



# **The Impact of the Built Environment on Resilience to Crime in Khayelitsha, South Africa**

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## ABSTRACT

South Africa is struggling to control the markedly high rate of crime experienced within its borders. Despite various attempts at controlling crime and disorder, little effort has been made to understand why there are certain neighbourhoods experiencing lower crime rates than what would be expected given their theoretically disadvantageous settings. Understanding what is driving this resilience to crime could aid policy-makers to develop initiatives that aim to increase the resilience to crime in neighbourhoods throughout South Africa. While crime affects the lives of nearly every South African, its impact is felt particularly severely by those residing in informal settlements. This research hopes to add to the sparse research on neighbourhood resilience to crime which has not yet been investigated in a quantitative and systematic way in South Africa.

Drawing on theories from environmental criminology, this research identifies neighbourhood-level built factors that promote resilience to crime in neighbourhoods in Khayelitsha with theoretically disadvantageous settings. We used crime data from 2006-2016 and socio-economic data to develop a Crime Resilience Index for Khayelitsha (CRIK) which quantifies the level of resilience to crime in neighbourhoods throughout the township. The relationships between the CRIK and a set of built neighbourhood-level factors were then examined to identify the built factors that drive resilience to crime.

According to the findings of this research, the most resilient neighbourhoods in Khayelitsha experience decreased access to various built environment factors, when compared to the least resilient neighbourhoods. That is, resilient neighbourhoods in Khayelitsha had moderately decreased access to a range of healthcare, education, and living infrastructures. Resilient neighbourhoods were also found to have decreased access to legally licensed liquor outlets but not with a significant association or the level expected from previous literature.

This research has contributed to the investigation of neighbourhood resilience to crime by identifying the neighbourhood-level built factors associated with resilience to crime. Further "place specific" resilience research in South Africa could aim to better understand the differences, as well as similarities, that exist between neighbourhood-level resilience in different settings.

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# 1. INTRODUCTION AND OVERVIEW

## *1.1 Background*

South Africa has a markedly high rate of crime. The country is struggling to control the daily crime that affects citizens, throughout the country. Khayelitsha, a partially informal township located in the Western Cape of South Africa, is not immune to this country-wide concern. Indeed, the Khayelitsha police precinct had a total of 8,839 crimes reported in 2017 alone (Crimestatssa.com, 2018) ranking it 8<sup>th</sup> in the worst ten precincts in the Western Cape for 2017, according to Crime Stats SA.

Khayelitsha has a population of roughly 400,000 and a population density of 10,000 per square kilometre. The township is subdivided into 28 sub-places according to the 2011 Statistics South Africa census. The census data makes use of several levels of dissemination. Small area layers (SAL) refer to the unit of dissemination that is a level lower than that of sub-places. These small area layers are created from a combination of all enumeration areas with a population less than 500, with adjacent enumeration areas within the same sub-place. Within the context of this study, each small area is considered a neighbourhood. Of course, while crime is notoriously high in Khayelitsha, the crime rates vary from neighbourhood to neighbourhood, with some neighbourhoods experiencing extremely high rates of violent crime and others much lower rates of violent crime than what would be expected given their similar environmental conditions. It is therefore necessary to determine why some neighbourhoods experience lower crime rates than can be expected, considering their theoretically disadvantageous environmental conditions. These “resilient” neighbourhoods can be used to determine which combination of built neighbourhood-level factors are resulting in these lower crime rates. These factors can then be used to inform decision-makers, in planning initiatives to improve the crime rates throughout Khayelitsha, and perhaps across the country.

There are many different meanings associated with the term resilience. This can be largely attributed to the complex and multi-dimensional nature of the term. Three classifications of resilience were identified by Rogers (2013): organisational, technological, and community resilience.

Organisational resilience can be defined as the ability of an organisation to anticipate, prepare for, react and adjust to any incremental change or sudden disturbance in order to survive and flourish (Denyer, 2017). This notion



describes the ability of an organisation to anticipate a change, but also to develop ways to simultaneously improve the organisation. Technological resilience is defined as the ability of a physical system to be able to perform at an acceptable and desired level when subject to various external forces or internal failures (Cairns, 2004), while community resilience is defined as the ability of a community to cope and adapt to challenges and adversity in a way that will promote successful achievement of the desired result. Accordingly, a resilient community is a community that is able to utilise the resources available to them in order to respond to, and recover from, an adverse situation in a positive manner. Moreover, a community that is resilient to crime is a community that is able to overcome adverse circumstances in a way that not only reacts to, but also proactively reduces the possibility of such criminal activity occurring. To date, very little research has been undertaken regarding what makes South African neighbourhoods resilient to crime in the face of theoretically disadvantageous settings.

Most scientific research has explored the concept of community resilience in the context of natural disasters or hazards (see Adger, 2003; Morrow, 2008). Resilience is a relatively new concept in criminology and as a result there has been very little research examining the resilience of communities to long-term, chronic adverse outcomes such as crime.

The majority of crime resilience research that has been performed has focused on the individual level, opposed to the community level. These research studies have, for examples, examined the resilience of individuals to sexual assault (see Bonanno, 2013), the resiliency factors among victims of child abuse (see DuMont et al., 2007), and what drives resilience amongst witnesses to family violence (see Ward et al., 2007).

Criminological theories study criminal behaviours and the criminal justice system. These theories are abstract in nature and form part of a much broader social science study that attempts to explain human behaviours and society (Akers, 2013). The aim of an environmental criminological theory is to gain an improved understanding of crime and its causes, by focusing on the locations, spaces, and objects that have either facilitated or prevented the criminal behaviour from occurring in space (Randa, 2014). Environmental criminology is a perspective which considers the causes of crime in a particular neighbourhood or area to be related to the nature of that area's environment, broadly speaking. There are several environmental criminological theories that can be examined in

order to better understand the role of neighbourhoods in affecting crime. These include the routine activities theory (see Cohen and Felson, 1979), rational choice theory (see Cornish and Clarke, 1987), and the social disorganisation theory (see Shaw and McKay, 1942). We will make use of the social disorganisation theory to guide one particular aspect of this research.

Environmental criminological theories such as the social disorganisation theory are well suited to examine the effects of neighbourhood-level factors on the community resilience to crime because they shift the focus from the criminal offender to the place-based or spatial factors of the environment in which the crime is occurring.

### ***1.2 Problem statement***

A number of neighbourhoods in Khayelitsha, South Africa have lower crime rates than what would typically be expected given their theoretically disadvantageous settings. It is not yet known whether or which built neighbourhood-level factors may possibly drive this resilience to crime in these neighbourhoods.

### ***1.3 Research questions***

This research hopes to provide answers for the following questions:

- i. Can environmental criminological theories be drawn upon to better understand what drives resilience amongst communities in Khayelitsha, South Africa with theoretically disadvantageous settings?
- ii. Can the level of resilience to crime in neighbourhoods of Khayelitsha, South Africa be quantified?
- iii. Which neighbourhoods within Khayelitsha “overachieve” in terms of low crime rates despite theoretically disadvantageous environmental factors?
- iv. Which built neighbourhood-level factors are driving the resilience to crime of neighbourhoods in Khayelitsha?

### ***1.4 Research aim and objectives***

The aim of this research is to identify which built neighbourhood-level factors make communities more resilient to crime despite their theoretically disadvantageous settings.

In order to achieve the aim of this research a number of objectives have been identified:

- i. To investigate which environmental criminological theories can be used to better understand what drives resilience

- ii. To identify the neighbourhoods within Khayelitsha that “overachieve” in terms of low crime rates despite their theoretical disadvantageous environments
- iii. To construct a crime resilience index which can quantify the level of resilience to crime, of each neighbourhood in Khayelitsha
- iv. To identify the built neighbourhood-level factors that drive resilience to crime in Khayelitsha

### ***1.5 Significance of the research***

This research is significant as it aims to identify which built neighbourhood-level factors drive resilience to crime in neighbourhoods in an extremely impoverished community. Previous research has not yet been conducted in this uniquely South African context.

This research uses a number of spatial analysis techniques to determine the built neighbourhood-level factors that drive resilience to crime in the neighbourhoods of Khayelitsha, South Africa. This cross-disciplinary approach applies spatial analysis techniques, using a geographic information system (GIS), in order to add a necessary spatial dimension to the research. This approach to research is significant, as it applies GIS and criminological theories to the concept of crime resilience, in a way that has not been widely utilised in previous studies.

### ***1.6 Type of research***

This empirical research involves the modelling and statistical analysis of crime and census-based neighbourhood-level data of Khayelitsha. The research is quantitative research in that it involves the use of regression modelling to construct a statistical index that provides a measure of crime resilience per neighbourhood where after each neighbourhood is classified as a resilience quintile of one (low resilience) to five (high resilience). A spatial analysis was also performed to determine the access of each resilience quintile to various built environment factors.

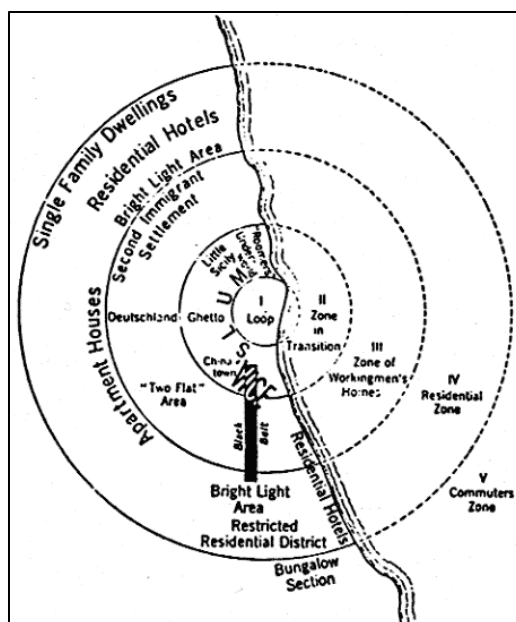
Moreover, this research is data-driven and concerned with the generation of new knowledge. That is, to determine the neighbourhood-level built environment factors influence the resilience to crime in neighbourhoods throughout Khayelitsha, Cape Town and developing a theoretical explanation of the findings. To date, no research has examined resilience to crime in impoverished settlements.

## 2. THEORETICAL FRAMEWORK

The application of spatial analysis to the study of crime began in early 19th century France by Martin Guerry, who published his essay on moral statistics of France in 1832. His work became one of the foundations upon which modern social sciences and criminology are based (Friendly, 2007). In this work, Guerry presented tables and thematic maps that showed that crime and suicide rates in France remained stable over time, when broken down by age, gender, region and time of year. The regularity of social factors created the possibility that human actions, such as crime, could be described by social laws.

Modern work however, examining the spatial dimension of crime has its roots in the work of Shaw and McKay (1942), who developed their social disorganisation theory of crime at the Chicago School of Urban Sociology in the 1940s.

In their work the researchers examined the distribution of delinquency among various groups in Chicago and attempted to identify the causes of high delinquency rates in certain neighbourhoods. Shaw and McKay's (1942) found that delinquency reduced outward from the centre of the city, and that neighbourhoods with high levels of delinquency also experienced high levels of social problems. They found that the central business district of cities, which tended to have no residential areas, exhibited high delinquency rates. They also identified that the zone of transition, just outside of the central business district, in which there is mixed land use, high residential mobility, heterogeneity and low income, had the highest rates of delinquency over time. They surmised that these areas had no social control or a sense of community and were socially disorganised. The zone of workingman's homes and the zone of white-collar workers located further away from the city centre displayed lower residential mobility, as well as less heterogeneity. These zones also displayed less delinquency and far greater social control. The zone of suburbia displayed the lowest crime rates, but also displayed good social control and very little residential mobility, high incomes and a highly homogenous population.



**Figure 1:** Concentric Zone Model applied to Chicago of the 1920s (Robert et al., 1925)

Shaw and McKay (1942) argued that it was the neighbourhood characteristics of Chicago which influenced the levels of delinquency being experienced and not the biological make-up of the delinquent as was the prevailing knowledge of the time. Their research was important as it meant that place matters and the cause of crime is not due to inferior biology or ethnic pathology, but rather due to the environment in which the crime is occurring.

The social disorganisation theory argues that a high degree of social and economic deprivation, high population turnover, and ethnic heterogeneity results in socially disorganised neighbourhoods which have an increased risk of crime and delinquency. The theory relates demographic, economic, social, family disruption and urbanization, as factors to crime (Andresen, 2006). More recently, the factors of ethnic composition, education level, population density and other variables that measure a neighbourhood's stability, have been applied to test the applicability of the social disorganisation theory in contexts outside of Chicago (see Sampson and Groves, 1989).

Sampson, Raudenbush, and Earls (1997) expanded on the social disorganisation theory by hypothesizing that collective efficacy was linked to reducing violence. They defined collective efficacy as the social cohesion occurring among neighbours in combination with their willingness to intervene on the behalf of the common good (Sampson et al., 1997). Multilevel analyses has shown that an increase in collective efficacy results in a higher

inter-neighbourhood reliability and a reduction in violence (Sampson et al., 1997). Modern social disorganisation theory combines the influence of neighbourhood-level ecological factors, with the concept of collective efficacy, to explain neighbourhood crime rates. This study further elaborated on the theory of social disorganisation by identifying collective efficacy, as the intervening variable between the characteristics of a neighbourhood and crime.

Collective efficacy can be used to explain why socially disorganised places have not yet been able to establish a common set of values or a sense of community (see figure 2). This can be attributed to a high population turnover and ethnic heterogeneity which may hinder solutions to crime (Andresen, 2014). If an area is not cared about by its inhabitants, or neighbours do not communicate, then few individuals will be able to identify criminal offenders (Andresen, 2014).

Critics of the social disorganisation theory note that some of the measures of social disorganisation rely on circular logic (Simpson, 2000). Circular logic is a logical fallacy that occurs when evidence is provided for the validity of a statement, which has already assumed the validity of the statement (X is true because Y is true, and Y is true because X is true). This criticism was made of Shaw and McKay's work, as they did not clearly differentiate between crime, as an output of social disorganisation, and the social disorganisation itself (Simpson, 2000).

Other critics also note that the social disorganisation theory cannot account for the individual or groups, in the same neighbourhood, that remain crime free or why a few individuals commit a highly disproportionate amount of the crime in an area (Walsh and Hemmens, 2011). These groups or individuals that are remaining crime-free can be said to be resilient to crime.

The social disorganisation theory now falls within a criminological school of thought termed environmental criminology. The term was coined in 1971 by C. Ray Jeffery, who called for a new school of thought within criminology to allow for better understanding of the environment in which crime occurs (Friendly, 2007). Environmental criminology is a collection of theories that share a mutual interest in criminal events and the immediate environments in which they occur (Wortley and Townsley, 2016). Environmental criminologists search for spatial patterns of crime and provide an explanation for these events, in terms of the environmental factors at play (Wortley and Townsley, 2016). They then derive models or theories that allow predictions to be made about

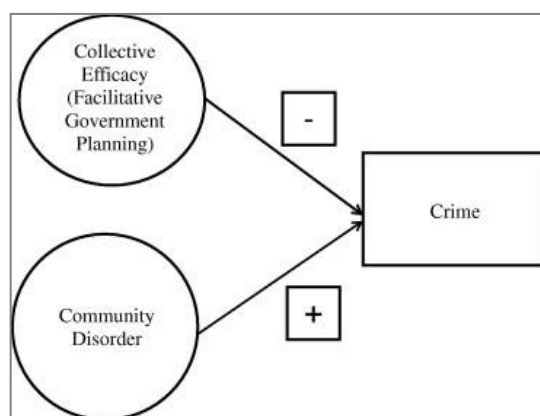
criminal behaviours, which can be used to inform decision-makers in the development of strategies that work to prevent crime (Wortley and Townsley, 2016).

Environmental criminology concentrates on the spatial location of crime, and how an individual's behaviour can be influenced by place-specific factors (Cozens, 2011). The social disorganisation theory was the seminal work that influenced the advent of environmental criminology but in addition to the social disorganisation theory, there are a variety of other environmental criminology theories that have been developed since, that place focus on different causal factors. We will make use of the social disorganisation theory to guide one the selection of variables for use in regression modelling to construct a statistical index that provides a measure of crime resilience per neighbourhood.

A second major environmental criminological theory is the routine activities theory of Cohen and Felson (1979). The RA theory argues that in order for a crime to occur there must be a convergence in space and time of the three essential elements: a motivated offender, a suitable target for crime, and the absence of a capable guardian, (see figure 3). This convergence of factors in space and time emphasizes the circumstances in which offenders will carry out criminal acts and not the characteristics of the offender themselves (Cohen and Felson, 1979). The presence of a guardian is assumed to deter offenders as they are then more motivated to act rationally. Some scholars have criticized that this theory fails to take into account the possibility that when crime becomes more difficult to commit in a certain location, then offenders are likely to commit their crimes in a different location (Lilly et al., 2010). Nevertheless, the theory remains seminal in this school of thought.

Another environmental criminological theory includes the rational choice theory of Cornish and Clarke (1986), which argues that offenders are rational in their decision-making, and can recognize, evaluate and respond to a variety of environmental factors and signals that are related to perceived risk and reward (Cozens, 2011). This theory refers to a reasoning criminal, whose criminal behaviour could be portrayed as rational, normal and commonplace (Cornish and Clarke, 1986). This theory argues that offenders will choose to commit a crime, only after considering both personal and situational factors. Therefore criminal behaviour is a product of careful thought

and planning. Several scholars have criticized that the rational choice theory assumes that all offenders are capable of making rational decisions (Schmalleger, 2011).



**Figure 2:** Sampson and Raudenbush's collective efficacy model (Rukus and Warner, 2013)



**Figure 3:** Routine Activities Theory (Sampson, 2013)

The crime pattern theory, a fourth environmental criminological theory, is closely related to the RA and rational choice theory and was developed by Brantingham and Brantingham (1995). This theory argues that there is a much stronger impact of place within the thought process of a criminal offender, then what was believed prior. Brantingham and Brantingham (1995), discussed the concepts of crime generators and crime attractors in the environment. Crime generators are the areas or facilities to which a large number of individuals are attracted such as shopping precincts, sports stadiums, and entertainment districts. Crime generators can produce crime by creating factors that attract concentration of people. Crime attractors, on the other hand are areas or facilities that create criminal opportunities such as: bar districts, insecure parking facilities, and large shopping malls. By identifying crime generators and attractors, Brantingham and Brantingham (1995) formed a foundation upon which the identification of environmental factors that impact neighbourhoods, can be based.

It is important to note that no single theory can adequately explain crime in every context and most often these theories are integrated in order to understand criminal behaviour in a more complex and complete manner.



### 3. LITERATURE REVIEW

#### *3.1 Crime, place and social disorganisation*

The opportunity for crime is created by the interaction of a potential offender with the potential target in a setting that makes crime easy, safe and profitable. This setting is the environment in which the crime occurs and it will display certain characteristics that create the opportunity for crime to take place. Research is increasingly being conducted to examine the relationship between crime and the environments in which it takes place.

The purpose of this study is to determine how the built environment of a neighbourhood can impact on the level of crime that may or may not occur there, despite theoretically disadvantageous neighbourhood settings. However, what a neighbourhood is, as well as its spatial extent, can be defined in many different ways, and must be defined for the context of this specific study. Neighbourhoods are a commonly utilised study area in the literature although they can be defined in many different ways. For example, a neighbourhood can be simply defined as the unit around an individual's home (Duncan et al., 2014), or it can be defined as the clusters of people who live in close proximity to each other in a specific geographical area (Avison, Aneshensel, Schieman, and Wheaton., 2009). While the former definition provides a simple demonstration of the explicit geographical context of the term neighbourhood, the latter definition defines neighbourhoods from a social perspective, in terms of the presence of connected persons. Furthermore, a structural dimension can be provided for the term neighbourhood, in that it can be expressed as the composition of socioeconomic and demographic characteristics of individuals that reside within a geographical area (Avison et al., 2009). The exact interpretation of the concept neighbourhood varies from study to study, however, in the context of this research study it will refer to a geographic area that is formed by administrative boundaries demarcated by the 2011 South African census as a small area.

Several research studies have been conducted that examine the impact of various neighbourhood-level characteristics on crime. These characteristics may directly impact on crime or increase the likelihood that criminal activity may occur and include built environment features such as risky places (see Eck, Clarke and Guerette, 2007; Felson, 1987) and alcohol outlets (see Day, Breetzke, Kingham, and Campbell, 2012) and. Eck et al. (2007) explored the concept of risky facilities that were associated with increased risk of neighbourhood crime, such as hospitals,

schools and train stations. Day et al., 2012 concluded that having a greater geographic access to alcohol outlets was associated with an increase in violent offences across the study area of New Zealand, while Hay, Whigham, Kypri and Langely (2009) found strong associations between the proximity of alcohol outlets and deprivation. This associates the levels of social deprivation with the proximity of certain built neighbourhood characteristics and the resilience to the crime of a neighbourhood.

In the present study only the built neighbourhood-level factors and their impact on resilience are examined as previous research has found that the social neighbourhood-level factors have little effect on the resilience to crime in neighbourhoods (see Breetzke and Pearson, 2015). The built environment refers to everything that is made, arranged or maintained by humans in order to fulfil human purposes to mediate the overall environment with results that affect the environmental context (McClure and Bartuska, 2011). Built neighbourhood characteristics may include healthcare, healthy living infrastructure, education, and vices. Access to each of these infrastructures can be calculated using different indicators such as measuring the distance to the nearest hospital or clinic.

While the focus of this study is to examine the impact of built neighbourhood-level factors that impact on resilience to crime in neighbourhoods of Khayelitsha, South Africa, the social disorganisation theory has been used to identify the variables that can be used to model the resilience of neighbourhoods. This study is not a test of the framework of the social disorganisation theory per se but rather utilises the theory to determine which factors drive resilience to crime in neighbourhoods.

Environmental criminological theories place great importance on the role of neighbourhoods in affecting criminality. According to the social disorganisation theory neighbourhoods with high levels of economic deprivation, racial heterogeneity, residential mobility and family disruption, were more likely to be socially disorganised and thus prone to higher crime rates. This theory was further expanded by Sampson, Raudenbush, and Earls (1997), to include the concept of collective efficacy. These researchers found that neighbourhoods that are able to share a common objective, have residents that are more likely to intervene on behalf of the common good and have reduced rates of crime.

A key consideration of the social disorganisation theory is the way society impacts on both social issues and environmental concerns. Social ecology focuses on the relationships between people and their social, economic and political environments. A study by Thompson and Gartner (2014) examined homicides that occurred in Toronto, Canada and found that a relationship exists between the homicides and the community structure in Toronto. The study found that neighbourhoods with high levels of economic disadvantage, a high population of young, black residents, and greater residential instability had higher homicide rates.

The central tenets of the social disorganisation theory have been tested on numerous occasions in varying contexts. Kennedy et al. (1991), for example, used measures of unemployment, urbanization, and poverty, and found that the effect of social disorganisation on homicides, in Toronto, Canada, was strong. Porter and Purser (2010) also tested the theory using exploratory spatial data analysis and spatial regression, in the United States, to determine the effect of marriage rates on the implementation of the social disorganisation theory. In another example, Allen and Cancino (2012) examined the effects of social disorganisation on juvenile property crime in the predominantly Latino, United States-Mexico border region. These researchers found mixed effects for the social disorganisation interactions and suggested that further comparative study between distinct geographical environments will yield greater insights on how the local context interacts with the established tenets of the social disorganisation theory.

The theory has also been tested across multiple spatial scales, from street segments (see Weisburd, Morris and Groff, 2009) to census blocks (see McCord and Ratcliffe, 2007) to whole cities and regions (see Allen and Cancino, 2012). For example, Andresen (2006) explored the spatial aspect of criminal activity in Vancouver, Canada, using social disorganisation and routine activity theory by employing a spatial regression between crime rates and socio-economic characteristics at the census tract scale. He found strong support for these two criminological theories and found in particular that high unemployment and the presence of young populations were strong predictors for crime. Locally, Breetzke (2010b) tested the social disorganisation theory by analysing the various relationships between measures of social disorganisation and violent crime rates in the city of Tshwane. This study found that that violent crime in Tshwane can be associated with socioeconomic deprivation and residential mobility. This study

additionally demonstrated that certain aspects of the Western criminological theory can apply to South Africa, but also identified important variations in the ecological dynamics of violent crime in different cultural contexts. While in most instances the theory of social disorganisation has been supported by research studies, there have been methodological issues reported by a number of researchers (Braga and Clarke, 2014).

### **3.2 Resilience**

Resilience at the community level, can be viewed as a developmental process that involves an exposure to adversity and hardship, with significant risks, that is followed by positive adaptation leading to a good outcome (Rutter, 2006).

Most scientific literature has explored the concept of community resilience in the context of natural disasters or hazards. For example, Crittenden (2001) found that after the 1991 eruption of the Pinatubo volcano in the Philippines, a town requires support from the state to engage in a comprehensive plan to guide reconstruction of a more disaster resilient community. Resilience research, in this concept, is understandable as these events often lead to significant damage to the social, natural and built environment systems.

Current literature examining resilience has predominantly focused on the factors that impact the resilience of an individual, rather than on communities. Smith, Park, Ireland, Elwyn and Thornberry (2013) for example, examined the impact of positive educational experiences in mid-adolescence on the mitigation of exposure to substantial maltreatment and the reduction of young adult antisocial behaviour. In other studies, ecological factors were found to promote or interfere with the emergence and stability of individual resilience following maltreatment during childhood (DuMont et al., 2007). Studies have also been conducted to determine the impact of sexual assault on individual resilience. For example, Bonanno (2013), found that while sexual assault is an adverse and challenging event, it results in victims being resilient.

Neighbourhood resilience in other contexts such as health has been investigated and include Tunstall, Mitchell, Gibbs, Platt, and Dorling (2007) who investigated age-specific mortality rates in Britain and found that similarly economically disadvantaged areas had varying mortality rates. They determined that there could not be just one factor responsible for these results. Van Hooijdonk, Droomers, van Loom, van der Lucht and Kunst (2007)

examined the health resilience of areas within the Netherlands, based on their socio-economic level and found that urbanisation and residential segregation based on age, ethnicity and marital status may have a significant impact on the resilience of these areas.

A number of other studies have identified that environmental factors have a significant impact on resilience in communities, including Pearson, Pearce and Kingham (2013) who examined the paradox of low mortality rates despite high social deprivation in neighbourhoods of New Zealand. The research also considered the neighbourhood characteristics that may be contributing to this positive health resilience. Area-level mortality data between 2005 and 2007, and socioeconomic data were used to develop the Resilience Index New Zealand (RINZ). This index quantified the levels of neighbourhood resilience across the country. The relationships between this measure and the built, social and physical characteristics of a city were then examined.

The study found that resilient neighbourhoods had poorer access to gambling and alcohol outlets, better access to safe drinking water, and overall lower levels of environmental deprivation. A need for a better proxy for social cohesion was also identified in communities. This study emphasized the importance of ‘place-specific’ resilience factors that can reduce the mortality rates experienced in some neighbourhoods, but may increase those rates in others. While their study attempted to determine the neighbourhood-level factors that impact on the resilience of a neighbourhood to mortality in New Zealand, the methods, and importance of the study mirror that of the intended study of neighbourhood-level factors, and their impact on resilience to crime in neighbourhoods of Khayelitsha, South Africa. While the method and modelling techniques used for this study may be similar to that of the final intended study, it is important to understand the differences between the neighbourhood-level characteristics in New Zealand, and those of a relatively impoverished township in South Africa. These differences may result in different findings and thus different conclusions.

Resilience to crime at the individual level has been well documented, but only a handful of studies have focused on the resilience of neighbourhoods to crime. Notably, Platts-Fowler and Robinson (2013) who examined the key neighbourhood features that appear to promote community resilience in Sheffield, United Kingdom, did not consider just resilience to crime but rather the resilience to a number of community pressures, such as community

safety and cohesion, health and wellbeing, and inclusion (voting, truancy, and education attainment). This study compared a number of key stressors (deprivation, income, and unemployment) against various neighbourhood measures, including the rate of crime. The study then ranked neighbourhoods in Sheffield based on how often they were identified as an outlier. Various neighbourhood features were identified, in both the social and physical context, as having an impact on the community resilience to crime.

Another study by Breetzke and Pearson (2015) identified the neighbourhood-level characteristics that aid in the promotion of crime resilience in New Zealand neighbourhoods. This research provided an examination of community resilience to criminal behaviour that had, in fact, not yet been explored in great detail. The findings provided an empirical identification of neighbourhood resiliency factors within communities.

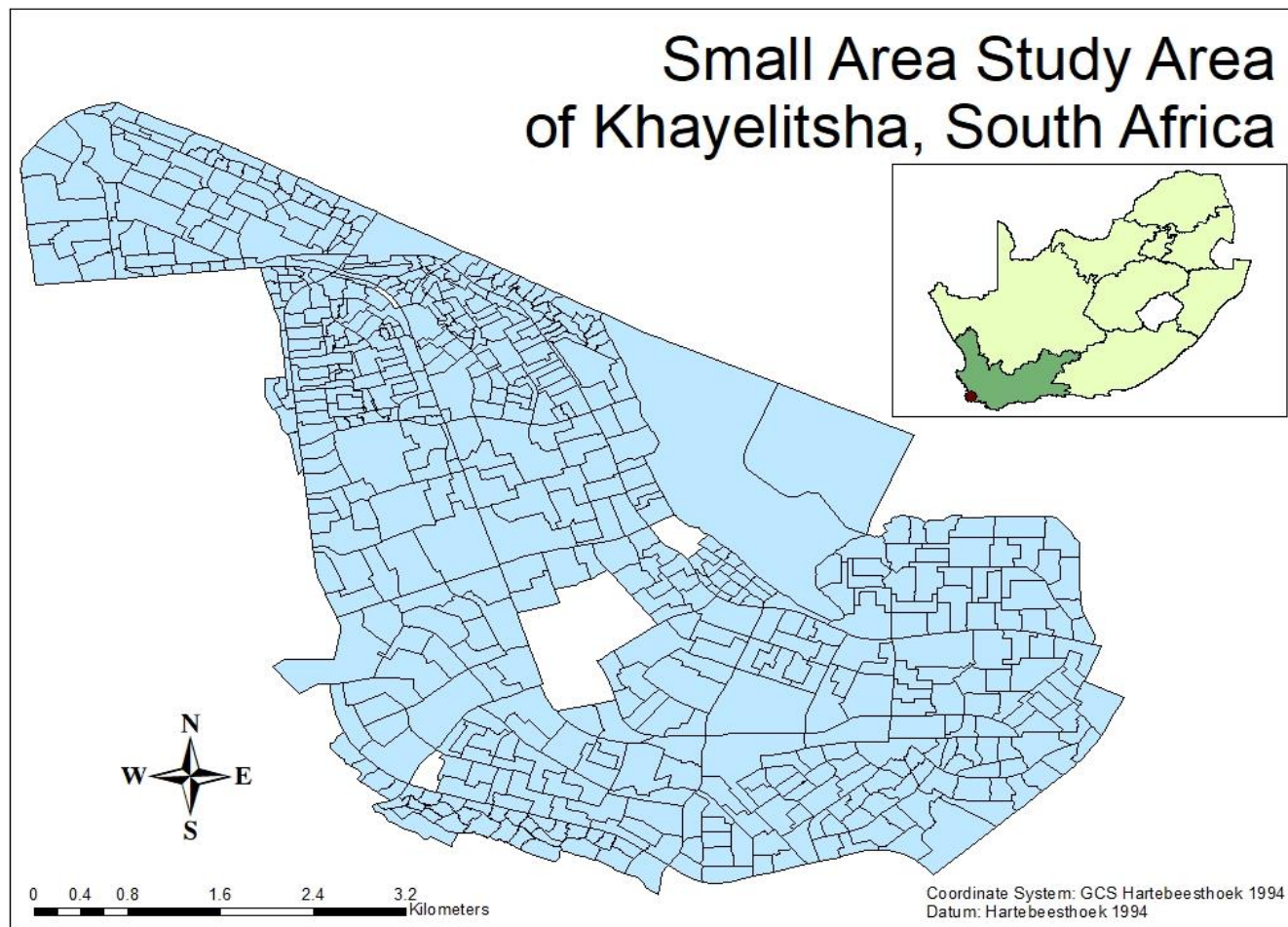
A number of environmental criminological theories were used to improve understanding of factors which drive community resilience, and then a crime resilience index was created for New Zealand that quantified the levels of resilience in each neighbourhood throughout the country. The residuals, from a regression model, were used to create this index, which was referred to as the Crime Resilience Index for New Zealand (CRINZ). This index was then used to examine the relationships with other neighbourhood factors in the social and built environments, in order to understand what can make certain neighbourhoods “overachieve” in terms of their lower crime rates, despite their theoretically disadvantageous environments.

The report identified that access to built environment factors tended to decrease across neighbourhoods stratified by resilience. Meaning, that if neighbourhoods have decreased access to various built environment factors, such as healthcare, living infrastructure and education, then they are more likely to be resilient to crime. It was found that there was very little impact of the social environment on the level of resilience to crime in New Zealand neighbourhoods.

The researchers concluded that it is vital to understand how and why certain communities respond in different ways despite being in similar environments. This can enable a community to respond more effectively to stressful environments, and thus build resilience. Additionally, they noted the importance of identifying the ‘place-specific’ resilience factors that can aid in the reduction of crime levels in neighbourhoods.

## 4. THE STUDY AREA

The study area utilised in this research is Khayelitsha, South Africa (see Figure 4).



**Figure 4:** Map of the study area: Khayelitsha, South Africa

Khayelitsha, Xhosa for “Our New Home”, is a partially informal township located in the Western Cape of South Africa. The township is an area of approximately 38.71 square kilometres and is located approximately 30 km from the central business district of the City of Cape Town. It is located on the Cape Flats between Table Bay and False Bay. The Cape Flats is a low-lying, flat area of land that is situated to the south-east of the Cape Town central business district. Townships in South Africa usually develop on the outskirts of towns and cities. Historically

these portions of land were referred to as locations that were assigned, by the Apartheid government, for non-Whites to reside in, most often forcibly under the implementation of the Group Areas Act of 1951.

While the city of Cape Town initially opposed the implementation of the Group Areas Act, which assigned racial groups to different residential and business sections in urban areas, by the 1980s, Cape Town was one of the most racially segregated cities in South Africa (Saff, 1998).

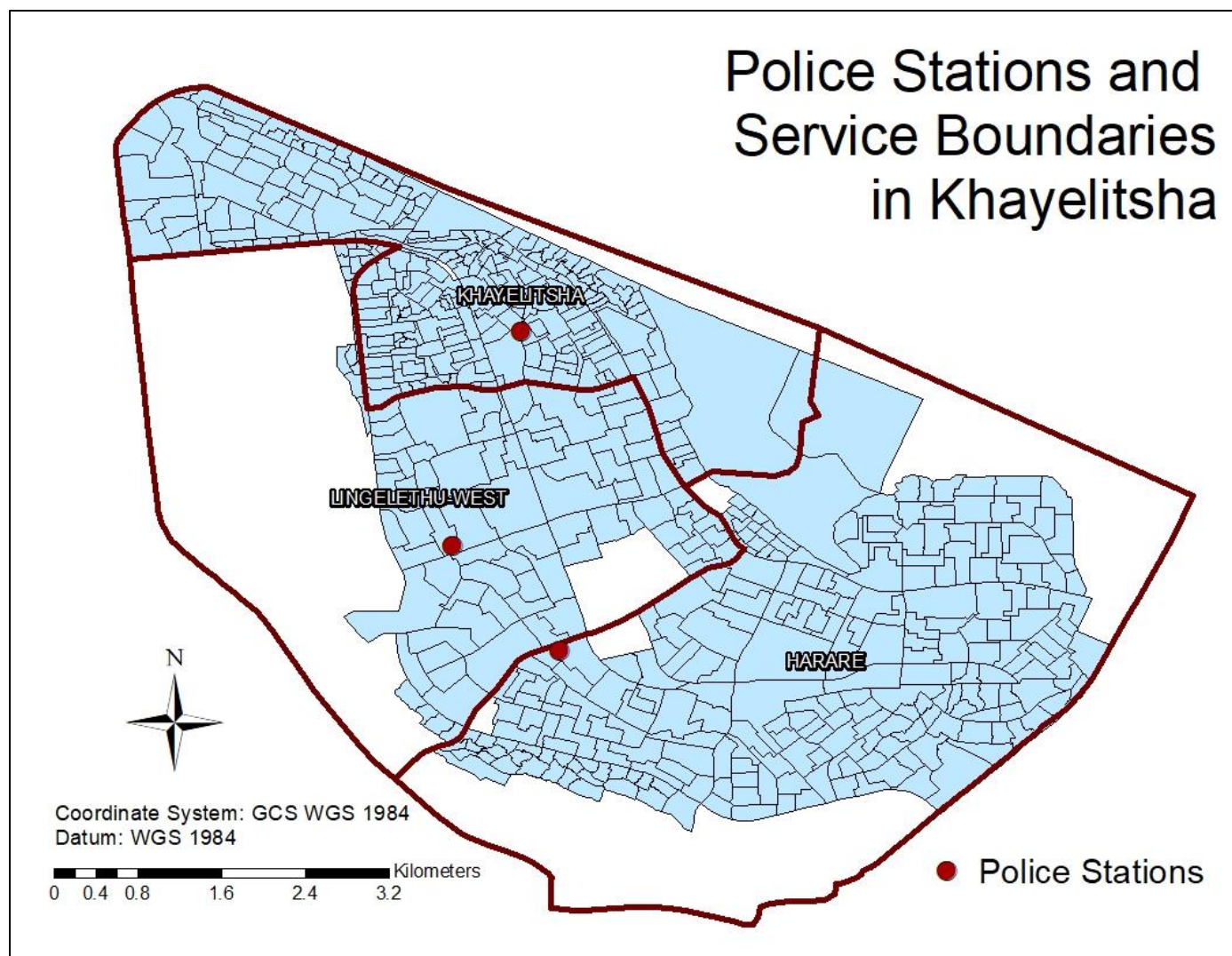
In 1983, the Minister of Cooperation and Development, Dr Piet Koornhof, announced that a 3,220-hectare site was to be established to the south-east of the City of Cape Town. This site was to house all the legal residents of the Cape Peninsula, living in squatter camps or existing townships. This was considered a solution to the rapidly increasing migration of people from the Eastern Cape, and the overcrowding of existing townships in Cape Town.

The resultant township of Khayelitsha has a recorded population of approximately 400,000, the vast majority of whom are Black African (98%), with 49% represented by the male population (SDI&GIS, 2013). There are roughly 120,000 households with a recorded average household size of 3.30, of which 45% reside in formal dwellings and 74% have a monthly income of R3, 200 or less. Only 62% of the labour force of Khayelitsha is employed and only 36% of individuals aged over 20 years old have completed Grade 12 or higher.

Khayelitsha is subdivided into 28 sub-places and 254 small areas according to Statistics South Africa (see figure 4). The South African 2011 census data makes use of several levels of dissemination. Small area layers (SAL) refers to the unit of dissemination that is a level lower than that of sub-places. These small area layers are created from a combination of all enumeration areas with a population less than 500, with adjacent enumeration areas within the same sub-place.

Khayelitsha is one of the most violent locations in urban South Africa, and ranks among the top policing areas in South Africa for violent crimes such as murder, rape and aggravated robbery. There are currently three police stations situated within the Greater Khayelitsha Policing Precinct: Harare, Lingeletu-West and Khayelitsha South African Police Force Stations (see figure 5). The causes of crimes in South African townships are numerous and vary from township to township. Du Toit and Neeves (2007) identified poverty, the transience of the population and the historical lack of effective policing as the underlying factors of violent crime in Khayelitsha.





**Figure 5:** Map of police stations and service boundaries in Khayelitsha, South Africa

## 5. DATA AND METHODS

### 5.1 Data

#### 5.1.1 Crime data

Crime data for this research study was obtained from the South African Police Services (SAPS). This data was not collected by the researcher herself as it was supplied by her supervisor. Thus the crime data for this research is secondary data. There are three police precincts in the greater Khayelitsha policing area: Khayelitsha, Lingeletu-West, and Harare. We obtained crime datasets for all three SAPS precincts in comma-separated value files (csv) and in ESRI shapefile format (shp). The crime datasets contained information such as incident code, time (hour, and minute), date (year, month, day, weekday, Sat/Sun), location (X-Coordinate and Y-Coordinate) and type of offence that occurred within Khayelitsha between 2006 and 2016.

Table 1 presents certain descriptive statistics of the crime rate per 1000 population in each neighbourhood for all crime types recorded from 2006 to 2016 in the greater Khayelitsha area. While there are a number of different categories of crime within the area of Khayelitsha, it was decided to aggregate all crimes together into a single dataset for the purpose of this research. Andresen and Linning (2012) addressed the appropriateness of aggregating across crime types when performing spatial crime analysis and found that the aggregation of crime types was only appropriate when using census tracts and dissemination areas. Aggregations can only be considered appropriate when conducting research that makes use of micro-spatial units of analysis such as street segments. Their study emphasizes the need to carefully consider the spatial units of analysis used when conducting spatial crime analysis. This is of specific importance to the study as I make use of census data at the small area layer level of aggregations, which has an average area of 0.046 square kilometres, and thus disaggregation is appropriate to aggregate the crime data although it is duly acknowledged that different crimes have different *modus operandi*'s and motivations.. However, the emphasis of this research is on examining resilience to *all crime* occurring in Khayelitsha.

### 5.1.2 Census data

The 2011 census data collected by Statistics South Africa was used to generate the independent variables used in the regression analysis. The data was obtained from the University of Pretoria, and the Supercross Interactive Data tool, and was utilised to generate the appropriate neighbourhood-level variables required. The 2011 census data is available at multiple units of aggregation, but for the purposes of this study, the small area layer level of aggregation was utilised. It is important to note that the 2011 census was the last census performed within South Africa, and is thus presently the most up to date socio-demographic data for South Africa.

### 5.1.3 Ancillary data

In order to examine the relationship between the built environment and resilience to crime in neighbourhoods in Khayelitsha, data pertaining to the built environment of Khayelitsha was obtained from the City of Cape Town Open Data Portal, the Western Cape Liquor Authority and from the Department of Basic Education (see tables 2 and 3).

**Table 1:** Count of crimes (2006-2016) and descriptive statistics of crime rate per 1000 population for each neighbourhood in the greater Khayelitsha policing area

Crime Category	N	Minimum	Mean	Maximum	Std. Deviation
Property Crime	3994	0	9.79	272.73	17.93
Sexual Crime	5415	0	12.92	292.68	20.51
Violent Crime	55999	0	137.91	3146.34	223.04
Total	65408	0	160.13	3609	258.39

Before analyses could be performed, the data required cleaning and editing. All small areas that had a population of zero were removed from the dataset. These neighbourhoods are most often examples of industrial or commercial neighbourhoods and thus contained no socio-demographic information. These neighbourhoods were removed in order to normalise the data by population. The data sets used to indicate the measures of neighbourhood built characteristics were also cleaned and edited.

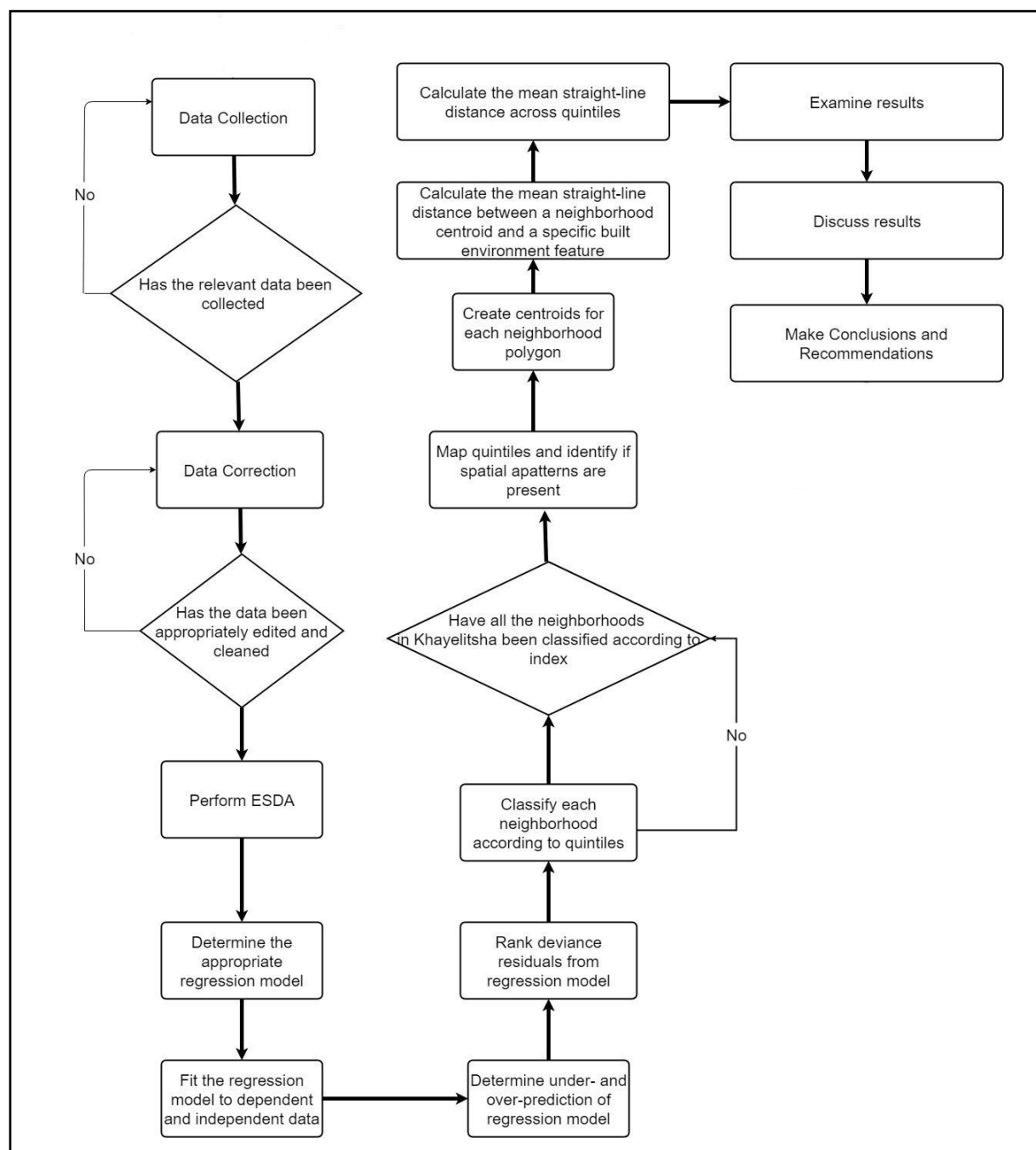
**Table 2:** Built neighbourhood factors and data sources

Characteristic	Feature	Data Source	Year
Healthcare	Clinics	City of Cape Town Open Data Portal	2016
	Fire stations	City of Cape Town Open Data Portal	2016
	Police stations	South African Police Service	2017
	Hospitals	Department of Health	2012
Living infrastructure	Community centres	City of Cape Town Open Data Portal	2016
	Community parks	City of Cape Town Open Data Portal	2016
	District parks	City of Cape Town Open Data Portal	2016
	Greenbelts	City of Cape Town Open Data Portal	2016
	Libraries	City of Cape Town Open Data Portal	2016
	Places of worship	City of Cape Town Open Data Portal	2016
	Sportsgrounds	City of Cape Town Open Data Portal	2016
	Cemteries	City of Cape Town Open Data Portal	2016
	Integrated Rapid Transport bus stops	City of Cape Town Open Data Portal	2016
	Integrated Rapid Transport bus routes	City of Cape Town Open Data Portal	2016
	Pools	City of Cape Town Open Data Portal	2016
	Cape Cares facilities	City of Cape Town Open Data Portal	2016
	Landfills	City of Cape Town Open Data Portal	2016
	Municipal courts	City of Cape Town Open Data Portal	2016
	Recreational hubs	City of Cape Town Open Data Portal	2016
	Public open spaces	City of Cape Town Open Data Portal	2016
	Waterbodies	City of Cape Town Open Data Portal	2016
Education	Primary schools	Department of Basic Education	2016
	Secondary schools	Department of Basic Education	2016
Vices	Valid license liquor outlets	Western Cape Liquor Authority	2017

## 5.2 Method

### 5.2.1 Research plan

Figure 6 shows the steps undertaken in the research.



**Figure 6:** Flow chart of the research plan

At the start of the research project, the crime data for Khayelitsha, together with the demographic data from the 2011 census and ancillary data of built environment factors in Khayelitsha were collected. Once the relevant data was collected, the data was edited and cleaned to ensure that all the data used in the research, was in the appropriate projection and at the required scale. Once the data had been appropriately corrected, exploratory spatial data analysis (ESDA) was performed. ESDA provides a foundation for spatial modelling, in a way that can highlight and explain spatial patterns that may occur in the data. ESDA also assisted in the selection of an appropriate regression model for the study.

Importantly, the method employed for this research project was divided into two parts. The first part involved the development of a crime resilience index for Khayelitsha. Once an appropriate regression model was selected the index was developed by fitting the model to the dependent and independent variables and determining areas of model over- and under-prediction. The areas of model under- and over prediction were then used to rank the deviance residuals obtained from the regression model. After ranking the deviance residuals, each neighbourhood in the study area was classified according to resilience quintiles from one (low) to five (high). Once all the neighbourhoods had been classified into resilience quintiles, Moran's I was calculated to determine if there were any apparent spatial patterns that exist. (i.e., do resilient neighbourhoods cluster together?)

The next part of the method involved an examination of the built neighbourhood-level characteristics against the crime resilience index. That is, to determine the nature of the relationship between neighbourhoods stratified by resilience and access to various built environment factors. Access to the built environment for neighbourhoods was calculated using the mean straight-line distance between the centroid of neighbourhoods and the closest built environment factor. The mean straight-line distance was then calculated for each resilience quintile, averaged per neighbourhood resilience quintile and examined, discussed and a theoretical explanation provided explaining which neighbourhood-level built environment factors influence the resilience to crime in observed neighbourhoods within the study area of Khayelitsha, Cape Town.

**Table 3:** Built environment factors in Khayelitsha

Characteristic	Measure	N
Healthcare	Clinics	15
	Fire stations	2
	Police stations	4
	Hospitals	2
Living infrastructure	Community centres	13
	Community parks	51
	District parks	2
	Greenbelts	15
	Libraries	7
	Places of worship	43
	Sportsgrounds	9
	Cemeteries	4
	Integrated Rapid Transport bus stops	39
	Integrated Rapid Transport bus routes	6
	Pools	5
	Cape Cares facilities	9
	Landfills	3
	Municipal courts	3
	Recreational hubs	5
	Public open spaces	97
	Waterbodies	130
Education	Primary schools	39
	Secondary schools	20
Vices	Valid license liquor outlets	63

### 5.2.2 Method

The Crime Resilience Index for Khayelitsha (CRIK) was developed by fitting a regression model and generating deviance residuals from the final regression model for each neighbourhood. All neighbourhoods in Khayelitsha were then classified as a quintile between one (low resilience) and five (high resilience) using these deviance residuals in order to create the CRIK. Each quintile group contained 116 or 117 SALs, for a total of 583 SALs. The dependent variable in the regression model was the crime rate per 1000 persons for each small area of Khayelitsha, over the ten year study period. A small area layer (SAL), according to the 2011 South African Census, was created by combining all the adjacent enumeration areas with populations less than 500 within the same sub-place. There are 583 SAL units that make up the study area. Table 4 shows the variation in size, the population density, and the crime rate per 1000 population between these SAL units. The SAL units in the study area are extremely densely populated, which is not an uncommon phenomenon within impoverished townships in South Africa.

**Table 4:** Descriptive statistics of the SAL units in the study area (n=583)

	Minimum	Mean	Maximum	Std. Deviation
Area (square kilometre)	0.006	0.047	1.980	0.097
Population	20	671	1729	237
Population density (per square kilometre)	42	25227	103292	15391
Crime rate (per 1000 persons)	0	160	3609	258

The dependent variable in the regression model was the crime rate per SAL per 1000 individuals. The independent variables used in the regression model were selected using the social disorganisation theory as a theoretical framework. The emphasis of this study is not on testing the framework of the social disorganisation theory per se but rather using it to select theoretically-specified variables that have been universally found to be associated with increased crime risks in neighbourhoods. The theory of social disorganisation is a now well-known theoretical perspective that has identified neighbourhoods with high levels of economic deprivation, racial



heterogeneity, residential mobility and family disruption, as being more prone to higher crime rates (Shaw and McKay, 1942). Accordingly, independent variables were selected using these factors as a basis. For example *economic deprivation* was measured using: 1) the percentage of population unemployed, 2) the percentage of individuals with highest education level being less than Grade 12, and 3) the percentage of the population earning less than R12, 800 per month per small area.

Economic deprivation is considered a key component of the social disorganisation theory, as it has been found to generally be positively associated with increased crime rates in neighbourhoods (see Livingston, Kearns, & Bannister, 2014; Martinez, Stowell, & Lee, 2010).

Identifying a neighbourhood measure of *ethnic heterogeneity* in a South African context is complicated. Indeed, the country has four ethnic groups as measured by the South African 2011 census (Black African, Coloured, Indian or Asian, or White). A study by Thompson and Gartner (2014) examined the social ecology of homicides that occurred in Toronto, Canada, and found that neighbourhoods with a high population of young, black residents had higher homicide rates. In a study in New Zealand by Breetzke and Pearson (2015), the percentage Maori (the indigenous Polynesian people of New Zealand that make up roughly 15% of the country's population), was used as a measure of ethnic heterogeneity. In order to show a measure of ethnic heterogeneity in Khayelitsha, the measure selected should exhibit some variation. Initially, racial group was considered as a possible measure (see Thompson & Gartner, 2014) but this measure of ethnic heterogeneity for Khayelitsha is nonsensical, as 98.6% of the population identify as black African. The language spoken was considered next (see Peterson & Das, 2017), but this measure of ethnic heterogeneity for Khayelitsha is inappropriate, given that 90.54% of the population are Xhosa speaking. Another measure considered was religious affiliation (see Javanmard, 2013) however, the data for religious affiliation in South Africa is presently only available at the sub place level and was collected in 2001. It was found that the majority of residents in Khayelitsha were affiliated with Christian churches (approximately 80%) but the measure was not employed due to the unavailability of the data for use at the small area level. It was still deemed necessary however, to include a measure of ethnic heterogeneity, as it is a key component in the social disorganisation theory. It was finally decided to use the percentage of people born outside the Western Cape (58%)

as a measure of ethnic heterogeneity for this study as it represents a sense of ‘differentness’ to the local community that were born and reside in the Western Cape.

Residential mobility has been used as a measure in several studies that made use of the social disorganisation theory (see Bernasco & Nieuwbeerta, 2005; Breetzke & Pearson 2015), and has been traditionally associated with the lack of cohesion and collective efficacy in neighbourhoods. This is due to the difficulty in forming bonds and integrating effectively in highly mobile communities. To represent *residential mobility*, two measures were used: 1) the percentage of Khayelitsha residents that have moved from their dwelling over the last five years, and 2) the percentage of individuals renting.

Family disruption, such as divorce or separation and single-parent households, is considered to be a factor in the prevalence of crime in neighbourhoods (see Jobes, 2004; Kwong Wong, 2012; Kwong Wong, 2011). To represent family disruption in Khayelitsha, the *percentage of individuals divorced or separated*, along with the *percentage of female-led households* was utilised.

While not a factor identified by the social disorganisation theory, *percentage male aged between 15 and 34 years of age* is a subpopulation that has been identified in previous literature as associated with an increase in crime in neighbourhoods (see Gruenewald & Remer, 2006; Hirschi & Gottfredson, 1983; Phillips, 2006). These subpopulations have been merged to represent a single measure in this study.

The descriptive statistics of the dependent and independent variables used in the study are shown in table 5. The Moran’s I statistic was used to identify whether was spatial clustering evident in the variables. In order to ensure that multicollinearity did not occur within the independent variables, a correlation matrix between the independent variables was created (see table 6).

A moderately strong correlation was found between the percentage born outside the Western Cape and percentage with an education less than a matric, which is an indication that internal migrants have lower levels of education and may migrate to the Western Cape in search of employment (see table 6). Another moderately strong correlation was found between the percentage of foreign-born and percentage renting, which indicates that most foreign-born citizens are renting and do not own property. Variables with correlation values above 0.7 were removed

from the analysis to ensure that no variables are predicting one another, avoiding multicollinearity. These variables, such as percentage foreign-born and percentage people born outside the Western Cape, are predicting one another, as all individuals that are born outside of South Africa were also born outside of the Western Cape.

**Table 5:** Descriptive statistics of the dependent and independent variables used in the regression model

		Min	Mean	Max	Std. Deviation	Moran's I
Dependent variable						
	Crime rate per 1000 people	0	160.6	3609.8	258.4	0.045**
Independent variables						
Social deprivation	% individuals with less than a matric education	38.5	76.4	100	7.4	0.435***
	% individuals unemployed	0	17.5	48.3	9.4	0.061***
	% individuals earning less than R12,800	32	89.9	100	12.3	0.147***
Ethnic heterogeneity	% individuals born outside of the Western Cape	12.9	57.7	95.3	12.9	0.398***
Residential mobility	% individuals renting	0	3.3	25.4	3.7	0.284***
	% individuals migrated in the last five years	0	1	10.6	1.3	0.264***
Family disruption	% female headed households	3.5	12.9	21.3	2.8	0.066***
	% individuals divorced/separated	0	1.7	5	0.9	0.040**
Males between ages 15 - 34	% males between ages 15 - 34	13.4	21.9	33.2	2.9	0.203***

\* p < 0.05 \*\* p < 0.01 \*\*\* p < 0.001

**Table 6:** Correlation matrix of the independent variables used in the regression model

	%M15_34	%ELess12	%Rent	%FHoH	%HSize6	%Bafr	%DivSep	%ILess128	%ILess64	%BOWC	%Foreign	%Mig	%Unem
%M15_34	1.0												
%ELess12	.305**	1.0											
%Rent	-.292**	-.484**	1.0										
%FHoH	.099*	.124**	-.087*	1.0									
%HSize6	-.419**	-.291**	.369**	-.319**	1.0								
%Bafr	.120**	0.0	-.223**	.104*	-.083*	1.0							
%DivSep	-.101*	-.103*	0.1	0.0	.109**	0.0	1.0						
%ILess128	.092*	.223**	-.090*	0.0	0.0	0.1	0.0	1.0					
%ILess64	.156**	.351**	-.163**	0.1	-.095*	.102*	-0.1	.980**	1.0				
%BOWC	.421**	.525**	-.328**	.124**	-.624**	.120**	-.182**	0.1	.156**	1.0			
%Foreign	-.119**	-.370**	.497**	-.163**	.301**	-.161**	0.0	0.0	-.104*	-.182**	1.0		
%Mig	-.100*	-.281**	.448**	-.147**	.291**	-.158**	0.0	0.0	-0.1	-.142**	.933**	1.0	
%Unem	.213**	.267**	-.199**	0.0	-.189**	.094*	0.0	.102*	.151**	.219**	-.181**	-.148**	1.0

\*\*. Correlation is significant at the 0.01 level (2-tailed) \*. Correlation is significant at the 0.05 level (2-tailed).

F\_M15\_34: (% males between ages 15 – 34)

F\_ELess12: (% individuals with less than a matric education)

F\_Rent: (% individuals renting)

F\_FHoH: (% female headed households)

F\_HSize6: (% households with 6+ members)

F\_Bafr: (% individual black African)

F\_DivSep: (% individuals divorced/separated )

F\_ILess128: (% individuals earning less than R12,800)

F\_ILess640: (% individuals earning less than R6,400)

F\_BOWC: (% individuals born outside of the Western Cape)

F\_Foreign: (% individuals foreign born)

F\_Mig: (% individuals migrated in the last five years)

F\_Unem: (% individuals unemployed)

In order to select the most appropriate regression model the mean and variance of the dependent variable (crime rate per SAL) were examined. The variance over the mean was used to determine the appropriateness of the selected regression model. It was observed that the variance was over 400 times the mean. Further evidence of over-dispersion was identified after fitting a Poisson model and a goodness of fit test. (Deviance chi-square = 166,725.001, Pearson chi-square = 166,725.425, log likelihood = -54,798.416, AIC = 109,616.832). The results of these tests confirmed the use of a negative binomial regression model. In order to rule out any spatially correlated errors, Moran's I was calculated (Moran's I statistic = 0.047) which found no evidence of spatial dependence and hence the use of a spatial model was not required. Thus the final model assumed a negative binomial distribution with crime rate per 1000 population as the dependent variable and the percentage working population unemployed, percentage population with less than a matric, percentage population with less than R12, 800 income per month, percentage female head of house, percentage individuals divorced or separated, percentage renting, percentage born outside of the Western Cape, percentage migrated in the last five years, percentage population not practicing a religion and percentage males between 15 – 34 as the independent variables.

To determine the under- (low resilience) and over-prediction (high resilience) of neighbourhoods, the deviance residuals from the final regression model, were generated for each neighbourhood. The generated residuals were then ranked and grouped into quintiles of high (5) or low (1) resilience. Each quintile group consisted of multiple neighbourhoods (n = 116 or 117). These quintiles were mapped to determine if any spatial clustering was present (see Figure 8).

In order to determine the impact of certain built environment factors on neighbourhood-level resilience to crime in Khayelitsha, the relationships between the resilience index and various built environment factors were examined. Once all the neighbourhoods of Khayelitsha were grouped into quintiles, the distance from a geometric centroid produced for each neighbourhood to all the related built environment factors was calculated using straight-line distance. The mean distance to each facility was calculated for each neighbourhood and the ratio between the neighbourhoods of high to low resilience, along with the Spearman's rank correlation coefficient were also used. Finally, the p-values between the resilience quintiles and the built environment neighbourhood-level factors were calculated to determine significance.

## 6. RESULTS

The results of the regression model used to develop the Crime Resilience Index for Khayelitsha (CRIK) are shown in Table 7. The models Pearson Chi-Squared value (937.852) indicates that the model does adequately fit the data while the omnibus test p-value ( $p < 0.001$ ) indicates that the model was statistically significant. The largest significant independent effect (as shown in the Incident Rate Ratio (IRR)) was found for percentage male between 15 and 34, followed by the percentage of female-headed households and percentage of the population that rent.

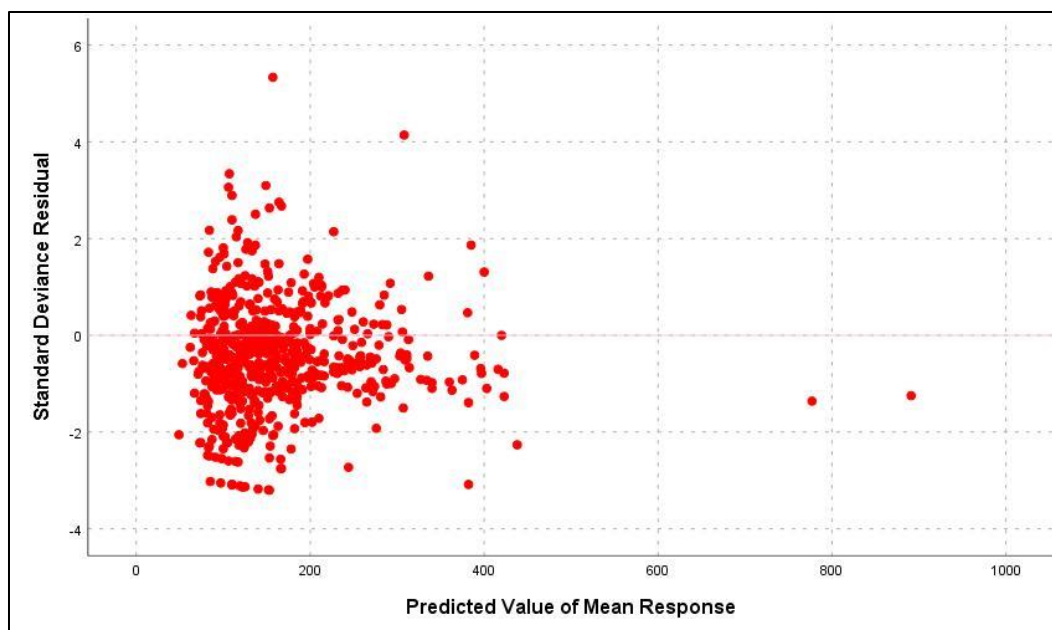
After fitting the regression model, the residuals were identified. Residuals are the errors associated with predicting or estimating outcomes. A scatter plot of the residuals is shown in figure 7 and indicates that while most of the deviations are not significantly away from zero, a number of outliers were identified as those values with standardized Pearson deviance residuals above that of absolute two. To quantify neighbourhoods of model under- (non-resilient) and over-prediction (resilient), we generated deviance residuals from the final regression model for each neighbourhood. The residuals were rank ordered and the values corresponding neighbourhoods were classed into quintiles of high (5) to low (1) resilience to create the crime resilience index for Khayelitsha (CRIK). Each quintile group contained 116 or 117 neighbourhoods, for a total of 583 neighbourhoods (see figure 8). After mapping the quintile classifications of each neighbourhood, it appeared that the quintiles were spatially random. However, Moran's I, with a queen contiguity, was computed for the quintiles ( $I = 0.2472$ ;  $p\text{-value} = 0.001$ ;  $z\text{-value} = 14.9384$ ) and found evidence of spatial clustering of resilience values (see figure 8).

An examination of the relationship between the resilience quintiles and the built environment factors are shown in Table 8. In the event that a factor fell outside of the study area but remained the closest facility to a neighbourhood it was considered to fall in the study area. Access to the built environment factors generally decreased across neighbourhoods stratified by resilience. The size of the relationship between built environmental factors and the resilience quintiles varied only slightly across the various factors, as indicated by the ratios of the distances in the high resilience quintile (five) compared with the low resilience quintile (one). The size of these relationships varied from 0.86 (for the distance to greenbelts or district parks) to 1.68 (for the distance to waterbodies).

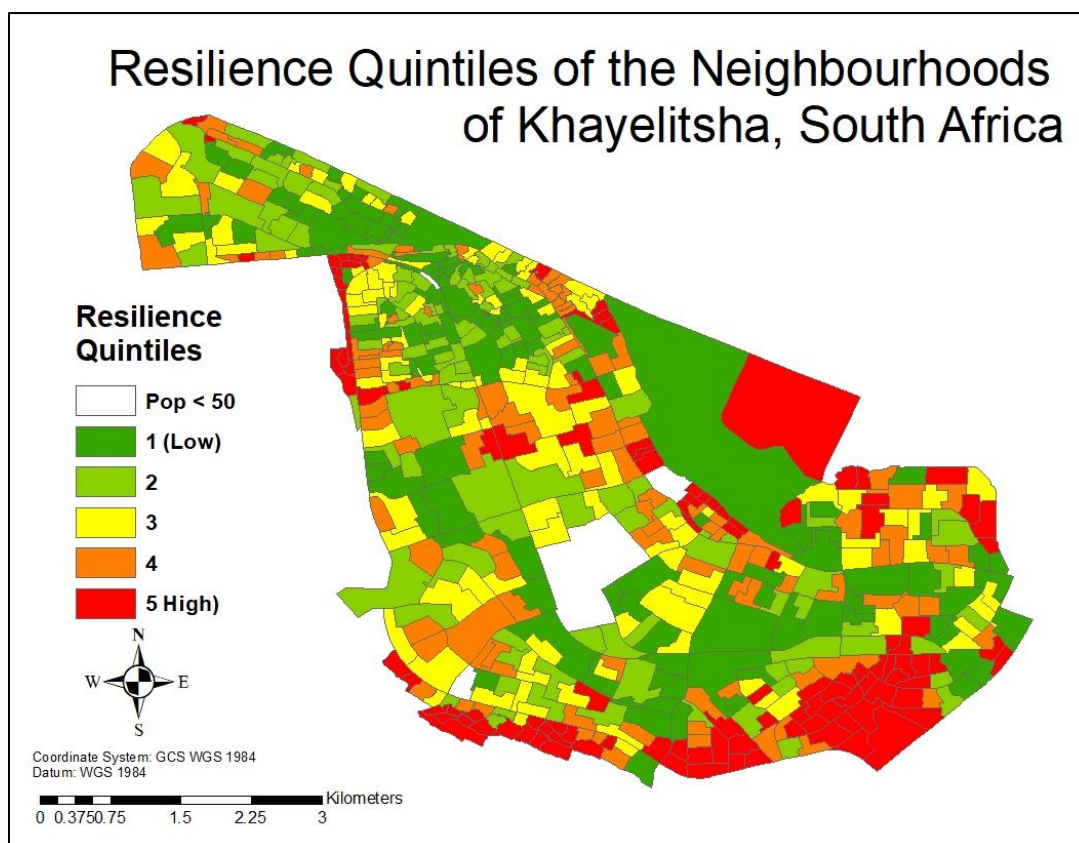
**Table 7:** Results of the negative binomial regression used to create the CRIK

					Upper	Lower
Independent Variables		IRR	SE	p-Value	95% CI	95% CI
Social deprivation	% individuals with less than a matric education	0.98	0.00	0.00***	0.98	0.98
	% individuals unemployed	1.00	0.00	0.00***	1.00	1.00
	% individuals earning less than R12,800	1.00	0.00	0.00***	1.00	1.00
Ethnic heterogeneity	% individuals born outside of the western cape	0.99	0.00	0.00***	0.99	0.99
Residential mobility	% individuals renting	1.05	0.00	0.00***	1.05	1.05
	% individuals migrated in the last five years	1.03	0.00	0.00***	1.03	1.04
Family disruption	% female headed households	1.06	0.00	0.00***	1.06	1.07
	% individuals divorced/separated	0.94	0.00	0.00***	0.93	0.95
Males between ages 15 - 34	% males between ages 15 - 34	1.07	0.00	0.00***	1.06	1.07

\* p &lt; 0.05 \*\* p &lt; 0.01 \*\*\* p &lt; 0.001



**Figure 7:** Scatter plot indicating residuals in the negative binomial regression



**Figure 8:** Map of the resilience quintiles of each neighbourhood in Khayelitsha



**Table 8:** Neighbourhood-level built environment factors organised by the CRIK

Neighbourhood Factors - Built Environment		Low		High					p-value
		R1	R2	R3	R4	R5	R5:R1	RHO	
Healthcare	Clinics (distance)	0.65	0.72	0.73	0.77	0.84	1.29	0.18*	0.00
	Fire stations (distance)	1.38	1.42	1.48	1.60	1.85	1.34	0.25*	0.00
	Police stations (distance)	1.62	1.48	1.55	1.65	2.17	1.34	0.22*	0.00
	Hospitals (distance)	2.78	2.66	2.56	2.43	2.42	0.87	-0.16*	0.00
Living infrastructure	Community centres (distance)	0.59	0.58	0.59	0.69	0.82	1.38	0.25*	0.00
	Community parks (distance)	0.46	0.41	0.37	0.39	0.46	1.02	0.01	0.87
	District parks (distance)	2.96	3.06	2.87	2.64	2.55	0.86	-0.13*	0.00
	Greenbelts (distance)	1.17	0.94	0.97	0.87	1.00	0.86	-0.08	0.06
	Libraries (distance)	0.75	0.82	0.81	0.96	1.17	1.55	0.31*	0.00
	Places of worship (distance)	0.60	0.57	0.57	0.57	0.81	1.36	0.15*	0.00
	Sportsgrounds (distance)	1.00	1.00	1.05	1.05	1.29	1.28	0.18*	0.00
	Cemteries (distance)	2.96	2.79	2.84	2.93	3.11	1.05	0.14*	0.00
	IRT bus stops (distance)	0.72	0.79	0.80	0.79	0.75	1.04	0.01	0.87
	IRT bus routes (distance)	0.50	0.50	0.54	0.50	0.58	1.17	0.05	0.22
	Pools (distance)	2.72	2.60	2.50	2.34	2.43	0.89	-0.14*	0.00
	Cape Cares facilities (distance)	0.94	1.00	0.99	1.02	1.02	1.09	0.05	0.19
	Landfills (distance)	3.35	3.22	3.03	3.05	3.43	1.02	-0.03	0.50
	Municipal courts (distance)	2.87	2.80	2.64	2.48	2.50	0.87	-0.14*	0.00
	Recreational hubs (distance)	1.38	1.30	1.30	1.44	1.99	1.45	0.27*	0.00
	Public open spaces (distance)	0.41	0.47	0.41	0.39	0.47	1.15	0.03	0.48
	Waterbodies (distance)	0.24	0.29	0.27	0.30	0.41	1.68	0.19*	0.00
Education	Primary schools (distance)	0.37	0.36	0.39	0.40	0.56	1.53	0.25*	0.00
	Secondary schools (distance)	0.56	0.50	0.52	0.52	0.74	1.33	0.21*	0.00
Vices	Valid license liquor outlets (distance)	0.42	0.35	0.35	0.39	0.44	1.04	0.04	0.37

(distance) = Distance in kilometres from centroid \*Correlation is significant at 0.01 level

The ratio (R5:R1) refers to the proportional differences in distances found between resilience quintiles 1 and 5. It was calculated by comparing the mean distance to the built environment factors from the neighbourhoods with the lowest resilience (R1) to highest resilience (R5). This ratio indicates that a resilient neighbourhood has x times the distance to travel to access a particular built environment factor when compared to the least resilient neighbourhoods.

A positive Spearman's rank coefficient (RHO) indicates that a higher resiliency in neighbourhoods is associated with a greater distance to a built environment factor. A negative Spearman's rank coefficient indicates that more resilient neighbourhoods are associated with a shorter distance to a built environment factor.

### ***6.1 Healthcare***

The ratio (R5: R1) indicates that more resilient neighbourhoods have a shorter distance to travel to access hospitals (0.87). Interestingly, resilient neighbourhoods have decreased access to clinics (1.29), fire stations (1.34), and police stations (1.34) than more resilient neighbourhoods. The Spearman's rank correlation coefficients proved significant for all built factors and while they indicated that more resilient neighbourhoods are associated with decreased access to clinics, fire stations, and police stations, it also indicated that more resilient neighbourhoods are associated with increased access to hospitals. A linear increase was found in access to clinics and fire stations across resilience quintiles, while there was a linear decrease in access to hospitals. Access to police stations was found to be moderately high in the least resilient neighbourhoods but lowers before increases linearly across the remaining resilience quintiles. According to these findings, the built environment of resilient neighbourhoods in Khayelitsha can be characterized as having predominantly decreased access to healthcare facilities with the exception of hospital access.

### ***6.2 Living infrastructure***

Resilient neighbourhoods have shorter distances to travel in order to access district parks (0.86), municipal courts (0.87), swimming pools (0.89), and greenbelts (0.86), although the latter association was not significant. These findings indicate that there is increased access to these factors in more resilient neighbourhoods, meaning

that neighbourhoods in the vicinity of district parks, municipal courts and swimming pools are more likely to be resilient to crime.

More resilient neighbourhoods were found to have decreased access to community parks (1.02), landfills (1.02), Integrated Rapid Transport bus stops (1.04), Cape Cares facilities (1.09), public open spaces (1.15), and Integrated Rapid Transport bus routes (1.17), but these associations were not found to be significant.

Access to cemeteries (1.05), sportsground (1.28), places of worship (1.36), community centres (1.38), recreational hubs (1.45), libraries (1.55), and waterbodies (1.68) were all found to be decreased in resilient neighbourhoods. Meaning that more resilient neighbourhoods have less access to these factors and these results were all found to be significant.

The Spearman's rank correlation coefficients of distance to libraries, recreational hubs, community centres, waterbodies, sportsgrounds, places of worship, and cemeteries, along with the prior mentioned living infrastructures, further indicates that the increasing distance to these factors is associated with higher resilience in neighbourhoods.

While only ten of the living infrastructure factors were found to be significant, it is clear that a distinction can be made between these factors, regarding whether they encourage or discourage neighbourhood resilience to crime. Meaning that we cannot assume resilient neighbourhoods have decreased access to *all* living infrastructures, but rather that there is a complex interplay of living infrastructure factors affecting neighbourhood resilience to crime in Khayelitsha.

### **6.3 Education**

Interestingly, resilient neighbourhoods in Khayelitsha were also found to have decreased access to educational facilities. Both primary and secondary schools have positive Spearman's rank correlation coefficients, that are significant, which indicates that the higher a neighbourhood's resilience the greater the distance to a school. However, primary schools (1.53) exhibited a greater proportional difference in distance than secondary schools (1.33). Access to both categories of schools increased linearly across resilience quintiles but the least resilient neighbourhoods in Khayelitsha were found to be situated far closer to primary schools (0.37) than secondary schools

(0.56). According to these findings, resilient neighbourhoods in Khayelitsha are situated a greater distance from educational facilities, then less resilient neighbourhoods.

#### **6.4 Vices**

The ratio (R5: R1) indicates that more resilient neighbourhoods have decreased access to validly licensed liquor outlets, although rather surprisingly this association is not significant. The distance to a validly licensed liquor outlet is 1.04 times greater among resilient neighbourhoods than less resilient neighbourhoods. The results did indicate that there is a less than 80 metre difference in access across resilience quintiles which could potential indicate that in Khayelitsha, vices do not play a role in driving resilience to crime. However, this is unlikely according to previous literature on the relationship between crime and the access to alcohol. The impact of unlicensed alcohol outlets on the neighbourhood resilience to crime in Khayelitsha cannot be ignored, and the use of this variable in future research may yield a more accurate and applicable association.

#### **6.5 Overall**

Rather surprisingly our results collectively indicate that more resilient neighbourhoods in Khayelitsha tend to have decreased access to educational facilities and healthcare facilities, with the exception of hospitals. Aside from access to district parks, municipal courts, swimming pools there is an indication that more resilient neighbourhoods in Khayelitsha have decreased access to living infrastructure, while the potential effect of vices has not been found significant using the available measure.

## 7. DISCUSSION AND CONCLUSION

Resilience, as a concept, has not yet been adequately formalised in the field of environmental criminology. Resilience, as a term in itself, is appealing as it suggests an optimistic prospect for the impoverished communities in South Africa that are commonly associated with high crime risks. Determining which characteristics of the built environment can promote resilience to the various risk factors in informal communities is a crucial tool for planners and policymakers, as well as law enforcement, tasked with reducing crime and protecting these communities. In this study, we attempted to add to the sparse research on neighbourhood resilience to crime which has not yet been investigated in a quantitative and systematic manner in South Africa. Evidence is provided in this study of resilience to crime in neighbourhoods of Khayelitsha, Cape Town. That is where the crime levels are much lower than expected in certain neighbourhoods in the township given their socio-economic circumstances. While doing so, several factors were identified as being potentially able to lower crime in other similar informal communities. It must, however, be emphasized that socioeconomic drivers of crime in neighbourhoods should not be ignored, but rather augmented with the knowledge gained from this study.

Findings from this study are supported by Breetzke and Pearson (2015) who found that access to a range of built factors thought to increase the liveability of neighbourhoods (i.e. distance to clinics, distance to schools) was least among more resilient neighbourhoods in New Zealand. In the present study however, while access to both primary and secondary schools, along with most healthcare facilities (i.e. fire stations, police stations and clinics) was less in more resilient neighbourhoods of Khayelitsha, access to hospitals was greater. While the majority of living infrastructure factors investigated in this study proved to be less accessible in more resilient neighbourhoods, some of these factors (district parks, municipal courts, and pools) were found to be more readily accessible. The results of this study when compared to the results from the study performed in New Zealand, raise questions concerning the differences experienced between the resilience to crime in the more formal neighbourhoods of New Zealand versus the informal neighbourhoods of Khayelitsha.

The greatest proportional differences in distances found between the highest and lowest resilience quintiles for the 24 built variables examined were for waterbodies, libraries, primary schools, recreational hubs, community centres and places of worship.

Decreased access to waterbodies was the greatest proportional difference in distances found between the highest and lowest resilience quintiles. Most of the waterbodies occurring in Khayelitsha are storm water ponds which are constructed basins that are built for the capturing and storing of storm water runoff from developments. Storm water ponds have been found to be associated with high crime levels (see Botha, 2005; Rohrer and Armitage, 2015). Crime attractors are locations, sites or properties that are specifically targeted by offenders (Brantingham and Brantingham, 1995). I argue that waterbodies in Khayelitsha act as crime attractors, in that they are unlikely to be under good surveillance or protection and are commonly associated with increased vegetation that can serve as an effective location for individuals to hide both prior to and after committing a criminal offense. Additionally, many informal settlement residents may be using these waterbodies as a means to wash their clothes, or even selves, which will make them vulnerable to crime.

Interestingly, the distances to primary schools exhibited the next greatest proportional difference in access found between the highest and lowest resilience quintiles in the New Zealand study. The present study also found that access to both primary and secondary schools was decreased for resilient neighbourhoods in Khayelitsha. Previous research in Maryland, United States notes that schools that are low on resources will be less likely to have adequate supervision for youth, providing opportunities for crime (Roman, 2002). Based on the findings from this study it could be that schools that lack order or are characterized by resource deprivation are generators of crime. It could also be that resource-deprived schools impact violence after school. Additional research may find a connection between schools and the presence of disaffected youth which is a factor that previous literature has found to be related to the presence of crime (see Breetzke, 2010; Gottfredson and Hirschi, 1990; Sandford et al., 2008). Supplementing this work, the results of the present study indicate that decreased proximity to informal settlement schools can potentially play a role in engendering resilience to crime in neighbourhoods.

Decreased access to recreational hubs and community centres in Khayelitsha were also found to play a role in engendering neighbourhood-level resilience to crime. Recreational hubs are public spaces that serve as social locations for people to meet, relax, and exchange ideas. Most of the recreational hubs in Khayelitsha are youth or recreational centres which may again link to the increased presence of youth. Community centres are public locations where community members gather for organised group activities, social support, and public information. In Khayelitsha, community centres are most often civic centres that are used for the meetings of various groups (charities, sports clubs or civil societies), and are located usually in the centre of a community. A great deal of the theoretical focus of environmental criminology at the neighbourhood level has examined the identification of crime generators and crime attractors (see Kurland et al., 2014; Steenbeek et al., 2012). Crime generators are categorised by the attraction of large numbers of people for reasons unrelated to any particular instance of crime (Brantingham and Brantingham, 1995). Recreational hubs and community centres are, therefore typical examples of crime generators which attract a large number of potential offenders and victims, thereby providing increased opportunities for crime. Having a greater distance to travel in order to access these built environment factors means that neighbourhoods will not attract such large numbers of people to one location and consequently there will be less opportunity for a criminal offense to occur.

Decreased access to licensed liquor outlets was found for more resilient neighbourhoods but this association was found to be non-significant. The impact was considerably less than what was expected based on previous literature which has found strong associations between increased access to alcohol and crime (see Day et al., 2012; Pridemore and Grubestic, 2013). We speculate this may be due to the presence of many unlicensed outlets supplying individuals with alcohol (sheebens or taverns) within Khayelitsha. According to a study performed by the Department of Community Safety for Western Cape (2016), of the 1044 available alcohol outlets in Khayelitsha, 83 % were unlicensed. This study found that for every one licensed liquor outlet in Khayelitsha, there were five unlicensed outlets (Western Cape Department of Community Safety, 2016). Thus we cannot assert that the data used in this research accurately represented the number of establishments that are available for this vice in Khayelitsha. The use of the true dataset will most likely show that access to these outlets impacts on the resilience

to crime in neighbourhoods. It is possible that further analysis of this particular type of vice facility, along with that of gambling facilities, may yield a result that aligns more closely to that of previous studies.

A surprising find of this study was that access to police stations was decreased for the most resilient neighbourhoods. There could be a number of possible explanations for this finding which relate to an individual's decision to report a crime to the relevant authorities. It is possible that resilient neighbourhoods are addressing local crime issues on their own without the need to go to the police. It has been found that the reported crime rates, particularly of common robbery and thefts, are understated by as much as 40 % (see O'Regan and Pikoli, 2014). This topic may require further research to determine why neighbourhoods in Khayelitsha appear to be less resilient to crime when located close to police stations, and whether this trend repeats in similar informal settlements throughout South Africa.

Access to district parks and swimming pools was found to be increased in more resilient neighbourhoods of Khayelitsha. Previous studies found that parks are often considered to be associated with increased crime in neighbourhoods. A study by Groff and McCord (2012) for example found that specific characteristics of parks impact crime levels, as the researchers found that community parks with fields or courts for organised recreational activity tend to experience lower crime rates. The researchers speculated that this may be due to the use of facilities by organised leagues rather than impromptu games. Another supposition made by the researchers was that there is increased territoriality felt by frequent users of the facilities which increased the level of informal guardianship and surveillance of the park itself. We speculate that district parks in Khayelitsha, along with the presence of swimming pools, moderate any criminogenic effects experienced in the surrounding neighbourhoods. Increased access to hospitals were also found to be a characteristic of resilient neighbourhoods in Khayelitsha.

The results of this research indicate that, in terms of building resilience to crime in neighbourhoods, it is beneficial to reside at a greater distance from both crime attractors and other built environment factors (schools, clinics, community centres, recreational hubs). This unexpected result suggests that the social environment may play a greater role in determining neighbourhood resilience to crime. We observed that the more resilient neighbourhoods in Khayelitsha had higher population densities per square kilometre than the least resilient



neighbourhoods. Living in densely populated areas can be associated with both positive and negative influences on crime. More densely populated places provide greater opportunities for crime, but may also lead to greater resiliency in neighbourhoods through greater social cohesion. Collective efficacy has been found to be higher in more densely populated places (see Putnam, 2000; Williamson, 2002) with the model for collective efficacy strongly suggesting that population density is indirectly related to crime, as it is based on disadvantage which decrease the social trust exhibited by a community.

It is difficult to contrast the results of this study with other research given the lack of particularly local research investigating the linkage. Further research is required to understand resilience to crime in informal communities in South Africa. Regarding the use of the social disorganisation theory in this study I found support for the use of this international spatial theory of crime in this context. Findings from a study by Breetzke (2010a), also found some support for the social disorganisation theory in post-apartheid South Africa. In his study Breetzke (2010) found that two out of the three measures of social disorganisation effects were significant, but additionally found that disaffected youth and African immigration had significant effects on crime trends. Interestingly, their study also found that race in South Africa did not have a significant effect on crime trends. Another study by Breetzke (2010b) also found some support for the social disorganisation theory in the city of Tshwane. A positive association was found between the rate of violent crime and certain measures of social disorganisation such as socioeconomic deprivation, and residential mobility, however, there were a number of conflicting findings as well. The study also motivated a need for future studies that measured social disorganisation with different indicators than those used in that study. Work by Lancaster (2013) examined the relationship between murder rates in South Africa and several socioeconomic measures informed by a number of environmental criminological theories, including the social disorganisation theory. The study found that in the South African context only a few of the socioeconomic factors were found to have significant relationships with murder rates. This study also suggested that further research should be undertaken at more disaggregated levels (SAL level) to yield more meaningful findings. Overall the studies that applied the social disorganisation theory in a South African context have findings that offer moderate support for the theory, but suggest that new indicators need to be created for this specific local context and setting.

The present study utilised the social disorganisation theory to quantify the resilience to crime of neighbourhoods in Khayelitsha and while it was not the central aim of this study to test the theory, similar challenges were encountered during the application of the theory in this context.

The secondary aim of this research was to provide insights that aid in decision making and policy forming processes particularly related to crime prevention. The idea is that this information can guide interventions, applications and policies that would improve the lives of individuals living in communities and potentially drive and inspire resilience in other communities plagued with high crime rates. Identifying neighbourhoods that are displaying a high level of resilience to crime, despite their theoretically disadvantageous settings, may allow stakeholders to understand not only what drives their resilience but also how to plan interventions in neighbourhoods with lower resilience. The present study was the first study to examine neighbourhood level resilience in an informal settlement and could further aid policy-makers to drive initiatives that aim to increase resilience in other informal communities throughout South Africa. We believe that this study has identified a number of characteristics particularly in the built environment that may impact on the neighbourhood-level resilience to crime, and has provided a platform for future research in this vital area.

It is anticipated that the findings can serve as a preface for the quantification of resilience to crime across all neighbourhoods in South Africa. Further "place specific" resilience research in South Africa is required that could aim to better understand the differences, as well as similarities, that exist between neighbourhood-level resilience in different settings, be they in other informal settlements, in more formal urban areas, or in rural settings.

## ***6.1 Threats to validity***

### ***6.1.1 Internal***

Internal threats to validity may compromise our confidence that there is a relationship that exists between the dependent and independent variables. An internal threat to validity for this research would lie in the specific socio-demographic variables (i.e. census data) utilised in the development of the Crime Resilience Index of Khayelitsha (CRIK). To account for this threat the independent variables used to fit the regression model were tested for multicollinearity. In order to ensure that multicollinearity did not occur within the independent variables, a

correlation matrix between the independent variables was created and analysed (see table 6). Variables with correlation values above 0.7 were removed from the analysis to ensure no variables are predicting one another, avoiding multicollinearity.

A further threat to internal validity lies in the appropriateness of the data for use in a specific regression model. Evidence of overdispersion was identified after fitting a Poisson model and so the use of a negative binomial regression model (a generalization of the Poisson model that does not need to satisfy the assumption that the variance is equal to the mean) was selected for use, which mitigated the potential threat to internal validity.

### *6.1.2 External*

An external threat to validity will compromise the repeatability of the results in contexts other than it was found in. In essence, the employed methodology must be repeatable in order to guarantee that the research can be repeated in other contexts. This research was performed in the context of an informal settlement in South Africa. While the methodology employed is simplified enough to allow future repetition, it is advisable that further research is performed on the applicability of measures of the social disorganisation theory in differing contexts.

## *6.2 Limitations*

It is acknowledged that there are a number of limitations to this study. First is the reliance on the available crime data as the sole indicator of crime in Khayelitsha. Additionally, all crime incidents in Khayelitsha from 2006 to 2016 were used as a single measure for crime rather than making use of separate categories of crime. While there are known limitations to the use of police data to measure crime (see Herbert and Harries, 1986), particularly in a South African context (see Bruce, 2010; Burger, 2018; Overall et al., 2008), previous research has shown that making use of official police datasets will usually produce results that are consistent with crime victimisation studies (see Ceccato and Dolmen, 2011, McDowall and Loftin, 1992). Furthermore, the South African Police Service (SAPS) is the only provider of official crime datasets for South Africa.

Second, resilience is a very complex and multi-faceted concept and that making use of only a selection of built characteristics to examine what drives resilience at the neighbourhood-level is a simplification of this concept.

Resilience could be related to the personal characteristics, or circumstances, of the individual (see Elliott et al., 2006, Hipp, 2013). We acknowledge this is a limitation of the study, however, it should be emphasized that the aim of this study was to add to the existing knowledge of how and why theoretically disadvantaged communities experience lower crime rates than other communities, despite their neighbourhood-level similarities. A challenge also exists when sourcing accurate and complete spatial datasets for the built environment in Khayelitsha, which limited the number of measures that could be utilised for this study. At least one measure was used for each factor group (healthcare, living infrastructure, education and vice). There are a number of unlicensed, informal and thus undocumented establishments that provide alcohol and gambling facilities for Khayelitsha. This data, however, is difficult to obtain and furthermore to ensure the accuracy of these datasets would be questionable at best.

Third, the use of straight-line distance from the geometric centroid of the neighbourhoods to the built environment factors as a measure of access is problematic. While it would arguably be more accurate to make use of distances along road networks, it should be noted that a large portion of Khayelitsha is informal and individuals will often make use of footpaths that are a direct path to a facility rather than an "official" road. It is also noted that making use of a population-weighted centroid for each neighbourhood may have resulted in more accurate results. However, the mean population density per neighbourhood in Khayelitsha is 25227 individuals per square kilometre, which indicates that neighbourhoods are very densely populated and thus the use of a geometric centroid would be sufficient for this study.

Fourth, a number of measures used to develop the CRIK can be linked to the reporting of crime by individuals (see Warner and Pierce, 1993; Goudriaan et al., 2005). The influence of this relationship could limit the study, but I believe that this influence would not significantly impact the findings of this study. Furthermore, it is probable that any additional measures would likely also be linked to the reporting of crimes, or lack thereof, due to the nature of crime reporting in these communities. The most commonly expected neighbourhood-level crime causal factors aligned to the seminal spatial theory of crime (the social disorganisation theory) were used in the development of the CRIK.

Finally, this study did not consider resilience with respect to time, which may have proven to be a better test of neighbourhood resilience to crime. This factor may have limited the study but it must be considered that Khayelitsha is fluid and changing. The characteristics of the built environment in Khayelitsha may well change over time, making it an extremely difficult factor to consider for this study but warrants investigation in further studies.

### ***6.3 Ethical considerations***

Ethical considerations are the moral principles that guide research from inception to completion. As this study makes use of secondary/external data, there are a number of ethical considerations that are important to note. These include:

- i. The source of the datasets used for this research have been duly acknowledged.
- ii. The data used in this research was derived using ethical procedures.
- iii. Any possible conflicts of interest were investigated and determined to have no effect.
- iv. The data used in this research was used only for the intended agreed upon purposes.
- v. Sensitive information within the crime dataset was kept confidential.
- vi. The analysis and results of this research have been reported precisely and without bias.

### ***6.4 Recommendations for future research***

Studies examining neighbourhood resilience to crime has been neglected in the field of environmental criminology, despite being a potential aid to the role-players tasked with improving the lives of particularly disadvantaged communities. Future studies examining neighbourhood resilience to crime should aim to investigate aspects in the social environment that may drive resilience to crime in Khayelitsha. This will add another dimension to the analysis that will ensure an in-depth understanding of the role of the broader environment on resilience to crime particularly in informal settings. Moreover, further investigations examining the differences that exist between the resilience to crime in formal and informal settings would be a beneficial addition to resilience research.

I believe that the findings are applicable and insightful. However, it would be recommended that future research should be undertaken with the most up-to-date data available (both in terms of crime and socio-

demographic data) to ensure an accurate representation of the crime plaguing Khayelitsha. A potential investigation of the resilience to specific categories of crime in Khayelitsha may also further provide beneficial findings. Aligned with this investigation would be the inclusion of the effect of unlicensed versus licensed alcohol outlets on the resilience to crime in Khayelitsha.

A final recommendation would be the investigation of the applicability of the social disorganisation theory in informal settings such as Khayelitsha. By implementing a typically western spatial theory of crime that is not catering to an informal South African context, we do not take the uniquely South African context into account. By customising the various spatial theories of crime to suit the specific study context, we can improve on the accuracy and understanding of crime and disorder in informal communities in South Africa.

The aim of this research was to identify which built neighbourhood-level factors are making communities more resilient to crime despite their theoretically disadvantageous settings. By drawing on theories from environmental criminology I quantified the resilience for the neighbourhoods in Khayelitsha. I then examined the effect of various built environment factors on neighbourhood-level resilience to crime by comparing the access to certain built environment factors from the most resilient to least resilient neighbourhoods. Results indicated that the most resilient neighbourhoods in Khayelitsha experience decreased access to various built environment factors, when compared to the least resilient neighbourhoods. That is, resilient neighbourhoods in Khayelitsha had moderately decreased access to a range of healthcare, education, and living infrastructures. Resilient neighbourhoods were also found to have decreased access to legally licensed liquor outlets but not with a significant association or the level expected from previous literature

This research has contributed to the investigation of neighbourhood resilience to crime. By understanding which neighbourhood level built characteristics drive resilience to crime can allow researchers to supplement the existing knowledge in this area and can serve as a starting point for research on the improvement and response to potentially stressful environments particularly in informal settlements.

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