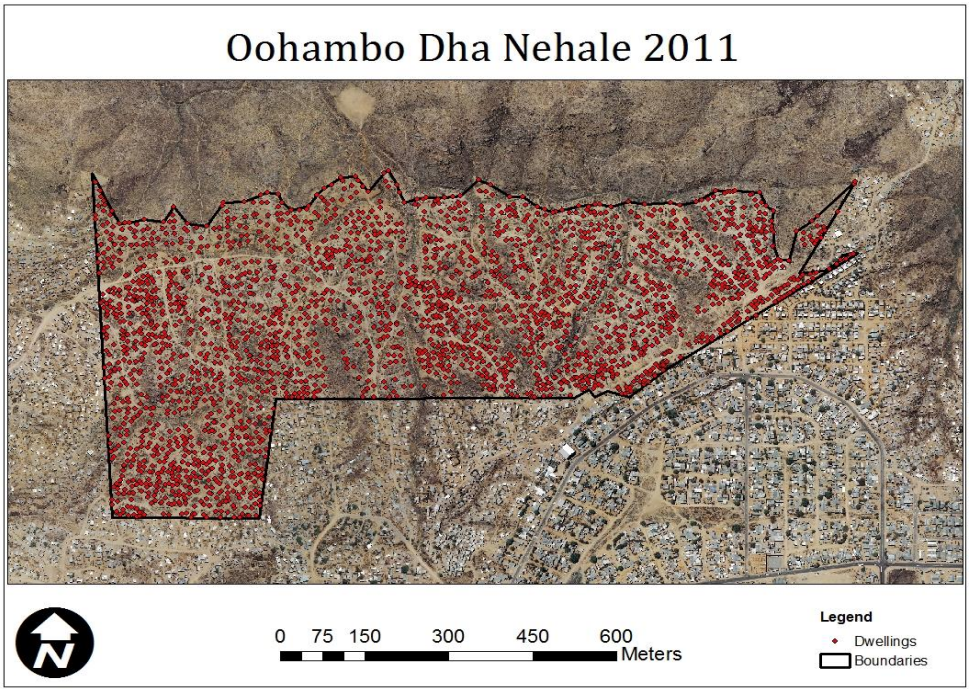


*Figure 18.* Dwelling points of Oohambo Dha Nehale

As mentioned in chapter three (section 3.7.4), the allocation of slope values to the dwellings introduces an error in the data. This error slightly affects the accuracy of the results. During the classification of dwellings into slope categories, there is a possibility of some dwellings not falling in any slope category. These results in the number of dwellings being classified to be less. There is also a chance that some dwellings can fall into two different slope categories, causing an increase in the number of dwellings than it was supposed to be. However, the magnitude of the error does not severely affects the results because the number of dwellings affected might be less than 20.

There was an increase in the number of dwellings from 2005 to 2008, and from 2008 to 2011 in the Oohambo Dha Nehale informal settlement. Both the population and area size also increased during these two periods.

The number of dwellings increased from 465 in 2005 to 1,642 in 2008, and from 1,642 in 2008 to 2,494 in 2011 as shown in Table 4 and Figure 19. The population of the area increased from 1,953 inhabitants in 2005 to 4,889 inhabitants in 2008, and from 4,889 inhabitants in 2008 to 9,228 inhabitants in 2011. On the other hand, the area expanded from 226,127 $m^2$ in 2005 to 443,882 $m^2$ in 2008 and from 443,882 $m^2$ in 2008 to 515,686 $m^2$ in 2011. Figure 20 shows the population size, while Figure 21 the area expansion during the various years.

Table 4

*Dwellings and Population Size in Oohambo Dha Nehale (2005—2011)*

| Year | Number of Dwellings | Population |
|---|---|---|
| 2005 | 465 | 1,953 |
| 2008 | 1,164 | 4,889 |
| 2011 | 2,494 | 9,228 |

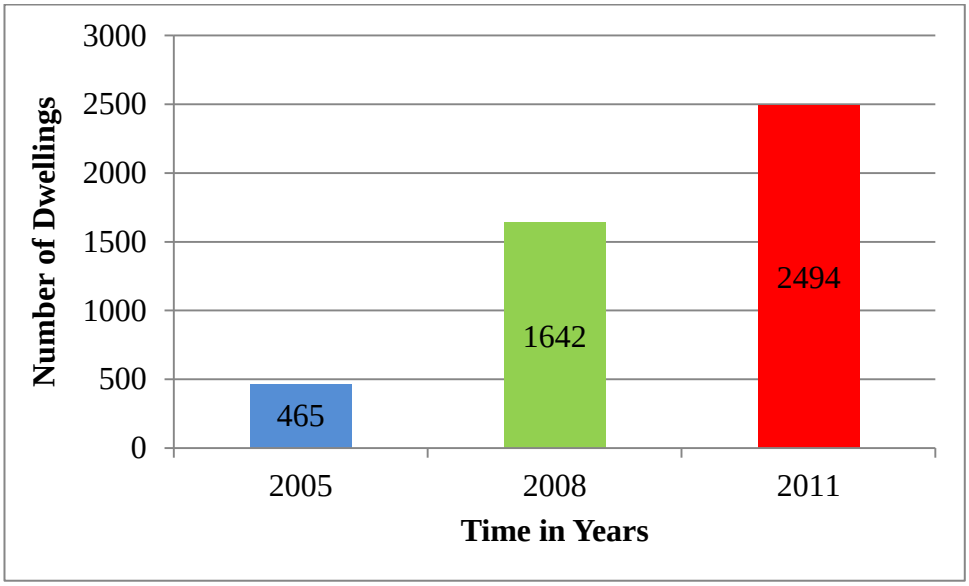


*Figure 19.* Dwellings in Oohambo Dha Nehale from 2005 to 2011

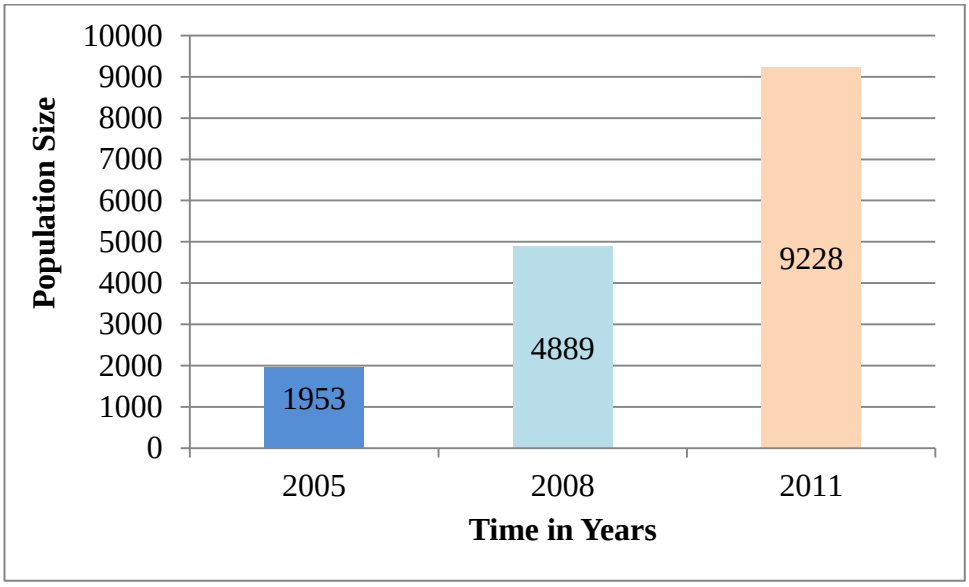


*Figure 20.* Population size for various years

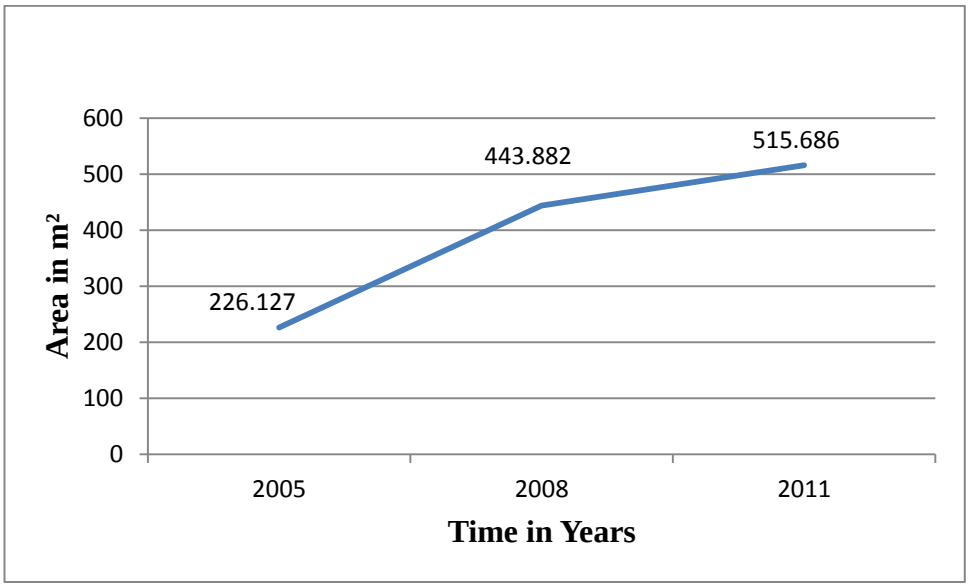


*Figure 21.* Expansion for various years

An increase in the number of dwellings and the population size were observed in the study area during the periods dating from 2005 to 2008, and from 2008 to 2011. Between 2005 and 2008, the number of dwellings in Oohambo Dha Nehale increased

by 1,177, which represents an increase of 84% over a period of three years. The population size increased from 1,953 in 2005 to 4,889 in 2008, a yearly average increase of 978. Between 2008 and 2011, dwellings increased in number by 852, a yearly average increase of 17%, while the population increased by 4,339 in 2011 from 4,889 in 2008.

Overall, the number of dwellings in Oohambo Dha Nehale increased by 2029 between 2005 and 2011, representing an average increase of 73% per year. The population size on the other hand, increased by 7,275 inhabitants between 2005 and 2011. Table 5, and Figures 22 and 23 show the changes in the number of dwellings and population size for these two time periods.

Table 5.

*Dwellings and Population Size for two 3-Year Periods*

| Period | Increase in Dwellings | | Increase in Population | |
|---|---|---|---|---|
| | Number | Percentage | Number | Percentage |
| 2005-2008 | 1,177 | 253 | 2936 | 150 |
| 2008-2011 | 852 | 52 | 4339 | 88 |

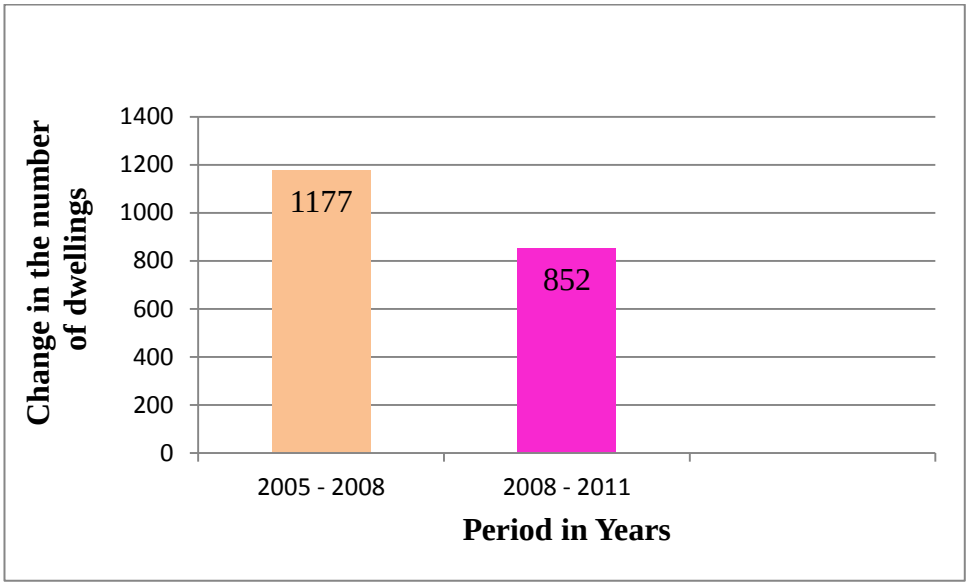


*Figure 22.* Changes in the number of dwellings in Oohambo Dha Nehale

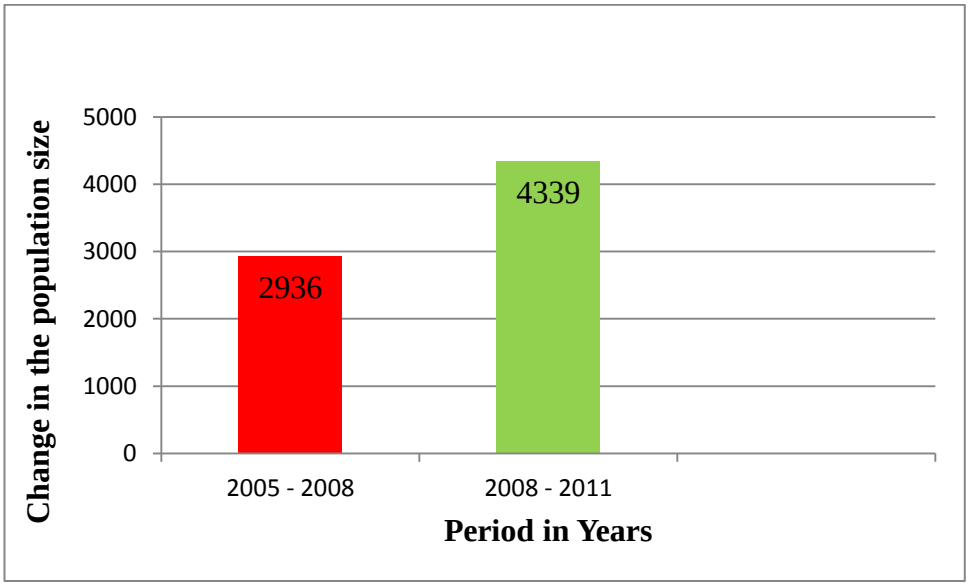


*Figure 23.* Changes in the population size of Oohambo Dha Nehale

Two large expansions were observed during the periods dating from 2005 to 2008, and from 2008 to 2011. The first expansion is estimated at 217,755 m², which represents an increase of 96.3 % over a period of three years between 2005 and 2008. The second

expansion was at 71,804 m², which represents an increase of 16.2 % for the period dating from 2008 to 2011. The overall expansion from 2005 to 2011 is estimated at 289,559 m², which represents an increase of 128.1 % over a six-year period. Figure 24 shows the area change.

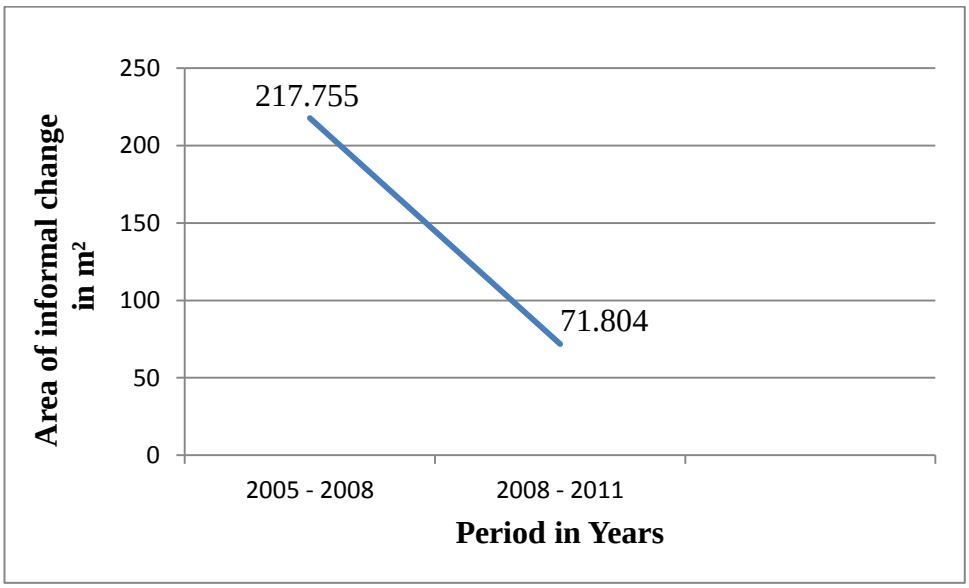


*Figure 24*. Area change over two periods in Oohambo Dha Nehale

## 4.3. SPATIAL PATTERN

Everything that has a location in geographic space inevitably creates or contributes to a spatial pattern. Geography devotes a large amount of attention to analysing, identifying, and explaining spatial patterns both in qualitative and in quantitative terms (Kwan & Din, 2008). Spatial patterns can be derived from the primitive concept of location but are themselves not considered primitive (Golledge, 1995).

The analysis of spatial patterns becomes particularly intricate, not only if we look at spatial patterns created by the location that entities have in space, but at the combination of spatial and attribute values from a quantitative perspective. Thus, theoretical construct is most famously summarised by Tobler's (1970) first law of geography (TFL). Everything is related to everything else, but near things are more related than distant things (Tobler, 1979).

By analysing the Spatial Autocorrelation Report for Oohambo Dha Nehale (Figure 25), we can determine whether or not there is any kind of clustering in our spatial autocorrelation happening anywhere in the data set.

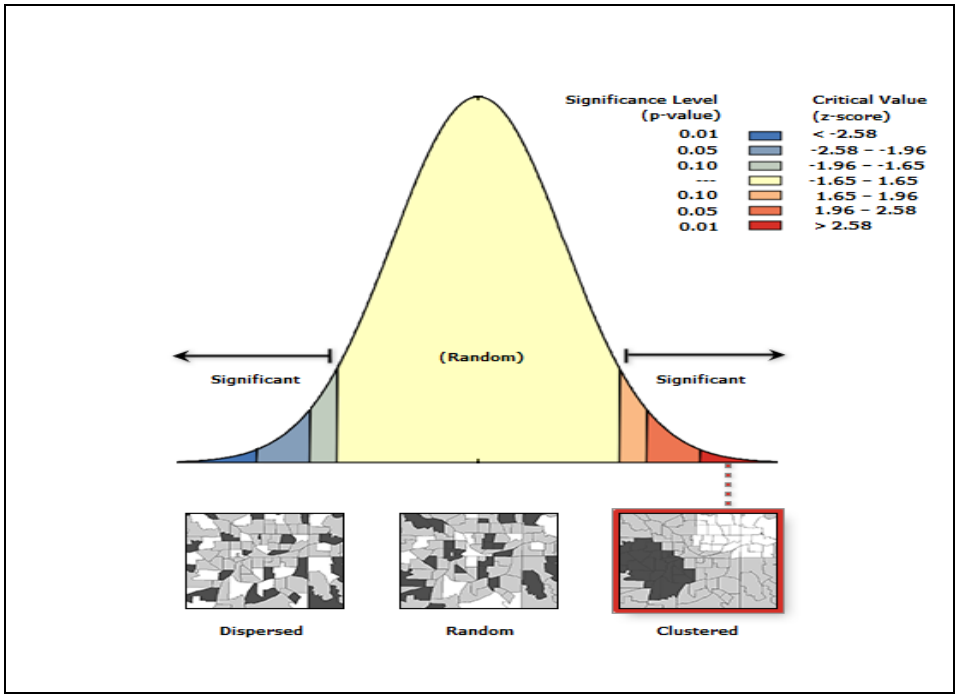


*Figure 25*. Spatial autocorrelation report for Oohambo Dha Nehale

There is a distinction that is made in all spatial autocorrelation measures (as well as in, for example, point pattern analysis), which can be differentiated using various spatial analysis methods. The distinction is between three kinds of patterns: clustered, dispersed, and random.

The spatial autocorrelation results indicated that dwellings in Oohambo Dha Nehale exhibited a cluster pattern. The index been computent in the spatial autocorrelation as Moron's index, shows that it is a positive number, which tells us that there is an apparent clustering of like values near each other. The *z*-score is positive with a large number of 128, therefore it is statistically significance and leaning towards a cluster scenario. Given the *z*-score of 128, there is less than a 1% likelihood that this clustering pattern could be the result of random chance.

## 4.4. SLOPE ANALYSIS

The type of slope found within an area is important in determining whether the land in that area is suitable for residential building purposes. Oohambo Dha Nehale is found in an area that is characterised by extremely mountainous terrain. Most of the land in the area has slopes ranging from steep to extremely steep, making it unsuitable for building purposes.

After assessing the results from the slope analysis in relation to the number of dwellings found on each slope class in Oohambo Dha Nehale (Table 6, and Figures 25 and 26), it is evident that the slope has a minor influence on where dwellings are built.

This is so because, many of the dwellings happens to be found on land that is unsuitable for building. There is a considerable difference between the Zuidam and the City of Windhoek slope classification in the study area (Table 6, and Figures 26 and 27). On the Zuidam Slope Classification (ZSC), 3.3 % of the dwellings in Oohambo Dha Nehale were built on land that was flat or gently sloping ($0^o$ - $4^o$), whereas in the City of Windhoek Slope Classification (CoWSC), 10.5 % of dwellings were found on suitable and moderately suitable land ($0^o$ - $6^o$).

Table 6

*Zuidam's and City of Windhoek's Slope Classification*

| Slope Code | Slope Classification | | Label | | Number of Dwellings Per Slope Class | | Percentage | |
|---|---|---|---|---|---|---|---|---|
| | Zuidam | CoW | Zuidam | CoW | Zuidam | CoW | Zuidam | CoW |
| 1 | 0° - 2° | 0° - 3° | Flat or Almost Flat | Very Suitable | 7 | 31 | 0.3 | 1.2 |
| 2 | 2° - 4° | 3° - 6° | Gently Sloping | Moderately Suitable | 75 | 233 | 3.0 | 9.3 |
| 3 | 4° - 8° | 6° - 8° | Sloping | Less Suitable | 461 | 279 | 18.5 | 11.2 |
| 4 | 8° - 16° | 8° - 11° | Moderately Sloping | Unsuitable | 1,751 | 692 | 70.2 | 27.8 |
| 5 | 16° - 33° | 11° - 33° | Steep | Extremely Unsuitable | 200 | 1,259 | 8.0 | 50.5 |

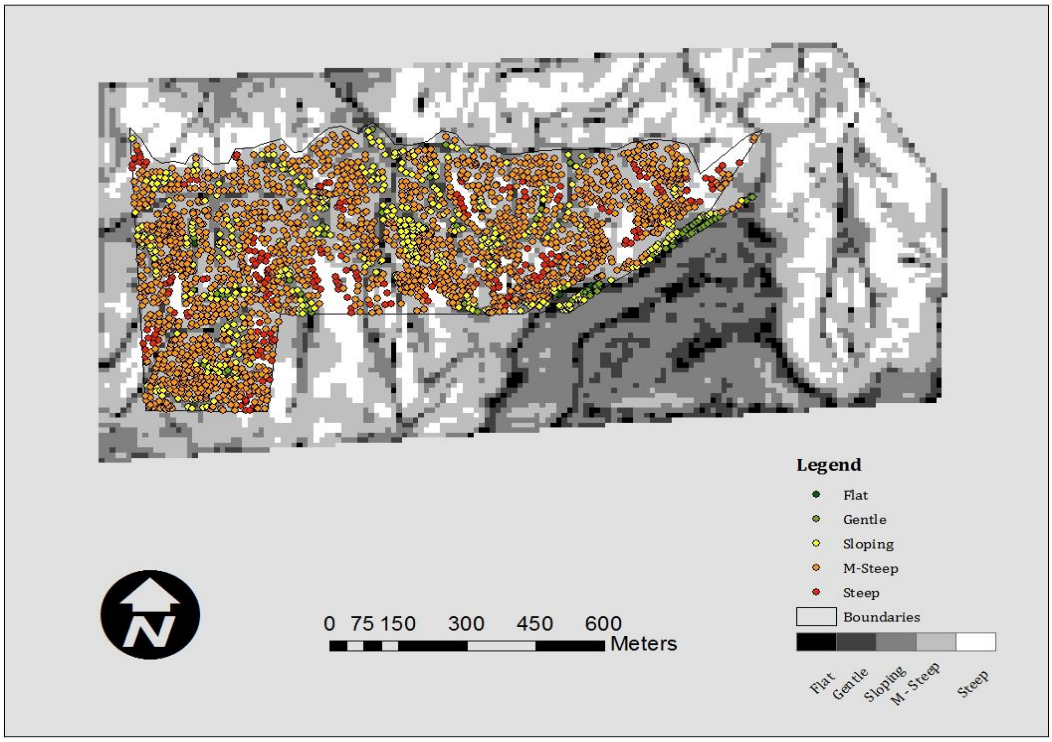


*Figure 26.* Zuidam's slope classification

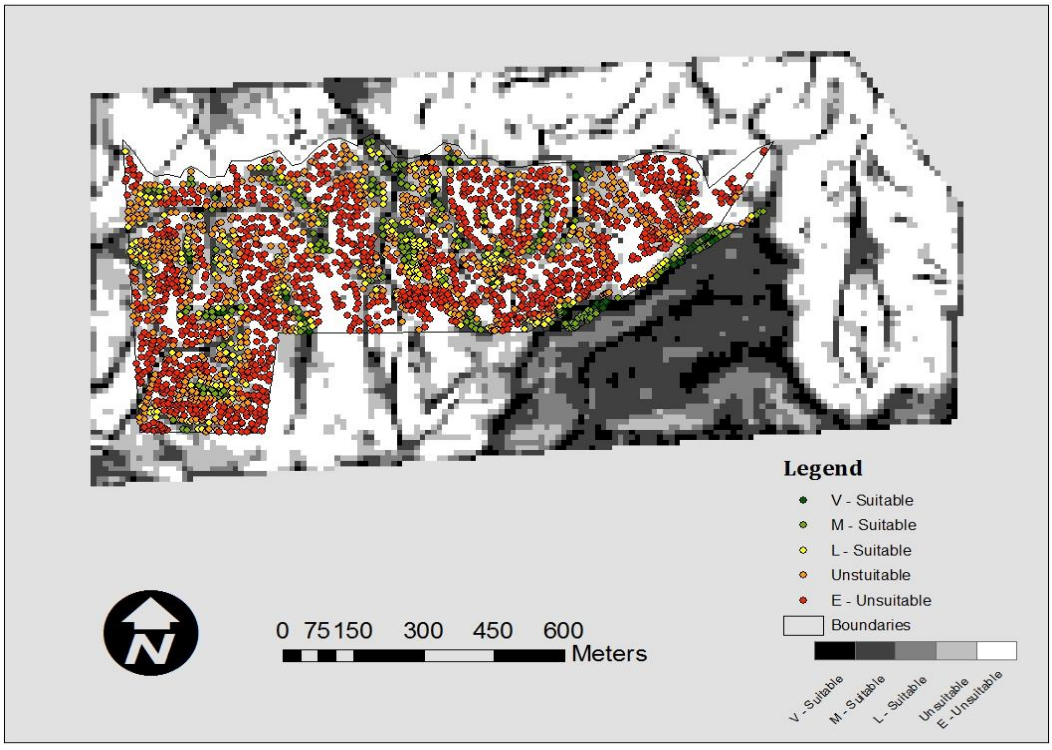


*Figure 27.* City of Windhoek's slope classification

About 18.5 % of the dwellings on the ZSC were found on land that was sloping ($4^{o}$ - $8^{o}$), while on the CoWSC only 11.2 % of dwellings were built on land with a less suitable slope. Following the ZSC, most dwellings in the study area (about 70.2%) were built on land with a moderate slope (8° – 16°), whereas with the CoWSC, about 77.5% of the dwellings in the study area were built on unsuitable and extremely unsuitable land.

# 5. DISCUSSION

## 5.1. INTRODUCTION

This section discusses the findings from the Results section. It incorporates discussions about the issue of expansion based on the dwellings (structures) in relation to the population growth, the spatial pattern, and factors that influence the pattern. It also examines the issue of slope in the area to determine the suitability of land for residential building purposes. This section winds up by making a comparison between the two slope classifications with regard to the number of dwellings per class.

## 5.2. STRUCURE INCREASE, POPULATION AND AREA EXPANSION

As discussed in chapter two (section 2.3), rapid growth of informal settlement is one of the biggest problems faced by cities in developing countries. These settlements are characterised by residents with low-income profiles, live under extreme poverty conditions and lack the proper financial means and infrastructures to cover their basic needs (World Bank, 2005). One of the main causes of these phenomena is urbanisation. In Windhoek, urbanisation has led to the development and growth of informal settlements immediately after independence.

Before independence, the apartheid government had discriminatory laws and policies designed and meant specifically for blacks. These laws prohibited blacks to move freely or settle anywhere they wanted, also prohibiting them to urban land

ownership. When Namibia gained independence in 1990, the apartheid laws and policies were abolished and the new government introduced the right of all Namibians to move freely, reside and settle in any part of the country. These led to an increased flow of people from rural to urban areas in search of employment.

According to Turok (2012), people move from rural to urban areas in search of employment, better standard of living and to have access to resources that are lacking in rural areas. Tvedten and Mupotola (1995) points out that, social and economic conditions in rural areas are difficult to many people and employment opportunities are limited. While on the other hand, urban areas provide opportunities for better jobs and other social amenities for a better life such as educational institutions, medical facilities, to name a few.

Eherbrecht (2014), states that, people who move from rural to urban areas, have a belief and perception that they will get employment easily, but once they are in the city, life becomes difficult. They end up being unemployed and unable to rent or buy a piece of land. Therefore, they have no other alternative but to occupy available land in already existing informal settlements without the consent of the municipality in charge. This results in informal settlement expansion.

Results attained in this study (chapter four), supports Turok's, Tvedten and Mupotola statement based on the fact that, they show an increase in the number of dwellings, population and area expansion in Oohambo Dha Nehale between 2005, 2008 and 2011 (See table 4, figure 18,19 and 20). This increase can be attributed to

rural urban migration, whereby there is a high flow of people to Windhoek in search of employments. According to NSA (2012), Windhoek has far been the major focus of urbanisation. The population in Windhoek has increased from 13.7% in 2001 to 16.2% in 2011. In Oohambo Dha Nehale, the population has increased from 1642 in 2005 to 8,729.

Between year 2005 and 2008 the number of dwellings in Oohambo Dha Nehale increased by 699 from 465 and the population size increased from 1953 to 4889. The area expansion on the other hand, increased from 226,127 m² to 515,686 m². Between the year 2008 and 2011, there was an increase of dwellings from 1164 to 2494, as well as the population size from 4889 to 9228. The area expansion increased by 71,804 m².

Overall, the lowest increase in the number of dwellings and the population size was experienced between the 2005-2008 time period, but the area expansion was the highest during that period. Based on stages of informal settlement development as discussed in chapter 2, results for the 2005-2008 period on area expansion can be categorised in the consolidation stage. According to Sliuzas (2008) during the consolidation stage, there is an increased outward expansion in area size.

During the 2008-2011 time period, the increase in the number of dwellings and the population size was the highest, were as the area expansion was the lowest. These results can be classified in the saturation stage of informal settlement development, whereby expansion of an areas stops and empty spaces gets filled up with new

structures. This stage is normally characterised by high overcrowding which exacerbate long conditions of informal dwellers (Sori, 2012).

## 5.3. SPATIAL PATTERN

Understanding the spatial pattern of human settlements and their geographical association are important for understanding the drivers of land use and land cover change, the relationship between environment and geological processes on one hand, culture and lifestyle on the other hand (Zhang, Xiao, Shortridge & Wu, 2013). Dwellings in Oohambo Dha Nehale informal settlement exhibited a cluster pattern that is influenced by various factors such as topography, access to water, proximity to transportation, density of the population, and influence of the community leader.

Dwellings found at the boundary of the area showed a linear clustering pattern. This pattern is influenced by the presence of the tar and gravel road, and the flatness of the land. The road's proximity influences people to build their houses close to it for easy access to transportation, thereby minimizing walking distance. The land has terrain characteristics such as flat, gently sloping, and sloping, making it easy and cheap to build houses.

Dwellings located in the hilly interior areas exhibited a more significant clustering pattern that is influenced by water availability, type of terrain (sloped), and mostly by the influence of the community leader. Dwellings that are clustered together happen to be found around and close to where there is water (water taps). That gives

them easy access to the water, which the use for their daily activities and to minimize the walking distances. The clustering of dwellings in areas that are unsuitable for building occurred by chance, because people just build where there is a vacant piece of land that is not characterised by big rocks.

## 5.4. SLOPE

The use of GIS was significant in slope analysis and made it easier to determine the suitability of the land in Oohambo Dha Nehale informal settlement for building residential purposes. Results indicates intriguing figures on the number of dwellings covered on each slope class of the ZSC and the CoWSC. See table 6 in chapter 3. The lowest number of dwellings where found to be built on land with slope value of 0-2º (almost flat) on the ZSC and from 0-3º (very suitable) on the CoWSC. On the other hand, the highest number of dwelling were located on land that was moderately sloping (8-16º) on the ZSC and unsuitable (11-33º) on the CoWSC.

This is a clear indication that many of the dwellings found in Oohambo Dha Nehale informal settlement are built on land that is unsuitable (moderately sloping) and extremely unsuitable (steep slope) for building purpose. Overall, more than 70 % of the dwellings in the study area were built on land that was not suitable for building. This shows that, the residents of Oohambo Dha Nehale did not adhere to the physical guidelines of the City of Windhoek with regard to slope and building requirements.

# 6. CONCLUSIONS AND RECOMMENDATIONS

## 6.1. INTRODUCTION

This section aims to provide concluding remarks based on the findings and point out recommendations, as well as areas of further research. The study explored the possibilities offered by the advancement of Geo-Information science and spatial analysis to improve the understanding of spatial dynamics of the Oohambo Dha Nehale informal settlement over the period from 2005 to 2011.

## 6.2. CONCLUSION

The demand for urban land will continue to increase, primarily due to pressure both from people migrating to cities in search of employment and resident demands for new households. This can lead to the formation of informal settlements within and around the city on land that is vacant and unoccupied. If new informal settlements emerge, pressure is placed on the authority, who are already struggling in managing informal settlements that already exist with regard to planning. Spatial analysis is key to the formulation and evaluation of physical planning initiatives and spatial data can be transformed into meaningful information that can help policy makers in preparing, developing and evaluating policy alternatives (Koomen, 2008). The number of dwellings and the populations increase in the study area were consistent with the findings of the population and housing census survey carried out by the National Statistic Agency of Namibia in 2011.

The results on the number of dwellings, population and area expansion can be used by the City of Windhoek (Geomatics department) to monitor the population growth of the settlement, the area expansion and the direction in which the area is expanding so that they can plan ahead. The spatial pattern of 2011 in Oohambo Dha Nehale informal settlement, shows features exhibited in most informal settlements of developing countries as described in section 2.21. The pattern is almost the same in most informal settlements in Windhoek.

Slope analysis results indicated that most of the dwellings in the study area are located on land with steep slope, classified as unsuitable for building purposes by the City of Windhoek. These dwellings can be vulnerable to natural disasters such as flood and mudslide. In addition, the area is characterised by rocks. The combination of steep slope and rocky area makes it difficult to upgrade the entire settlement. Therefore, some dwellings located on steep slope would need to be relocated to other areas that are flat. This information would assist the City of Windhoek have an idea on the number of dwellings that needs to be relocated to safer areas that are not vulnerable to natural disasters.

In conclusion, results attained in this research proves that GIS is an important tool that can be used in spatial analysis to understand the spatial dynamics of informal settlements in Windhoek. However, because of limited time, the spatial pattern for 2005 and 2008 was not carried out, only the one for 2011. This made the results for spatial pattern limited to adequately picture the spatial pattern of Oohambo Dha Nehale

informal settlement for 2005 and 2008. Therefore, there is a need to further carry out spatial analysis focusing on spatial pattern comparison between different years.

## 6.3. RECOMMENDATIONS

The research has identified the following broad recommendations because they can be applied to most of the informal settlements found in Windhoek.

### 6.3.1. Improvement of rural areas

Urbanisation is one of the main causes that leads to the development of informal settlements in Windhoek. In order to solve the problem of informal settlement, it is important to improve rural areas in other towns of the country, so that more employment is created. If improvement is only made in urban areas, the flow of people to urban areas will continue and this will make the situation worse. Rural areas that have more than 500 inhabitants can be declared village councils (like in the case of Bukalo) in the Zambezi region. Bukalo was a village, with more than 500 inhabitants, when it was declared a town, there were more employment opportunities. This can also be done to the villages in the country.

### 6.3.2. In-situ upgrading

Upgrading is a package of the basic services and security of tenure. In-situ upgrading is always on site and with as little relocation of residents as possible. It is

difficult to remove all the residents of Oohambo Dha Nehale informal settlements because they have stayed there for years, and now call it home. What can be done is to upgrade the settlement through provision of basic services and facilities in the area. Those that are located on land that pose a risk can be relocated to other areas provided by the City of Windhoek. The City of Windhoek should assist them with transport services and other costs that they might incur since most of them are unemployed.

### 6.3.3. Prevention of new informal settlements

The prevention of new informal settlements is critical to the sustainability and management of the City of Windhoek. This requires an adequate institutional and legal framework for land development regulation by the Government and by the City of Windhoek that facilitates the production of affordable land for residential uses, thus reducing the illegal occupation of land.

### 6.3.4. Managed land settlements

In order to minimize the growth and development of new informal settlements, sufficient planned areas should be provided by the City of Windhoek for informal settlement development. These areas can also serve as relocation places for those few people who have to be relocated when an informal settlement is being upgraded as mentioned in the section 6.3.2. All dwellings found in the settlement should be registered and recorded by the City of Windhoek, such that they keep track of new settlers in the area, thereby monitoring in-migration into the area and the population.

Monitoring the number of dwellings and the population may help alleviate the difficulty of gathering field demographic data in the future.

### 6.3.5. Upgrading of infrastructures

The amount of infrastructural facilities available in the informal settlements is grossly inadequate while some are not even available. Availability and adequacy of infrastructural facilities is a major factor that determines the environmental condition and liveability of any settlement. Therefore, efforts should be directed towards upgrading the existing ones while those that are not available should be provided.

This could be achieved through the preparation of a detailed infrastructure network plan for the community with population density being the major yardstick in determining adequacy. The design should allow for individual self-funded incremental service connections and affordable capital, maintenance, and user costs for services. Therefore, deliberate effort should be made to improve the livelihood of this category of people. Their means of livelihood, which is centred on informal sectors, should be both recognized and supported.

### 6.3.6. Residents' participation

It is very important to involve the inhabitants of the settlement (for example during the upgrading process) because it shows a start of an equal, democratic society, where residents can make their voices heard and affect the outcome to fit their needs. People feel bad when they cannot affect decisions that they are involved in.

Furthermore, people tend to take better care of their community or surroundings when they are involved and feel that they can influence their own and their community's future. Therefore, the City of Windhoek should try to involve the residents of the settlement when there are issues that they have to tackle in informal area, instead of deciding on their own without hearing from the people who live in those communities.

## 6.4. AREAS FOR FURTHER RESEARCH

Further research in spatial analysis should be carried out in Oohambo Dha Nehale to analyse the spatial dynamics of the settlements in terms of the population distribution, population density and number of dwelling and taps in the area. In addition, further research on the key driving forces of the settlement growth should be investigated, coupled with GIS techniques. Furthermore, the use of GIS and population census data can be researched as a tool for monitoring and planning informal settlement growth and upgrading.

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