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# An evaluation of alternatives to conventional addressing in two informal settlements of South Africa

by

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Submitted in partial fulfilment of the requirements for the degree

**Master of Science (Geoinformatics)**

In the Faculty of Natural & Agricultural Sciences

University of Pretoria

Pretoria

I, Yashena Naidoo declare that the dissertation, which I hereby submit for the degree MSc. Geoinformatics at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

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# Abstract

An address is used to provide identifiable information to describe a physical object's location unambiguously. Addresses are vital, not just for navigation but also for service delivery and city management. Conventional addresses are dependent on relative features, such as roads, and are structured in a manner that is easily recognisable by people. They also have significant meaning for a person's sense of belonging. With the growth of the population in South African cities, as well as in-migration, urban settlements continue to expand and become denser. These cities need to implement effective ways of assigning addresses to settlements, as existing addresses are not always assigned to dwellings in newer or informal areas. Due to rapid urbanisation, there is an increased demand for services and infrastructure brought on by the sudden growth. Therefore, address assignment in these rapidly growing settlements is not always effectively implemented due to the inability to manage the sudden increase in dwellings. The aim of this project was to evaluate the effectiveness of alternative addresses in two informal settlements in South Africa. What3Words, Mapcode and datum-based addresses were selected as alternatives because they are examples of addresses assigned based on location only; they are not relative to other features, such as roads or administrative areas. Alternative addresses were assigned to each dwelling in two informal settlements located in Mamelodi and Khayelitsha, respectively. The assigned addresses were evaluated based on a set of evaluation criteria, aimed to provide insight into the effectiveness of alternative addresses in lieu of conventional addresses in informal settlements. The results of the evaluation of these addresses can guide local government planning efforts regarding what would be the most effective choices for address assignment in informal settlements.

## Acknowledgements

I would first like to thank my supervisors, Prof Serena Coetzee and Dr Victoria Rautenbach, for all their guidance and support. You helped me become a better researcher, and I appreciate you always giving me the advice and encouragement to do better. This research would not have been possible without your guidance. It was an amazing privilege to work with you both.

The GMT 320 students whose fieldwork provided the dataset for Alaska, Mamelodi. It was a great experience to be a part of this group. The City of Cape Town for providing me with the data for the CT Section.

Lastly, I would like to thank my family, friends, and colleagues for all their support. I am grateful for everything that you have done to help me get this far.

# Table of Contents

# List of figures

# List of tables

# 1. Introduction

## 1.1 Overview

With the growth of the population in cities as well as the ever-increasing number of migrants due to urbanisation, urban spaces continue to expand. They are usually characterised by densely populated areas that comprise mostly human-made structures and house various urban functions. Due to the increasing demand for services and housing, people have resorted to encroaching on unoccupied land, resulting in informal settlements. Informal settlements can be defined as residential areas where the residents often do not have any form of tenure for the land or dwellings in which they reside (Avis, 2016). The dwellings constructed in these informal spaces are characterised by having poor infrastructure, high population densities and poor access to essential services, such as clean water, electricity and schools, health and welfare (Barry and Rüther, 2004; Lemanski and Town, 2009; Avis, 2016). This is a consequence of rapid urbanisation and the effects of globalisation affecting developing countries, resulting in cities that are not always able to effectively provide essential services for everyone (Cobbinah, Erdiaw-Kwasie and Amoateng, 2015). Governments are not able to effectively control the growth of informal settlements, and the existing urban planning systems may not have the necessary mechanisms to cope with such expansive growth in population and size.

With the growth of cities and the effects of urbanisation, conventional addresses are not always provided. An address is a commonly used identifier and is defined as structured information that provides an unambiguous description of an object for the purpose of identification and location (ISO/TC 211, 2011). Addresses are not only crucial for navigation and the location of dwellings, but they provide necessary information for facilitating service delivery in order to provide utilities and city management. Due to rapid urbanisation, local and municipal governments are not equipped to provide the resources and infrastructure necessary to manage such expansion. Therefore, address assignment in these informal settlements is a challenge (Farvacque-Vitkovic *et al.*, 2005). With no formal address assignment, ambiguities and inconsistencies may occur that lead to multiple dwellings having the same addresses or no address at all. Conventional addresses in South African urban spaces typically make use of street layouts to assign addresses. However, in an informal settlement, this may not be effective as the street networks are not clearly defined and consist of pathways and thoroughfares.

In South Africa, having a valid address is essential for access to several services such as opening bank accounts, as well as being able to register for voting. An address is a requirement of the South African Financial Intelligence Centre Act (Coetzee and Cooper, 2007) to access any financial service. The South African national standard pertaining to addresses (SANS 1883) defines an

address as a point of service delivery (South African Bureau of Standards, 2009). The lack of service delivery is an ever-present issue in South Africa, as shown by the number of protests that have occurred over the lack of service delivery, such as the #TswhaneShutdown, a movement organised by the South African Civic Organisation (SABC, 2019). An ineffective address can lead to problems, such as address duplications and ambiguities that may hamper efforts to improve service delivery (Coetzee and Cooper, 2007). Therefore, it is important to determine the factors that define an effective address.

A number of alternative addressing systems have been developed in response to the need for usable addresses. For instance, in South Africa, the ambulance response service, ER24, has incorporated the use of What3Words to improve their ability to locate and navigate to medical emergencies. What3Words was chosen as it provides a more accurate location than the address information that was used previously (de Wet, 2019). However, these types of addresses do not conform to the stipulations outlined in standards for addresses. The South African standard for addresses, SANS 1883, provides guidelines for the format in which an address should be, and these alternative addresses do not conform to these formats. An address such as What3Words assigns codes based on a location rather than an object, as it generates codes that are associated with a predefined grid which determines an address based on the grid cell in which a dwelling is located. Even though they are quite different from conventional addresses, they are being used increasingly in lieu of conventional addresses. However, these systems have not been systematically assessed and tested in informal settlements to determine their effectiveness in a rapidly changing environment where dwellings do not necessarily follow a discernible pattern (Kostof, 1993).

## 1.2 Problem statement

Many alternatives to conventional road-based addresses have been proposed; however, their ability to identify dwellings effectively and unambiguously in informal settlements has not been determined.

## 1.3 Research aim and objectives

The aim is to evaluate the effectiveness of a number of alternative addressing systems in two informal settlements in South Africa.

The objectives needed to achieve the aim:

1. Conduct an ongoing literature review on related work regarding addresses and informal settlements.

2. Based on the literature review, determine the criteria to be used for the evaluation of the effectiveness of addresses in informal settlements.
3. Assign alternative addresses to dwellings in two informal settlements of South Africa and evaluate the addresses against the evaluation criteria.
4. Based on the results, draw conclusions and recommendations on the use of alternative addresses in informal settlements.

## 1.4 Significance of research

Due to the rate of urbanisation and the need for housing in close proximity to employment opportunities, informal settlements are a significant part of South Africa's urban landscape. Most dwellings in these settlements do not have access to adequate essential services; therefore, it is important to determine what an effective address can be in order to aid service delivery in these regions. There is a need to help manage urban settlements so that they can be improved and in turn, the lives of the residents can also be improved (Barry & Rüther, 2004). Service delivery in informal settlements would be greatly improved with the use of an adequate address. The assignment of addresses to all informal settlements is a complex undertaking as not all settlements have similar layouts, particularly when using conventional addresses. An address that is effective in a certain type of informal settlement layout may not be as effective when applied to another layout.

At present, the addresses being used in informal settlements are often not useful for the residents or do not exist. Having an effective address will enable residents in these settlements to have a usable identifier of their place of residence that adds value to their sense of identity and place. An address will help facilitate service delivery, and access to utilities such as water, electricity, sewerage and emergency response (Coetzee *et al.*, 2011). Having access to an address can significantly improve one's life, not only because it can assist in access to services but also because it strengthens one's sense of belonging and an association with the area in which they live. To ensure smooth delivery of services, initiatives aimed towards informal settlement upgrading, such as the provision of social housing or service sites, should include address assignment in the planning processes and the results of this research can guide the implementation of such processes.

Determining what makes an address effective is crucial to ensuring it is well implemented. The criteria used to determine this effectiveness need to encompass all facets of an address such as the resources required to assign the addresses, methods used and its usability. In order for the evaluation to be informative, it is important to consider not only the process that is followed for address assignment itself but also how the addresses are received by the people that use them

and whether the community accepts the addresses that are created. Having an effective address is important so that it can be used by organisations as they enable society to be managed by the government and other organisations. A person cannot register to vote, or an ambulance cannot reach a person in need of medical assistance if they do not have an address; therefore, all people need to have a unique address.

## 1.5 Overview of sections in the dissertation

The remaining chapters in this dissertation are as follows:

**Chapter 2 – Informal settlements** examines literature on the characteristics of informal settlements, particularly focusing on South African informal settlements.

**Chapter 3 – Understanding addresses** looks at why addresses are needed and the ways in which addresses have been assigned around the world. It looks at different addresses that have been formally implemented by governments as well as alternative addresses that have been designed in an effort to meet the need for effective addressing.

**Chapter 4 – Methods** discusses the way in which the evaluation was conducted. This chapter discusses the process undertaken to determine how the criteria for evaluation were formulated and the evaluation of the alternative addresses in the study areas.

**Chapter 5 – Criteria for evaluation** is a presentation of each of the criteria that were formulated for the evaluation. The criteria have been grouped into themes that speak to different aspects of addresses that determine the effectiveness of the alternative addresses.

**Chapter 6 – Assignment of the alternative addresses** details the selection of the study areas and process of selecting the three alternative addresses: What3Words, Mapcode and the datum-based address. The methods that are employed to assign each type of alternative address to a dwelling is discussed.

**Chapter 7– Evaluation of the alternative addresses** is a presentation of the outcome of the assignment of the alternative addresses. The purpose of the evaluation is to determine how effective and efficient the alternative addresses are in an informal settlement based on the formulated evaluation criteria.

**Chapter 8 – Discussion of results** is an exploration of the overall outcomes from the evaluation of the addresses based on each evaluation criterion and with reference to the literature. This chapter puts into perspective the overall effectiveness of each of the addresses in relation to each other in order to determine which was the most effective.

**Chapter 9 – Conclusion** discusses the important insights that were formed during the process of undertaking this research and the significance that these insights may have to the consideration of the use of alternative addresses in lieu of thoroughfare based addresses.

# 2. Informal settlements

## 2.1 Introduction

With the increasing growth in urban population, people are drawn to economic hubs in the pursuit of better opportunities and improved quality of life. However, infrastructure in these urban areas is not able to cope with the increasing demand, including the demand for housing. In lieu of the lack of formalised housing, informal settlements have grown as a response to the need for housing. This chapter discusses the factors that have contributed to the presence of informal settlements in urban South Africa.

## 2.2 The effects of urbanisation on human settlements

Urbanisation is a complex process influenced by social and economic factors; it can be defined as the shift in population from rural to urban areas (Mcgranahan and Satterthwaite, 2014). It involves the transformation of a rural landscape into that of an urban one which is controlled by the physical characteristics of the area as well as its accessibility. The process of urbanisation often leads to the creation of areas in which there are innovation and production in order to effectively make use of available resources (Antrop, 2004). People are drawn to the opportunities brought on by growing industries and businesses, thus contributing to rapid urbanisation and growth of urban spaces (Landman, 2011). However, with the increase in rapid urbanisation and globalisation in developing countries, most cities are not able to adequately provide basic services for everyone. Thus, it becomes increasingly difficult for cities to cope with unplanned rapid urbanisation. Rapid urbanisation can lead to reduced positive socio-economic and environmental benefits of urbanisation. This is due to the fact that rapid urbanisation cannot be controlled by urban planning systems and policies implemented by governmental institutions (Cobbinah, Erdiaw-Kwasie and Amoateng, 2015). With the increasing demand for resources, it has led to encroachments of open spaces and the emergence of slums and informal settlements.

The growth of cities can be attributed to a number of factors, including rural-urban migration, natural population increase, and annexation. These urbanised cities offer economic opportunities, employment, and social development. They constitute areas in which modern productive and economic activities occur, modern living and are characterised by having high indicators of general health and wellbeing and social mobility (Brockerhoff, 2000; Carmody and Owusu, 2016). These cities become aspirational with the allure of modern amenities and the opportunity of employment, and they attract large numbers of employment seekers. However, African cities can be characterised by uncontrolled and large spatial expansion, known as urban sprawl (Cobbinah, Erdiaw-Kwasie and Amoateng, 2015). Urban sprawl can lead to unsustainable

land development and may encompass peripheral urban areas as well as non-urban land, such as agricultural land and can impede the improvement of infrastructure and service delivery. Due to the unguided manner of urbanisation and population growth, African cities have to contend with a number of issues, such as the unsustainable use of resources, unemployment, poverty and water and sanitation challenges (Cobbinah, Erdiaw-Kwasie and Amoateng, 2015). Rapid urban growth in cities has rendered many developing cities unable to provide basic services (Cohen, 2006). The poor public services and infrastructure and improper management are a great impediment to the economic growth of African cities (Carmody and Owusu, 2016), which stifles economies and makes it increasingly more difficult to improve the state of these cities. Cities must have robust infrastructure and policy frameworks to develop and maintain the necessary systems for the provision of services. Having an address system that can be effectively implemented would be an essential mechanism for city planning and management efforts.

Regardless of the challenges facing the capacity of cities, they continue to grow in population and size. As a consequence of the natural growth of population in cities as well as the ever-increasing number of migrants, the expansion of informal settlements increases. This expansion further exacerbates the issues of urban sprawl (Cohen, 2006). For the most part, in South Africa, the growth of housing for the urban poor occurs around the urban edge, in the form of low-income housing, backyard shacks, and informal settlements. Rapid urban population growth also makes it difficult to provide housing that is of decent quality as government policies and constraints often do not cater to lower-income brackets in an appropriate manner, leading to the production of informal dwellings in crowded settlements (Turok and Borel-Saladin, 2016). The need for low- and middle-income housing for wellbeing and social stability is an ever-increasing demand. Many cities in low- and middle-income countries struggle to provide adequate housing in suitable locations (Turok and Borel-Saladin, 2016). The design and type of housing that is required should be influenced by the livelihoods and jobs of those in need in order to effectively meet the demand for housing.

The use of geospatial information from various sources can be used to create a broader outlook on ways in which to solve the problem so that the solutions could be more encompassing, as well as an exploration of the space and the relationship between the informal settlements and the surrounding formal areas (Abbott, 2003).

## 2.3 Human settlements in urban South Africa

South Africa has a tumultuous past, in which the apartheid era made a significant impact on the political and socio-economic patterns of the country. Apartheid introduced various forms of

segregation and racial discrimination, in which the white race group was in a position of supremacy and repressed people of colour.

The socio-political impact of apartheid played a large role in influencing South Africa's urban form (Huchzermeyer, 2003). At an urban level, apartheid principles resulted in cities and towns having distinctive spatial forms and patterns due to segregation in terms of race as well as income, thus controlling urban growth. Townships and settlements were established on the urban boundary and were not well located. This resulted in large-scale commuting from these poorly serviced areas to the focal areas for economic activities, which were predominantly 'white' areas. Poor residents were either forced into these long commutes or were trapped in areas with fewer economic activities (Harrison, Todes and Watson, 2007). Due to apartheid-era policies, South Africa has a history of having overcrowded and under-serviced settlements on the urban periphery and housing policies cannot sufficiently meet the backlog of the housing demands in South Africa (Lemanski and Town, 2009; Turok and Borel-Saladin, 2016). Due to the growth of urban populations, it is critical to understand the vulnerability of South Africa's human settlements in order to mitigate the potential risks, such as natural disasters, in these areas (van Huyssteen, le Roux and van Niekerk, 2013). These vulnerable settlements need to be prioritised in order to improve the quality of life of the residents and to enable upward social mobility.

### 2.3.1 Meeting the demand for housing

Since the end of apartheid, there has been a growth in housing provided by the government, such as the houses that were subsidised by the National Housing Subsidy Programme as part of the Reconstruction and Development Programme (RDP) implemented in 1994 by the African National Congress (Charlton and Meth, 2017). The aim of the housing policy after 1994 was to assist in supporting lower-income households to access adequate housing (Landman and Napier, 2010). The democratic government set an ambitious target of providing one million houses within its first five years. This initiative was geared towards the construction of houses but also included funding for people buying houses, companies constructing rental properties, upgrading of hostels and service sites (del Mistro and Hensher, 2009).

A complicating factor of human settlement projects was the process of providing people with ownership over the piece of land on which they reside. It was thought that by providing low-income residents with property ownership, they would be empowered to join and invest in the capitalist economy (Lemanski, Charlton and Meth, 2017). However, this proved difficult as ownership does not enable the urban poor to invest capital that they do not have. It has been made clear that a focus on securing tenure is of more importance than having a title deed (Lemanski, Charlton and Meth, 2017). In the cases where people received houses and title deeds

to the property, they were often relocated much further away from the original settlement. This led to an array of new challenges, such as new economic burdens, social divisions, and individualisation. As the human settlement upgrading initiatives are development-driven, it focussed on meeting delivery targets rather than being people focused (Huchzermeyer, 2004; del Mistro and Hensher, 2009).

Due to the slowing rate of delivery, rising costs, low-quality materials and poor construction as well as fraud and corruption, people have had to find alternative means of housing. Even though a significant number of houses have been constructed to curb the growth of informal settlements, these settlements are still present and continue to grow, particularly those located close to metropolitan areas (Huchzermeyer, 2003; Turok and Borel-Saladin, 2016).

The construction of informal dwellings has been an occurrence in South Africa since the apartheid era due to restrictions on black migrants settling in cities. Those who had work permits were housed in units that were situated in townships. Due to rural-urban migration and the lack of housing, informal settlements grew on the urban edges of cities to accommodate people working in the cities (Harrison, Todes and Watson, 2007; Rautenbach *et al.*, 2015). These informal dwellings have become a significant part of South Africa's human settlements and highlight the disparities in the livelihoods of urban dwellers.

South Africa's towns and cities continue to be spatially divided long after the end of apartheid and the establishment of a democratic government. New and large-scale investments typically occur in the historically wealthier areas of cities (Huchzermeyer, 2003). Informal settlements and low-income housing projects are generally located on the urban edge, which makes it difficult for these people to have access to the resources that are available in the more urbanised areas.

### 2.3.2 Informal settlements in South Africa

Informality is a term that does define not only the physical nature of a settlement but also the social and cultural practices that do not adhere to the norm and are divergent from what is considered formal (Hernández-García, 2013). Informality in human settlements is often defined from a technical perspective by South African policymakers. It is used as a scientific concept that focuses on a particular aspect of informality, such as the illegality of informal settlements that often overshadows the conditions that necessitate the illegal occupation of land (Huchzermeyer, 2004). It is important to consider the perspective of those who live in these circumstances, as this is a more productive means of understanding the issue. Another important consideration that is often overlooked is the lack of basic services rights and services, as attention is usually drawn to the activity of illegal occupation rather than the reasoning behind it (Huchzermeyer, 2004). It is

further complicated by the ambiguity of the definition of informal settlements in South Africa, as it can refer to a dwelling that has been constructed or a large number of these structures that are illegally occupying a space. Most informal settlements that were established are located adjacent to townships, and only a few land invasions have resulted in a significant change to South Africa's urban form (Huchzermeyer, 2003). Between 2002 and 2014, the urban population living in informal settlements decreased from 17% to 11%; however, the percentage of households living in informal dwellings only dropped from 13.6% to 13.1% (Statistics South Africa, 2016). The proliferation of informal settlements in developing nations impacts negatively on the quality of life of its residents as informal settlements is characterised by poor physical infrastructure and housing conditions that may not be healthy (Wekesa, Steyn and Otieno, 2011). Statistics South Africa (Stats SA) defines an informal settlement as "an unplanned settlement on land which has not been surveyed or proclaimed as residential, consisting mainly of informal dwellings" (Statistics South Africa, 2004). In the 2019 General Household Survey conducted by StatsSA, it was reported that 12.7% of households lived in informal dwellings (Statistics South Africa, 2020). Populations of informal settlements tend to consist of the urban poor. The presence of informal settlements is indicative of an inability of the urban poor to access adequate housing. It also highlights the failure of government and stakeholders to develop the economy in a way that can sustain the general population and the inability of local spheres of government to implement policies and laws that would benefit the urban poor (Wekesa, Steyn and Otieno, 2011).

South Africa has several settlement types that range between formal and informal, legal and illegal, as well as planned and unplanned (Smit *et al.*, 2017; Smit, Musango and Brent, 2019). Informal settlements tend to introduce a component of unpredictability as dwellings that were there one day may be gone the next. However, informal settlements provide an ever-growing number of people with a place to live, particularly in developing nations (Wekesa, Steyn and Otieno, 2011). The layout patterns of informal settlements are difficult to define as the building patterns can be considered to be chaotic in nature (Glass & Bangay, 2006). Unlike in residential suburban areas, informal settlements have no defined boundaries as the boundaries of informal settlements continuously change due to the expansions of the settlements (Housing Development Agency, 2013; Rautenbach et al., 2015).

There are a number of characteristics that must be considered when attempting to understand the nature of an informal settlement, such as the building density, shape of the settlement and network design (Kohli *et al.*, 2012). The current physical and socio-economic state of informal settlements is not sustainable; however, they are a vital component of the growth of urban spaces, particularly in developing countries, and it is necessary to determine ways in which informal settlements can be developed so as to benefit its residents and improve their quality of life (Barry

and Rüther, 2004; Wekesa, Steyn and Otieno, 2011). Understanding the intricacies of informal settlements is necessary for effective planning and implementation of service delivery.

### 2.3.3 Informal settlement upgrading

In the mid-1980s, during apartheid, policies regarding informal settlements were typically focused on the demolition of informal settlements and the relocation of residents as the appearance of informal settlements was frowned upon (Wekesa, Steyn and Otieno, 2011). Land that was accessible to low-income groups required loans from the National Housing Commission to develop a settlement. In the early 1990s, there were a large number of people occupying open land, and the Independent Development Trust (IDT) was formed. This group initiated one of the first large scale informal settlement upgrading programmes. During the process, about 100 000 households were given access to site-and-services; this was an initiative that involved the provision of a piece of land with secure tenure and basic infrastructure that could be used by people to build their own dwelling (Wekesa, Steyn and Otieno, 2011), and settlement upgrading located on the periphery of settlements. However, this process was a private-developer driver and employed a technocratic approach and did not account for the complexities of these informal settlements (Huchzermeyer and Karam, 2006; Marais and Ntema, 2013).

In the post-apartheid government, there initially was no targeted policies or programmes geared towards informal settlement upgrading. It was assumed that the housing policy and housing subsidy programme that was implemented in 1994 would be able to eradicate the issue of informal settlements (Marais and Ntema, 2013). However, in 2004 the Upgrading of Informal Settlement Programme (UISP) was added to the National Housing Code. The “Breaking New Ground” policy provided some detailed upgrading of informal settlement and supports the eradication of informal settlements as the result of in situ upgrading, which was chosen as it was aligned with international practices, and relocation of people to more desirable locations so as to integrate these informal settlements into the urban landscape. The informal settlement upgrading instrument was formulated in response to the need to decrease the formation of an informal settlement but also acknowledges the existence of informal settlements and the need to assist in providing better services and access to its residents (Department of Human Settlements, 2004).

In response to the challenges faced by local governments, the National Upgrading Support Programme (NUSP) was established in 2008 to provide support to local governments and facilitate the process of the in situ upgrading of informal settlements (Huchzermeyer, Karam and Maina, 2014). The UISP was revised in 2009 and emphasised in situ upgrading of informal settlements rather than relocation. During this period, municipalities with sufficient resources

undertook a process to become accredited to take responsibility for housing activities. In order to be accredited, municipalities had to demonstrate their ability to plan, implement and maintain projects integrated into municipal integrated development plans (IDPs) (Tissington, 2012). In 2010, the Outcome 8 delivery agreement was signed between the South African President and the Minister of Human Settlements, with the goal of upgrading 400 000 informal settlement households by 2014 (Tissington, 2012; Huchzermeyer, Karam and Maina, 2014). This further emphasised the efforts of informal settlement upgrading.

The priorities of informal settlement upgrading should aim to improve the physical environment of the informal settlement, which involves the provision of infrastructure so that people have access to basic services and amenities such as water, electricity, and transportation (Wekesa, Steyn and Otieno, 2011). The development of land for housing is a complex task that requires cooperation amongst multiple sectors. The Spatial Planning and Land Use Management Act aims to provide a framework for spatial planning and land use management that allows for effective planning and management across all level of government. At a provincial level, legislation surrounding land use management and development may cover the incremental upgrading of informal settlements and include matters related to land tenure and provision of services. It also states that the land use management systems of all municipalities must consider the needs of informal settlements (Republic of South Africa, 2013). It is necessary to take into account the legal and administrative processes of recognition for these informal settlements at the different levels of government. This legislation creates a space within the different spheres of government to manage the issues surrounding land encroachment and illegal occupation to ensure that the delivery of services and housing in a planned and controlled manner.

By upgrading informal settlements, the result should be focussed on being inclusive of those who were previously excluded in these informal settlements as these areas are not always considered to be a part of the community and are often excluded. Transparent dialogue between government agencies and communities are vital to prevent conflict between members of the community and the authorities. This often occurs when the intentions of governmental agencies are misconstrued (Barry & Rüther, 2004). In upgrading these informal settlements, the focused efforts should be on reducing the vulnerability experienced by people that contend with these circumstances and in a way that is sustainable in terms of policy planning and implementation (Abbott, 2002).

Although there are subsidy schemes and housing programmes, the rate of administering these policies and construction cannot meet the housing deficit that exists. The lack of housing has resulted in illegal land invasions and the purchasing of unserviced plots of land. Vacant land close to industrial areas are usually converted into informal settlements so that people living in

informal settlements can afford the cost of commuting from the informal settlement if their place of employment is in the neighbouring industrial area.

## 2.4 The social significance of place names and addresses

Regardless of the structured form of cities, people often perceive their space in terms of physical features and landmarks. In areas where there are established addresses, people tend to have a passive attachment to those addresses. Few people would actively want to change their address, as to do so would mean the loss of something that is known and reassuring. Addresses, particularly those that are created with street names and numbers, often have meaning to the people that reside in that locality. These names acquire connations that are both personally and socially shared, similar to that of a popular store name in an area (Thale, 2007). Place names are often used in conjunction with wayfinding, and not having these names can make it difficult to orient oneself, particularly in a situation that requires a rapid response (Harber *et al.*, 2018). Informal settlements often do not have addresses that can provide its residents with this sense of belonging and ownership. They sometimes may be given multiple addresses in the forms of codes that have no resemblance to a conventional address that comprises a number and street name. It is not an adequate form of addressing as these addresses are arbitrarily assigned, without input from the community, and are often only available for use by the organisations that provided them. The issue then arises of having different addresses that are not consistent with what exists in the area (Routh and Bhavsar, 2016). It can also have the unintended consequence of giving these vulnerable communities a sense of estrangement and isolation from the more urbanised areas surrounding them.

The place is a relational concept that provides context for the relationship between people, their culture and the physical world. Words that are used to name a place have significance, and the act of naming a place expresses attachment to and ownership of that place. Municipalities in South Africa have developed policies that provide guidelines for the naming or renaming of streets and other geographical features, such as townships. These policies are intended to standardise the naming process according to the requirements set by the South African Geographical Names Council. The act of renaming and the provision of alternative names for places are forms of resistance to this process. For example, in March 2021, an informal settlement was established on the periphery of the township Mflueni in Cape Town. Although some residents know it as Izwelethu (which translates to ‘Our Land’ in isiXhosa), it is more commonly known as ‘Covid’ (Reinders, 2020). This resistance to naming or renaming also highlights the tensions that are resultant from the effects of colonialism on post-colonial spaces and the efforts to reclaim these spaces (Kearney and Bradley, 2009). Given South Africa's apartheid legacy, the country has

undergone a complex and sometimes contested process of renaming place and street names, such as the naming of the City of Tshwane metropolitan municipality. The process of renaming was undertaken in an effort to push forward South Africa's transformation process as a means of restoration and reparations to 'redress the injustices of the past' as envisaged by South Africa's Truth and Reconciliation Commission (Du Plessis, 2009).

The memory of a place name can have strong attachments for people; the process of remembering the name and events that may be associated with that place often have meaning for people. The places through which people traverse daily effects as people develop associations, whether positive or negative, with these places and their names (Kearney and Bradley, 2009; Swanepoel, 2012). An address can be an extension of a person's identity, especially when it is an important piece of information that is needed for a range of uses, particularly in South Africa. In providing addresses to people in informal settlements, it provides them with the opportunity to create or deepen that attachment to their space.

# 3. Understanding addresses

## 3.1 Introduction

Addresses are widely used and provide information about the location and identity of an object, such as a building. However, the process of assigning these addresses is quite diverse as countries adopt different policies and have to adapt to various types of regional layouts. This chapter discusses the types of addresses that have been used in South Africa, both conventional, such as the addresses based on streets, as well as alternative types of addresses that have been created to meet the demand for effective addresses.

## 3.2 A retrospective of addresses

One of the first representations of an address was signage and markers used to denote local place names and shop fronts in the 17th century in France. With an increase in the number of streets and buildings being constructed, the need to provide a way for people to find a location became necessary. This led to street names being inscribed into walls or on the side of buildings, and the municipal council assigned the names of these streets. As time progressed, the mediums used for the signage changed in order to account for the fading of paint and damages to signs (Farvacque-Vitkovic *et al.*, 2005).

European style addresses were adopted by a number of countries, such as America. Until the mid-nineteenth century, some American cities used pictorial signboards to identify commercial buildings. These signboards served as reference points for neighbouring buildings. The first addressing initiatives to be implemented in sub-Saharan Africa occurred in the early 1900s as the addresses that were proposed were an alternative to the costly and ineffective cadastral systems being used (Farvacque-Vitkovic *et al.*, 2005).

Due to urbanisation in recent decades, many cities have grown to accommodate the influx of people, such as in Johannesburg; the city and surrounding areas continue to grow in size and density. Therefore, the number of streets and houses has increased, and several streets, particularly in the less formalised areas, may remain nameless for long periods of time as the process of assignment can be time-consuming and contentious. People can have a strong attachment to their houses and the areas in which they live. Therefore, an address can provide a more profound sense of belonging for a person as well as identifying information to their location. Assigning an address must take into account how people may react towards a change in the structure or naming of their address (Farvacque-Vitkovic *et al.*, 2005; Thale, 2007).

In the past, addresses were typically used for postage and to provide a means of identification for people unfamiliar with an area (Coetzee and Bishop, 2009). With the development of technology, effective addresses can be a core source of data that can not only improve its use for tasks such as navigation. It can also provide value to information systems informing urban planning and policy development (Yildirim and Yomralioglu, 2004). Addresses are necessary for a wide variety of people for various uses, such as:

- Delivery of goods and services;
- Navigation, as people use addresses to identify their way and to orient themselves;
- Government institutions which need addresses for the planning of public services and to identify where people work and reside;
- Emergency services which need access to address data in order to be prepared; and
- Land services which require addresses for property registration and land-related issues (Coetzee and Cooper, 2007; Walker, 2008; Gakh, 2020).

## 3.3 Importance of an address

### 3.3.1 Defining an address

An address can be defined in different ways to highlight the function that an address should serve. For instance, the ISO 19160 standard defines an address as "structured information that is used to unambiguously ascertain the identification and location of an object". In South Africa, the standard for addressing, SANS 1883, defines an address as an "unambiguous point of service delivery". This speaks to the importance of addresses for the purpose of service delivery, particularly in areas that do not have access to basic services. Standards provide guidance and understanding as to the way in which addresses are composed and their use. SANS 1883 comprises three parts that are focused on three core areas of address: SANS 1883-1, *Geographic Information – Addresses, Part 1: Data format of addresses*; SANS 1883-2, *Geographic information – Addresses, Part 2: Guidelines for addresses in databases, data transfer, exchange and interoperability*; and SANS 1883-3, *Geographic information – Addresses, Part 3: Guidelines for address allocation and updates* (Coetzee and Cooper, 2007; Coetzee *et al.*, 2008)

Coetzee & Cooper (2008) state that the aim of the standard is to enable the interoperability of address data in order to facilitate the creation of a national address database. Addresses cannot be created in isolation from other planning mechanisms and should be in an accessible format that can be integrated into other databases. Standardising addresses and address data will be beneficial for the use of address assignment tools, as such tools can be reused and utilised by

multiple parties for capturing and assigning address data. This will also encourage the development of open-source address assignment and address management tools.

Defining an address is pivotal in understanding the purpose it should accomplish; it is also equally important to define the components that are required to create and assign the addresses. A conventional address in a South Africa urban residential area typically consists of a street number, street name and street type. Understanding what these address components inform the process of creating each component. Hence the need to define the overall system that has to be employed to assign addresses, as the ISO 19160 standard terms it, an address reference system. An address reference system is defined as the set address components and rules for the combining of these components into an address. This system specifies the components which are required to construct an address. The address also specifies the rules applicable to each component of the address, such as address numbering, street naming, subaddresses, and place names (Coetzee and Cooper, 2007). There are various types of addresses globally, as countries usually have different systems due to the difference in street networks and layouts throughout the world.

## 3.4 Conventional approaches to addressing

The format and components of addresses vary across the world, as countries attempt to develop systems that are most suited to that area. However, it is important for address systems to incorporate concepts that are most accepted by people, such as the use of grids or streets to implement addresses.

A common method for addresses to be assigned is through the use of street networks. For systems that depend on networks, such as roads and paths, it is important to determine the direction in which the numbering of the dwellings will take place as well as the pattern for the even and uneven numbers (Farvacque-Vitkovic *et al.*, 2005). This is necessary to ensure that the method yields a consistent result that can be repeated.

The method chosen to assign a unique identifier to dwellings is also of importance as the method used needs to be as effective as possible for the given situation. A common, number-based system used involves numbering dwellings sequentially while alternating between uneven numbers to the left side of the road or path and even numbers on the right side of the road. This is a simple method that is commonly used and well known. In South Africa, municipalities are responsible for the assignment of street names and numbers, and these numbers are often made visible on dwellings (Coetzee and Cooper, 2007). This is an example of a conventional address in South

Africa, which contains information regarding the street number, street name, suburb, city and postal code.

30 Oakdene Parks Drive
Oakdene
Johannesburg South
2190

### 3.4.1 Grid-based addresses

A grid-based address is assigned by making use of axes that usually extend from a common point of origin (the local 'zero' point for address numbers), and all numbers increase with distance from the point of origin. The axes define the zero point for numbering along streets that cross the axes. This system organises streets and addresses into a grid (ISO/TC 211, 2011). In a system that does not make use of a grid, each street or thoroughfare is addressed individually. Each thoroughfare has its own zero points used for addressing.

Discrete Global Grid Systems are an alternative to the typical grid-based systems used. ISO/DIS 19170-1, *Discrete Global Grid Systems – Part 1: Core reference system and operations, and equal-area Earth reference system* were developed to ensure consistency in developing these reference systems (International Organization for Standardization, 2020). Discrete Global Grid Systems (DGGS) are area-preserving reference systems based on the surface model of the Earth so as to also take into account the accuracy and precision of spatial data at both a global and local level.

The system makes use of a tessellation of the Earth to produce equal-area grids. Rectangular planar grids, such as typical reference systems based on projected Cartesian axes, are formed through the use of linear axes and a number of straight lines that extend from these axes. However, this may not be as effective for a curved surface as it is for a planar surface, as having a fixed cell size to represent equal areas may be problematic. Thus, the DGGS makes use of tessellations, either using triangular, quadrilateral or hexagonal cells to better represent the curved surface of the Earth. The PlanetRisk Discrete Global Grid System is an example of DGGS, developed to be a location reference system for big data. It made use of the Icosahedral Snyder Equal Area projection to transform the surface of the earth into icosahedrons, which were chosen as the polyhedron for the tesselation (Sahr, Dumas and Choudhuri, 2015).

In America, rural addresses are assigned based on the distance a dwelling is from a road. Each address number is determined by the distance (in miles to the closest one-hundredth of a mile) from the road upon which the resident resides. An alphanumeric grid that consists of the

addresses and streets are used to find locations. The assignment of this type of address involves marking the roads with a cardinal direction, and each road branching of that first road being given an alphanumeric code (Gribb, Czerniak and Harrington, 1990).

The conventional type of address used in grid-based layouts in America includes a street name and a number, where each block (which refers to a portion of the street that is not interrupted by another feature) was assigned a 'hundred' series of numbers. All numbering is even on the right side and uneven on the left side of the road. Each block is then assigned whole hundreds address ranges in ascending order from an intersection with a baseline; this meant that the addresses in that particular block would all have a number within a specific "hundred" range. (Georgia Spatial Data Infrastructure, 2000).

*3.4.1.1 The numbering of streets and objects*

The World Bank created a guideline that can be used for the purpose of address assignment in areas where the current addresses are ineffective and are not suitable for the region. The document provides information regarding the various applications of street addressing as well as a manual with steps that can be used to create and implement addresses, with a large focus on implementing addresses based on streets as this is a common way in which addresses are assigned (Farvacque-Vitkovic *et al.*, 2005).

Addresses can consist of different components, and this is dependent on the use of the address as well as the way in which the address is created. A common component in addresses is a number that is associated with an object, and there are a number of ways in which this number can be determined – in a classic numbering system, numbering dwellings sequentially while alternating between uneven numbers to the left side of the road or path and even numbers on the right side of the road. This is a simple method that is commonly used and well known. It depends on networks, such as roads and paths; it is important to determine the direction in which the numbering of dwellings will take place as well as the pattern for the even and uneven numbers. However, it is not necessarily an effective method for areas that are characterised by constant change and expanding in a manner that is not uniform, such as informal settlements. Informal settlements do not follow any set plan or organisation; thus, it would be challenging to implement such a numbering scheme (Farvacque-Vitkovic *et al.*, 2005).

The metric numbering system makes use of numbers that indicate the distance from a dwelling to the street, where the street is considered to be 'point zero'. This system is well suited for areas that are subject to rapid urbanisation, and it also takes into account the even and uneven numbering system, which is well known. A disadvantage for this system is that the numbers tend

to contain three to four digits, which may be more difficult to recall for the residents (Farvacque-Vitkovic *et al.*, 2005).

The decametric system is a method of numbering dwellings by placing numbers at equal intervals along a road or path. For instance, a number is placed every 10 metres. Streets are therefore segmented by a specified distance, and each segment is numbered using a pattern for the even and uneven numbers. An advantage of this system is that it combines key aspects of the metric system as well as the classic numbering system. However, a disadvantage of this system is that if there is more than one dwelling in a segment, the numbering system will have to include letters or some alternative to resolve the problem of having more than one dwelling in a segment. This may complicate the numbering system further and make it ineffective (Farvacque-Vitkovic *et al.*, 2005).

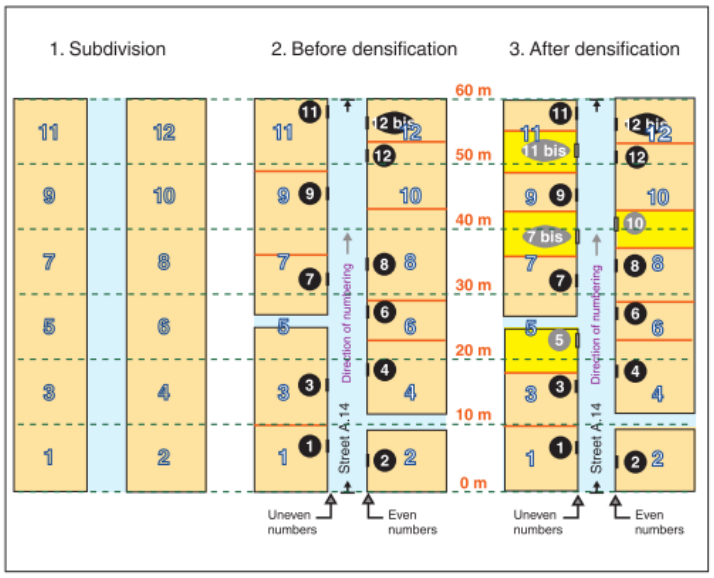



**Figure 3-1: Decametric numbering system**

Source: Farvacque-Vitkovic (2005)

Figure 3-1 is a graphical representation of the decametric system. It shows the segmenting of the area in 10m intervals, followed by the numbering of the segments and the assignment to numbers to each of the dwellings. It can be seen that even when there is not a dwelling in a segment, the number is still associated with that segment regardless of it being empty. In the case of there being two dwellings in the same segment, the second dwelling has an alphanumeric number assigned to it.

### 3.4.2 Area-based addresses

Addresses can also be assigned by making use of the relative position of an object in space. This involves assigning addresses based on an area, so that inside that area, addresses might be

assigned according to a spatial pattern or by parcel or lot numbers, or chronologically as the buildings are built.

Rural addressing in Saudi Arabia is an example of an area-based address. It is done using a predefined datum. Rural address numbers are calculated by dividing the distance in metres from the datum point by ten and rounding to a whole number. The convention of assigning odd numbers on the left, even numbers on the right in the direction of measurement is maintained in this system. An example, an address site 49532 metres from the datum point and situated on the right-hand side of the road will have a number 4952 (Department of Municipal Affairs, 2009).

The position of the datum point is determined according to the classification of the road being addressed. The datum point will be on the road of higher classification. Where possible, the exact position of the datum point shall be the road centre-line intersection point of the two roads, but it may also be the centre point of a circle (Department of Municipal Affairs, 2009).

In the State of Georgia in America, the process of assigning addresses is much more complex as it requires the determination of a reference point and the baseline streets as that coincide at the reference point. Streets that intersect the baseline streets are then assigned an order; for instance, the baseline street would be a first-order street and any street that intersects it would be a second-order street. The numbering system made use of distances from the reference point, in feet, as part of a formula to determine the house number; the street name was then determined by the proximity to a street (Georgia Spatial Data Infrastructure, 2000).

In Japan, addresses consist of three segments that include autonomous body names, geographic area names and codes, and numbers that identify an object. The top-level autonomous body is the *todofuken* (prefecture), and the second level is the *shichoson* (municipality). Areas within an area of this autonomous body are called *machi-or-aza* (districts). The third segment includes the numbers from the *chiban* (parcel numbers) that are organised within each *machi-or-aza* (district). The *chiban* (parcel numbers) with buildings are used for addresses. The *chiban* (parcel number) used inside the address is called a *banchi* (place number) (ISO/TC 211, 2011).

## 3.5 Alternative approaches to addressing

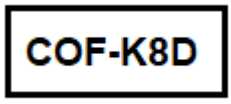
Conventional addresses implemented in urban areas in South Africa typically make use of a standard address format that includes a street number, street name, and street type; however, this is not always effective in all areas, particularly in informal settlements. Alternative addresses may be a possible solution to these conventional addresses as the alternative addresses are not always reliant on the same features that conventional addresses are.

However, there are a number of considerations that must be taken into account when determining what would be the most effective address, with a particular focus on the South African context. There is a need to explore addresses that can effectively handle the fast growth and densification of informal settlements. Given the number of addresses that have been developed and used throughout the years, it is important to determine the most appropriate criteria for deciding upon which address will be considered.

### 3.5.1 SnooCODE

SnooCODE (https://snoocode.com/) is an addressing application that was created for use in Ghana to assist in solving the problem of lack of addresses in developing countries. As an urbanising country, the formal addressing system has not been maintained, thus leading to new roads and buildings not having names or numbers (Douglas, 2015). It is a smartphone application that is able to assign a six-digit code that can be used as an address (El Ali *et al.*, 2016). It can be used to provide directions to any location and is accurate to within less than 25cm. SnooCODE RED is an application that was created to assist in an emergency situation to locate people in need and assist in the efficient use of emergency resources, such as ambulances.

An example of SnooCODE is:




This code can then be shared so that others can determine the location of the user using the code. The SnooCODE is said to be private unless it is being shared or it can be gained by a person allowed into the vicinity of one's location. The reason for using such a code is that it is easier for the user to recognise and remember a code that is derived using letters A to Z and numbers from two to nine. Hence, it can be used by people with low literacy levels (SnooCODE, 2018).

SnooCODEs are generated using an algorithm that assigns a code based on one's location. When incorporating SnooCODEs functions into another application, it allows for the developer to input the accuracy that is desired; however, the higher the accuracy, the more processing power is required (SnooCODE, 2018).

### 3.5.2 What3Words

What3Words (https://What3Words.com) is an online addressing application that divides the globe into 57 trillion 3 metre x 3-metre square, and each square is assigned a three-word address

that can be viewed and shared. The application makes use of a geocoder engine that is able to convert geographic coordinates into 3-word addresses and vice versa (El Ali *et al.*, 2016). The purpose of What3Words is to provide a simple way in which to assign an address that can be easily communicated.

The reason for using words for an address is that it is easily remembered and understood compared to addresses or codes that a composed of a sequence of letters and digits and does not require any technical skills to implement. The addressing system is available in a number of languages, including English, Spanish, French, Portuguese, Russian, Turkish, Swahili and Arabic (Jones, 2015).

This system makes use of an algorithm and a word list that has approximately 25,000 words for each language. There are a number of automated and human review processes to ensure that the words that are used are meaningful and are not offensive. The algorithm sorts the words, and it takes into account the word length, distinctiveness, frequency and ease of spelling and pronunciation. The more common and simpler words are used in populated areas, whereas longer words are associated with less populated areas (Jones, 2015; Jontz, 2016).

Figure 2 provides an example of an address that is assigned to a 3x3-metre square. The What3word algorithm for assigning the three-word address is proprietary, and per the terms and conditions of What3Words, the list of words may change without notice (What3Words, 2017).

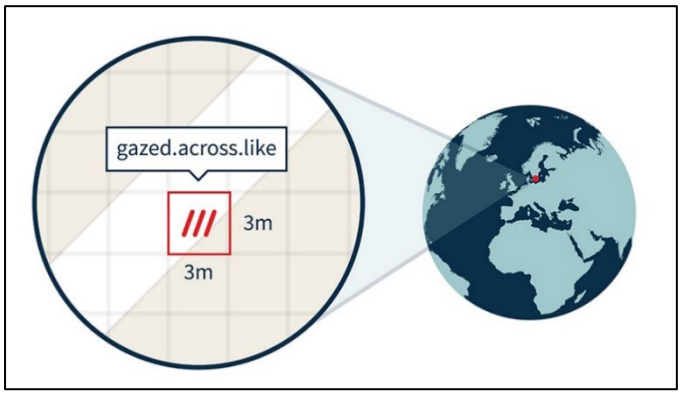



**Figure 3-2: What3Words address assignment**

Source: https://What3Words.com

### 3.5.3 Mapcode

Mapcode (https://www.mapcode.com/) is a system that defines a way to convert between the latitude and longitude of a location and a short code. The system can be implemented globally and would provide the shortest code to a location (Geelen, 2015). Mapcodes were developed in 2001 by Pieter Geelen and Harold Goddijn (Stichting Mapcode Foundation, 2008) and the system

was made available in the public domain in 2008. Mapcode has been implemented in a number of ways, such as assisting emergency services, land parcel identification and postal service identification (Stichting Mapcode Foundation, 2008).

The Mapcode source code is available under the Apache Licence version 2.0. The code comprises two groups of letters and digits that are separated by a dot (Stichting Mapcode Foundation, 2008). The code is based on six key ideas, which are as follows (Geelen, 2015):

- Codes only need to be accurate enough for day-to-day use.
- Codes make use of letters, as well as digits, so that there are enough combinations of nine letters and digits to uniquely identify every square metre on the surface of the Earth.
- Codes in a particular area, such as a country, can be designed to be shorter so that the codes in that region are unique to that particular area.
- A conversion does not need just to be based on formulae. For instance, Mapcode assigns codes to grid cells; the location of a coordinate within a particular grid will determine the Mapcode for that coordinate.
- Codes need do not all have to be the same length.
- Short codes are reserved for areas where the population density is high.

### 3.5.4 RoboCodes

RoboCodes is a type of address that can be assigned using an automatic algorithm that incorporates machine learning and computer vision approaches using satellite imagery. This approach aims to assign an address to unmapped areas that have no street names or addresses. To allow for automatic assignment of addresses, the system has to learn roads, regions, and blocks from satellite imagery. This is done for easier understanding for both people and machines as the use of geocodes may be more difficult for human understanding as they are not associated with road topology (Demir *et al.*, 2017).

Unlike addressing initiatives that make use of automatic geocoding, such as What3Words, this approach provides an alternative means of addressing that incorporates grid-based schemes and conventional street addresses. Geocoded addresses are not intuitive and human friendly as conventional street addresses because these addresses are not liked to road topology, as conventional street addressing is the accepted norm by people.

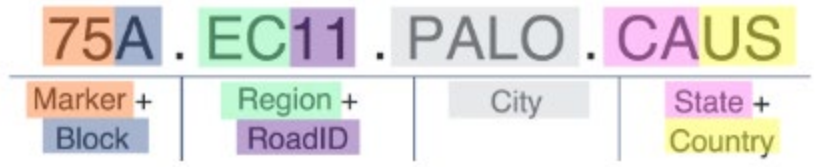



**Figure 3-3: RoboCode components**

Source: Demir et al. (2017)

Figure 3-3 is an example of a RoboCode; it shows the meaning of each segment of the code that is to be assigned. The first segment consists of a metre marker along a road and the block letter from that road; the block letter signifies the house number. The second segment contains a region label that is based on the orientation towards to city centre in the first character, and the distance from the city centre is defined in the second character. The third segment consists of the city, and the fourth segment states the state and country. The data of the third and fourth segments are based on census information from around the world. The third and fourth segments refer to the larger administrative boundaries used by the country (Demir *et al.*, 2017).

### 3.5.5 Geohash

Gustavo Niemeyer invented Geohashes in 2008. The purpose of Geohashes was to create a method of geocoding specific points as a short string that can be used in web URLs (Fox *et al.*, 2013). A geohash is a way of encoding latitude and longitude by grouping nearby points on the globe.

The globe is first divided by means of a vertical division into two halves, with the left half having a value of zero and the right half has a value of one. This is illustrated in Figure 3-4; however, at this level, the precision is not sufficient enough to provide a code that can pinpoint a location accurately (Whelan, 2011).


**Figure 3-4: Subdivision of the Earth by one bit**

Source: Whelan (2011)


**Figure 3-5: Subdivision of the Earth by two bits**

Source: Whelan (2011)

In order to improve the precision of Figure 3-4, the halves must be further divided by a horizontal division. In Figure 3-5, the half labelled '0' is further divided into two halves, whereby each half is assigned a value of zero and one, respectively. To further improve the precision, the '00' portion of the Earth is divided into two halves that are labelled '0' and '1' respectively, as seen in Figure 3-6. In doing so, the precision increases as more subdivisions are created horizontally and vertically (Whelan, 2011).

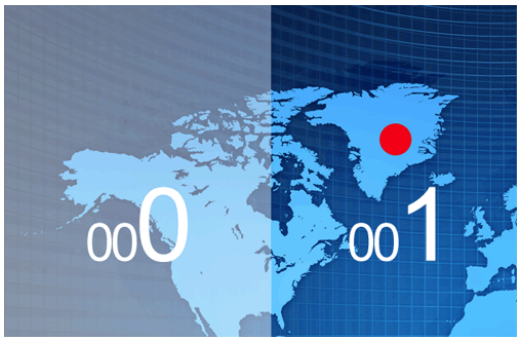



**Figure 3-6: Subdivision of the Earth by three bits**

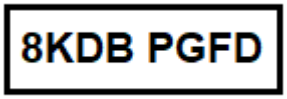
Source: Whelan (2011)

Each subdivision occurs horizontally and vertically. The process of subdivision can continue until the precision that is required is obtained, for instance, to obtain a geohash of a location at street level. This process makes the geohash longer in length, as with each subdivision, the number of binary digits increases. Once the binary string has been produced, the bits are then divided into groups of five and assigned a character based on the arrangement of the five bits. It makes use of 32 characters, excluding 'A', 'I', 'L' and 'O' (Whelan, 2011; Povišer, 2017).

### 3.5.6 Natural Area Code

Natural Area Code (NAC) is a proprietary system that requires licences to use. The algorithm and all the generated NACs are copyrighted content of NAC Geographic Products Inc. The codes are made up of at least two parts and at most three parts. The first provides the latitude, the second the longitude and the third part refers to the altitude as the arctangent of the altitude relative to the Earth's radius in a suffix to a code (Povišer, 2017).

An example of a Natural Area Code:




The Natural Area Coding System is a geodetic system with its origin at the Earth's gravity centre and an axis extending infinitely. It makes use of a set of characters that includes both letters and numbers. Each character in the character set represents an integer ranging from 0 to 29 (NAC Geographic Products Inc, 2002). The first character represents longitude, the second represents latitude, and the third character represents altitude. The system divides the whole range of longitude, latitude and into 30 discrete divisions respectively, each of which is named by one character from the character set according to the order of the characters (NAC Geographic Products Inc, 2002).

An eight-character NAC can be used as a universal address for postal services, delivery services, emergency services, and taxi services because it can identify an area less than 25 metres by 50 metres anywhere in the world. A 10-character NAC can be used as a property identity code for each property, which specifies a reference area less than 0.8 by 1.6 metres on a property anywhere in the world (NAC Geographic Products Inc, 2002).

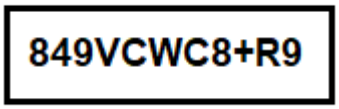
### 3.5.7 Open Location Code (or Google Plus Code)

Open Location Code is a method of encoding a location into a form that is easier to use rather than having to make use of longitude and latitude. It is also known as Plus codes, as these codes include a '+' character. A '+' symbol is inserted into the code after the eighth digit, and this helps recognise shortened code fragments and distinguishes four- or six-digit codes from postal codes. This system was developed to assign addresses to areas in which streets do not have names and buildings are not numbered; it is also a method that can be used to replace existing street addresses (Google, 2018).

Plus codes represent an area rather than a point. However, as digits are added to the code, the more precise the code will be in describing a location. There are no data tables to look up or online services required to make use of the system. The algorithm is publicly available and can be used without any restrictions. It is shorter than latitude and longitude because it uses a higher number base. It uses a number base of 20 because, with a base of 20, 10-character codes can represent a 14-metre x 14-metre area, which is suitable for the size of most buildings. It also allows for the creation of a 20 character subset that includes characters from 0 – 9 and from A – Z that does not spell words (Rinckes and Bunge, 2018).

These codes encode coordinates in WGS84; thus, latitude and longitude are represented in degrees. As the code represents an area, the length of the code denotes the precision of it. A two-digit code has a height and width of 20 degrees. In code, the first digit represents the latitude, and the second digit represents the longitude (Rinckes and Bunge, 2018).

An example of an Open Location Code:



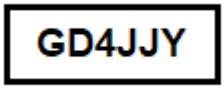

The example above represents the area covered by a Plus code, which is approximately an area of 13.9m × 13.9m. A 10-digit code is precise enough for many locations; however, in areas with a higher density, such as informal settlements or apartment blocks, the area covered by a ten-digit code may include more than one building. A 12-digit code would be less than $1m^2$ and may lead to multiple cells covering the same building. However, an 11-digit code might be preferable because it is shorter, and represents a slightly lower precision compared to the 12-digit code. (Rinckes and Bunge, 2018).

To create an 11-digit code, the grid cell for a 10-digit code is divided into a 4 × 5 cell grid and each cell is then identified by a single digit. Plus codes can be shortened for people that reside within a specific area by removing parts of the code that denote the overall locality. For instance, the people residing in a particular city do o require the part of the code identifying the city as they are interested in a more precise location. The shortening of code only requires that the location of the code, and the location of the place, are within approximately 40 kilometres -50 kilometres from each other (Rinckes and Bunge, 2018).

### 3.5.8 MapmyIndia

MapmyIndia (https://www.mapmyindia.com/) is a company that provides a number of location services, such as navigation, fleet management, and geo-analytics. Their goal was to create a comprehensive and accurate database of addresses and location information (CE Info Systems, 2018).

An example of MapmyIndia eLoc:




MapmyIndia is a system that was created for the purpose of navigation and logistics. A national address database was created for India in which an identifier, known as an eLoc, which consists of a 6-character digital address. The eLoc was generated using an algorithm that assigned a unique location to every address. There are a number of applications and services that have been established by MapmyIndia, such as online applications, web maps and tracking solutions (CE Info Systems, 2018).

### 3.5.9 Summary of alternative addressing systems

| | ***Purpose*** | ***Coverage*** | ***Licensing conditions*** | ***Scale of use*** |
|---|---|---|---|---|
| *SnooCODE* | SnooCODE aims to provide everyone with an address to assist in navigation and service delivery in Ghana | It was created with Ghana, with the possibility of future expansion into other African countries. | SnooCODE is freely available through the mobile application created, and developers can incorporate SnooCODE into their application | The level of accuracy is dependent on the developer, as it can be adjusted. However, the higher the level of accuracy, the more processing capability is required and the longer the address |

| | *Purpose* | *Coverage* | *Licensing conditions* | *Scale of use* |
|---|---|---|---|---|
| *What3Words* | Using a grid of 3m × 3m cells, provide an address that comprises three random words. The purpose is to provide an address that is accessible and easier to use, compared to code-based addresses | What3Words can be used internationally and is available in a number of different languages. It is being used in car and fleet navigation, delivery systems as well as for assistance in emergency services. A number of companies have adopted this system such as Aramex, Mercedes- Benz, and Navmii | What3Words is a company and owns the intellectual property rights of this system. To make use of What3Words within an organisation, licensing must be bought. However, basic functions such as locating an address can be done freely using their website and using their mobile application | It is dependent on the 3metre x 3metre cell size that is used to assign addresses |
| *Mapcode* | Mapcode using a method of converting latitude and longitude into a code that comprises of letters and numbers for the purpose of assigning addresses that are not based on physical features, such as roads | Mapcodes can be used internationally and offers an option for both an international and local Mapcode for a location. It is intended to assist with emergency services and provide addresses to areas where there may be none | The Mapcode source code is licensed under the Apache License version 2.0 license. It is freely available for use by any person and has been in the public domain since 2008 | Its default is set at a 5-metre accuracy; however, finer resolutions can be chosen. The trade-off is that the Mapcode does become longer |

| | *Purpose* | *Coverage* | *Licensing conditions* | *Scale of use* |
|---|---|---|---|---|
| *RoboCodes* | Assigns an address through the use of machine learning and algorithms that requires satellite imagery to locate and assign addresses | This method has been tested in Northern America. The aim of this process is to assign an address that is human friendly as conventional addresses are as well as precise as code-based address systems | This method does not have a platform from which it can be deployed | The accuracy of address assignment is dependent on the resolution of the satellite imagery being used and the level of detail that is required. The more precise the location, the longer the address becomes |
| *Natural Area Code* | NAC is a geodetic system that is used to assign a code based on a location within this system. IT makes use of longitude and latitude to assign the values to the components that the code comprises | This method can be used internationally | Natural Area Codes are copyrighted content of NAC Geographic Products Inc., and it is a proprietary system that requires a license to use | The accuracy of the location of the code is dependent on the length of the code one is willing to use. A 10-character long code can identify and the area approximately 25 metres by 50 metres |
| *Open Location Code* | Converts latitude and longitude to a code that consists of both letters and numbers based on a grid | This system can be used internationally to assign addresses. The aim of this system is to assign an address to all people and to replace existing address | Open Location Code source code is licensed under the Apache License version 2.0 license. It is part of Google's open-source systems | The precision of the location is variable as the longer the code is, the more precise the location will be |

| | *Purpose* | *Coverage* | *Licensing conditions* | *Scale of use* |
|---|---|---|---|---|
| | | systems that are ineffective | | |
| *MapmyIndia* | Makes use of a 6-character digital address that is meant to assist with navigation and monitoring of assets, such as fleet organization | The system is designed for use in India | Copyrighted by CE Info Systems Pvt | MapmyIndia's address data is able at different levels of granularity to account for the varying structures of addresses across India |

**Table 3-1: Addressing systems**

## 3.6 The role of addresses in informal settlements

Having usable addresses make it possible to strengthen urban management initiatives and policies. It is important to have addresses as they can be used for the maintenance of urban infrastructure and facilities, urban planning as well as providing data that can be used to mobilise and effectively distribute local resources.

### 3.6.1 The role of addresses in city management

Having an effective system to assign addresses and an effective method of storing the address data is pivotal for city management. Addresses provide a wealth of information when used in conjunction with other city management systems. With the advancement in technology, spatial information systems can be used in a number of fields, and they are particularly useful in assisting planning and policymaking for government institutions. South African cities need to implement effective ways of assigning addresses to communities in order to improve and create more sustainable urban management plans (Abebrese, 2019). The use of addresses for the location of real-world entities is important for information as address data provides a necessary link between entities and information linked to these entities from various sources (Yildirim and Yomralioglu, 2004). For instance, a person's tax information, banking details, and identification details can all be linked by that person's address.

Address data is a valuable resource; therefore, it would be beneficial for the sharing of such data as well as ensuring that the data is collected and stored in a standardised manner so that it can

be available for all users. However, large datasets must be able to handle a variety of address formats, and local datasets require a higher level of positional accuracy so that the data can be effectively used (Zandbergen, 2008). Some of the advantages of sharing address data include improved data quality, cost-saving, return on investment, reduction in time used for data collection as well as improved user satisfaction. This shows that the sharing of address data can be beneficial to both the public and private sectors (Sebake and Coetzee, 2012).

However, with the rapid growth of informal settlements, the upgrading and implementation of address systems can be a complex problem. The requirements of a targeted area need to be properly understood in order to implement the most effective technology (Gakh, 2020). Ineffective address assignment may lead to address duplications, incorrect addresses, and discrepancies in the updating of data. This is problematic as it impacts the systems that use such data; for instance, incorrect addresses lead to undelivered postage which has a negative impact on postal services as these packages are not being delivered due to incorrect information. Poor quality address data can also impact mobility and transportation, which in turn affects accessibility. If address assignment is not updated in conjunction with development, it can inhibit other planning systems such and land use management (Adebambo, Olusegun and Omolola, 2020).

In several countries, producers of address data combine the data in order to create an integrated address database at a national level. In South Africa, national address datasets can only be obtained by being purchased from particular private vendors. Having access to such data can enable the establishment of a national address database, which will allow for access to address information from a centralised point and all addresses and their related reference data would be of a particular standard, such as SANS 1883 (Coetzee and Cooper, 2008). Street addressing in South Africa has been tasked to municipalities by the South African Geographical Names Council (Republic of South Africa, 1998). The purpose of the South African Geographical Names Council Act 118 of 1998 was to establish an advisory body to oversee the standardising of geographical names. As a result, a number of metropolitan municipalities, such as City of Tshwane and City of Cape Town, developed comprehensive policies on how to implement the naming of objects, such as streets.

Address data is important for the delivery of services to the population. In South Africa's Constitution, it is stated that every citizen has the right to basic services such as adequate housing, clean water, health care services, basic education, and security. It is the government's responsibility to ensure that these rights are being met for all citizens. It is, therefore, imperative to have a good understanding of where services are required, and this can be accomplished by having updated and reliable address information. Address information is also important when

determining priority areas for service delivery, as it is necessary for both the planning and roll-out of services in these areas (Coetzee and Bishop, 2009).

### 3.6.2 Address challenges in South Africa's informal settlements

A number of challenges arise due to addresses that are usable. Having access to an address can greatly improve one's life. For instance, with an address, individuals can gain access to services that might not have been afforded to them previously, especially those who reside in rural areas (Coetzee *et al.*, 2011).

An address is important in many sectors of society. For the public and citizens, addresses make navigation easier throughout the area around them. It is also necessary for access to emergency services and facilities. Local municipalities benefit from having effective street addresses as it facilitates urban management and can be used in tools for planning and managing of services, such as tools for tax collection. The private sector also makes use of street addresses for the purpose of maintaining utilities and telecommunications networks and collecting fees (Farvacque-Vitkovic *et al.*, 2005).

The transport network of informal settlements may have irregular patterns as streets are constructed of different materials and have varying widths. In less developed areas, such as informal settlements, there may not be discernible or adequate street layouts or networks, and these areas typically have poor access to surrounding areas (Kohli *et al.*, 2012). Thus, implementing addresses based on street networks may not be as effective due to the irregular nature of these networks in informal settlements.

It is challenging to collect accurate data that is required for procedures such as mapping, land valuation, urban planning and service delivery in areas that are continuing to grow and develop (Abbott, 2001). Geospatial information plays a crucial role in understanding the layout and growth of an area, particular areas that grow rapidly and without any prior planning (Routh and Bhavsar, 2016). Therefore, it is important to ensure that this data meets a particular standard and can be used across multiple information systems.

It is essential for all address data that may be managed locally by municipalities to be maintained at a standard that is recognised nationally, so that this data may then be integrated nationally. In South Africa, there are a number of different organisations that assign addresses, both in the public and private sectors. For instance, almost all of the rural addressing in South Africa has been done nationally by the South African Post Office, Statistics South Africa, national departments, national utilities, and private companies (Coetzee and Cooper, 2007). This emphasises the

importance of having standards in place to ensure that these different datasets capture, store and maintain the data in a format that allows for the integration of these datasets.

This shows that there is a need for accurate and descriptive spatial data for all settlements in South Africa. It is essential to understand the nature of the layouts and dynamics of informal settlements in order to assign addresses effectively. By evaluating different alternative addresses, the most effective address can be assigned in order to assist policy makers in improving service delivery in these informal settlements.

# 4. Methods

## 4.1 Introduction

The purpose of this chapter is to provide information regarding the selection of the study areas as well as the methods and procedures applied to meet the research objectives. The chapter will discuss the decision-making behind choosing the alternative addresses and the criteria for the evaluation of the alternative addresses in the study areas and how the evaluation was conducted.

## 4.2 Production process

Figure 4-1 is a diagram of the stages that were followed to meet the objectives outlined in Chapter 1. The first stages required a literature search to formulate the evaluation criteria, decide upon the alternative addresses and select the study areas. Once this was done, the addresses were then assigned to the study areas so that the evaluation could be conducted based on the criteria. The outcomes of the evaluation were then used to determine the effectiveness of the alternative addresses.

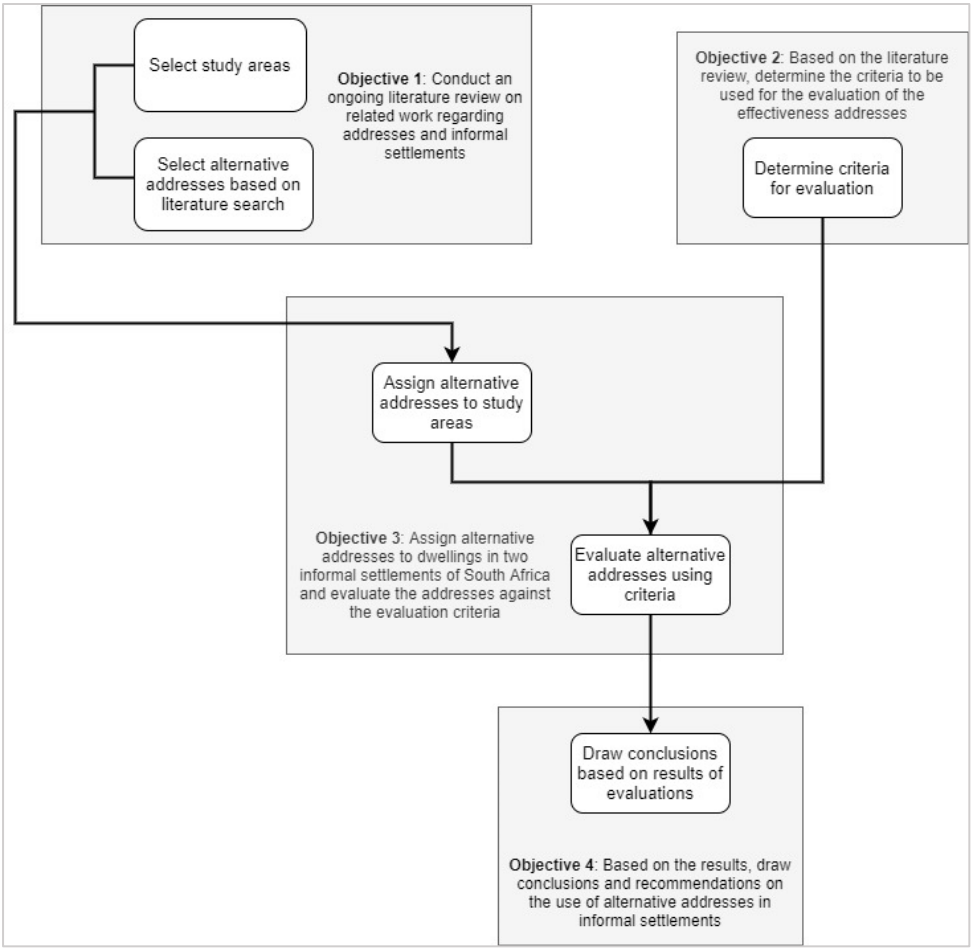



**Figure 4-1: Workflow to evaluate alternative addresses**

## 4.3 Selection of alternative addresses

Due to the need for addresses that are usable and accessible, different types of addresses have been implemented globally, albeit conventional or alternative, to meet this need. A literature search was done to identify alternative addresses that have been used in other regions, as discussed in Chapter 3. After understanding how these addresses functioned, the most appropriate alternative addresses were chosen based on whether it could be implemented in South Africa. The selection of the alternative addresses for assignment is discussed further in Chapter 6.

South Africa has spatial arrangements and layouts that differ from other countries; therefore, it was important to be mindful of the fact that an address that was successful in another country or area may not be as successful in South Africa. Another important consideration is the accessibility of the alternative address so that it may be applied in South Africa; this refers to the cost of possible licenses versus addresses that are open source and freely available. Lastly, the requirements needed for implementation, which include hardware, software and skills requirements must also be taken into account in selecting the most effective alternative address.

## 4.4 Selection of study areas

Two informal settlements were taken into consideration, as each of the informal settlements has markedly different characteristics. The first is an informal settlement in Mamelodi, City of Tshwane, known as Alaska, and the second is the CT Section in Khayelitsha, City of Cape Town.

Alaska was chosen due to familiarity with the area and its surroundings as fieldwork was conducted here during the researcher's undergraduate studies to obtain data regarding the location of dwellings and structures in the settlement. The CT Section in Khayelitsha was included in the study as the data was provided by the City of Cape Town to gain some understanding of the area. The study areas are further described in Chapter 6.

Point features were created to represent each dwelling in the two study areas. In Alaska, fieldwork was done, and the resultant data was in the form of polygons representing each dwelling. In the CT Section, the City of Cape Town provided a polygon-based dataset that represented the dwellings in this informal settlement. Centroids for each dwelling were then used as the point of reference for each address as it was not possible to know the location of the entrance of every dwelling in both the study areas. Subsequently, three addresses were assigned to each dwelling, one according to each alternative addressing method (What3Words, Mapcode and datum-based).

## 4.5 Determining criteria for evaluation

Although address standards can define the structure of an address's component, alternative addresses that have been developed do not conform to what is considered a conventional address. It is important to take into consideration the impact these addresses may have, not only in the implementation of these alternative addresses but also on the community and the people that will need to use them (Farvacque-Vitkovic *et al.*, 2005; Thale, 2007; Coetzee, Cooper and Ditsela, 2011).

The criteria used for the evaluation were decided upon through the use of literature and personal experience. The formulated list of criteria will result in a robust evaluation that takes into account the various perspectives of addresses and addressing challenges. For instance, the presence of inconsistencies and duplications will impede the effectiveness of the system; therefore, it is important to determine if the system will produce such oddities.

The criteria for which the alternative addresses will be evaluated are based on personal experience and literature about addresses and their components. A number of key themes, described in Chapter 5, emerged that would be the basis of the evaluation.

## 4.6 Evaluation of alternative addresses based on criteria

The purpose of an address is to provide an identifier for a location of an object, such as a dwelling. Therefore, the criteria for the evaluation must take into account the ability of the chosen system to assign an address that is both efficient and effective in locating an object.

The assignment of the alternative addresses to the informal settlement layouts requires the implementation of different methods as each alternative address does not assign addresses in the same way, for instance, some alternative systems may make use of grid cells to determine the location of objects, whereas others may require a coordinate pair of the object to provide an address. The results of the assignment of these addresses will then be evaluated to determine the efficiency and effectiveness of the system. This is done by comparing the results of the address assigned to each evaluation criteria to determine how well the address fared to determine the effectiveness and efficiency of the addresses.

# 5. Criteria for evaluation

## 5.1 Introduction

Each of the alternative addresses that were chosen makes use of different methods for address assignment; for instance, What3Words makes use of random words, and Mapcode uses a code that comprises both letters and numbers. It is important to have a series of evaluation criteria that look at the alternative system performance, the structure of the address and the impact of its use. This chapter discusses the criteria that will be used for the evaluation.

## 5.2 Key themes

Evaluating the effectiveness of addresses is a complex process, and the following themes were used to provide a broader understanding of the relevance of the evaluation criteria determined in this chapter. The themes encompass what would determine the effectiveness of the alternative addresses:

**The uniqueness of addresses.** This is an important theme as an address would not be effective if it cannot provide an address that is unique to every dwelling. If there are duplicates and inconsistencies, the address will not be useful; for instance, it would be difficult for navigation if there are multiple dwellings with the same address.

**Physical and digital representation of addresses.** The purpose of an address is to provide information about a location; therefore, for it to be usable by people, it needs to be physically visible, legible understandable. It should also be translatable in a digital context, as it should be understandable when used in a digital format in other systems. Data is an important resource, and addresses should be in a format that provides value.

**Suitability for informal settlements.** As the study areas that have been chosen are informal settlements, it is imperative that the systems handle informal settlements as effectively as they do more formalised areas. Informal settlements do not follow urban planning designs and do not have the well-developed infrastructure; therefore, for an alternative system to be considered effective, it must be able to address dwellings within this dynamic environment.

**Community response to addresses.** A community must be able to not only make use of these addresses but also be willing to accept the addresses assigned to them. As important as it is for a system to be efficient and highly functional, it would not be useful if the community does not accept it.

**The usefulness of addresses in other applications.** Integration and interoperability are important factors to take into account when looking at addresses. It would not be useful to have an address that cannot be used in conjunction with pre-existing systems and applications. This may lead to it not being used given the difficulty it may cause to introduce another system that does not coincide with what already exists.

**Requirements for address assignment.** Another important consideration is what is required for the assignment of an address. This includes hardware, software and licensing conditions. This is important to take into account as it may determine the suitability of a system. It would not be feasible to have a system that requires the purchasing of equipment and licensing when there are other systems that require less and are more cost-effective.

## 5.3 Evaluation criteria

The following criteria were developed based on literature and experience related to the study areas and addresses in South Africa. The criteria that were formulated for the evaluation are intended to determine whether the addresses could be beneficial in navigating and locating dwellings as well as to help improve systems that rely upon addresses so as to improve management of urban services and to create a system that makes it easier to locate places where dwellings had developed in a disorganised fashion (Farvacque-Vitkovic *et al.*, 2005). The criteria discussed in this chapter relate to the themes that have been outlined.

### Theme 1. Uniqueness of addresses

*C1. Is it possible for an address to unambiguously identify a single dwelling?*

One of the most important criteria to take into account is whether the assigned address can unambiguously identify a dwelling (Coetzee and Bishop, 2009). The purpose of an address is to provide information that is able to locate a specific object, clearly and accurately. This must be taken into account, as the address assignment process should provide an address that provides an explicit identifier to a location, particularly the location of dwellings. The address must provide descriptive information that would allow for easy wayfinding and navigation and understanding of the location of the dwelling, based on the address components.

For instance, while doing fieldwork in Alaska, Mamelodi, it became apparent that the rudimentary addresses that were being used did not account for all dwellings. This became apparent due to the fact that a dwelling would have an address, but the backyard dwellings often did not have their own addresses.

*C2. Is it possible for each dwelling to have a unique address?*

For an address to be used effectively, every dwelling should be assigned a unique address. If not, duplications can render the system inefficient and will cause errors when used. If one were trying to find one's way to a particular dwelling, and only knew the dwelling's address, it would cause confusion if there was more than one dwelling with the same address. The problem then arises of determining which dwelling it is that one is looking for.

Not having unique addresses can also be particularly problematic when trying to integrate the address systems with systems that have already been established and make use of addresses, for instance, a system that requires addresses for access to utility services and payment of accounts (Coetzee and Cooper, 2007). Duplicates and inconsistencies may provide an inaccurate representation of reality since having multiple dwellings with the same address will provide an inaccurate understanding of the location of dwellings.

## Theme 2. Physical and digital representation of addresses

*C3. Is it possible for an address to be assigned automatically to a set of dwelling (point) features?*

With the advances in technology and new methods of assigning addresses, automatic assignment of addresses is a possibility that should be taken into consideration. Being able to assign addresses based on an algorithm could potentially be more effective as it reduces the chance of human error. In doing so, it may allow for a more efficient and faster process of address assignment.

Given that large informal settlements can be established in relatively short periods of time without any notice, it would be advantageous to have a system that can handle these unforeseen circumstances with ease. There should not be a need for manual address assignment as this could introduce errors and inconsistencies through human error. Having an address system that does not require addresses to be assigned, updated and maintained manually is advantageous. This would be beneficial because a digital repository for address data can be used to link other information to the address, such as personal information or information related to land administration. This could be particularly useful for facilitating social services in vulnerable communities. The system must also be accessible to a number of stakeholders that need the information, such as in the implementation of e-government services.

*C4. How can an address be displayed on a dwelling?*

Even though it is important for a system to be accessible digitally, it is also important that an address can be displayed physically (Lind, 2001). This assists with navigation and wayfinding,

particularly if addresses follow a pattern. It provides a way of verifying an address of a dwelling and can be used as points of reference. For instance, if one is using a satellite navigation system to locate a dwelling, one can verify that one is at the correct location by checking the physical address signs present on buildings or along streets. It is even more valuable if one is trying to find one's way on the ground; having signs would make the task of locating a particular dwelling much easier. The ability to represent addresses through signage is also advantageous, as there is often no street signage and address markers are not properly implemented or are not present.

Signage and visibility of addresses are necessary for urban environments so that they can be more easily navigated. Having street names visible and numbers on houses is, typically, the method used for the conventional approach of addressing based on thoroughfares or roads. Not only does it assist with navigation, but it also lends itself to strengthening the social identity that is associated with one's address.

However, there are challenges associated with physical representations, such as signs. There are costs involved in the production and setting up of such signs, and this may be a hindrance to the process. Another challenge is also vandalism, as people may deface and damage signage to express grievances; therefore, it may not always be feasible to go through this exercise. There is also an issue of ensuring that signs are maintained and that new signage is erected when areas expand and develop.

*C5. Is it possible for the address to be represented and maintained in a (digital) database?*

Data has become an especially important commodity as it is necessary for informed decision-making. There is a need for a robust address system to support services offered by a number of stakeholders, such as the implementation of e-government services (Lind, 2008). A current and accurate registry of addresses would be particularly useful when attempting to implement online services related to utilities, for instance, registering and making payments for utilities, such as electricity and water.

Creating a database makes the address data a centralised source that all other systems make use of. It would be more effective than if multiple stakeholders had their own addresses that were not able to integrate with others and had varying levels of data quality. Having a digital system would allow for more rapid dissemination of data and opens up new avenues for analysis of such data. In establishing an electronic repository for addresses, it can help reduce the number of duplications and inconsistencies that may occur. By using databases, error checking and maintenance can be done on a continual basis by the system and does not require as much human interaction as a manual system would.

## Theme 3. Suitability for settlement layouts

*C6. Does the addressing system accommodate the expansion and changes to the spatial arrangement of dwellings?*

Human settlements do not all conform to the same spatial arrangement, as the location of dwellings is typically dependent on the topography of the area in which they are situated. In areas where comprehensive planning has been conducted, settlements follow a pattern. However, current systems may no longer be able to cope with the rapid growth of urban areas and informal settlements (Kohli, Stein and Sliuzas, 2016), particularly in areas that have been newly established, and there have never been formal addresses.

One cannot predict the way in which an informal settlement may expand or densify. An example of this would be the presence of backyard dwellings. It can be possible that an informal settlement may not outwardly expand its borders; however, the proliferation and densification caused by backyard dwellings cannot be overlooked.

*C7. Does the address accommodate the irregular nature of an informal settlement (for example, thoroughfares that do not follow a set pattern)?*

A significant characteristic of informal settlements is that transport networks are irregular, not only in the type of road or path but also the type of surface (Kohli, Stein and Sliuzas, 2016). This speaks to the nature of informal settlements and the lack of planning and intention behind the arrangement and spread of dwellings and access routes. It further emphasises that these settlements arise from an urgent need for housing, regardless of the form it takes.

It is apparent in the study areas that have been chosen that the layouts of these settlements do not follow any guidelines or plans as there are no apparent patterns in the ways the dwellings are arranged or the way in which thoroughfares are laid out. For instance, in a conventional thoroughfare addressing scheme, every dwelling will have access to the main road and dwellings on the right of the road have even numbers and dwellings on the left have odd numbers. However, in areas where they have been no formal planning, such as in informal settlements, dwellings do not follow a discernible pattern, and this must be taken into account by any addressing approach.

## Theme 4. Community response to addresses

*C8. Will people easily remember the address?*

One of the main purposes of an address is to be used for navigation and wayfinding; therefore, it is important for an address to be easily recognisable and intuitive so that people can remember it with ease (Coetzee, Cooper and Ditsela, 2011). The owner of a dwelling should be able to

provide people with an address that can be easily recalled by the recipient. It is also important to consider whether people are able to remember multiple addresses, as one does not only have to remember one's own address but also the addresses of importance to one's own life, such as places of employment and locations of family.

In South Africa, the common address format is that of a street number, street name, town, and postal code. However, with the name changes and the inefficiency of the postal service, it would not be useful to make use of an address that people do not easily understand as it will diminish the practicality of having an address to identify a person's location.

*C9. Does the address support the social and civic identity of people living at the addresses?*

An address empowers people as it provides them with an identity that can be used to access services. It provides people with a sense of belonging to have an address, as an address is necessary for a multitude of things, such as for voting in elections, accessing financial services and service delivery (Coetzee, Cooper and Ditsela, 2011).

An address that contains both numbers and words, which is conventional in South Africa, may be seen as more user friendly compared to identifiers that are usually assigned to portions of land. An identifier may be seen as being more utilitarian and does not lend itself to have significant meaning to the owner of that dwelling.

The use of words can also be contentious, particularly the use of names of important people, as people may not be as accepting of such concepts if their beliefs do not allow for it. However, people generally do not like numeric or alphanumeric codes, as there may be a cultural or historical association to the names of places (Coetzee, Cooper and Ditsela, 2011).

Another consideration is people's willingness to accept the algorithm that determines their address. People may be less likely to accept an address if they have not been allowed to have any input regarding the process. An address can be seen as another way in which we perceive the space that we consider our own; therefore, it can be expected that people may not want an address that is arbitrarily assigned to them.

Given South Africa's legacy of apartheid and segregation, these social issues must be taken into account. For instance, people may not be accepting of a numerically based address as it may have negative associations related to dormitory and township living in comparison to having a street number and street name, that was associated with the more affluent and 'white' areas.

*C10. How can the address facilitate human navigation and wayfinding to a dwelling by providing clues about their spatial arrangement?*

Addresses are meant to provide a means of locating an object. If addresses follow a sequence or pattern that is discernible in a group of dwellings, it is useful for locating an object (Lind, 2001). For instance, in a conventional thoroughfare address system, the numbers will increase from one direction to the other, and with systems that are dependent on distances, the distance increases as one moves away from the focal point; thus, the numbers increase.

These systems provide a recognisable pattern that can be easily understood and used, particularly when one does not have access to a navigation system and must find a location using the addresses and landmarks around oneself. It provides valuable information for when one is trying to navigate through an unfamiliar space, especially without access to a satellite navigation system or to a smartphone.

## Theme 5. The usefulness of addresses in other applications

*C11. Is it possible for the address to be incorporated into tools?*

Addresses are needed by a number of organisations, both public and private; therefore, it is necessary for addresses to be accessible across various platforms (Coetzee and Bishop, 2009). With the development of technology and digital media, the interoperability of address data must be taken into consideration. This refers to the need for the data to be used over a range of systems and software. For the addresses to be accessible, they cannot be contained through the use of a unique system. The data should be able to be used in a navigation system as effectively as it can be used in a city management system. A private company that needs address data should be able to locate and use the data for its own purposes as easily as a town planner can for the purpose of city management.

The integration of address data into different systems is important as there are a variety of purposes in which addresses are required. For instance, address information is often used as a form of verification by banks and municipalities for billing. The South African Revenue Services requires address information for all taxpayers. This data must be translatable across different types of systems not only for ease of use but also to ensure data quality. It is not efficient for different organisations to have their own address databases that cannot be shared, as they all do not use the same formats.

*C12. Is it possible for the address to be optically scanned and recognised (for example, for mail sorting)?*

It is something that should be considered as it can assist processes such as mail sorting and courier services. It can be particularly useful for buildings that have multiple units, such as apartment blocks, as each unit would have its own unique address.

Having an address that can be optically scanned is a unique challenge as it requires the address to be in a particular format and style that can be read by a scanner, the most common type of format being a barcode. This has implications for how an address may be stored and the possibility of a system having to account for additional data that may be associated with an address.

*C13. Is it possible for the address data to be freely shared as open data?*

Having a standardised system for the allocation of addresses that can be accessed by all organisations would be very advantageous as such data can be useful at a number of levels. If this data is to be freely shared, it is important to ensure that there is oversight for the integrity and accuracy of the data. It may be necessary for data custodians to manage the data producers as well as the requests for such data.

The Spatial Data Infrastructure (SDI) Act of 2003 outlines the facilitation in the way in which spatial data should be shared by data providers as well as the way in which metadata should be captured and stored. This is to assist in a better understanding of the data that these data sets hold and sharing of these spatial data sets. The SDI Act is important to consider, as it provides valuable guidelines for the way in which spatial datasets, particularly address data, should take into account to ensure that the data set is easily understood and usable.

However, not all addresses can be used freely, and some may require licensing. This makes accessing the data more difficult and requires payment for access. Companies that cannot afford to do so will then not have access; this is very restrictive to the manner in which the data can be used. It is also not feasible for important data, such as addresses, to be licensed for specific uses. It is vital to understand what restrictions there may be in the accessing and sharing of address data.

## Theme 6. Requirements for address assignment

*C14. What are the possible software and hardware requirements for address assignment and maintenance of the address?*

When attempting to assign addresses, the requirements needed for the assignment must be defined and budgeted for (Coetzee and Bishop, 2009). The software, hardware, and skills required for creating and maintaining an address system must be accounted for as this impacts not only the funding that will be required but also the scope of what is possible. This is to ensure the continuity and sustainability of the implementation of any type of address.

It would not be useful to produce addresses that are not understood and cannot be effectively used by the people that need to manage and operate the system that assigns those addresses. In the same vein, it would be pointless to develop plans for a system if there is no possibility of gaining access to the hardware and software required to implement it. As important as it is to account for the physical requirements of a type of application, it is equally important to understand the skills and knowledge required not only to run it but also to maintain it, to ensure that data quality is ensured.

# 6. Assigning alternative addresses

## 6.1 Introduction

This chapter discusses the study areas as well as the selection of the addresses that will be applied. The process of assigning addresses will be discussed so as to provide an understanding of how these alternative addresses function. These addresses will then be used for the evaluation to determine how suitable each address is in an informal settlement environment based on the criteria described in Chapter 5.

## 6.2 Study areas

The study areas that were chosen for the assignment of the alternative addresses were two informal settlements located in two different parts of South Africa. The informal settlements are Alaska, situated in Mamelodi, a township in Gauteng, and the CT Section, which is in Khayelitsha, a township in the Western Cape. Figure 6-1 provides an overview of the areas in which the study areas are located.

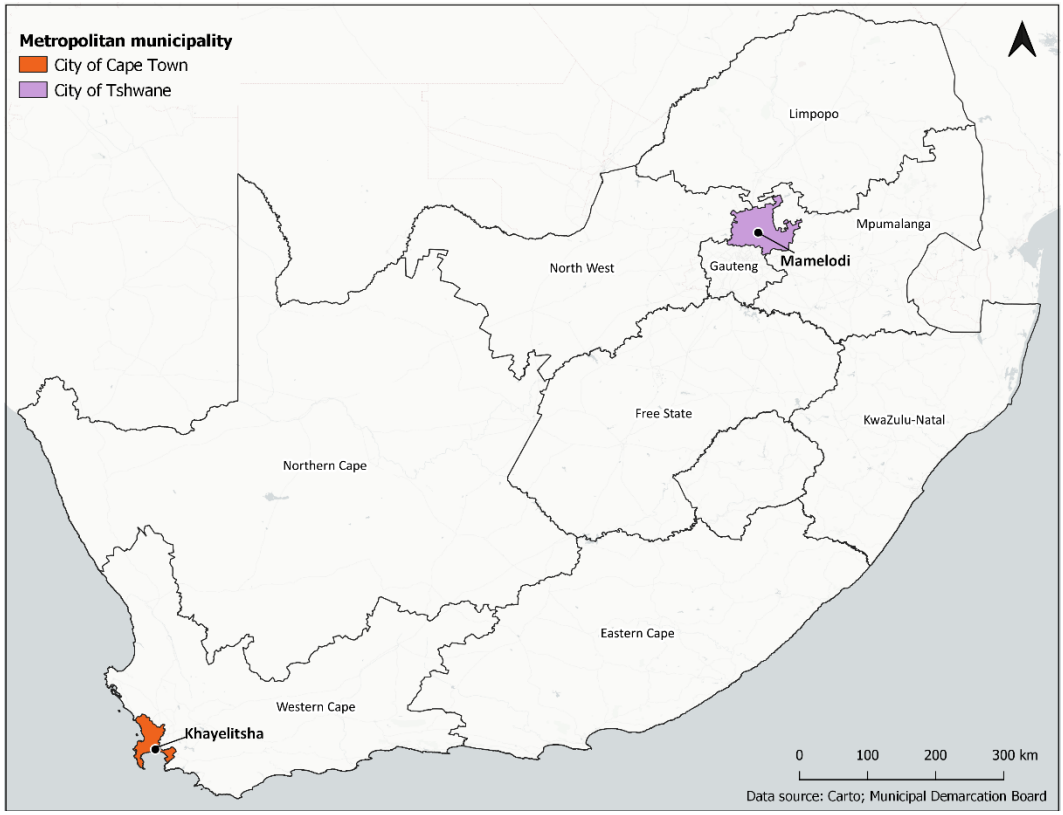



**Figure 6-1: Location of study areas**

### 6.2.1 Alaska, Mamelodi

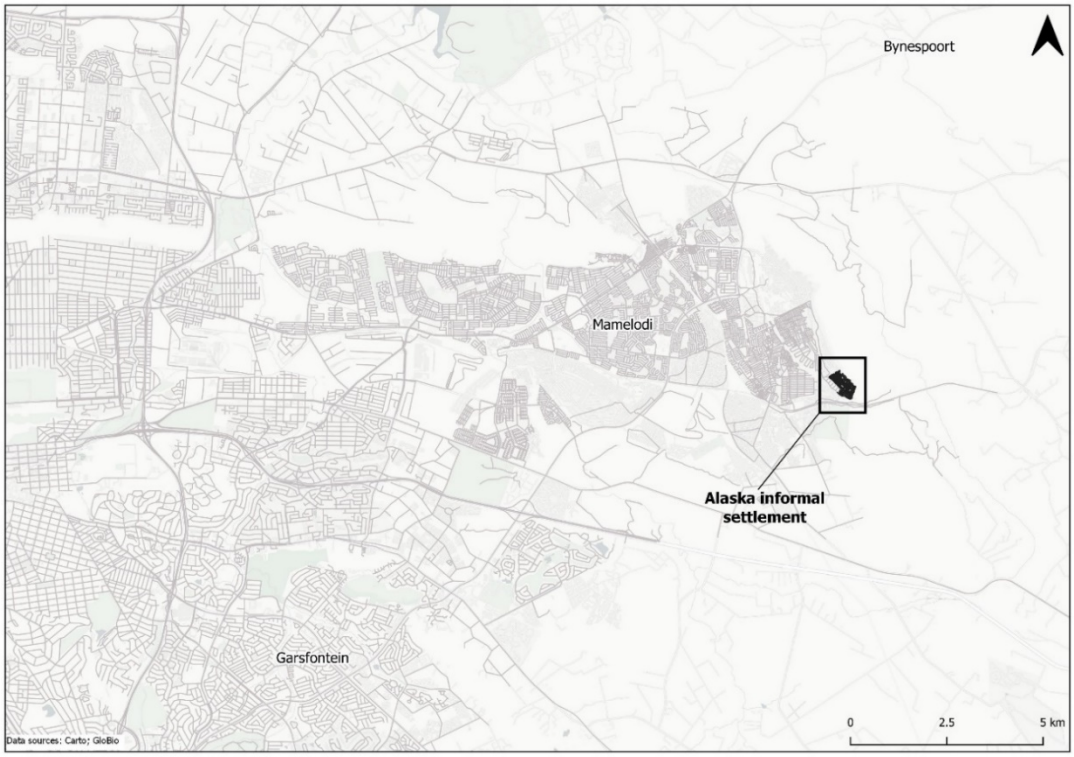



**Figure 6-2: Overview of Alaska in relation to its surroundings**

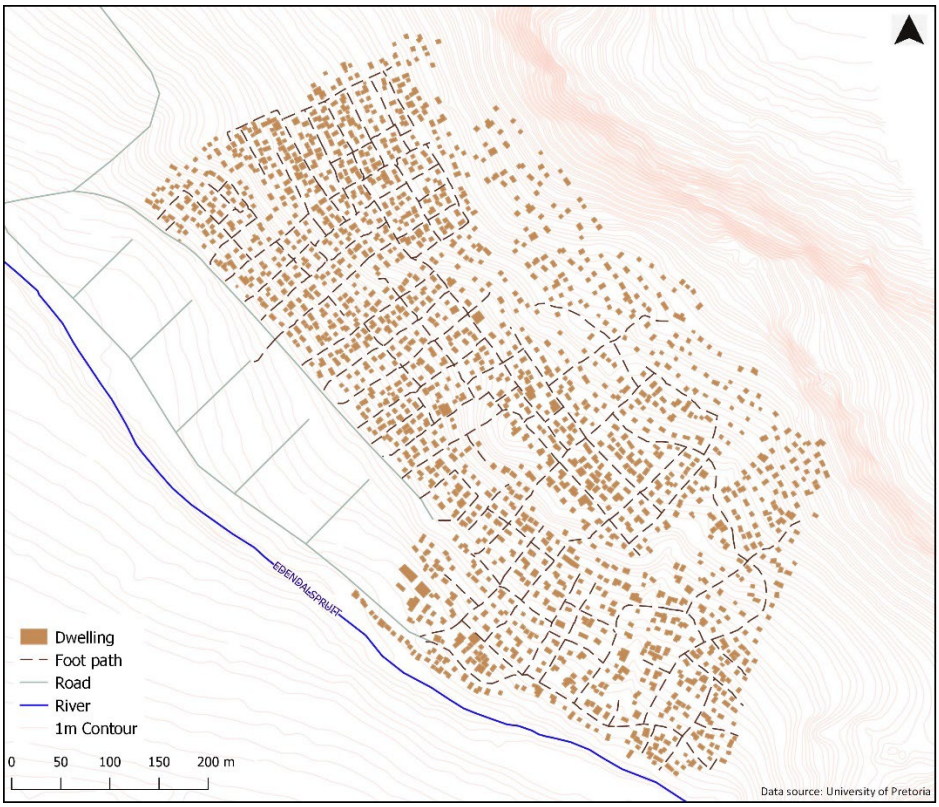



**Figure 6-3: Alaska informal settlement layout**

Mamelodi is a township located in the northeast of Pretoria, Gauteng and is part of the City of Tshwane metropolitan municipality, as shown in Figure 6-2. Alaska is an informal settlement located on the periphery of the Mamelodi township. It has approximately 1,540 informal dwellings and covers an area of approximately 72 hectares. According to the residents, it was named Alaska because of its remote location on the outskirts of Mamelodi, furthest from the economic activities of the city centre, similar to the state of Alaska in the USA which is situated in the northwestern area of the North American continent. Alaska is constrained on the far north-eastern side by a steep and rocky cliff face that dominates the landscape, as seen in Figure 6-3. The south-western boundary is the Edendalspruit.


**Figure 6-4: Addresses on dwellings in Alaska**

Source: Yashena Naidoo

Figure 6-3 shows that the dwellings within the informal settlement are quite dispersed, particularly in the areas that have an incline. As the dwellings are not always densely located, there are fairly well-established pathways that can be used to navigate the informal settlement. The informal settlement is located next to more established RDP housing. There is also the presence of backyard shacks in the properties of a number of the RDP houses. Figure 6-4 consists of images taken of dwellings in the informal settlement during the study. Some dwellings had three addresses, whereas others had one or two addresses only. The "CD" address and address starting with "500" were assigned by local authorities, and the "AL" address was assigned by the community. Unfortunately, it was apparent that neither of these addresses was consistent as not all dwellings were assigned addresses based on the same type of address, as can be seen in the images in Figure 6-4.

### 6.2.2 CT Section in Khayelitsha, City of Cape Town

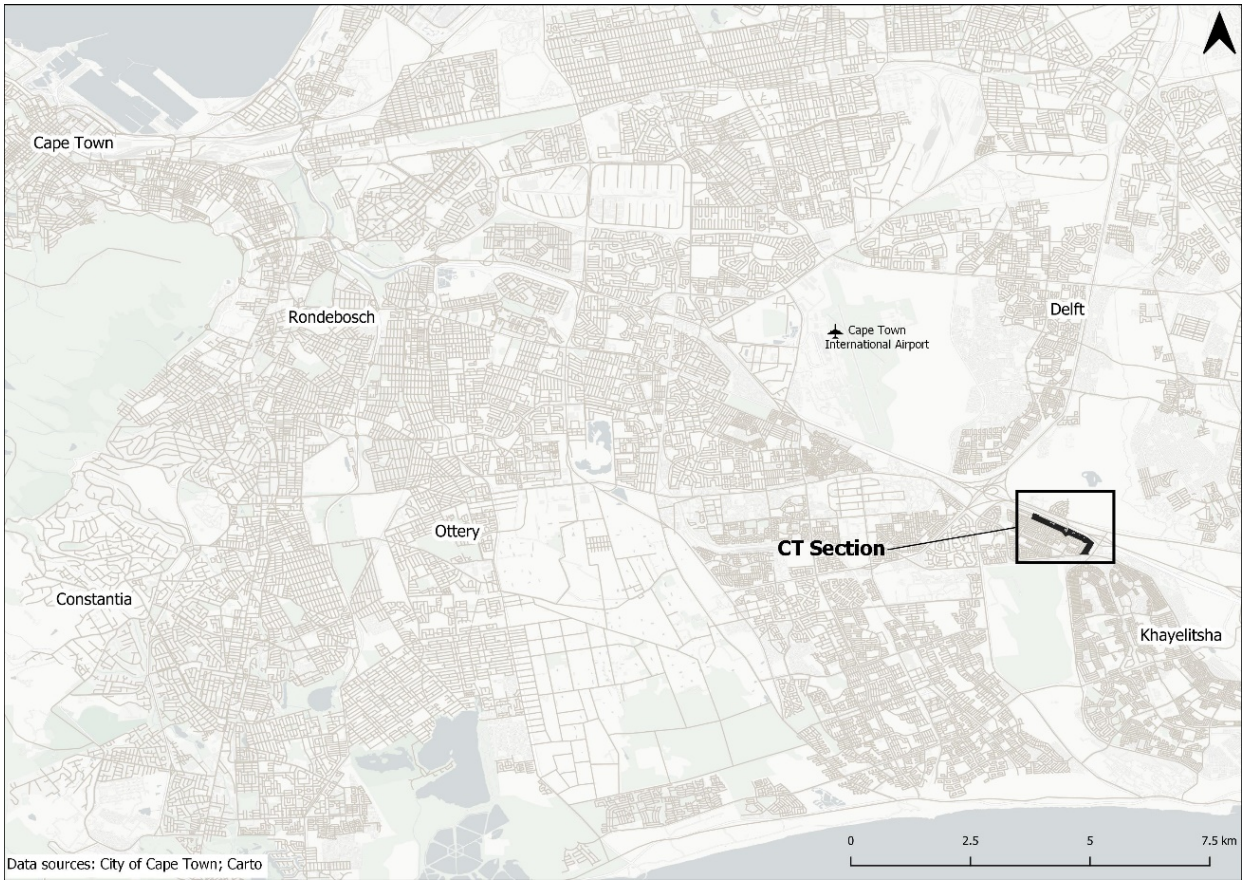



**Figure 6-5: Overview of CT Section in relation to its surroundings**


**Figure 6-6: CT Section settlement layout**

The CT Section is located in Khayelitsha, City of Cape Town, and was established about 15 to 20 years ago. It is located to the south of Cape Town International airport, as seen in Figure 6-5. It has approximately 180 dwellings per hectare. This area borders the more formalised residential area of Khayelitsha.

Figure 6-6 shows that the dwellings in the informal settlement are much denser and more concentrated, compared to that of Alaska, Mamelodi. The informal settlement is located at the edge of a more formal and established neighbourhood, in which the dwellings have formal streets, and there is clear planning in the layout and design of the street network and dwelling.

## 6.3 Selection of the alternative addresses

As discussed in Chapter 4, the selection of alternative addresses needs to be conducted in order to determine that the alternative addresses can be assigned in the study areas. A number of alternative addresses were investigated during the literature review. These alternative addresses were discussed in Chapter 3 and were included in the literature review because they each provided unique ways of identifying locations as well as assigning these identifiers. Addresses such as SnooCODE and MapmyIndia were considered as they were created and implemented in

regions where existing addresses were not effective, thereby giving rise to the creation of these types of addressing approaches. It was also important to take into account addresses that were created during different time periods; for instance, Mapcode was created in 2001 and released into the public domain in 2008, whereas What3Words was developed in 2013 and is not open source.

Based on the alternative addresses discussed in Chapter 3, addresses such as those assigned by SnooCODE and MapmyIndia are not applicable as they were created for specific countries, namely Ghana and India. Robocodes is an interesting method for address assignment; however, it requires data for physical features, such as roads. Although it is a very detailed algorithm, the study areas may not have the data required to proceed with such an algorithm. Open Location Code (Plus codes) has become a popular alternative address as it is incorporated into the Google platform; however, it will not be used for this evaluation because the Plus code can become quite long for higher accuracy: for a 10-metre accuracy, the Plus code will have ten characters.

What3Words and Mapcode were chosen as the alternative addresses to be used. What3Words and Mapcode both provide an address that does not depend on topology; however, the types of codes they provide are quite divergent. Mapcode makes use of a short code that uses both digits and letters, whereas What3Words makes use of three random words. The alternative addresses also have different levels of accuracy, as Mapcode uses 5m × 5m cells, and What3Words makes use of 3m × 3m cells.

What3Words is an online addressing application that divides the globe into 57 trillion 3m × 3m square (What3Words, 2019), and each square is assigned a three-word address that can be viewed and shared. The application makes use of a geocoder engine that is able to convert geographic coordinates into 3-word addresses and vice versa (El Ali *et al.*, 2016).

Address assignment using the What3Words principles will be applied to the informal settlement layouts. The use of applications such as What3Words has gained popularity; thus, it is important to determine the effectiveness of this method as an address.

Mapcode is an address application that defines a way to convert between the latitude and longitude of a location and a short code. It can be implemented globally and would provide the shortest code to describe a location so that the code may be simpler to recognise and use as an address (Geelen, 2015).

These alternative addresses were chosen for the evaluation because they each provide a unique way of assigning addresses. Each address makes use of methods that differ from the way in which conventional addressing is done in South Africa. The alternative addresses that were chosen to

have been implemented in other parts of the world as an alternative to the currently used addresses may not be working as effectively.

The literature search identified a number of the alternative addresses that make use of grids for the purpose of assigning addresses. Examples are Mapcode and What3Words. However, another alternative method of addressing was also considered for the evaluation, namely one using datum points, as implemented in Saudi Arabia for address assignment. This method of assigning addresses has been used in rural areas as well as sparsely populated areas where dwellings were quite far apart, and there was no need for dense road networks. It is a more practical method for handling an irregular spatial pattern of dwellings (Department of Municipal Affairs, 2009).

The datum and the point of origin that is used to assign the address is a crucial component, as it speaks to the way in which the address will be created. The datum (point of reference) was determined by using a road intersection where possible, or a road with a higher classification. The distance from this point to the location of a property was then used to determine the address number (Department of Municipal Affairs, 2009). Datum-based addresses do not rely on a global reference system, but rather the local reference system, as it is created to encompass the area of interest. Making use of datum-based addresses is similar to the other alternative addresses being considered as it accounts for the location of a dwelling and is not dependent on street networks and physical features.

When an address is based on the coordinates of the dwellings rather than on roads and footpaths, it is imperative to know the characteristics of the datum that is used for the region of interest so as to ensure that the identifiers assigned to each dwelling will be unique.

## 6.4 Datum-based addresses

The datum-based address makes use of the location of the dwelling in relation to a datum that is specifically defined for a particular area of interest. The address is assigned with reference to the datum, rather than a physical feature, such as a road or pathway. It is based on the Saudi Arabian method of addressing which is used in Abu Dhabi to assign address numbers to rural properties (Department of Municipal Affairs, 2009). The use of a particular datum point (point of origin) is what makes this address different to other address systems, and this is why we refer to it as ‘datum-based’ addressing.

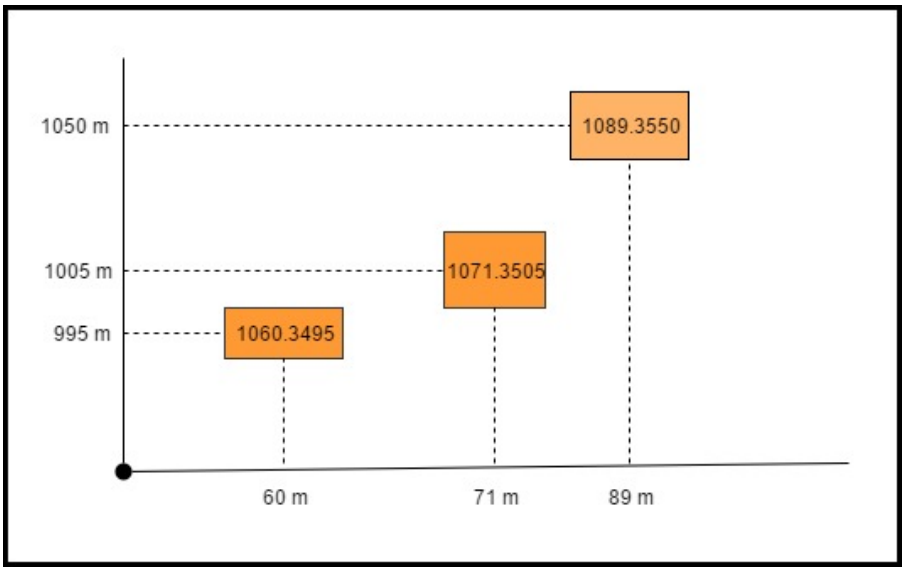



Figure 6-7: Datum-based addressing method

Figure 6-7 is a graphical representation of the method used for the datum-based address assignment. The intersection of the y axis and x axis represents the datum point. The datum point signifies the point from where the distance to the address is measured. Each dwelling is then assigned an address based on its planar distance from the axes extending from the datum point. The datum-based addresses reflects the dwelling's distance (in metres) from each axis.

A datum point was set for each informal settlement at the south western corner of its bounding box. An address is assigned in the form of two groups of four digits separated by a point. The first four digits are a representation of the planar distance from the dwelling to the x axis with the addition of a constant value, and the second group of four digits is a representation of the planar distance from the dwelling to the y axis with the addition of a constant value, as is shown in Figure 6-7. The constant values are added to create unique values for each informal settlement.

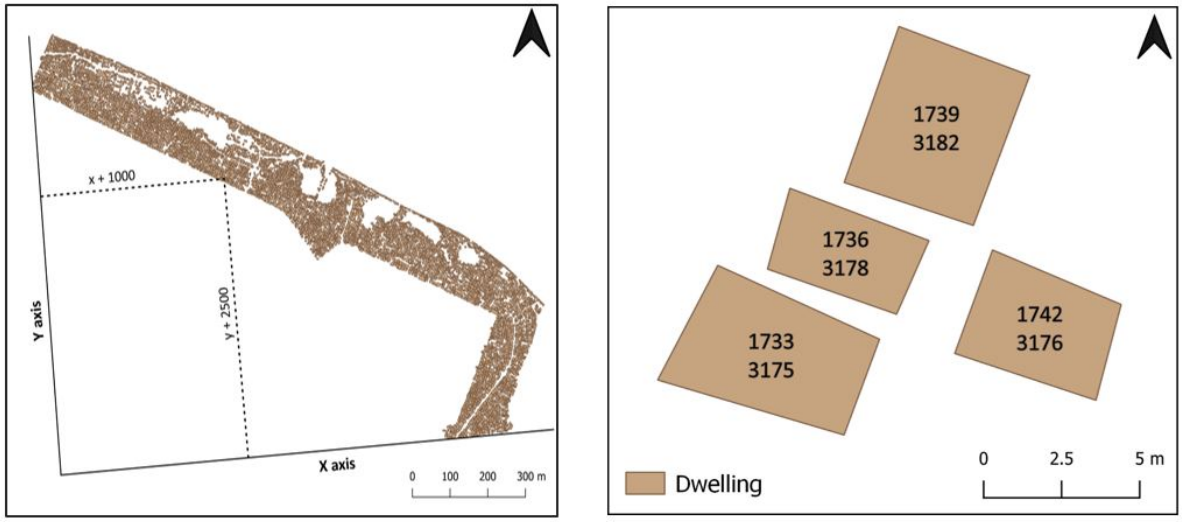



**Figure 6-8: Datum-based addresses for Alaska**

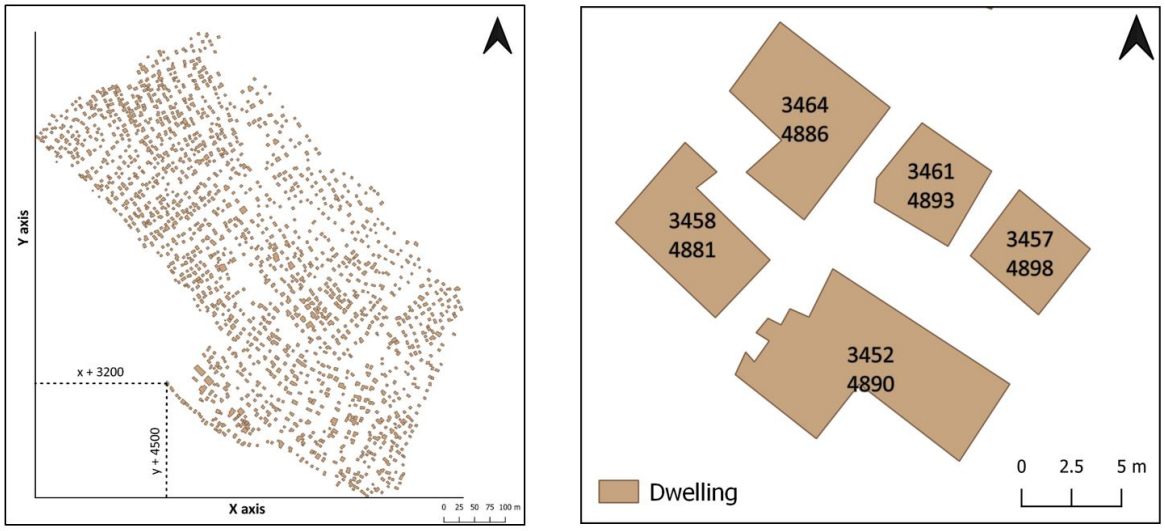



**Figure 6-9: Datum-based addresses for the CT Section**

This addressing system provides an unambiguous address based on the position of the dwelling in relation to this local datum point within the bounding box covering the informal settlement. It is important that the datum point must be defined in order to perform the address reference. The datum point is an integral aspect of the address approach as it is the reference point from which the axes used to identify distances of the dwellings to the reference system is established. Should the datum point not be appropriately chosen, the addressing system may not be able to allocate addresses that are not within the region defined from the datum point.

An algorithm was used in order to create an address that would be unique for each dwelling; it made use of the WGS 84 UTM 35S coordinate system for the informal settlement in Alaska, to orient the datum point. Figure 6-8 and Figure 6-9 show a simple representation of how the datum-based address is conceived for the informal settlements. Figure 6-8 is a depiction of Alaska, which

makes use of the constant value of 3200 for the x axis and 4500 for the y axis. These constant values are added to the distance from each axis to create the address. These figures illustrate the bounding boxes for each informal settlement, within which unique addresses can be assigned. The WGS 84 geodetic datum (the default for the dataset) was used to orient the datum point used for the CT Section informal settlement in Khayelitsha, and a constant value of 1000 for the x axis and 2500 for the y axis was used in order to determine the distances of the dwellings in relation to the datum point axes.

## 6.5 Mapcode

Mapcode is an alternative address that assigns an address by way of converting between the latitude and longitude of a location and a short code. It can be applied globally and would provide the shortest code to describe a location. Since Mapcodes are applicable to a global extent, shorter codes are provided for smaller regions. Every location has two Mapcodes, one in relation to its global extent and another associated with the country it lies in. For instance, South African Mapcodes is shorter than its international counterpart as it does not include the code that identifies the country (Geelen, 2015).

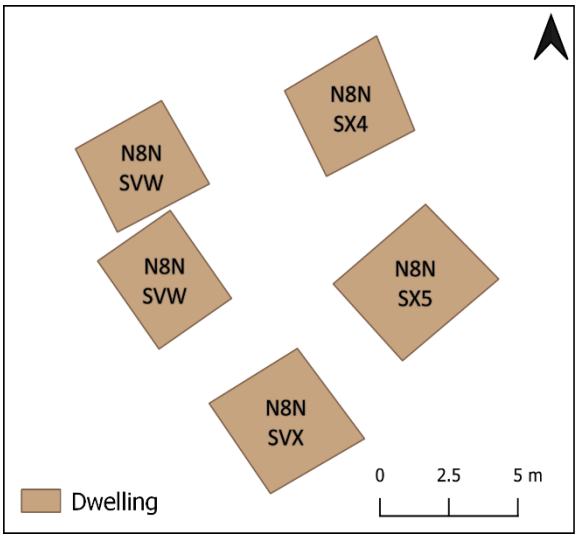



**Figure 6-10: South African Mapcodes**

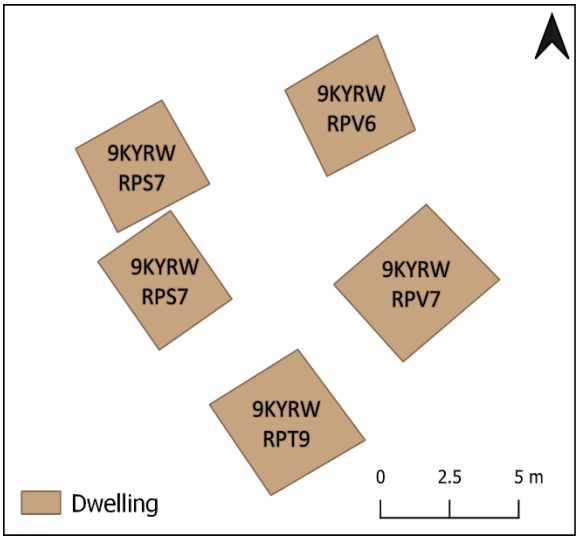



**Figure 6-11: International Mapcodes**

Figure 6-10 is a depiction of Mapcodes assigned in the South African locality, whereas Figure 6-11 shows the Mapcodes assigned to the same dwellings but in an international context. The international Mapcodes are longer than the South African Mapcodes, and the codes differ from each other. Figure 6-12 shows the online interface that can be used to determine a Mapcode based on the coordinates of an addressable object; there is also a mobile application that provides the same functions as the online interface. It was decided that the default scale of 5-metres would be

used when assigning this address. This is the default scale used by Mapcode; using this scale allows for effective comparison of the assignment of Mapcodes to the two informal settlements. It would not be feasible to make use of different scales and defining what an appropriate scale can be quite subjective. Mapcodes can also be generated through the use of a Microsoft Excel plugin that makes use of the free web services created by Mapcode. This makes it possible to convert a large list of coordinates to the equivalent Mapcodes.

It can be seen that the codes are six characters long comprising a group of two characters and a group of three characters separated by a full stop. The codes are made up of both letters and digits. Using Mapcodes allows for the distinguishing of areas as dwellings with similar codes are located in a certain region. For the purpose of this evaluation, the Mapcodes were derived using the 5m × 5m grid. There is functionality to provide Mapcodes at higher precision; however, the code will increase in size. All the dwelling locations were obtained from a fixed scale (Geelen, 2015).

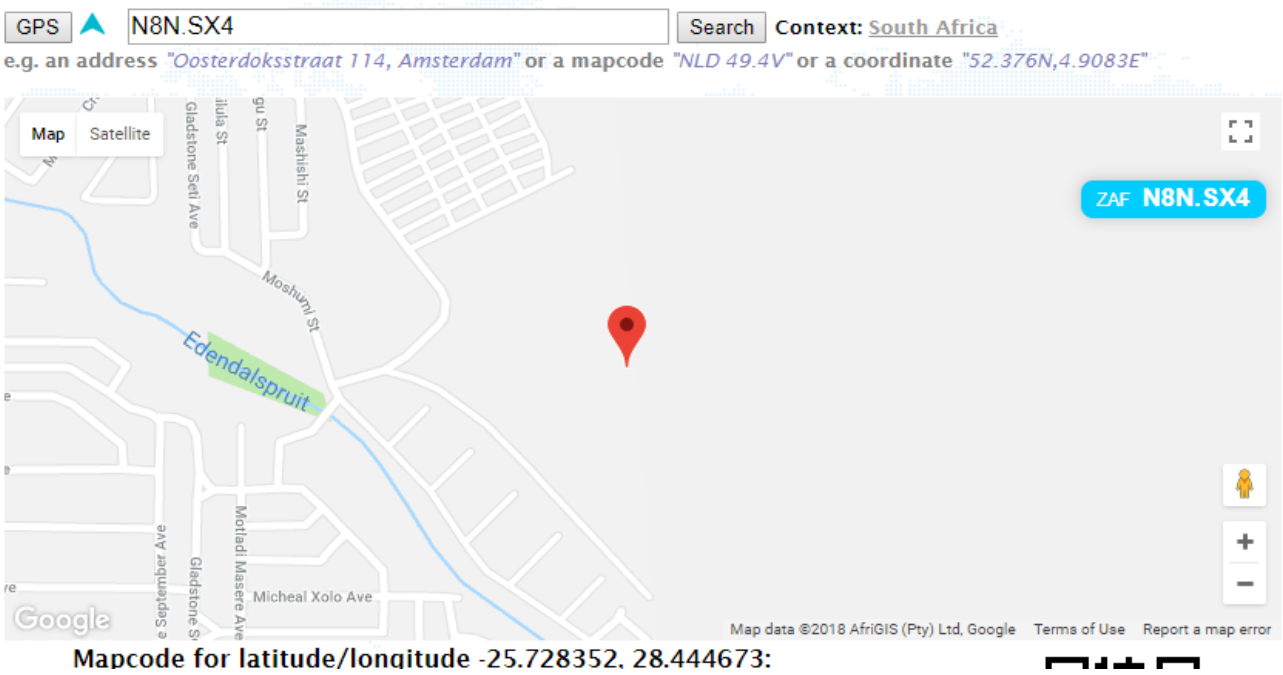



**Figure 6-12: Mapcode online interface**

(Source: www.mapcode.com)

## 6.6 What3Words

What3Words is an address that creates a grid consisting of 57 trillion 3m × 3m cells that encompass the world (What3Words, 2019). Each square is then assigned a three-word unique identifier that can be viewed and shared. The application makes use of a geocoder engine that converts geographic coordinates into three-word addresses and vice versa (El Ali *et al.*, 2016). The central point of each dwelling was used as the reference position for address reference.

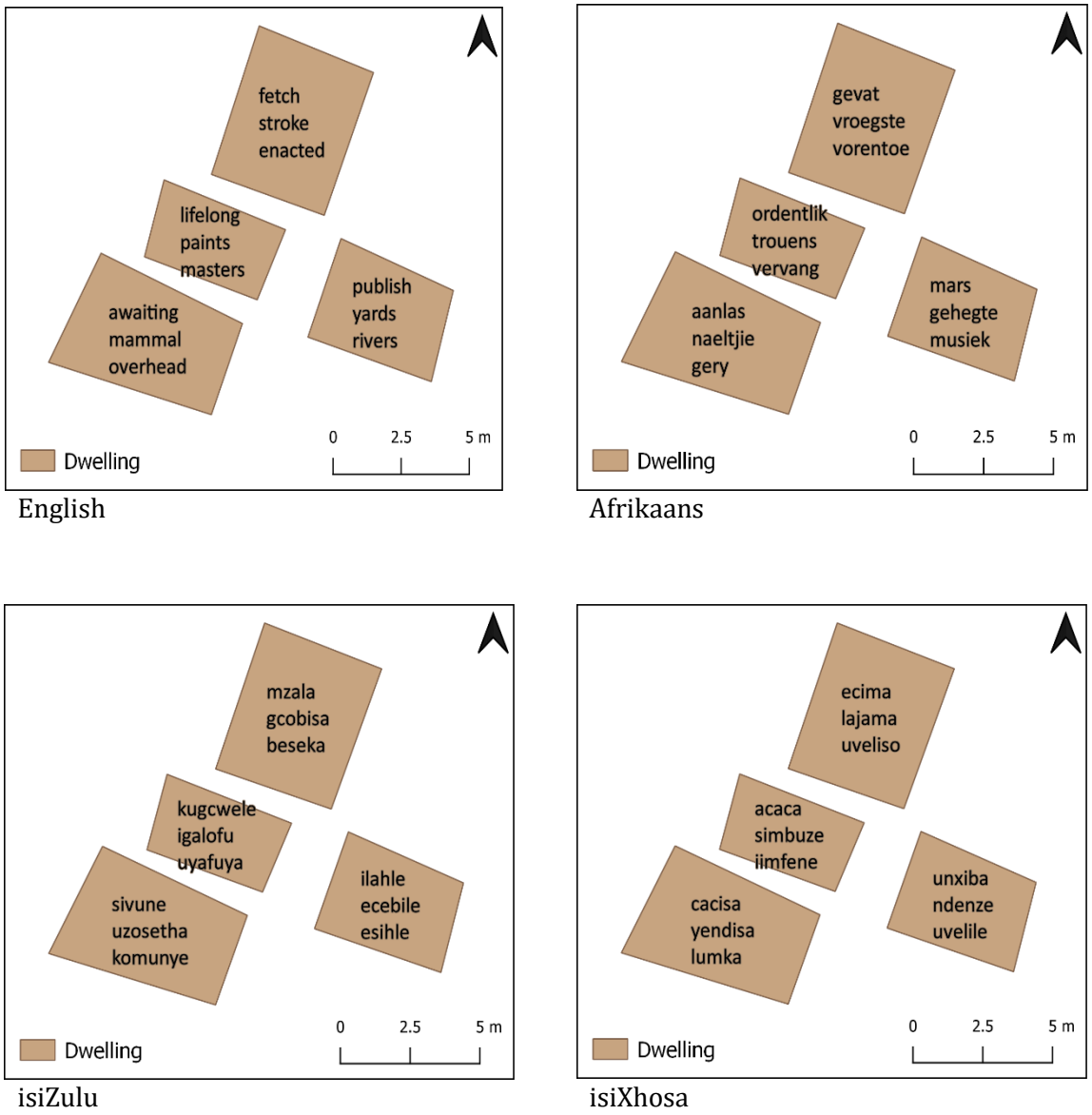



**Figure 6-13: What3Words assigned in different South African languages**

Source: https:\\What3Words.com

Figure 6-13 shows the What3Words addresses that have been assigned to dwellings in the CT Section using the online What3Words interface in a few South African languages. The addresses comprise three random words that have been assigned to each dwelling. What3Words has also added a number of South African languages, such as Afrikaans, isiZulu, and isiXhosa, for use as addresses. However, the words are not directly translatable between languages. Unlike the datum-based address and Mapcode, What3Words addresses do not follow any discernible pattern. However, in order to generate What3Words addresses for multiple dwellings, I was required to apply for a developer API key in order to access the functions, such as the plugins that can be used to assign What3Words addresses to a list of addresses. With the developer key, the

online interface is limited to 100 conversions at a time, while without the developer key, only 25 conversions can be done at a time.

# 7. Evaluation of alternative addresses

## 7.1 Introduction

This chapter is a discussion of the application of the evaluation criteria outlined in Chapter 5 to the alternative addresses selected. These alternative addresses will be scrutinised to as to determine if they are an effective alternative in the study areas.

## 7.2 Evaluation of the datum-based address


**Figure 7-1: Datum-based address for a subset of dwellings in the CT Section**


**Figure 7-2: Datum-based addresses for a subset of Alaska**

Figure 7-1 and Figure 7-2 show the datum-based addresses that have been assigned to dwellings in the CT Section and Alaska, respectively. The addresses for the CT Section and Alaska were assigned by using QGIS functions and SQL (see Annexure 1). SQL was used to formulate the address. A bounding box of the area surrounding each informal settlement was used to determine the area in which the addresses are assigned. Using the axes from the bounding box, the distance from the x axis and a distance from the y axis was calculated in QGIS for a dwelling. The constant values were then added to these distances. The first four digits represent the distance from the x axis and the second group of digits represents the y axis.

## Theme 1. Uniqueness of addresses

*C1. Is it possible for an address to unambiguously identify a single dwelling?*

When using the centroid for the dwellings in the CT Section and Alaska study areas, this address was able to unambiguously identify dwellings, as each centroid used represented a dwelling. Therefore, each dwelling was assigned an address by virtue of the fact that there was a point identifying each dwelling in the informal settlements.

*C2. Is it possible for each dwelling to have a unique address?*

In the CT Section, there were 4,585 dwellings, and in Alaska, there were 1,538 dwellings. Every dwelling was assigned an address. It was accomplished by determining the most appropriate absolute values to be incorporated into the algorithm used to create unique addresses for each dwelling. The reason for the length of the address was a result of trying to have a unique address for as many dwellings as possible. For each of the study areas, the algorithm had to be tailored to be as effective as possible. After assigning the addresses, the addresses were checked for duplications, and none were found for either of the study areas.

## Theme 2. Physical and digital representation of addresses

*C3. Is it possible for an address to be assigned automatically to a set of dwelling (point) features?*

After determining the axes, the distances from the x axis and y axis to a dwelling centroid was calculated using a QGIS function. This was then used to calculate the two parts of the address. The addresses were automatically assigned to the dwellings in the CT Section and Alaska once the distances were calculated. However, the address is dependent on having a predefined set of dwelling points to assign addresses to. Should the informal settlement become inwardly or outwardly denser, the parameters used in this algorithm would have to be re-evaluated to ensure that addresses remain unique.

*C4. How can an address be displayed on a dwelling?*

The address could be displayed on the dwelling, as it only comprises a set of eight digits. This can be displayed in a number of mediums. The implementation of such infrastructure will require funding and planning before it can be successfully implemented.

However, it is quite a departure from conventional street addresses as it is not as it does not comprise any words or letters. This may prove difficult for developing street signage; it may be more feasible to have signage for areas rather than streets, particularly when there are no identifiable streets or footpaths.

*C5. Is it possible for the address to be represented and maintained in a (digital) database?*

The addresses assigned by this address can be stored and maintained in a digital database, as the algorithm produces and stores the assigned addresses as an attribute of the dwelling point data. The addresses generated were included in the shapefiles associated with the dwelling point data. These files were also saved to a local PostgreSQL server for data checking.

It can, therefore, be incorporated into other technologies that require addresses, such as an application for navigation. It can also be integrated into government systems so as to enable better service delivery and strategic planning.

### Theme 3. Suitability for informal settlements

*C6. Does the address accommodate the expansion and changes to the spatial arrangement of dwellings?*

This alternative address is dependent on the predefined point data of dwellings to assign addresses; therefore, if this data is accurate and current, it will be able to accommodate changes in the informal settlements and assign addresses accordingly. As this address requires a datum point to be defined, it is important that the most appropriate point is chosen, as this point marks the origin of the axes that are used to determine the datum address extent. Currently, the alternative address performs assignment in one quadrant; should the settlement expand beyond this region, the algorithm would have to be adjusted to account for this.

A shortfall of this type of address is that it may not be able to manage the growth of the informal settlement should the growth occur out of the region from the datum point; therefore, it is important to choose an appropriate datum point before performing address assignment.

*C7. Does the address accommodate the irregular nature of an informal settlement, for example, thoroughfares that do not follow a set pattern)?*

As the method for address assignment does not base its addresses on physical features, such as road networks, it can accommodate the irregular nature of an informal settlement. The lack of formal planning of where dwellings should be does not impede the effectiveness of the assignment of this alternative address.

The datum-based address is able to handle the irregular nature of informal settlement layouts as the method used for assigning addresses does not rely upon physical features, such as pathways or roads, unlike in conventional addresses.

### Theme 4. Community response to addresses

*C8. Will people easily remember the address?*

This address consists only of digits, which is quite different from conventional addresses, which contain both a number and location descriptor in the form of a street name. This may mean that it could take people time to adjust to having such an address. Given that the numbers are sequential, they may be easier for people to remember.

*C9. Does the address support the social and civic identity of people living at the addresses?*

It is not clear as to whether this address would support or detract from a person's sense of belonging to their place of residence, as numbers do not necessarily hold the same significance and meaning that words may have. This may be advantageous, given South Africa's tumultuous history, as having such an address may not receive an inflammatory response that words may have. For instance, having an address that consists only of digits would not inspire the same type of feeling as having an address with the street name of a person that you may not respect. However, having an address such as this may be considered to be impersonal as it does not hold any of the significance that is associated with words.

*C10. How can the address facilitate human navigation and wayfinding to a dwelling by providing clues about their spatial arrangement?*

The datum-based addresses can be used to facilitate navigation and wayfinding as they follow a sequential pattern that can be used to navigate through the settlement. As can be seen in Figure 7-3, the numbers are based on the coordinates of each dwelling; they represent the grid that was used to determine the address; therefore, if one were to move in one direction, the numbers would increase, and if one were to move in the opposite direction, the numbers would decrease. Therefore, these addresses can be used practically

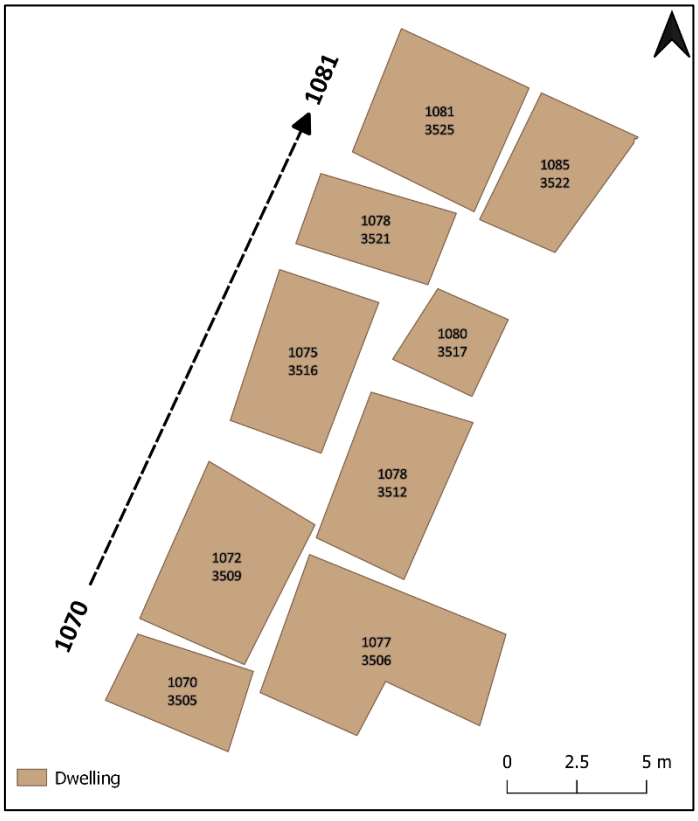



**Figure 7-3: Sequential nature of datum-based addresses**

A device that is GPS-enabled would be most appropriate to use in order to find locations accurately, as these addresses may not be easily recognisable; thus, this may lead to technological challenges and the lack of knowledge by the users as to how to navigate using such an address.

## Theme 5. The usefulness of addresses in other applications

*C11. Is it possible for the address to be incorporated into tools?*

It would be possible for this address to be incorporated into other tools, as the algorithm that was used to create the addresses can be integrated into another system. It is only important that the logic that was used to create this address is maintained so that it remains effective. However, this address was created for a particular locality and will need to be reassessed and amended to cover larger areas, although in doing so, the length of the address will increase to maintain the ability to assign unique addresses.

*C12. Is it possible for the address to be optically scanned and recognised (for example, for mail sorting)?*

This address could be used for optical scanning; however, it would require each address to be assigned some type of image or barcode that can be read by a scanning device in order for it to be effective. Having an address that only consists of digits may be helpful in preventing errors that occur in the conventional addresses, such as incorrect spelling of words and inconsistent use of addresses due to street name changes.

As the addresses are stored digitally, it is possible to be used in optical systems, in which a device can be used to access information regarding a particular dwelling based on the address. The device should be able to be linked to the database that stores the address data.

*C13. Is it possible for the address data can be freely shared as open data?*

As this system was created using open-source software and data was provided freely, there was no need to procure any licensing or adhere to any copyright restrictions. The address data can, therefore, be freely shared as open data. The code and method used can be shared freely so that other developers may incorporate it into their applications.

## Theme 6. Requirements for address assignment

*C13. What are the possible software and hardware requirements for address assignment and maintenance of the address?*

This address would require equipment to maintain and store the data needed for address assignment as well as storage for the addresses. The process of address assignment has minimal

requirements for physical assets for use in this context; however, it would require skilled individuals to assign and maintain this type of address over time.

## 7.3 Evaluation of Mapcode


**Figure 7-4: Mapcodes assigned for a subset of dwellings in the CT Section**

Data source: www.mapcode.com

**Figure 7-5: Mapcodes assigned to a subset of dwellings in Alaska**

Data source: www.mapcode.com

Figure 7-4 and Figure 7-5 show a subset of dwellings from the CT Section and Alaska, respectively, and each dwelling is labelled with its assigned Mapcode. For the purpose of this evaluation, the Mapcodes were generated with the standard 5metre x 5metre layout.

## Theme 1. Uniqueness of addresses

*C1. Is it possible for an address to unambiguously identify a single dwelling?*

To assign Mapcodes to the dwellings in both the CT Section and Alaska, centroids representing the dwellings in both settlements were used in the process. Therefore, the Mapcode made use of a coordinate for every dwelling to assign a Mapcode.

The Mapcodes were assigned at a scale of 5m, and in using this it was apparent that there were a number of duplicates in the addresses, therefore a Mapcode could not unambiguously identify a single dwelling. In Alaska, 201 Mapcodes were found to have duplicates. In the CT Section, 1,533 Mapcode duplicates were present.

*C2. Is it possible for each dwelling have a unique address?*

After this type of address was assigned, it was clear that it could not assign unique addresses to every dwelling. When using the 5m layout, there are clusters of dwellings that have the same Mapcode. This occurred in both the CT Section and Alaska study areas where if a group of dwellings fell into the same grid cell, they were all assigned the same Mapcode associated with the grid cell.

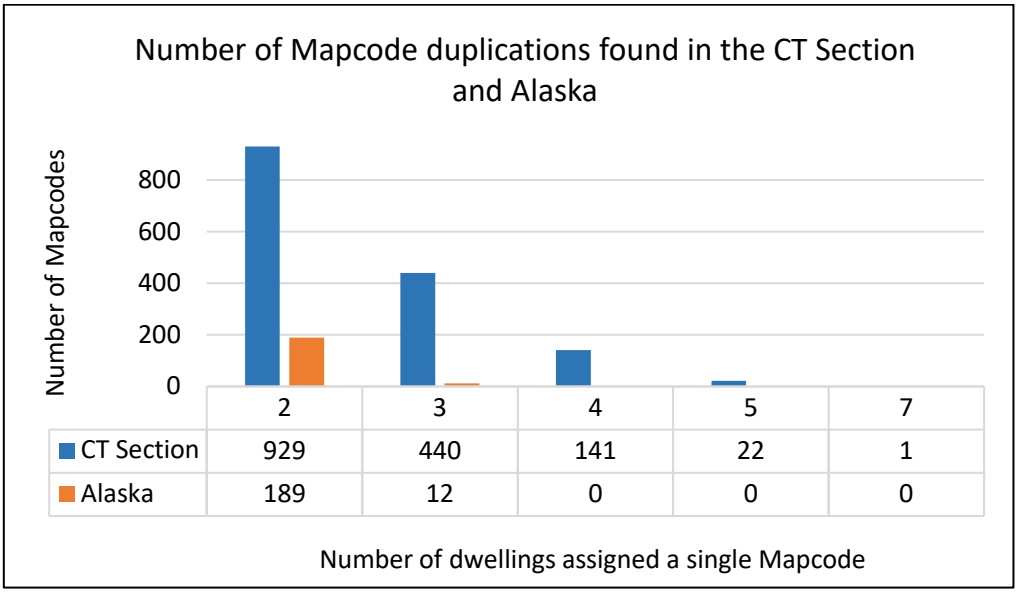


**Figure 7-6: Duplicate Mapcodes in the CT Section and Alaska**

Figure 7-6 represents the number of duplicates found in the CT Section and Alaska. The largest number of duplicates was found in the CT Section. In the largest category, each of the 929 Mapcodes were assigned two dwellings in the CT Section. Figure 7-7 shows that one Mapcode was assigned to seven dwellings in the CT Section. In Alaska, the largest number of dwellings a single Mapcode was assigned to was three, as can be seen in Figure 7-8.

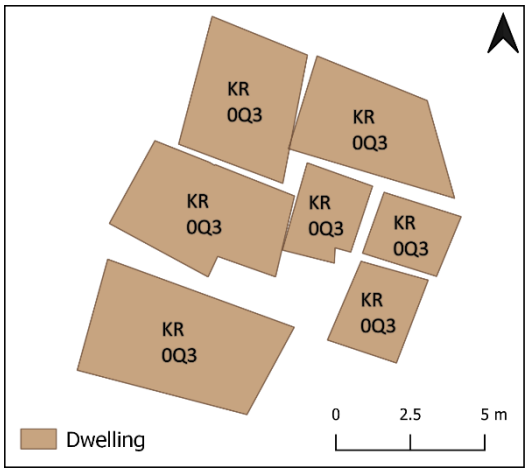



**Figure 7-7: Mapcode duplicates in the CT Section**

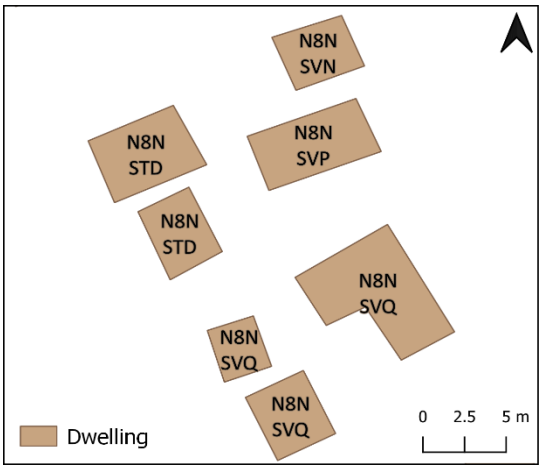



**Figure 7-8: Mapcode duplicates in Alaska**

## Theme 2. Physical and digital representation of addresses

*C3. Is it possible for an address to be assigned automatically to a set of dwelling (point) features?*

These Mapcodes were automatically assigned using the centroids of the dwelling polygons. Using the coordinates for each dwelling, a Mapcode could be assigned using a batch processing function to assign the Mapcodes. Mapcodes are dependent on the use of coordinates; therefore, any system that makes use of Mapcodes must be able to convert location data into geographical coordinates before they can be used.

*C4. How can an address be displayed on a dwelling?*

As the Mapcode is not particularly long, it can be displayed on dwellings. It only comprises digits and letters; therefore, it would be relatively simple to create signage not only for dwellings but also areas.

As Mapcode does not make use of road networks or physical features, the Mapcode would be better used to denote areas in which dwellings have similar Mapcodes rather than delineating

streets or pathways. Figure 7-9 shows the unique way in which Mapcodes can be used to identify areas in the structure of the code.


**Figure 7-9: Area identifiers using Mapcode**

*C5. Is it possible for the address to be represented and maintained in a (digital) database?*

Mapcodes are created from a digital system; therefore, the addresses can be stored and maintained in a digital database. This address makes use of a grid, in which each grid cell has been assigned a Mapcode. The key point in this process of assigning Mapcodes is to understand the locations of dwellings so that the dwelling is associated with the Mapcode. A batch process was used to assign the Mapcodes, using an Excel spreadsheet that incorporated the Mapcode API. This data was then appended to the spatial data of the informal settlements for ease of use.

## Theme 3. Suitability for informal settlements

*C6. Does the address accommodate the expansion and changes to the spatial arrangement of dwellings?*

Informal settlements do not conform to any planned patterns; therefore, it is difficult to predict in what ways that it could densify or expand. It is apparent that this address does not handle the dense nature of the CT Section or Alaska particularly well given the number of duplicates that are present. It would be possible to use a finer resolution for address assignment, but this would mean that the Mapcode would be longer than the standard one that has been used. Determining the most appropriate resolution would also be difficult as informal settlements have varying characteristics.

*C7. Does the address accommodate the irregular nature of an informal settlement (for example, thoroughfares that do not follow a set pattern)?*

As the method for address assignment does not base its addresses on physical features, such as road networks, it can accommodate the irregular nature of an informal settlement. The lack of formal planning of where dwellings should be does not impede the assignment of this alternative address; however the density of the informal settlements are an issue.

Mapcode is able to handle the irregular nature of informal settlement layouts as the method used for assigning addresses does not rely upon physical features, such as pathways or roads, similar to the datum-based address.

## Theme 4. Community response to addresses

*C8. Will people easily remember the address?*

It will be difficult to know if people would be able to remember a Mapcode easily. However, the addresses are relatively short, so that would lead to it being easier to remember. As seen in Figure 7-9, the ability of Mapcodes to identify areas can make this type of address easier to understand and use. However, the large number of duplications, particularly in the CT Section, make this an ineffective alternative address.

*C9. Does the address support the social and civic identity of people living at the addresses?*

As this address does not make use of any words and consists only of digits and letters, it does not have connotations associated with it; therefore, people may be more inclined to accept such an address. As with the datum-based addresses, Mapcodes can be considered as a more neutral form of an address. However, it does differ from what is conventionally used for addresses, and this may mean that people would be less accepting of it.

*C10. How can the address facilitate human navigation and wayfinding to a dwelling by providing clues about their spatial arrangement?*

These addresses can be used for wayfinding as the addresses do follow a pattern that is recognisable and can be used to navigate through space without the need for some type of navigation device.

In both the CT Section and Alaska, the issue with this address is that the addresses are not unique and there are duplicates that have been taken into account. Therefore, locating a particular dwelling may prove more difficult as an address may be associated with more than one dwelling in that vicinity, as depicted in Figure 7-6.

## Theme 5. The usefulness of addresses in other applications

*C11. Is it possible for the address to be incorporated into tools?*

This address reference can be incorporated into other tools, as it is a freely available address application that can be used by anyone. It is the aim of the Mapcode Foundation to allow everyone to access this system for the purpose of addressing, therefore promoting the integration of Mapcode into other systems, such as utility services. This system can be integrated into government organisations and be accessed digitally, which enables ease of use so that it can help improve service delivery.

For instance, a Mapcode can be found using a mobile application that makes use of Mapcodes. It is possible for Mapcodes to be displayed on dwellings and, given the short length of these addresses, and the sequence in which the addresses follow, a Mapcode may facilitate navigation. However, the duplication of Mapcode addresses is a serious downside.

*C12. Is it possible for the address to be optically scanned and recognised (for example, for mail sorting)?*

These addresses are stored digitally; therefore, it is possible to use them in optical systems, in which a device can be used to access information regarding a particular dwelling based on the address. The device should be able to be linked to the database that stores the address data. This can be done if the Mapcodes are linked to some type of barcode or scannable image.

*C13. Is it possible for the address data can be freely shared as open data?*

This data can be freely shared as open data, as this address is available to anyone and can be accessed through multiple formats, such as through the use of a mobile device or a desktop computer. Having such easily accessible data would be an excellent way in which to integrate systems, particularly government systems, so as to prevent having multiple databases of varying data quality.

## Theme 6. Requirements for address assignment

*C14. What are the possible software and hardware requirements for address assignment and maintenance of the address?*

This a freely available application that can be used by anyone, making it possible for address data to be shared openly. Mapcode's source code is available for developers to access and integrate into online applications. Therefore, any software and hardware costs incurred will be minimal as the Mapcode is available to all users. However, there will be expenses with regard to the maintenance and storage of data related to the addresses.

## 7.4 Evaluation of What3Words


**Figure 7-10: What3Words addresses assigned to a subset of dwellings in the CT Section**

Data source: https://What3Words.com/


**Figure 7-11: What3Words addresses assigned to a subset of dwellings in Alaska**

Data source: https://What3Words.com/

Figure 7-10 and Figure 7-11 show a subset of dwellings from the CT Section and Alaska, respectively, and each dwelling is labelled with its assigned What3Words address. For the purpose of this evaluation, the language that has been chosen for the addresses is English.

## Theme 1. Uniqueness of addresses

*C1. Is it possible for an address to unambiguously identify a single dwelling?*

What3Words makes use of three words that describe a location. The application has predefined addresses in the form of three words that identify a 3m × 3m cell. This address cannot effectively and unambiguously identify single dwellings as it is constrained to the predefined 3m × 3m cell, and it is possible for more than one dwelling to share space in the same cell.

*C2. Is it possible for each dwelling to have a unique address?*

What3Words is not always able to assign a unique address to each dwelling as duplications of addresses were found during the assignment of this alternative address, particularly in the CT

Section, as it is considerably denser than Alaska. In the CT Section, there were six What3word addresses that were duplicated.

| What3word address | Number of dwellings assigned to the address |
|---|---|
| bills.revives.sorters | 2 |
| dark.various.orders | 2 |
| fury.later.marker | 2 |
| pinks.heads.bangle | 2 |
| puzzled.swimmer.stone | 2 |
| flipper.doctor.along | 2 |

**Table 7-1: Duplicate addresses in What3Words**

## Theme 2. Physical and digital representation of addresses

*C3. Is it possible for an address to be assigned automatically to a set of dwelling (point) features?*

What3Words addresses can be assigned to point features, as this is what was used for the address assignment. The centroids of the dwelling polygons were used to represent each dwelling in both the CT Section and Alaska. However, What3Words is dependent on the use of coordinates and requires any location information to be in that particular format before it can be used for address assignment.

*C4. How can an address be displayed on a dwelling?*

A What3Words address can be displayed on a dwelling, as it only requires materials needed to create the three words that represent that location. Thus, every dwelling would have an address that is represented by three random words. The feasibility of physical representations of What3Words is dependent on the willingness of communities and local authorities to make use of the address and set aside funding and resources for the signage.

*C5. Is it possible for the address to be represented and maintained in a (digital) database?*

What3Words addresses can be stored and maintained in a database and accessed through digital media. What3Words attempts to make its addresses accessible to a larger audience through the use of online platforms. This address requires access to technology to determine an address; it is necessary to access the application that has been devised. This system has predefined addresses assigned to each grid cell; therefore, this would need to be linked to the dwelling data in order to determine the addresses. In order to assign these addresses, an API key was required to access the functions for batch processing.

## Theme 3. Suitability for informal settlements

*C6. Does the address accommodate the expansion and changes to the spatial arrangement of dwellings?*

What3Words is able to assign addresses to dwellings automatically and can handle the dynamic nature of informal settlements to an extent. However, it may not be able to handle the densification of dwellings effectively, should more than one dwelling centroid be located in a particular grid cell. Then both dwellings would have the same address. Given that addresses are predefined for 3m × 3m cells, it may not be able to manage changing spatial arrangements within an informal settlement.

*C7. Does the address accommodate the irregular nature of an informal settlement (for example, thoroughfares that do not follow a set pattern)?*

It is apparent that this address is not as effective in denser locations and was not able to handle the dense nature of the CT Section particularly well, as evidenced by duplication of addresses found. As this alternative address makes use of a predefined grid for address assignment, the irregular patterns of an informal settlement do not impede the assignment of the address in either of the study areas. Having the coordinates for all the dwellings was all that was required in order to go about the address assignment. The absence of well-defined infrastructures, such as roads, was not a deterrent.

## Theme 4. Community response to addresses

*C8. Will people easily remember the address?*

It would be difficult to ascertain as to whether people would be able to remember an address that consists of three random words easily. It could be quite confusing to have to remember multiple addresses of this type as the words have no association with the areas. The type of words that an address may consist of could also be an obstacle, particularly if they are quite long and not easily understood.

*C9. Does the address support the social and civic identity of people living at the address?*

For the address assignment using What3Words in both the study areas, English was used for the language of choice as this was the automatic option. The words that appeared in some of the addresses were quite long and not familiar, as they are not words that are used in regular conversation. This may mean that people are not likely to be as accepting of this as an address, particularly in communities where English is not a predominant language. What3Words does

have alternative language options such as Afrikaans, Zulu, and isiXhosa, however, the words are not translatable to each language, so only one language can be used at a time.

*C10. How can the address facilitate human navigation and wayfinding to a dwelling by providing clues about their spatial arrangement?*

It would be somewhat challenging to use these addresses for navigation and wayfinding if one does not have some sort of device that is compatible with What3Words. As the addresses only use words, there are no sequences or patterns that could be followed in order to navigate, as shown in Figure 7-12. If a person were to find themselves in one of the study areas, for example, it would be difficult for them to orient themselves and try to find a dwelling based on its address given the random nature of the words used by What3Words.

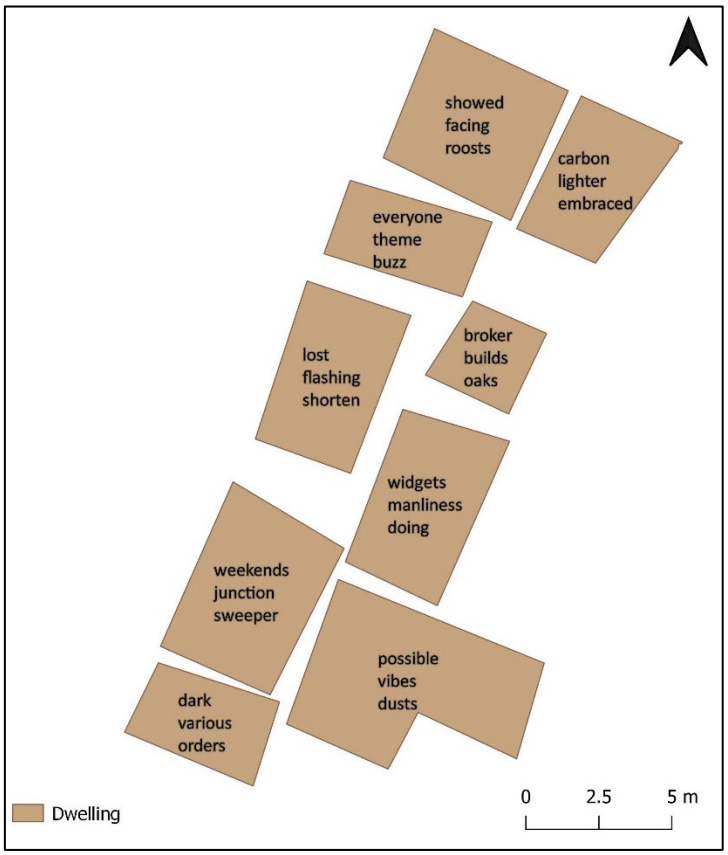



**Figure 7-12: Wayfinding using What3Words**

## Theme 5. The usefulness of addresses in other applications

*C11. Is it possible for the addresses to be incorporated into tools?*

It would be possible to incorporate these addresses into other tools and applications; however, as this application is proprietary technology, a licence would have to be obtained to use it. The application is freely available for people to use for personal use, but for it to be used in

organisations, rights to the application must be obtained; therefore, funding must be taken into consideration. What3Words does offer developer APIs to make use of some of the free functions, such as searching for a What3Words address.

*C12. Is it possible for the address to be optically scanned and recognised (for example for mail sorting)?*

These addresses can be incorporated into systems that make use of optical scanning and cataloguing. What3Words has been used for courier services and delivery of packages by a number of courier companies. This shows that this application can be used in conjunction with optical scanners and for delivery; however, it is not freely available for use.

*C13. Is it possible for the address data can be freely shared as open data?*

What3Words addresses are freely available for people to use to look up addresses and find locations; however, What3Words requires users to make use of developer licences and the products offered by the company if What3Words is to be used on a larger scale. This makes What3Words not as accessible as other online address tools.

## Theme 6. Requirements for address assignment

*C14. What are the possible software and hardware requirements for address assignment and maintenance of the address?*

There are requirements for hardware and software that must be taken into consideration for the assignment of this alternative address, as without the basics the application for address assignment would not be functional. There are licensing conditions that must be taken into account for using What3Words. There are limitations to the free services that are offered; therefore licences will be required to make use of all the features offered by What3Words. As What3Words is also being incorporated into other commercial software such as Esri ArcGIS, this may lead to costs being incurred, with regard to maintenance and assignment of address if proprietary software is required.

## 7.5 Summary of evaluation

| Criteria | Datum-based address | Mapcode | What3Words |
|---|---|---|---|
| **Theme 1. Uniqueness of addresses** | | | |
| **C1. Is it possible for an address to unambiguously identify a single dwelling?** | Unambiguously identifies each dwellings using centroids in the CT Section and Alaska, | Could not unambiguously identify all dwellings at the 5-metre scale. Duplicates were present | Could not unambiguously identify all dwellings. Duplicates were present |
| **C2. Is it possible for each dwelling to have a unique address?** | It was possible to assign unique addresses to every dwelling | Not possible to assign unique addresses to every dwelling. Duplicates present in the CT Section and Alaska. | Not possible to assign unique addresses to every dwelling. Duplicates present in the CT Section |
| **Theme 2. Physical and digital representation of addresses** | | | |
| **C3. Is it possible for an address to be assigned automatically to a set of dwelling (point) features?** | Addresses were automatically assigned to the dwellings points in the CT Section and Alaska. | A Mapcode API was used to generate the Mapcodes in a batch, using dwelling centroids. | What3Words requires coordinates for address assignment; centroids were used. |
| **C4. How can an address be displayed on a dwelling?** | It is possible for the addresses to display this address on physical mediums. | A Mapcode can be displayed on dwellings. It only comprises digits and letters. | A What3Words address can be displayed on a dwelling. |
| **C5. Is it possible for the address to be represented and maintained in a (digital) database?** | The addresses assigned by this address can be stored and maintained in a digital database. | Mapcodes are created from a digital system; therefore, they can be stored and maintained in a digital database. | What3Words addresses can be stored and maintained in a database and accessed through digital media. |
| **Theme 3. Suitability for settlement layouts** | | | |
| **C6. Does the addressing system accommodate the expansion and changes to the spatial arrangement of dwellings?** | This address may not be able to manage the growth of the informal settlement should the growth occur out of the bounding box range | Future expansion of these informal settlements would lead to more duplications. | More duplications of addresses will occur should the informal settlement densify |
| **C7. Does the address accommodate the irregular nature of an informal settlement?** | It can accommodate the irregular nature of an informal settlement. | Mapcode can accommodate the unplanned nature of informal settlements. | The irregular patterns of an informal settlement does not impede address assignment |
| **Theme 4. Community response to addresses** | | | |
| **C8. Will people easily remember the address?** | The sequential numbers may be easy to remember. | Mapcodes are relatively short, making it easier to remember. | The words in as address may not be easily understood. |

| Criteria | Datum-based address | Mapcode | What3Words |
|---|---|---|---|
| **C9. Does the address support the social and civic identity of people living at the addresses?** | It is not clear as to whether this address affect a person's sense of belonging to their place of residence, | The format could be considered neutral; people may be more inclined to accept. | What3Words may not be easily accepted in communities where English is not a predominant language. |
| **C10. How can the address facilitate human navigation and wayfinding to a dwelling by providing clues about their spatial arrangement?** | It can be used to facilitate navigation and wayfinding, using the sequential numbers | The addresses follow a pattern that is recognisable and can be used to navigate. | There are no sequences or patterns that could be followed in order to navigate. |
| **Theme 5. The usefulness of addresses in other applications** | | | |
| **C11. Is it possible for the address to be incorporated into tools?** | It would be possible for this address to be incorporated into other tools. | Mapcodes can be incorporated into other tools. | It would be possible to incorporate it into other tools and applications. |
| **C12. Is it possible for the address to be optically scanned and recognised?** | This address could be used for optical scanning | These addresses are stored digitally; it is possible to use them in conjunction with optical equipment | These addresses can be incorporated into systems that make use of optical scanning and cataloguing. |
| **C13. Is it possible for the address data to be freely shared as open data?** | There are no restrictions to sharing this address method and data as open data. | This data can be freely shared as open data. | What3Words addresses are freely available for personal use. Commercial use would require licensing. |
| **Theme 6. Requirements for address assignment** | | | |
| **C14. What are the possible software and hardware requirements for address assignment and maintenance of the address?** | This address would require equipment to maintain and store the data needed for address assignment as well as storage for the addresses | Mapcode's source code is available for developers to access and integrate into online applications and systems for address assignment | There are limitations to the free services that are offered; therefore, licences will be required to make use of all the features offered by What3Words. |

**Table 7-2: Evaluation of alternative addresses**

# 8. Discussion of results

## 8.1 Introduction

Upon evaluation of the alternative addresses, it is apparent that the addresses performed differently in the themes discussed for the evaluation. It was necessary that each type of address be subjected to a range of criteria that not only looked at the method and technical details of address assignment but also considered the usability of each the addresses. This chapter will discuss how the alternative addresses fared in their assignment in the two study areas based on the evaluation criteria.

## 8.2 The uniqueness of addresses

One of the key factors of having an effective address is its ability to provide information that can be used to unambiguously identify a dwelling and its location (Coetzee and Bishop, 2009). The alternative addresses that were used, particularly What3Words and Mapcode, both assigned addresses based on predefined grids, where What3Words made use of a 3m × 3m grid, Mapcode employed a 5m × 5m grid; therefore, each grid cell already had an address assigned to it. The datum-based address did not make use of a grid; it was reliant on the geographic coordinates of a dwelling to assign an address.

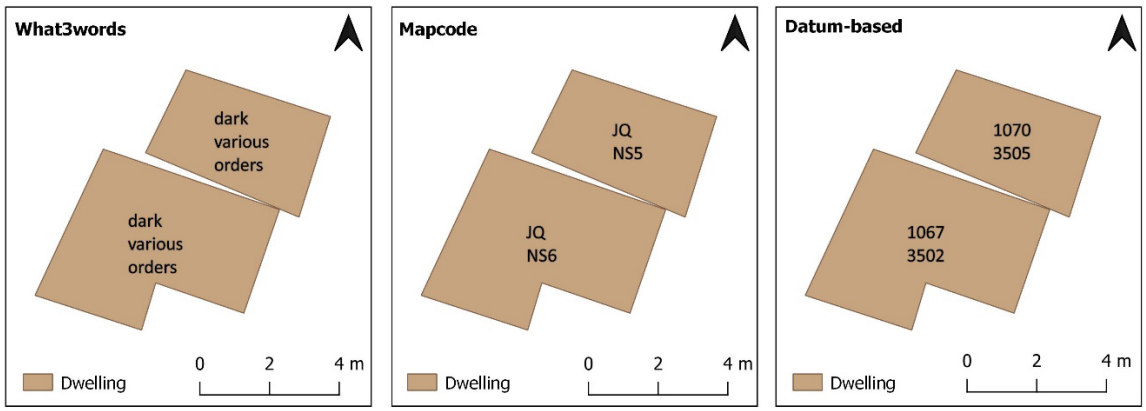



**Figure 8-1: What3Words duplicates compared to Mapcode and datum-based addresses**

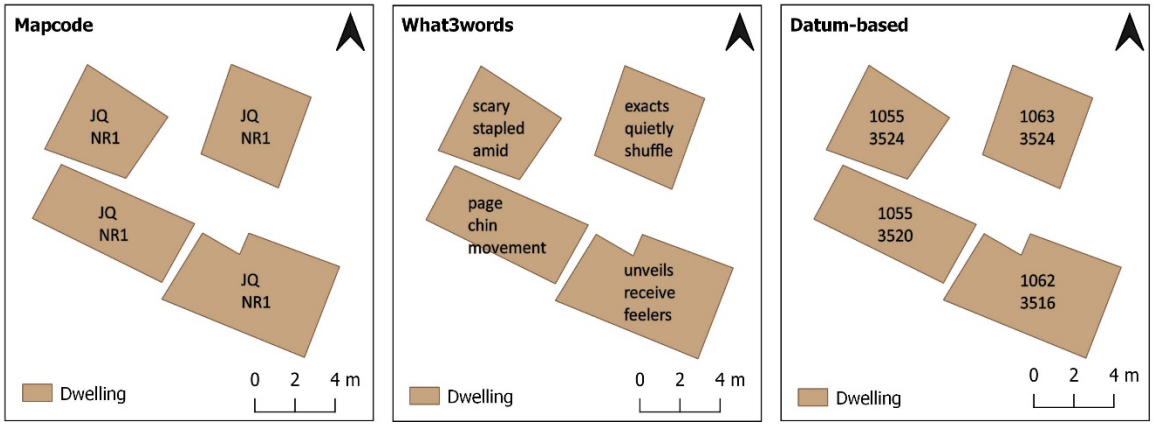



**Figure 8-2: Mapcode duplicates compared to What3Words and datum-based addresses**

Conventional addresses are typically associated with physical objects, such as buildings or parcels of land (Coetzee and Cooper, 2007). If a conventional address were to be assigned in the study areas, the address could not be assigned unless there is a physical dwelling. However, the alternative addresses that were applied in the two study areas did not focus on the identification of a physical object or cadastral delineations but rather a location in space. This meant that an address could be assigned to any location, regardless of whether a dwelling was present or the land was to be used for residential purposes. For all three alternative addresses, the centroids for the dwellings were used to assign the addresses. With Mapcode and What3Words, duplications occurred when multiple centroids were present in the same grid cell. Figure 8-1 shows duplicate What3Words addresses compared to the Mapcode and datum-based addresses for the same dwellings. Figure 8-2 show an example of Mapcode duplications and the corresponding What3Words and datum-based addresses for those dwellings. Figure 8-1 and 8-2 both illustrate that the duplication of addresses of one alternative address may not have resulted in duplications when using another alternative address.

## 8.3 Physical and digital representation of addresses

With the establishment of standards such as ISO 19160 and SANS 1883, it is important to consider the format and type of data that an address requires and comprises. Such standards provide important information regarding the manner in which addresses should be developed to allow for the information to be usable and to enhance its interoperability (Coetzee and Bishop, 2009). Even if alternative addresses do not follow the guidelines that have been set by these standards, they would still be useful if they account for the principles of these standards. It would not be useful for municipalities to go through the exercise of assigning new addresses if those addresses cannot be used by other organisations at different levels of influence.

In South Africa, each municipality is responsible for address assignment within its bounds. This responsibility was given to the municipalities by the South African Geographical Names Council (Coetzee, Cooper and Katumba, 2020). It would not be useful if each municipality implemented different types of addresses that cannot be integrated into a comprehensive provincial address database that would further feed into a national address database. The three alternative addresses that were applied can be stored and maintained in a database. The address data for the two informal settlements have been stored on a local PostgreSQL database and Excel spreadsheets. The primary format for these alternative addresses is currently digital, as all address assignment and storage has been done through digital media. It highlights the importance of all these alternative addresses to have a digital interface and output given the increasing use and need for technology to provide ease of access. There is a need for the application used for address assignment to be able to integrate with others so as to share information and be more efficient.

Even if a dwelling were to overlap multiple grid cells, the address that was assigned was based on the centroid location. Therefore, if the locational coordinate was the front door instead of the centroid, there may have been a different outcome in an address that was assigned. Although the datum-based addresses do not use grids, the addresses are also dependent on the locational coordinate that was used, and if a different point of reference was used, the address that was assigned to a dwelling would also be different to the address assigned using the centroids of dwellings. Being able to assign addresses using point data is undoubtedly useful and quite effective, but the effectiveness of the address assignment is very much dependent on the accuracy of the point dataset and would require constant updating to ensure that the data is current. This became apparent due to the presence of overlapping polygons that resulted in the exclusion of dwellings, and the polygons with errors were not assigned centroids.

Access to reliable data, particularly address data, is important across multiple organisations and disciplines and having a freely accessible address database would go a long way in assisting with the efficiency of systems and service delivery (Coetzee and Bishop, 2009). Mapcode is a freely available alternative address that can be used by anyone, making it possible to address data to be shared openly. Therefore, any software and hardware costs incurred will be minimal as the Mapcode is available to all users. It is the aim of the Mapcode Foundation to allow everyone to access for the purpose of addressing, therefore promoting the integration of Mapcode into other systems, such as utility services (Stichting Mapcode Foundation, 2008). The datum-based addresses can also provide the address data as open data as it does not have any licensing restriction, unlike What3Words, which does require licensing and may not allow for its data to be shared as open data.

## 8.4 The usefulness of addresses in other applications

Addresses can be a pivotal mechanism to which all systems can connect to (Lind, 2008). This would limit the need for other organisations to create their own address applications, and it is easier to ensure that data quality remains consistent if there is only one system being used for addresses. All the alternative addresses that were applied have the potential of being integrated into tools and applications. Both Mapcode and What3Words have mobile applications and online interfaces that can be used to find the location of a given address for the respective address applications. These applications also offer tools that developers can use to integrate the functionalities into other platforms.

Having an address that is interoperable among different types of databases and systems is particularly important when considering the development of a national address register or database (Coetzee *et al.*, 2008). The datum-based addresses also have the potential of being used in tools as the algorithm can be integrated into systems that require addresses to perform as an important linkage between systems. The datum-based addresses also make use of algorithms that can be incorporated into other tools and technologies, thus making the addresses more accessible through other forms of technology, such as smartphones as well as other systems. However, the algorithm would have to be adjusted in order for the addresses to be unique. As Mapcode is also freely available, it can also be incorporated into other systems easily; it is important to note that Mapcodes for South Africa were used and not the international Mapcodes for the study areas. In order to use What3Words in larger systems, it would require that licensing for What3Words products be obtained before it can be incorporated into other tools.

## 8.5 Suitability for informal settlements

As discussed in Chapter 2, informal settlements are a predominant feature in South Africa's urban landscape. With the growing demand for housing and the lack of delivery of services from the government, informal settlements provide a space for people who cannot access privileged spaces. Informal settlements should not be seen as something that will be resolved through settlement upgrading and relocation. They require immediate attention for service delivery and infrastructure especially considering that these settlements house some of the most vulnerable people whose needs should be a priority (Thwala, 2005; Wekesa, Steyn and Otieno, 2011; Marais and Ntema, 2013). It is important to recognise that informal settlements are a part of South Africa, and even with informal settlement upgrading initiatives, they continue to grow and establish themselves to meet the need for housing.

The initial thought of achieving this is to ensure that service delivery happens in these informal settlements, and this is where there is an urgent need for addresses. SANS 1883 defines an address as a 'point of service delivery' (South African Bureau of Standards, 2009); this further highlights the importance of service delivery in South Africa. However, implementing addresses in informal settlements is a complex undertaking since informal settlements do not conform to any urban planning mechanisms and may be the result of the occupation of vacant land, meaning that people do not have tenure or ownership of the land which their dwelling occupies. Since informal settlements are unplanned, there are no set patterns or infrastructure networks (Kohli *et al.*, 2012) that can be used for the implementation of conventional addresses. The assignment of alternative addresses in the study areas highlights that these types of addresses do have a certain advantage by not being constrained to physical features, such as road networks. The alternative addresses are not dependent on physical features, such as roads and thoroughfares, to perform address assignments as each address requires the location of the dwelling for address assignment in the study areas.

The alternative addresses performed adequately in the current state of Alaska and the CT Section; however, Mapcode produced the most duplicate addresses compared to What3Words and the datum-based addresses. As What3Words only uses a 3m grid, this may lead to the possibility of further duplications, particularly in areas where there is a pronounced increase in the density of buildings. This is likely, given the prevalence and growth in the number of dwellings that are being constructed in informal settlements and perhaps backyard shacks (Turok and Borel-Saladin, 2016). The dynamic nature of informal settlements must always be taken into account when implementing any type of address, as it may not always be possible to predict the way in which these settlements may change, whether it may be an outward expansion or inward densification. The density and location of dwellings is the more important factor for the effective assignment of the alternative addresses than the layout of related physical features.

## 8.6 Community response to addresses

One of the most common uses of an address is for wayfinding, as addresses are supposed to provide information that describes the location of an object, such as a dwelling. Signage and the visibility of addresses are also important to orient oneself, especially for people not familiar with an area (Harber *et al.*, 2018). There is a possibility for the alternative addresses to be displayed on dwellings as it would not require any special material or signage to do so. However, it is important to consider the funding implication of producing physical signage, not only for dwellings but also for the areas. During the assignment of the alternative addresses, given the difference of these addresses from conventional addresses, the alternative addresses may not be

conducive to conventional street signage, as none of these addresses makes use of any physical features as points of reference. It would, perhaps, be more appropriate to assign signage referring to general areas rather than features, such as streets. This may be difficult, particularly for alternative addresses such as What3Words, which makes use of a fixed 3m grid cell size.

Given the difference in the format of alternative addresses to conventional addresses that people are familiar with, it is difficult to understand whether people would find it easy to remember the addresses assigned. The datum-based addresses comprised two groups of digits; Mapcode assigned an address that comprised both letters and digits, and the What3Words address was made up of three random words. A 1951 study by two psychologists at the University of Miami, Florida, showing that people's capacity for short-term recall was far better for words than for letters and digits (Howgego, 2017). This indicates that What3Words would be more easily remembered rather than a Mapcode or datum-based address. However, a What3Words address does not provide as much information as the three random words, unlike Mapcode and the datum-based addresses, which produce sequential addresses that can be used to infer distances and regions based on the addresses. It is crucial that people remember their addresses; it is also just as important for them to acknowledge and accept the addresses that have been assigned.

Place names and addresses are not only important to assist in service delivery and wayfinding, but they are also an extension of a person's sense of belonging and can provide people with a means of ownership over the dwelling in which they reside (Thale, 2007). The act of renaming towns and streets elicited an array of impassioned responses across South Africa, from those wanting to retain the original names and others pushing for transformation and change to usher in a new legacy. This turbulent process further emphasises the meaning which names have on people, regardless of whether it may be positive or negative (Webb, 2018). Although What3Words does accommodate a number of languages that can be used as addresses, it does not support the use of multiple languages to be used in the same instance. In the CT Section and Alaska, the English words that were assigned to dwellings were not common and were often quite long. As the addresses are predefined, the words cannot be changed; therefore, if a person is opposed to their What3Words address, they cannot change it.

In South Africa, there was a large response to the changing of the names of streets and places alike. The act of changing names can be seen as a symbolic act of reparation in response to the gross human rights violations that occurred during apartheid. Although it does not have a direct impact, it is symbolic of the untying of the destructive patterns that were forced upon the country during that era (Swart, 2008). Each of the alternative addresses makes use of different formats, such as the datum-based address that comprises digits, and this may seem like an address that would be easily accepted as it does not inspire the same resonance that words do. Mapcode is

similar in that the address is also in the form of a code that uses both digits and letters. However, it may not be as well accepted, particularly if it reminds people of the addresses used during apartheid in which more affluent areas were afforded the luxury of street names and numbers, and peripheral areas were only given a number.

This is particularly pertinent to an address as it is quite a personal piece of information that people see value in, particularly in South Africa, where it is not only an identifier of your location but is also needed to access services. However, it is difficult to understand people's feelings towards something like an alternative address when it has not been implemented in a community.

## 8.7 Requirements for address assignment

When considering the implementation of these alternative addresses, the possible software and hardware needs should be taken into account for these alternate addresses to be integrated into existing infrastructure.

It is also important to keep in mind the skills and people that would be required to maintain these addresses, particularly when the lack of capacity and skills in South Africa (Thwala, 2005). Therefore, the costs of setting up the application for address assignment as well as the people required to run it must be considered; this poses an interesting opportunity not only to employ an address application that would be more efficient but also assist with the upskilling of people.

The type of address that is chosen for implementation should take into account the response and feelings of the community, as a technocratic approach to address assignment with no community engagement may not yield the desired outcome, and valuable information can be gleaned from the input of the community. Without community support and buy-in, any type of address that is applied would fail because if the community does not accept it and use it, it would be useless and ineffective in its intended purpose.

# 9. Conclusion

## 9.1 Introduction

After performing the evaluation of the addresses, it was apparent that determining an address that is effective for all urban settlements is a complex undertaking. This chapter will discuss the results and the overall impressions gained during the process of address assignment and evaluation based on the objectives that were outlined.

## 9.2 Summary

### 9.2.1 Objective 1: Conduct an ongoing literature review on existing work regarding addresses and informal settlements

During the process of the literature review on addresses, it was clear that addressing in South Africa is a topic that is not extensively covered, hence the heavy reliance on a key number of articles and standards that were used to gain an understanding of addressing and its complexities. Although there is extensive literature that can be found around on addresses internationally, it was apparent that the address assignment process is a complex issue that is not unique to South Africa. It was difficult to find work related to the South African context pertaining to addressing in informal settlements and dynamic environments. It was an interesting exercise as it provided exposure to different types of addresses that have been used around the world, and the processes that were employed able to yield satisfactory results.

### 9.2.2 Objective 2: Based on the literature review, define the criteria to be used for the evaluation of the effectiveness addresses

The criteria that were chosen for the evaluation took into account the findings from the literature search and the application of personal experience and knowledge so as to ensure that it was well rounded and provided a holistic view of the requirements for an address, such as the implementation, usability and user requirements. It was discussed in Chapter 5. The criteria that were chosen were then further grouped into thematic areas: uniqueness of addresses, physical and digital representation of addresses, conformance with informal settlements, community response to addresses, the usefulness of addresses in other applications and the requirements for address assignment. This was done to provide a more straightforward means for understanding the effectiveness of the addresses and spoke to the differences and challenges that can be found in informal settlement across South Africa.

### 9.2.3 Objective 3: Assign alternative addresses to dwellings and evaluate the addresses against the evaluation criteria

A number of alternative addressing systems are available, so it was important to investigate as many as possible before deciding on what would be used for the evaluation. This process involved doing a literature review on various alternatives and then systematically identify which alternative addressing systems, described in Chapter 3, would be the most appropriate for implementation in a South African context. The selection criteria took into account the characteristics of the addressing systems, such as the scale that the addressing was done at, the extent it covered, and licensing conditions required. This process resulted in the choice of What3Words, Mapcode, and a datum-based address.

After the assignment of the three alternative addresses was completed, the resultant addresses and the process that was undertaken to perform the assignment were then evaluated. The evaluation was conducted using a set of 14 criteria that were formulated and outlined in Chapter 7. These criteria are based on literature. An important factor in the evaluation was the ability of the alternative addresses to anticipate and effectively handle the rapid changes within these settlements. From the evaluation of the three addresses, it is clear that deciding on a particular alternative address that performed the best was quite a complex process, as each type of address had both strengths and weaknesses in different areas of the evaluation.

### 9.2.4 Objective 4: Based on the results, draw conclusions and recommendations on the use of alternative addresses in informal settlements

The assignment of these alternative addressing systems was only conducted in two informal settlements, and these informal settlements do not represent all urban settlements in South Africa. Therefore, this evaluation should be performed on a larger number of informal settlements as well as other settlement types to understand better the effectiveness of the addresses used. The implementation of an appropriate address is a complex process in which a number of factors must be taken into account.

Upon the evaluation of the alternative addresses used in this project, it was clear that the alternative addresses had both advantages and disadvantages. Therefore, there are a number of factors that must be taken into account with regard to the layouts of informal settlements in order to implement an effective alternative address that can be applied to all informal settlements, such as the possibility of expansion and increasing density of these settlements.

## 9.3 Conclusion

The evaluation of the alternative addresses highlighted both the strengths and weaknesses of the alternative addresses. From the three alternative addresses, the datum-based address was the only addressing system that did not produce any duplications. However, this was only possible because it was tailored to assign unique addresses in the study areas. In order to implement an address such as this, it would require the development of a custom system, and this may not be a feasible option for long-term maintenance. Whereas Mapcode and What3Words are both established addressing systems that have been used for other services, such as logistics and emergency response in South Africa, the datum-based addressed has not been tested in a 'real-life' scenario.

Although Mapcode produced the largest number of duplicate addresses, the addressing system does have the capability of assigning addresses at smaller scales. The smaller resolution employed by What3Words resulted in far less duplication compared to Mapcode. It would be important to determine what that scale would be best for ease of use. However, What3Words would require licensing to be implemented by municipalities because its free services are limited to personal use. This is not the case with Mapcode and the datum-based address, which both are freely available. It is difficult to know whether people in informal settlements would be willing to accept an address that consists of three words, compared to the code format of Mapcode and the datum-based address. As this was a desktop study, it was not possible to engage with people to confirm what their thoughts are of these alternative addresses.

Addresses are a critical part of urban living, and this evaluation can be beneficial to guiding planning efforts by the government. It is important to ensure that they are not overlooked so that everyone can have access to the services that are afforded by having an address.

## 9.4 Future work

It would be beneficial to engage the community in order to determine their opinions of the various addresses. These engagements would be able to provide a better understanding of what the community members would consider being an appropriate address that is in line with their social and civic identity (Paar and Rekittke, 2011). For instance, an address based on English words may not be appropriate in a community of predominantly non-English speakers. Engagement with stakeholders responsible for address assignment would also be helpful in gaining an understanding of what should be considered for an address to be effective,

Making use of other study areas would also assist in gaining a better understanding of the effectiveness of these addresses, not only including other informal settlements but including

refugee camps and settlements that are more transitional in nature. The inclusion of other evaluation criteria, both quantitative and qualitative, would be helpful in expanding the range of the various components or address and address assignment that can be evaluated. It would also be useful to use different addressing methods, such as Open Location Code, in the evaluation as there are a number of options that are available and consider using different data to determine the locations of dwellings, such as the use of image classification on raster data.

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# Annexure 1. SQL used for datum-based addressing

**CT Section**

```
--Creating the axes
SELECT ST_Extent(geom)
FROM ct_4326;
SELECT ST_SetSRID(ST_Extent(geom),4326) as bextent
INTO ct
FROM ct_4326;
--y axis
SELECT ST_MakeLine(ST_MakePoint(ST_XMIN(ST_SetSRID(ST_Extent(geom),4326)
),ST_YMIN(ST_SetSRID(ST_Extent(geom),4326)
)),ST_MakePoint(ST_XMIN(ST_SetSRID(ST_Extent(geom),4326)
),ST_YMAX(ST_SetSRID(ST_Extent(geom),4326) )))
INTO ct_liney
FROM ct_4326;
--x axis
SELECT ST_MakeLine(ST_MakePoint(ST_XMIN(ST_SetSRID(ST_Extent(geom),4326)
),ST_YMIN(ST_SetSRID(ST_Extent(geom),4326)
)),ST_MakePoint(ST_XMAX(ST_SetSRID(ST_Extent(geom),4326)
),ST_YMIN(ST_SetSRID(ST_Extent(geom),4326) )))
INTO ct_linex
FROM ct_4326;
--Creating the address
SELECT * FROM ct_4326 AS ct;
SELECT ct.id, MIN(x.lengthx)as lengthX, ct.geom
INTO ct_new
FROM public.ct_4326 ct, public.line_x x
WHERE ST_Crosses(ct.geom, x.geom)
GROUP BY ct.id
SELECT ct.id, MIN(y.lengthy)as lengthY, ct.geom
INTO ct_new2
FROM public.ct_4326 ct, public.line_y y
WHERE ST_Crosses(ct.geom, y.geom)
GROUP BY ct.id
SELECT ct_new.id, ct_new.lengthX, ct_new2.lengthY, ct_new.geom
INTO ct_updated
FROM ct_new, ct_new2
WHERE ct_new.id=ct_new2.id
ORDER BY ct_new.id
SELECT ct_updated.id, ROUND(ct_updated.lengthx+1000) as new_x,
ROUND(ct_updated.lengthy+2500) as newq_y, ct_updated.geom
INTO ct_updated2
FROM ct_updated
SELECT ct_updated2.id, CONCAT(new_x, '.', new_y) as nmbr, ct_updated2.geom
INTO ct_done
FROM ct_updated2
```

**Alaska**

```
SELECT ST_Extent(geom)
FROM alaska_settlement_valid;
SELECT ST_SetSRID(ST_Extent(geom),32735) as bextent
INTO alaska_dtm
FROM alaska_settlement_valid;
--y axis
SELECT ST_MakeLine(ST_MakePoint(ST_XMIN(ST_SetSRID(ST_Extent(geom),32735)
),ST_YMIN(ST_SetSRID(ST_Extent(geom),32735)
)),ST_MakePoint(ST_XMIN(ST_SetSRID(ST_Extent(geom),32735)
),ST_YMAX(ST_SetSRID(ST_Extent(geom),32735) )))
INTO alaska_yaxis
FROM alaska_settlement_valid;
--x axis
SELECT ST_MakeLine(ST_MakePoint(ST_XMIN(ST_SetSRID(ST_Extent(geom),32735)
),ST_YMIN(ST_SetSRID(ST_Extent(geom),32735)
)),ST_MakePoint(ST_XMAX(ST_SetSRID(ST_Extent(geom),32735)
),ST_YMIN(ST_SetSRID(ST_Extent(geom),32735) )))
INTO alaska_xaxis
FROM alaska_settlement_valid;
-- creating address
SELECT * FROM alaska_settlement_valid as al;
SELECT al.gid, MIN(x.dist_x) as LengthX, al.geom
INTO al_new
FROM public.alaska_settlement_valid al, public.length_x x
WHERE ST_Crosses(al.geom, x.geom)
GROUP BY al.gid
SELECT al.gid, MIN(y.dist_y)as LengthY, al.geom
INTO al_new2
FROM public.alaska_settlement_valid al, public.length_y y
WHERE ST_Crosses(al.geom, y.geom)
GROUP BY al.gid
SELECT al_new.gid, al_new.LengthX, al_new2.LengthY, al_new.geom
INTO al_updated
FROM al_new, al_new2
WHERE al_new.gid=al_new2.gid
ORDER BY al_new.gid
SELECT al_updated.gid, ROUND(al_updated.lengthx +3200) as new_x,
ROUND(al_updated.lengthy +4500) as new_y, al_updated.geom
INTO al_updated2
FROM al_updated
SELECT al_updated2.gid, CONCAT(new_x, '.', new_y) as nmbr,
al_updated2.geom
INTO al_final
FROM al_updated2
```