# CRIME OPPORTUNITY & RISK FORECASTING: A NEW PERSPECTIVE APPLIED TO STREET ROBBERIES IN JOHANNESBURG CENTRAL, SOUTH AFRICA

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## Abstract

Despite the prevalence of street robberies in South Africa in general and Johannesburg Central specifically, existing crime forecasting methodologies could largely not be implemented due to their narrow theoretical foci, inherent complexity, excessive costs, and questions about their accuracy. The current study's aim was therefore to design and develop a new crime forecasting model called Crime Opportunity & Risk Forecasting (CORF) to address these limitations within the South African context. The CORF model addressed the first limitation of narrow theoretical foci through the integration of a synthesized template from a set of Criminological theories collectively referred to as Opportunity Theories. The remaining limitations were addressed through the CORF model's inherently uncomplicated, cost-effective and thorough design that resulted in the successful forecast of 81% of street robberies that took place in Johannesburg Central during April 2017. This successful forecast identified the lack of surveillance and the presence of cash-based services as salient crime risk factors in the field site. Furthermore, the successful forecast indicated that the CORF model could provide valuable academic insights for scholars and present governments with a formidable new tool to prevent crime.

MONASH SOUTH AFRICA

**Declaration**

**This thesis is an original work of research and contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or writer by another person, except where due reference is made in the text of the thesis.**

**FRANCOIS VAN JAARSVELD**
**July 2021**

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**TABLE OF CONTENTS**

**Page**


**Abstract** ..... **3**
**CHAPTER 1: BACKGROUND AND INTRODUCTION** ..... **4**
**1.1. Introduction** ..... **4**
**1.2. Key Concepts** ..... **8**
1.2.1. Street Robbery ..... 8
1.2.2. Crime Forecasting ..... 8
1.2.3. Crime Prevention ..... 8
**1.3. Problem Statement and Rationale for the Study** ..... **8**
**1.4. Research Question:** ..... **10**
**1.5. Aim** ..... **10**
**1.6. Objectives** ..... **10**
**1.7. Hypotheses** ..... **10**
**1.8. Methodological Justification** ..... **11**
**1.9. Chapter Outlines** ..... **11**
**1.10. Conclusion** ..... **11**
**CHAPTER 2: LITERATURE REVIEW AND THEORIES** ..... **13**
**2.1. Introduction** ..... **13**
**2.2. Street Robbery in Context** ..... **13**
2.2.1. Prevalence of Street Robberies in South Africa ..... 13
2.2.2. Street Robberies in Johannesburg Central ..... 15
2.2.3. Risk Factors for Street Robberies ..... 16
**2.3. Crime Forecasting Approaches** ..... **17**
2.3.1. Hot Spot Analysis ..... 18
2.3.2. Near-Repeat Methods ..... 19
2.3.3. Spatiotemporal Analyses ..... 20
2.3.4. Data Mining ..... 21
2.3.5. Risk Terrain Analysis ..... 22
2.3.6. Summary of approaches under review ..... 23
**2.4. The Opportunity Theories** ..... **24**
2.4.1. Routine Activity Theory ..... 25
2.4.2. Crime Pattern Theory ..... 25
2.4.3. Broken Windows Theory ..... 26
2.4.4. Crime Prevention through Environmental Design ..... 27
2.4.5. Situational Crime Prevention ..... 28
2.4.6. Multi-Contextual Criminal Opportunity Theory ..... 30
**2.5. Integration of Opportunity Theories and Theoretical Base** ..... **30**
2.5.1. Means of Integration ..... 31
2.5.2. Opportunity Theories Template as Theoretical Base ..... 31
**2.6. Conclusion** ..... **35**
**CHAPTER 3: METHODOLOGY** ..... **36**
**3.1. Introduction** ..... **36**
**3.2. Population of the Study** ..... **36**
**3.3. Selection of Field Site** ..... **37**
**3.4. Selection of Reference – and Forecasted - Time Periods** ..... **38**
**3.5. Selection and Processing of Dependent and Independent Variables** ..... **38**

3.5.1. Selection of Dependent Variable/Crime Type ..... 38
3.5.2. Independent Variables ..... 40
3.5.2.1. Selection of Corresponding Specific Principles ..... 40
3.5.2.2. Transformation of Specific Principles into Crime Opportunity Questions ..... 40
3.5.2.3. Division of Questions into Data Types ..... 40
**3.6. Data Collection ..... 41**
3.6.1. Construction of Data Schedule ..... 41
3.6.2. Selection of Data Sources ..... 42
3.6.3. Baseline Census of Questions ..... 42
**3.7. Data Analysis ..... 43**
3.7.1. Data Cleaning ..... 43
3.7.2. Escalation to Crime Risk Factors through Integration into Vector Grids ..... 43
3.7.3. Forecasting ..... 47
3.7.4. Assessment of Accuracy ..... 49
**3.8. Analysis of Contextual Street Robbery Data ..... 50**
**3.9. Ethics ..... 50**
**3.10. Conclusion ..... 51**
**CHAPTER 4: RESULTS ..... 52**
**4.1 Introduction ..... 52**
**4.2 Street Robbery Data ..... 52**
4.2.1 Street Robbery Totals ..... 53
4.2.2 Days of the Week ..... 54
4.2.3 Times of the Day ..... 55
4.2.4 Number of Perpetrators ..... 56
4.2.5 Number of Victims ..... 56
4.2.6 Victims' Sexes ..... 57
4.2.7 Victims' Actions Immediately Prior to Robbery ..... 57
4.2.8 Weapons and Physical Violence ..... 58
4.2.9 Presence of Weapons ..... 59
4.2.10 Types of Weapons Used ..... 59
4.2.11 Prevalence of Physical Violence ..... 60
4.2.12 Types of Physical Violence ..... 60
4.2.13 Injuries ..... 61
4.2.14 Items Taken ..... 62
**4.3 Spatial Analysis Results ..... 62**
4.3.1 Street Robbery Locations ..... 62
4.3.2 Overall Results ..... 63
4.3.2.1 Weights for March 2017 ..... 63
4.3.2.2 Successful Forecasts ..... 67
4.3.2.3 Results for Alternative Methods of Analysis ..... 74
4.3.3 Sub-Analyses Results ..... 75
4.3.3.1 Week 1 Daytime ..... 75
4.3.3.1.1 Weights ..... 75
4.3.3.1.2 Successful Forecasts ..... 76
4.3.3.2 Week 1 Night-Time ..... 76
4.3.3.2.1 Weights ..... 76
4.3.3.2.2 Successful Forecasts ..... 77
4.3.3.3 Week 2 Daytime ..... 77
4.3.3.3.1 Weights ..... 77

4.3.3.3.2 Successful Forecasts ..... 78
4.3.3.4 Week 2 Night Time ..... 79
4.3.3.4.1 Weights ..... 79
4.3.3.4.2 Successful Forecasts ..... 80
4.3.3.5 Week 3 Daytime ..... 80
4.3.3.5.1 Weights ..... 80
4.3.3.5.2 Successful Forecasts ..... 81
4.3.3.6 Week 3 Night Time ..... 81
4.3.3.6.1 Weights ..... 82
4.3.3.6.2. Successful Forecasts ..... 82
4.3.3.7 Week 4 Daytime ..... 83
4.3.3.7.1 Weights ..... 83
4.3.3.7.2 Successful Forecasts ..... 84
4.3.3.8 Week 4 Night Time ..... 84
4.3.3.8.1 Weights ..... 84
4.3.3.8.2 Successful Forecasts ..... 85
4.3.3.9 Weekend Day Time ..... 85
4.3.3.9.1 Weights ..... 85
4.3.3.9.2 Successful Forecasts ..... 86
4.3.3.10 Weekend Night Time ..... 87
4.3.3.10.1 Weights ..... 87
4.3.3.10.2 Successful Forecasts ..... 87
4.3.3.11 Summary of Results from Overall and Sub Analyses ..... 88
**4.4 Conclusion ..... 89**
**CHAPTER 5: INTERPRETATION ..... 90**
**5.1 Introduction ..... 90**
**5.2. Discussion of the results ..... 90**
**5.3. Achievement of Research Question, Aim, Objectives and Hypotheses ..... 91**
**5.4. Spatial Results in Terms of the Opportunity Theories Template ..... 92**
5.4.1. Criminological Theories ..... 93
5.4.2. Broad Principles ..... 94
5.4.3. Sub-Principles ..... 94
5.4.4. Specific-Principles ..... 95
5.4.5. Crime-Risk Questions ..... 95
5.4.6. Summative Table: Opportunity Theories Template Results Overview ..... 98
**5.5. Limitations of the Study ..... 99**
**5.6. Value of the Study ..... 99**
**5.7. Future Applications of the CORF Model ..... 100**
**5.8 Recommendations ..... 101**
**5.9 Conclusion ..... 102**
**References ..... 104**
**Annexure A: MUHREC Approval Letter ..... 111**
**Annexure B: SAPS Approval Letter ..... 112**
**Appendix ..... 113**

# CHAPTER 1: BACKGROUND AND INTRODUCTION

## 1.1. Introduction

Robberies are highly prevalent in South Africa and represent a salient threat to citizens' rights to safety (SAPS, 2016:27). The South African Police Services (SAPS) classifies this crime type under the category of "robbery with aggravating circumstances", which entails the procurement of a victim's cash and/or possessions through the use of weapons and/or force (SAPS, 2016:27). The 'robbery with aggravating circumstances' sub-category envelops several distinct sub-types, in which businesses, banks, cash in transit (CIT) vehicles, trucks and private vehicles are targeted.

However, incidents in which pedestrians are victimized in public areas such as streets, transport nodes and parks are undoubtedly the most common robbery sub-type that occurs in South Africa (ISSAfrica, 2020; SACN, 2017:88). Informally known as street robberies, this crime type accounted for the majority (57.7%) of 'robbery with aggravating circumstances' incidents in the country between 2012 and 2017 (CrimeStatsSA, 2017)[1]. This percentage was considerably higher in the police jurisdiction of Johannesburg Central (81.4%) during the 2016/2017 reporting period (CrimeStatsSa, 2017). In fact, Johannesburg Central recorded the highest number of street robberies in the country between 2016 and 2020 (SAPS, 2020).

Furthermore, Leggett's study of street robberies in the Johannesburg Central area confirmed that these robberies had profound emotional, physical, and financial effects on victims. Indeed, his study showed that the perpetrators intimidated victims by outnumbering them and using weapons such as firearms and knives (Leggett, 2003: 65-66). Moreover, street robbers in the area often assaulted victims to the extent that their injuries necessitated hospital treatment. (Leggett, 2003: 65). In addition to these

[1]The statistics in the current study for street robberies that fall under the 'robbery with aggravating circumstances' category are provisional because the SAPS do not expressly capture data for the category. This figure was arrived at through a subtraction of the overall figures for 'robbery with aggravating circumstances' from all the robbery crime-types that the SAPS expressly capture, i.e., in which banks, businesses, CIT, trucks and vehicles are targeted. The final figure may also include robberies of motorists in which their personal belonging (but not their vehicles) are taken. Furthermore, street robberies technically also fall under the SAPS' category of 'common robbery', in which neither physical force nor weapons are used. The statistics of street robberies that fall under 'common robbery' were not included because they were not available.

emotional and physical traumas that street robberies inflicted on victims, the incidents entailed the loss of valuables such as cash, electronic goods, and jewellery, most of which were uninsured (Leggett, 2003: 67).

Despite the severity of these crimes, Leggett reported that victims very seldom reported the incidents to the police, due to a general lack of confidence in their ability to recover the stolen items. Moreover, the SAPS do not expressly capture statistics for street robberies and rather focus on the other sub-categories in the “robbery with aggravating circumstance'' category, which entail the loss of higher value cash and goods. Indeed, the SAPS also prioritises truck hijackings, CIT robberies, bank robberies, residential- and business robberies over street robberies (ISSAfrica, 2020). Nonetheless, the crime type’s prevalence does imply some arrests and convictions, which further burden the already overwhelmed criminal justice and correctional systems (ISSAfrica, 2009).

These issues related to the relevant government departments’ responses to street robberies. In addition, the crime type’s prevalence and severity underline the urgent need to find a practical means of prevention. The current study will investigate the feasibility of one such solution, called crime forecasting. Although Criminologists in the United States of America (USA) and the United Kingdom (UK) have accumulated a wealth of knowledge on the topic, a survey of available South African studies showed that crime forecasting approaches were largely ignored as a means of crime prevention (Cloete &Spies, 2009: 139).

Nonetheless, an authoritative review of available crime forecasting approaches in the USA, from the Rand Corporation, provides descriptions of five prominent crime forecasting approaches that could potentially be used in South Africa (Hollywood, McInnis, Perry, Price & Smith 2013:2).

The first approach in the Rand Corporation’s Review related to Hot Spot Analysis, which included a set of techniques that aimed to address a very prevalent finding in the spatial distribution of crime locations in the USA. This finding read that a large proportion of crimes often clustered in a relatively small number of areas (Eck, Chainey, Cameron, Leitner & Wilson, 2005:1; Hollywood, et al. 2013:19). The Hot Spot

Analysis techniques' primary aim was, therefore, to identify these clusters or 'hot spots' through an investigation of previous crime locations. The approach assumed that the locations of these hot spots would remain relatively stable, which led them to argue that future crimes would also occur in these areas (Chainey, Tompson & Uhlig, 2008:4; Perry, et al. 2013:19).

Near-Repeat Methods, the second approach in the review, added that incidents of crime clustered in time, in addition to space. More specifically, the approach held that future crimes would occur in the vicinity of, and soon after, criminals' initial offences. The approach explained that criminals would soon return to the same areas because they already knew the available escape routes and the locations of valuable items (Perry, et al. 2013:45; Townsley, Homel & Chaseling, 2003:616). However, this approach did not allow for a thorough analysis of crime locations over time and omitted several relevant crime-related contexts (Moreto, Piza & Caplan, 2014: 1102-1103).

The third approach in the review, called Spatiotemporal Analysis, largely addressed this dearth through a focus on the ways in which various environmental and temporal factors influenced the spatial distribution of crime locations. These methodologies considered a wide array of socio-economic factors, land usages, weather conditions and previous crime locations in relation to temporal aspects such as the days of the week, months of the year, holidays and seasons (Perry et al., 2013:44-45). The analyses of these independent variables then allowed the researcher to identify future times and locations that could record crime incidents. This approach, however, relied on traditional statistical software packages and techniques, which imposed a limit on the number of causal variables that could be investigated, which possibly compromised the accuracy of crime forecasts (Kang & Kang, 2017:2; Perry et al., 2013:36).

Data Mining, the fourth approach in the review, addressed this limitation through sophisticated software products and statistical techniques that could analyse larger databases and a wider array of crime risk factors. Scholars then used these techniques to extract complex patterns to forecast the times and locations of future crimes more accurately (Kang & Kang, 2017:2; Perry et al., 2013:36). However, this

area of study was complex and difficult to understand without prior training and experience.

In contrast, the final approach in the review, Risk Terrain Analysis, was considerably more intuitive and easily understandable. It simply argued that future crimes would occur at the locations of crime risk factors. The most prominent model in this approach was called Risk Terrain Modelling (Caplan & Kennedy's 2011). This heuristic process started with the subjective and ad-hoc identification of known crime risk factors. The locations of these various risk factors were then used to create separate maps on a Geographic Information System (GIS) program. These maps were then stacked on top of each other, and the locations with clusters of risk factors, were forecasted to be at a high risk for future crimes (Caplan, Kennedy & Miller, 2010:70-94).

A set of theories, in Criminology, collectively referred to as Opportunity Theories regularly informs and supports these crime forecasting approaches. In a general sense, this set of theories investigates the ways in which opportunities in the physical environment influenced criminals' decision-making processes (Natarajan, 2011:3). These decisions were framed in terms of Rational Choice Theory's meta-theoretical premise that criminals would only commit crimes when they could obtain something valuable without being punished (Cornish & Clarke, 1986). Other contributors to the field then added various factors that further influenced these cost-benefit analyses, which included the routine activities of the role players (Clarke & Felson, 1993:2; Cohen & Felson, 1979: 588), practical and situational variables (Clarke, 1995:109; Cornish & Clarke, 2003:47; POPCentre, Sa), as well as the forms (Crowe, 2000:36, Jeffery, 1990; Newman, 1972:2; Wilson & Kelling, 1982:4) and functions (Brantingham & Brantingham, 1995:7-8), of built environments.

The following portion of the chapter will extrapolate, from the abovementioned literature, the key concepts for the current study. Thereafter, the related problem statement and rationale for the study is introduced, before the chapter presents the ways in which the study will address the relevant issues through a presentation of the stated research question, aim, objectives, and hypotheses. Finally, a methodological justification and chapter outlines are provided before the conclusion presents a summary of the chapter.

## 1.2. Key Concepts

The key concepts and definitions of the study relate to street robbery, crime forecasting and crime prevention.

### *1.2.1. Street Robbery*

The definition of street robberies from Monk, Heinonen & Eck, (2010:1) was selected due to its comprehensiveness. It holds the following six characteristics:

- the offender targets a victim.
- the victim was a pedestrian.
- the offender attempted or completed a theft of cash or property.
- the offender used force or the threat of force against the victim.
- the offender used a weapon or the threat of a weapon against the victim and
- the offender may have also grabbed valuable items from the victim without the use of threat/force/weapons.
- the offence occurred in a public place including streets, public parks and abandoned buildings.

### *1.2.2. Crime Forecasting*

Furthermore, the study's definition of crime forecasting was adopted from the Rand Corporation's authoritative review of available approaches (Hollywood, et. al., 2013:2). This definition referred to the usage of quantitative, statistical and geospatial techniques to identify likely future locations of crime.

### *1.2.3. Crime Prevention*

The Rand Corporation's definition of crime prevention includes police visibility at the high-risk locations, identified via crime forecasting methods, which effectively prevents crimes from occurring. (Hollywood, et. al., 2013:2).

## 1.3. Problem Statement and Rationale for the Study

However, none of the available crime forecasting methodologies are appropriate for widespread implementation in South Africa, due to their overly narrow theoretical foci,

inherent complexity, excessive costs and issues related to accuracy, as further discussed below:

- Firstly, it is still largely unclear whether the underlying Opportunity Theories can explain the spatial distribution of crime in the country. Indeed, they were developed in the USA and the United Kingdom (UK) and only seldom tested in the South African context (Natarajan, 2016:1). In light of this dearth in the literature, it would be prudent to adapt a crime forecasting model in South Africa that could include a wide theoretical base. The relevant model could then simultaneously test various theories and corresponding risk factors from this base, which would expedite the identification of significant independent variables. This proposed need for a South African crime forecasting model, with a wide theoretical base, leads to the first challenge to implementation in the country. This challenge relates to the fact that not all the available crime forecasting approaches allow for the inclusion of such a wide base, due to overly narrow areas of theoretical focus.
- Secondly, many of the crime forecasting approaches were too complex and assumed advanced prior knowledge of Geographic Information Systems (GIS) and statistics (Lee & Eck, 2017:1). Arguably, this excludes South Africa, at least to some extent, due in part, to a lack of these skills in the country (Breetzke, Eksteen & Pretorius, 2011; Hall, 1999:11; Mkhongi & Musakwa, 2020).
- Thirdly, the proprietary software products attached to several crime forecasting approaches were possibly too expensive for widespread distribution in South Africa (Lee & Eck, 2017:1), due to unfavourable exchange rates with their countries of origin, the USA and UK.
- Finally, and in a similar vein to the first obstacle, it is still largely unclear whether existing crime forecasting methodologies could accurately forecast the times and locations of crime incidents in the country. These methodologies were mostly developed and tested in the USA and the UK and were only very seldom tested in South Africa (Cloete, Spies, 2009: 139).

These challenges led to the rationale for the current study, which is to address the need for a crime forecasting approach specifically designed for the South African context. This context dictates that such an approach should have a wide theoretical

base, in addition to an easily understandable and cost-effective model. Furthermore, the high prevalence of crime in the country demands that the model should be able to accurately forecast the locations and times of future crime incidents in order to assist with prevention efforts. As such, the researcher designed and developed the CORF model, and the current study is a preliminary testing of that model within the Johannesburg CBD, which leads to the following research question, aim and objectives.

## 1.4. Research Question:

How might the newly designed and developed crime forecasting model, CORF, be appropriate in the South African context?

## 1.5. Aim

The aim of the current study is therefore to determine whether the newly designed and developed crime forecasting model, CORF, is appropriate for the South Africa context, and if so, how.

## 1.6. Objectives

The following four objectives were formulated to reach this aim:

- To integrate a broad theoretical base into the CORF model through using a specifically formulated synthesized template of Opportunity Theories.
- To determine the complexity of the CORF model.
- To contextualise the CORF model as cost-effective and not reliant on expensive software programs.
- To determine whether the CORF model could accurately forecast the spatio-temporal distributions of street robberies in the Johannesburg CBD of South Africa.

### 1.7. Hypotheses

1. $H^a$: The CORF model will accurately forecast more than 50% of the street robberies that took place in the Johannesburg CBD of South Africa during April 2017.
2. $H^0$: The CORF model will not accurately forecast more than 50% of the street robberies that took place in the Johannesburg CBD of South Africa during April 2017.

## 1.8. Methodological Justification

As mentioned in this chapter's introduction, there existed five broad categories of crime forecasting approaches: Hot-Spot Analysis, Near-Repeat Methods, Spatiotemporal Analysis, Data Mining, and Risk Terrain Analysis. The last-mentioned approach was chosen to form the basis of the CORF model and this study because it best fit the four objectives identified in this chapter. More specifically, it could include a large number of risk factors, was not overly complex and did not necessitate the purchase of expensive software packages. Its accuracy in the South African context was not yet determined; however, neither were any of the other approaches. Furthermore, the Risk Terrain Analysis was also appropriate for the proposed CORF model due to its inherent foundation in quantitative and GIS-related analyses, which signify the current predominant research frameworks for studies that focus on crime forecasting. The Literature Review will provide additional information in this regard.

## 1.9. Chapter Outlines

The remaining chapters of the study will illustrate that the CORF model reached the stated aim and related objectives of representing a crime forecasting approach suitable for the South African context. In this sense, the literature review chapter will introduce the theoretical base of the CORF model and illustrate that it was broad enough to satisfy the first objective of the study. The description of the CORF model in the subsequent chapter will then clearly show that it is sufficiently uncomplicated and cost-effective to satisfy the study's second and third objectives, respectively. Thereafter, the results chapter will illustrate that the CORF model confirmed the study's fourth objective and hypotheses and that it could accurately forecast more than 50% of the street robberies in the Johannesburg Central jurisdiction. Finally, the interpretation chapter will assess the extent to which the study reached the stated aim and objectives and will interpret the findings in relation to the literature review.

## 1.10. Conclusion

In conclusion, Chapter 1 firstly showed that street robbery was a prominent challenge faced by South Africa in general and Johannesburg CBD specifically. The chapter then further illustrated that existing crime forecasting methodologies could largely not be

implemented in the country to combat this crime type, due to their narrow theoretical foci, inherent complexity, excessive costs, and questions about their accuracy. The remainder of the chapter outlined the ways in which this study would address these challenges, through a new South African based crime forecasting model, CORF. The ways in which the CORF model would tackle the challenges of implementation was clarified through the identification of the study's aim, objectives, and hypotheses. The chapter then provided a justification of the chosen methodology to reach this aim, and the way in which the remaining chapters are structured.

# CHAPTER 2: LITERATURE REVIEW AND THEORIES

## 2.1. Introduction

This review will provide additional information on street robberies in South Africa and the relevant risk factors in the literature, before it delves into the available crime forecasting approaches. These approaches are then continuously assessed in terms of their suitability for the South African context, which requires the necessity of a wide theoretical base, intuitiveness, affordability and accuracy. Opportunity Theories are then explored in further detail before the theoretical framework for the Crime Opportunity & Risk Forecasting model is identified. Finally, the conclusion provides a summary of the chapter and relates it to the first obstacle to crime forecasting in the South African context, that is, the need for a wide theoretical base.

## 2.2. Street Robbery in Context

This subsection on street robbery will provide additional information on its prevalence in the country through a presentation of the relevant statistics. Thereafter, available findings from a study in South Africa will provide insights into street robberies in the context of Johannesburg Central. Finally, findings from international studies that specifically focused on the risk factors linked to street robberies will be explored.

### *2.2.1. Prevalence of Street Robberies in South Africa*

As mentioned in the first chapter of this study, robbery as an overarching category is highly prevalent in South Africa (SAPS, 2016:27). However, to determine the prevalence of robberies in which pedestrians are targeted in public spaces (street robberies), is an arduous task in the South African context. Indeed, the SAPS do not keep record of street robberies and no such sub-category exists in their statistical records. Instead, the SAPS only captures statistics on robbery sub-types which involve comparatively higher financial losses such as bank robberies, business robberies, CIT-robberies, truck and vehicle hijackings (ISSAfrica, 2020). The prevalence of street robberies can therefore only be inferred through a subtraction of the overall totals in the SAPS' figures for 'robbery with aggravating circumstances' from all the existing totals for the robbery sub-types for which the SAPS keep record. The resulting figure effectively includes all serious robberies not officially recorded as a distinct sub-

category. In addition to robberies in which pedestrians are targeted, this resulting figure also includes incidents in which perpetrators rob motorists of their personal belongings without taking their vehicles. In addition, the SAPS' sub-category of 'common robbery' makes no distinction of sub-types, which effectively prevents the inclusion of lesser serious street robberies in which no force or weapons were used.

Nonetheless, the available SAPS statistics gave an indication that street robberies as a distinct sub-category were responsible for the largest proportion of robberies in South Africa. In fact, the sub-category accounted for the majority (57.5%) of 'robbery with aggravating circumstances' incidents between 2012 and 2017 (CrimeStatsSA, 2017). This proportion was even higher within the Johannesburg Central SAPS jurisdiction (81.4%) during the 2016/2017 reporting period (CrimeStatsSa, 2017). This station also recorded the highest number of street robberies in the country during that period. The following table presents the top 10 stations in the country which recorded the highest number of street robberies in the 2016/2017 reporting period:

**Table 1: Top 10 Police Stations – Robbery with Aggravating Circumstance – 2016/2017**

| No | Police Station | Street Robberies | Car-jacking | Residential Premises | Non-Residential Premises | Truck Hijacking | Bank Robbery | Cash in Transit | Total |
|---|---|---|---|---|---|---|---|---|---|
| **1** | Johannesburg Central | **1781** | 151 | 25 | 225 | 5 | 0 | 0 | **2187** |
| **2** | Khayelitsha | **1146** | 145 | 116 | 115 | 7 | 0 | 0 | **1529** |
| **3** | Nyanga | **920** | 257 | 276 | 40 | 5 | 0 | 0 | **1498** |
| **4** | Pinetown | **864** | 238 | 125 | 119 | 0 | 0 | 0 | **1346** |
| **5** | Hillbrow | **1053** | 98 | 22 | 135 | 0 | 0 | 0 | **1308** |
| **6** | Honeydew | **540** | 149 | 337 | 152 | 5 | 0 | 0 | **1183** |
| **7** | Durban Central | **898** | 66 | 7 | 149 | 0 | 0 | 0 | **1120** |
| **8** | Jeppe | **581** | 238 | 94 | 143 | 2 | 0 | 0 | **1058** |
| **9** | Ivory Park | **422** | 163 | 298 | 156 | 3 | 0 | 0 | **1042** |
| **10** | Mitchells Plain | **887** | 54 | 39 | 38 | 0 | 0 | 0 | **1018** |
| | **Total** | **9092** | **1559** | **1339** | **1272** | **27** | **0** | **0** | **13289** |

In addition, Johannesburg Central police station also consistently recorded the highest number of street robberies in the country between 2017 and 2020 (SAPS: 2020). The table below presents the top 10 stations which recorded the highest number of street robberies in the country over a three-year period:

| Table 2: Top 10 Street Robbery Totals – 2017-2020 | | | | | |
|---|---|---|---|---|---|
| **No** | **Station** | **2017/2018** | **2018/2019** | **2019/2020** | **Total** |
| **1** | JHB CENTRAL | 1 554 | 1 741 | 1 430 | **4 725** |
| **2** | HILLBROW | 1 140 | 1 182 | 968 | **3 290** |
| **3** | KHAYELITSHA | 913 | 1 068 | 931 | **2 912** |
| **4** | NYANGA | 997 | 955 | 817 | **2 769** |
| **5** | DURBAN CENTRAL | 900 | 873 | 766 | **2 539** |
| **6** | PINETOWN | 675 | 639 | 677 | **1 991** |
| **7** | MOROKA | 487 | 493 | 566 | **1 546** |
| **8** | UMLAZI | 411 | 485 | 507 | **1 403** |
| **9** | TEMBISA | 380 | 410 | 597 | **1 387** |
| **10** | HONEYDEW | 396 | 457 | 449 | **1 302** |

### *2.2.2. Street Robberies in Johannesburg Central*

Ted Leggett's survey of street robbery in the Johannesburg Central area revealed the contexts that preceded the incidents, the profiles of perpetrators, the relevant modi operandi and the criminal justice system's response to the crimes.

In relation to the contexts that preceded the crimes, the study showed that victims were in public spaces, such as streets, immediately prior to the robberies (Leggett, 2003: 66). Furthermore, some victims received their pay cheques before the robberies and were inebriated (Leggett, 2003: 67).

The study also identified African males from South Africa as the most common perpetrators. Other perpetrators were identified as South African Coloured males, in addition to males from Zimbabwe and Mozambique. Police officers were also identified as some of the perpetrators and certain victims knew the perpetrators personally. Furthermore, a substantial proportion of perpetrators were motivated by the need for drugs (Leggett, 2003: 66-67).

The modi operandi of the robberies included the presence of three or more robbers who target individual victims. These perpetrators regularly threatened victims with weapons such as guns and knives. The victims were also often assaulted and several of the incidents resulted in physical injuries that necessitated medical assistance. Some victims were also fatally wounded. Leggett surmised that this high level of

violence was indicative of an element of expressiveness in the sense that the crimes allowed the criminals to vent feelings of anger and frustration (Leggett, 2003: 65-66). Furthermore, these perpetrators typically took cash, electronic goods and jewellery, most of which were uninsured (Leggett, 2003: 67).

Most of the victims in the survey did not report the robberies. This was due to a declared feeling that the crime was not important enough to report, a general distrust of the police and negative previous experiences with the police. Furthermore, some of the victims reported that the police did not registered their cases (Leggett, 2003: 68). In addition, the cases that were registered very seldom resulted in arrests and convictions (Leggett, 2003: 69). Moreover, the police recovered very few of the stolen items (Leggett, 2003: 67).

Although these findings from Leggett's study provided valuable insights into the experience of street robbery victims, it identified relatively few risk factors that were linked to street robberies. The following subsection provides additional findings from the literature in this regard.

### *2.2.3. Risk Factors for Street Robberies*

Street robbery risk factors could be divided into features that either communicated to criminals a lack of reprisal for their crimes, or the attractiveness of a target. Regarding the former, several studies identified the lack of surveillance as a crucial risk factor for street robberies. The results indicated that the absences of formally employed security guards (Welsh, Mudge & Farrington, 2010: 314), in addition to formal (Welsh, Mudge & Farrington, 2010: 314) and informal-car guards (Baker, 2002:41) were linked to robberies. This was also the case for the absences of CCTV cameras (Minnaar, 2002: 175), private security placards (Singh, 2005: 154) and street lights (Pease, 1999: 69). Furthermore, a study that focused on the Johannesburg Central police jurisdiction found that the presence of peeling paint, graffiti, broken windows and structural damage were linked to the abuse and robbery of sex workers. The study found that these physical features in the built environment communicated to the perpetrators a sense of non-ownership and a resulting lack of consequence for their crimes (Van Jaarsveld, Shoba & Chakuvinga, 2013:1).

In contrast to perpetrators' avoidance of perceived 'cost', other studies have highlighted the risk factors in the built environment that make street robbery appealing to criminals. Some of these studies found that cash-based services attracted street robbers due to the reasonable assumption that the persons in the vicinity would be in the possession of cash. This finding was confirmed by Irvin-Erickson's (2014: 125) study on criminogenic features' influences on street robberies in the city of Newark, New Jersey, USA, which identified the presence of formal businesses as an attractor for street robbers. In a similar vein, Bernasco & Block's (2011:35) study of street robberies in Chicago, USA found that incidents often occurred in the vicinities of cash-based services. More specifically, this study identified the entrances to bars (Bernasco et.al., 2011:35), liquor stores (Bernasco et. al., 2011:48), fast food outlets, and restaurants (Bernasco & B, 2011:34) as risk factors for this crime type. A study in British Columbia, Canada also linked shopping centres, (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 62), hotels (Kinney et. al., 2008:69), bus stops and train stations to incidents of crime (Kinney et. al., 2008:71). Finally, an unpublished dissertation on robberies in the province of Gauteng, South Africa found that the presence of Automatic Teller Machines (ATMs) and banks were also linked to robberies (Thobane (2017:2).

## 2.3. Crime Forecasting Approaches

The following subsection will describe the available crime forecasting approaches that could potentially assist with the forecast and prevention of the street robberies in Johannesburg Central. These approaches were selected for consideration due to their inclusion in the Rand Corporation's authoritative review of methodologies that were available to law enforcement operations in the USA (Perry et al., 2013). The first two approaches primarily used previous crime locations to forecast future locations - Hot Spot Analysis and Near-Repeat Methods. Thereafter, the methodologies that included a wider list of environmental factors will be described. These include Spatiotemporal Analysis, Data Mining and Risk Terrain Analysis.

### *2.3.1. Hot Spot Analysis*

The first approach related to Hot Spot Analysis, which included a set of techniques that aimed to address a very prevalent finding in the spatial distribution of crime locations in the U.S. This finding read that a large proportion of crimes often clustered in a relatively small number of areas (Eck, Chainey, Cameron, Leitner & Wilson, 2005:1; Perry, et al. 2013:19). The Hot Spot Analysis techniques' primary aim was therefore to identify these clusters or 'hot spots' through an investigation of previous crime locations. The approach then assumed that the locations of these hot spots would remain relatively stable, which led them to argue that future crimes would also occur in these areas (Chainey, Tompson & Uhlig, 2008:4; Perry, et al. 2013:19). The most prominent techniques included Nearest Neighbor Hierarchical clustering (Nnh) and Kernel Density Estimation (KDE) (Chainey, 2013:7).

Hot-Spot Analysis seemed to be suitable for South Africa at first glance. Firstly, the required data for Hot-Spot Analysis, i.e., the past locations of crime, were readily available in South Africa, due to the fact that the SAPS routinely kept record of them (SAPS, 2017:14). In addition, an open-source software programme called CrimeStat (Levine; 2010) could identify crime hotspots and was freely available.

However, Hot-Spot Analysis also presented certain challenges to implementation in South Africa. Indeed, it was yet unclear whether South African crime locations could successfully be forecasted through Hot-Spot Analysis, because most of the studies that tested it were based in the USA, UK and Canada. (Andresen, 2005:258; Braga, Papachristos & Hureau, 2014:633; Chainey, Reid & Stuart, 2002:4; Chainey, 2013:7; Ratcliffe & McCullagh, 1999:385). As mentioned in the background of the current study, this lack in South Africa's Criminological literature also extended to other crime forecasting approaches, in addition to their underlying Criminological theories. This arguably implied the need for a South African crime forecasting approach that could simultaneously test a wide array of underlying theories. However, Hot-Spot Analysis was based on the singular focus of crime 'hot-spots', which effectively precluded the inclusion of a wide theoretical base. Furthermore, the methodologies were quite complex and required substantial prior knowledge of GIS, which largely precluded their use in South Africa, due to a general lack of these skills (Breetzke, Eksteen & Pretorius, 2011; Hall, 1999:11; Mkhongi & Musakwa, 2020).

Some scholars have also critiqued Hot Spot Analysis for its overemphasis on past crime locations, at the expense of other relevant contextual factors, which inevitably compromised the accuracy of forecasts (Kennedy, Caplan, Piza, 2011:340). The approach also drew criticism for its assumption that 'hot spots' remained stable over time. Instead, scholars argued that these crime 'hot spots' were dynamic and that their locations inevitably changed (Kennedy, Caplan, Piza, 2011:340).

### *2.3.2. Near-Repeat Methods*

The Near-Repeat Methods partially improved upon Hot-Spot Analysis' inability to engage with the temporal dynamics of crime locations. It achieved this through an argument that criminals would re-offend soon after, and in close proximity to the locations of their initial offences, due to the fact that these areas were familiar to them (Perry, et al. 2013:45; Townsley, Homel & Chaseling, 2003:616)

Jerry Ratcliffe (2008) utilised this argument to develop a Near Repeat Calculator, which was open-source and therefore easily distributable in South Africa. The application of Near Repeat Methods in South Africa however, also posed certain challenges. Firstly, the near-repeat argument was mostly only tested in the USA and the UK (Ratcliffe & Rengert, 2008:58; Short, D'orsogna, Brantingham & Tita, 2009:325; Townsley, Homel & Chaseling, 2003:615; Wells, Wu & Ye, 2012:186). Therefore, it was yet unclear whether it could accurately forecast crimes in the South African context. This issue was underlined by a Brazilian study which found that the Near-Repeat approach did not accurately forecast burglaries due to an inherently different building infrastructure in that country (Chainey & Da Silva, 2016:9).

Furthermore, and similar to Hot Spot Analysis, the entire approach was built on a singular focus, which in this case was repeat victimisation. This implied that its basic structure did not allow for the inclusion of a wide theoretical base, as per the requirement for a crime forecasting approach in South Africa. Some of the methodologies also relied on complex statistics and included expensive and proprietary software programmes such as Predpol. The latter product was based on an argument that the spatial distribution of crime locations followed a pattern similar to earthquakes and their subsequent aftershocks (PredPol, 2013).

In addition, the Near Repeat approach did not allow for a thorough analysis of crime locations' variations over time. Moreto, Piza & Caplan (2014: 1102-1103) also noted that the Near-Repeat approach largely ignored the surrounding contexts in which crimes occurred, which arguably compromised the accuracy of its crime forecasts.

### *2.3.3. Spatiotemporal Analyses*

The Spatiotemporal Analysis crime forecasting approach improved on these points of inadequacy through a focus on the ways in which various environmental and temporal factors influenced the spatial distribution of crime locations. These methodologies considered a wide array of socio-economic factors, land usages, weather conditions and previous crime locations in relation to temporal aspects such as the days of the week, months of the year, holidays and seasons (Perry et al., 2013:44-45).

One such notable contribution belonged to a proprietary programme from Information Builders, called the Law Enforcement Application Software, which allowed users to identify likely crime hot spots across specific hour-blocks (Information Builders, 2006). Another noteworthy methodology related to a spatiotemporal generalized additive model (ST-GAM) and a local spatiotemporal generalized additive model (LST-GAM) from Wang & Brown, (2012:36-41). This methodology firstly used a GIS programme to identify the locations of previous crimes, geospatial features and general attributes such as socioeconomic indicators. These factors were then indexed by time and used to forecast the locations and times of future crimes.

However, Spatiotemporal Analysis was mostly only tested in the USA and UK (Grubesic & Mack, 2008:292; Leitner & Helbich, 2011: 213) and only seldom in South Africa (Breetzke and Cohn, 2012:643). It did, however, consist of the ability to include a wide theoretical base, as per the current study's requirement for South Africa.

Some of the methodologies attached to Spatiotemporal Analysis, such as Brown & Wang's (2012:36-41) ST-GAM and LST-GAM models were quite complex, however, and required advanced prior knowledge of GIS and statistics. The relevant proprietary software attached to the approach was also possibly too expensive for widespread distribution in South Africa because they originated in the USA.

Spatiotemporal Analysis' reliance on traditional statistical software packages and techniques also imposed a limit on the number of causal variables that could be investigated at any given point. This limit arguably compromised the accuracy of the approach's crime forecasts due to the forced omission of possibly relevant causal factors (Kang & Kang, 2017:2; Perry et al., 2013:36).

### *2.3.4. Data Mining*

Data Mining addressed this limitation through sophisticated software products and statistical techniques that could analyse comparatively larger databases from a wider array of crime risk factors. Scholars then used these techniques to extract patterns from databases to forecast the times and locations of future crimes (Kang & Kang, 2017:2; Perry et al., 2013:36). Two of the most relevant techniques for crime forecasting related to clustering and classification. Clustering algorithms sought to identify data with similar attributes and then made crime predictions on when they would re-appear. Classification methods identified patterns in past observations related to crime risk, which were then used to make predictions about future observations (Perry et al., 2013:35).

These Data Mining techniques may possibly be appropriate in the South African context, at least to some extent, due to the fact that they could simultaneously test the risk factors that originate from a wide theoretical base. In addition, the approach included a free and open-source software product called Weka that is available in South Africa (Bifet & Kirkby, 2009).

However, studies that applied Data Mining to crime forecasting were mostly conducted in countries other than South Africa such as the USA and Bangladesh (Chan & Bennett, 2016:22; Hassani, Huang, Silva & Ghodsi, 2016:139; Joh, 2014:35). Moreover, this area of study was complex and difficult to understand without prior training and experience.

### *2.3.5. Risk Terrain Analysis*

The subfield of Risk Terrain Analysis generally represented a more intuitive approach than Data Mining. It simply argued that future crimes would occur at the locations of crime risk factors (Perry, et al. 2013:50).

The first contribution to this approach belonged to DigitalGlobe's proprietary software program called Predictive Analytics for Security & Law Enforcement (DigitalGlobe, Sa). This product identified future locations at risk for crime through the measurement of distances to possible risk factors in the physical environment.

The second methodology from this approach belonged to Caplan & Kennedy's (2011) Risk Terrain Modelling. This heuristic process started with the subjective and ad hoc identification of known risk factors, often derived from Opportunity Theories' Crime Pattern Theory (Brantingham & Brantingham, 1995). As a result of this theory's inclusion, Risk Terrain Modelling often added land usages that were categorised as 'crime attractors' (Brantingham & Brantingham, 1995:7-8) to its list of crime risk factors. These included land usages such as retail business outlets, schools, entertainment venues, restaurants, bars, shopping centres, apartments and pawn shops (Caplan & Kennedy, 2011:368). Risk Terrain Modeling also utilised Crime Pattern Theory's concept of travel demand, which considered the proximities between criminals and possible victims (Brantingham & Brantingham, 1995:11). As a result, it included crime risk factors such as the locations of previous drug arrests and gang members' residences (Caplan & Kennedy, 2011:368).

The locations of these various risk factors were then used to create separate maps on a GIS program. These maps were then stacked on top of each other and the locations with clusters of risk factors were considered to be at a comparatively higher risk for crime in the future (Caplan, Kennedy & Miller, 2010:70-94).

However, most studies that tested Risk Terrain Analysis approaches were conducted in the USA, with no known applications in South Africa. (Barnum, & Piza, 2016:205; Kennedy et al., 2011:368;). The underlying theory of Crime Pattern Theory was also not tested in South Africa, despite one known exception (Hiropoulos & Porter, 2014:17).

Nonetheless, Risk Terrain Modelling could include a large number of risk factors, despite the fact that its authors only selected a few at a time and also only on an ad hoc basis. Furthermore, the basic premise of Risk Terrain Modelling was not overly complex and did not require advanced prior knowledge of statistics and GIS techniques. Finally, although Risk Terrain Modelling's methodology included a purchasable software package, its methodology was freely available.

### *2.3.6. Summary of approaches under review*

In summary, these five crime-forecasting approaches varied in their abilities to meet the four criteria for an appropriate crime forecasting approach in South Africa, as mentioned in this study's first chapter.

1) Firstly, Spatiotemporal analysis, Data Mining and Risk Terrain Analysis did not preclude the inclusion of a wide theoretical base with its accompanying risk factors. This was, however, not the case for the Hot Spot Analysis and Near-Repeat approaches.

2) Secondly, most of the crime forecasting approaches consisted of complex mathematical, statistical and GIS techniques, which arguably precluded their widespread distribution in the South African context. Risk Terrain Modelling was, however, an exception in this regard.

3) All the crime forecasting approaches had proprietary software products attached to them, the cost of which would arguably be too expensive for widespread distribution in South Africa. Nonetheless, open-source software programs were also available in most of the approaches, except in the case of Risk Terrain Modelling.

4) Finally, none of the five approaches were extensively tested in South Africa and it was yet unclear whether they could accurately forecast incidents of crime in the country.

In a general sense however, Risk Terrain Analysis outperformed the other approaches that were described in this brief review. Although its underlying Criminological theories and methodology were not widely tested in South Africa, it did not preclude the inclusion of a wide theoretical base. Furthermore, despite the presence of commercial software products attached to this approach, the basic tenets of its methodology were freely available and intuitive. Risk Terrain Analysis was therefore selected as the most

suitable base for a South African crime forecasting approach. The following table summarises the results of the review:

| Table 3: Crime Forecasting Approaches' Appropriateness for South Africa | | | | |
|---|---|---|---|---|
| **Crime Forecasting Approach** | **1) Capacity to Include a Wide Array of Theories and Risk Factors** | **2) Intuitive Methodologies** | **3) Open-Source / Proprietary Software** | **4) Accurate Forecasts in South Africa** |
| **Hot Spot Analysis** | No | No | Open-Source Software | Unknown |
| **Near-Repeat Methods** | No | No | Proprietary and Open-Source Software | Unknown |
| **Spatiotemporal Analysis** | Yes | No | Proprietary and Open-Source Software | Unknown |
| **Data Mining** | Yes | No | Proprietary and Open-Source Software | Unknown |
| **Risk Terrain Analysis** | Yes | Yes | Proprietary Software and Purchasable Software (with open-source methodology available) | Unknown |

However, the fact still remained that Risk Terrain Analysis' underlying theoretical base of Crime Pattern Theory was not yet widely tested in South Africa. This was also largely the case for the set of theories from which Crime Pattern Theory originated, i.e., Opportunity Theories. This set of theories will be described in greater detail because it will ultimately form the theoretical basis for current study's crime forecasting approach.

## 2.4. The Opportunity Theories

A set of theories collectively referred to as Opportunity Theories focused on the situations that surrounded crime events, rather than mainstream Criminology's emphasis on criminals and their motivations (Natarajan, 2011:3). These theories were all based on an adapted version of Economics' Rational Choice Theory, which posited that, criminals were hedonistic, self-interested and rational beings who conducted cost-benefit analyses before they committed acts of crime. More specifically, it held that criminals only acted when these analyses led them to believe that they could obtain something valuable without being punished (Cornish & Clarke, 1986). Various other contributors to the subfield elaborated on this basic meta-theoretical premise to

further explore the situational variables and opportunities which influenced these cost-benefit analyses. These included Routine Activity Theory, (Cohen & Felson, 1979: 588; Clarke & Felson, 1993:2), Crime Pattern Theory (Brantingham & Brantingham, 1995:7-8). Broken Windows Theory (Wilson & Kelling, 1982:4), Crime Prevention through Environmental Design (CPTED) (Crowe, 2000:36, Jeffery, 1990; Newman, 1972:2) and Situational Crime Prevention (Clarke, 1995:109; Cornish & Clarke, 2003:47; POPCentre, Sa).

### *2.4.1. Routine Activity Theory*

Firstly, Routine Activity Theory (Cohen and Felson 1995:109) added a time-aspect to criminals' decision-making processes. It argued that criminals would only decide to commit acts of crime when their daily routine activities led them to share a common space with suitable victims that could provide them with something valuable. In addition, they would only commit these crimes in the absence of capable guardians who could mete out punishment. (Cohen & Felson, 1979: 588; Clarke & Felson, 1993:2)

Studies on street robberies in Seattle, Washington, in the USA have provided some support for Routine Activity Theory (Groff 2007:98; Groff 2008:95). However, the theory was not thoroughly tested in South Africa, and it was yet unclear whether it could explain street robberies in the country. One of the few exceptions in this regard was an unpublished dissertation by Thobane (2017: 280-281) who applied Routine Activity Theory and the other Opportunity Theories to associated robberies in the Gauteng province in South Africa. This crime type referred to incidents in which victims were robbed on the way to or from a banking site (Thobane, 2017:2). The other application of Routine Activity Theory in South Africa related to a study by Warchol and Harrington (2016: 21) who found that the theory could successfully explain the illegal abalone trade.

### *2.4.2. Crime Pattern Theory*

However, Routine Activity Theory only focused on the routines of role players and did not fully explore the physical locations in which crimes occurred. Crime Pattern Theory addressed this point of scarcity and argued that the functions of the built environment

dictated the routine activities of role players and, by extension, also influenced criminals' decisions to commit crime (Brantingham & Brantingham, 1995:5).

These built environments included 'crime generators' such as shopping centres and office blocks that naturally attracted a large number of people. The criminals who visited these locations initially did so due to their inherent function, i.e., to shop or go to work. A crime was then eventually committed when these criminals came across opportunities to do so (Brantingham & Brantingham, 1995:7). In contrast, 'crime attractors' related to built environments that criminals visited with the intention to commit acts of crime (Brantingham & Brantingham, 1995:8). The theory also introduced the notion of 'nodes', which referred to central locations in one's field of awareness that were habitually visited, such as places of work and leisure (Brantingham & Brantingham, 1995:10). 'Paths' indicated the routes that one took to arrive at these 'nodes'.

Criminals and victims often shared common 'nodes' and 'paths', which facilitated contact and the commissioning of crimes. This also translated into the concept of travel demand, which related to the distances between the 'nodes' of victims and potential criminals. For instance, people who lived close to potential criminals were at a higher risk for victimisation than persons who lived further away from them (Brantingham & Brantingham, 1995:11).

Groff and Taylor's (2013) study on public housing in Philadelphia, USA showed that Crime Pattern Theory could explain street robberies in the area. However, no studies have attempted to test whether it could explain street robberies in the South African context. Nonetheless, Hiropoulos and Porter (2014:17) showed that the theory could accurately explain 'thefts out of motor vehicle' incidents in South Africa's Gauteng province.

### *2.4.3. Broken Windows Theory*

Crime Pattern Theory, however, only focused on the functions of the built environment and generally neglected the ways in which its forms influenced criminals' cost-benefit analyses. Nevertheless, Broken Windows Theory addressed this issue through a focus on signs of disorder in the built environment, such as broken windows, structural

damage to buildings and peeling paint. The theory argued that these signs of disorder created in criminals an impression of non-ownership, which led them to believe that they did not need to expect any negative repercussions for any crimes they committed in the area. The theory further argued for a zero-tolerance stance towards any signs of disorder, since they would inevitably lead to increasingly serious forms of crime. An often-cited example was criminals who came across a building with a broken window who then further vandalised the building and ultimately committed street robberies in the direct vicinity (Wilson & Kelling, 1982:4).

However, no studies have tested whether Broken Windows Theory could explain street robberies in South Africa. The only attention the theory received in the country was from Bezuidenhout (2011:33), who used it to motivate for improved road safety through zero tolerance towards minor violations.

### *2.4.4. Crime Prevention through Environmental Design*

Similar to Broken Windows Theory, Crime Prevention through Environmental Design (CPTED) focused on the ways in which the forms of the built environment influenced the cost-benefit analyses of criminals. More specifically, CPTED held that certain design features in the built environment created the impression in criminals that the legitimate users of the space would not protect themselves and punish them for acts of crime they would commit in the area. Therefore, CPTED's design principles aimed to influence the legitimate users of built environments to protect themselves, as encapsulated in Newman's (1996:1) notion of 'defensible space'. The theory aimed to facilitate 'defensible space' through the principles of natural surveillance, territoriality, image and milieu.

*Natural surveillance* and its accompanying principle of *access control* were facilitated by designs that allowed legitimate users to observe the activities in the built environment. This would allow them to identify suspicious strangers and intervene by contacting the relevant authorities (Crowe, 2000:36). For the legitimate users to be willing to do this, the theory added that the design of the built environment should engender in them a sense of *territoriality* or ownership (Crowe, 2000:36). The feelings of ownership were more readily prompted in legitimate users of the space when the built environment had an *image* that it was properly cared for. Lastly, *milieu* related to

the notion that the built environment surrounding a property should also ascribe to the principles of surveillance, territoriality and image (Newman, 1972:2).

Similar to the other theories in this subsection, CPTED and its various tenets were not thoroughly tested in South Africa. Instead, scholars mostly only used the theory to educate the South African public about crime prevention (Kruger & Landman, 2008:75).

### *2.4.5. Situational Crime Prevention*

Lastly, Situational Crime Prevention provided specific practical guidelines that were designed to communicate to criminals that any acts of crime would result in higher costs than any benefits they would receive (Clarke, 1995:91). Towards this end, it presented five principles with accompanying sub-points. The first principle was to increase the effort of crime, which would be achieved through measures such as target hardening, access control and the deflection of offenders. The second principle related to the increase of risks for criminals via the extension of guardianship, the provision of natural surveillance and the reduction of anonymity (Clarke, 1995:109; POPCentre, Sa). The third principle aimed to reduce the rewards that criminals may obtain from crime. This would be achieved through the removal of targets, the identification of property and the disruption of markets (Clarke, 1995:109; POPCentre, Sa). The fourth principle sought to reduce provocations through the reduction of frustrations, the avoidance of disputes and the neutralisation of peer pressure. The final principle aimed to remove the excuses for crime through the communication of rules and instructions and the control of drugs and alcohol (POPCentre, Sa). The summative table below provides additional information in this regard:

| Table 4: Situational Crime Prevention Principles | | | | |
|---|---|---|---|---|
| **A. Increase the Effort** | **B. Increase the Risks** | **C. Reduce the Rewards** | **D. Reduce Provocations** | **E. Remove Excuses** |
| **1. Target harden**<br>*Steering column locks and immobilisers<br>*Anti-robbery screens<br>*Tamper-proof packaging | **6. Extend guardianship**<br>*Take routine precautions: go out in group at night, leave signs of occupancy, carry phone<br>*'Cocoon' neighborhood watch | **11. Conceal targets**<br>* Off-street parking<br>*Gender-neutral phone directories<br>*Unmarked bullion trucks | **16. Reduce frustrations and stress**<br>* Efficient queues and police service<br>*Expanded seating<br>*Soothing music/muted lights | **21. Set rules**<br>*Rental agreements<br>*Harassment codes<br>*Hotel registration |
| **2. Control access to facilities**<br>*Entry phones<br>*Electronic card access<br>*Baggage screening | **7. Assist natural surveillance**<br>*Improved street lighting<br>*Defensible space designs<br>*Support whistleblowers | **12. Remove targets**<br>*Removable car radio<br>*Women's refuges<br>*Pre-paid cards for pay phones | **17. Avoid disputes**<br>*Separate enclosures for rival soccer fans<br>*Reduce crowding in pubs<br>*Fixed cab fares | **22. Post instructions**<br>*'No Parking'<br>* 'Private Property'<br>*'Extinguish camp fires' |
| **3. Screen exits**<br>*Ticket needed for exit<br>*Export documents<br>*Electronic merchandise tags | **8. Reduce anonymity**<br>*Taxi driver IDs<br>*'How's my driving?' decals<br>*School uniforms | **13. Identify property**<br>*Property marking<br>*Vehicle licensing and parts marking<br>*Cattle branding | **18. Reduce emotional arousal**<br>*Controls on violent pornography<br>*Enforce good behavior on soccer field<br>*Prohibit racial slurs | **23. Alert conscience**<br>*Roadside speed display boards<br>* Signatures for customs declarations<br>*'Shoplifting is stealing' |
| **4. Deflect offenders**<br>*Street closures<br>*Separate bathrooms for women<br>*Disperse pubs | **9. Utilize place managers**<br>*CCTV for double-deck buses<br>*Two clerks for convenience stores<br>*Reward vigilance | **14. Disrupt markets**<br>*Monitor pawn shops<br>*Controls on classified ads<br>*License street vendors | **19. Neutralize peer pressure**<br>*'Idiots drink and drive'<br>*'It's OK to say No'<br>*Disperse troublemakers at school | **24. Assist compliance**<br>*Easy library checkout<br>*Public lavatories<br>*Litter bins |
| **5. Control tools/weapons**<br>*'Smart' guns<br>*Disabling stolen cell phones<br>*Restrict spray paint sales to juveniles | **10. Strengthen formal surveillance**<br>*Red light cameras<br>*Burglar alarms<br>*Security guards | **15. Deny benefits**<br>*Ink merchandise tags<br>*Graffiti cleaning<br>*Speed humps | **20. Discourage imitation**<br>*Rapid repair of vandalism<br>*V-chips in TV's<br>*Censor details of modus operandi | **25. Control drugs and alcohol**<br>*Breathalyzers in pubs<br>*Server intervention<br>*Alcohol-free events |

Similar to the other Opportunity Theories however, Situational Crime Prevention was not thoroughly tested in South Africa. In light of this absence in the literature, the Crime Opportunity & Risk Forecasting approach included a consolidation of these theories as a theoretical base to facilitate the identification of significant variables.

### *2.4.6. Multi-Contextual Criminal Opportunity Theory*

A seminal contribution to Criminology called the Multi-Contextual Criminal Opportunity Theory (MCOT) (Wilcox, Land and Hunt, 2003: 59-67) bears to be mentioned. The theory integrates the traditions of Routine Activity Theories and Social Control-Disorganization into a single theoretical framework. In this sense, it considers both the criminal opportunities created by the confluence of an attractive target, a motivated offender and the absence of a capable guardian with the breakdown of societal control. Moreover, the theory further differentiates this confluence in terms of both individual and environmental levels of analysis. This theoretical framework allows for the inclusion of a wide array of independent variables, including both individual and aggregated socio-demographic, employment, housing and marital status data etc.

The inclusion of variables related to MCOT into the current study would have undoubtedly provided a more comprehensive theoretical framework for the CORF model. Moreover, it could have contributed towards the elimination of spurious relationships during the analysis phase of the current study. However, MCOT was excluded from the current study because its social control disorganization tenets fell outside of the CORF model's exclusive focus on the traditional crime opportunity theories. Indeed, the traditional crime opportunity theories already offered a high number of independent variables. Moreover, the inclusion of MCOT's focus on social control disorganization would have possibly added an excessive number of independent variables to the CORF model, which could have prevented the timeous submission of the dissertation.

## 2.5. Integration of Opportunity Theories and Theoretical Base

The following subsection will present the manner in which the relevant theories were integrated into a synthesized template, before the resulting theoretical base of the

current study is described. This description will clearly show that this base was exceptionally broad and that satisfied the first objective of the study.

### *2.5.1. Means of Integration*

The principles of the relevant theories were integrated through the concept of Conceptual Integration. This was appropriate due to the fact that the relevant theories held similar theoretical positions at different levels of analysis (Barak, 2002). This description fits Opportunity Theories because all its constituent theories were broadly based on Rational Choice Theory's meta-theoretical argument and focused on different factors that influenced this basic premise (Natarajan, 2011:3).

However, the different ways in which these theories operationalised their independent variables obstructed integration. Routine Activity Theory (Cohen & Felson, 1979: 588; Clarke & Felson, 1993:2), Crime Pattern Theory (Brantingham & Brantingham, 1995:7-8) and Broken Windows Theory (Wilson & Kelling, 1982:4) constructed these variables in terms of risk factors of crime. In contrast, CPTED (Crowe, 2000:36, Jeffery, 1990; Newman, 1972:2) and Situational Crime Prevention (Clarke, 1995:109; Cornish & Clarke, 2003:47; POPCentre, Sa) operationalised their independent variables as recommendations. This obstruction was addressed through the conversion of all the theories' independent variables into risk factors of crime.

### *2.5.2. Opportunity Theories Template as Theoretical Base*

This process of conceptual integration was facilitated through a structure of Broad-, Sub- and Specific-Principles. In accordance with the template's origin, the Broad-Principles related to Opportunity Theories' meta-theoretical base of Rational Choice Theory (Cornish & Clarke, 1986). As a result, the Broad Principles were listed as 'poor guardianship' (low cost) and 'attractive targets' (large benefit), as they encapsulated all of the subsequent principles in the template.

In turn, these Broad Principles drilled down into seven Sub-Principles that simultaneously related to several of the relevant theories. In this regard, the Broad-Principle of 'poor guardianship' related to the Sub-Principles of insufficient formal and informal guardians. In this context, formal guardians referred to persons paid for their

services such as the police and security services. The informal guardians included persons not paid for their services, such as members of community organisations. The Broad-Principle of ‘poor guardianship’ also related to insufficient technological aids and the built environment’s limitations on guardianship. In turn, the Broad Principle of ‘attractiveness of targets’ related to the materialistic and emotional rewards that targets represented to criminals and the ease with which criminals could find them.

Each one of these Sub-Principles entailed several Specific Principles, which were directly related to specific theories. In this regard, the Sub-Principle of ‘Insufficient Formal Guardians’ related to the Specific Principles of ‘limited surveillance ’ (Clarke & Felson, 1993:2; Clarke, 1995:109; Cornish & Clarke, 2003:47; Cohen & Felson, 1979: 588;;; POPCentre, Sa), the absence of access control (Cornish & Clarke, 2003:47; Clarke, 1995:109;; POPCentre, Sa) and the inability to control facilitators such as firearms and knives (Clarke, 1995:109).

The Sub-Principle of ‘Insufficient Informal Guardians’ drilled down into the Specific Principles of their absence (Clarke, 1995:109; Cohen & Felson, 1979: 588;) and inabilities to conduct access control (Clarke, 1995:109). It also included the presence of persons who could not easily defend themselves, such as older people, women and children (Cornish & Clarke, 2003:47).

The Sub-Principle of ‘Insufficient Technological Aids’ also included various Specific-Principles. These related to the absence of manned and automated surveillance technologies and access control technologies (Cornish & Clarke, 2003:47). It also included insufficient target hardening technologies such as poor burglar doors, locks and safes (Clarke, 1995:109).

Finally, the ’poor form of the built environment’ Sub-Principle related to the Specific-Principles of compromised territoriality, poor image and milieu. It also included any aspects in the built environment that obstructed surveillance (Crowe, 2000:36, Jeffery, 1990; Newman, 1972:2).

The template's Broad-Principle of 'Attractive Targets' is now described. The first relevant Sub-Principle, i.e., 'materialistic gains' entailed the Specific Principles of high financial worth (Cohen & Felson, 1979), the ability to easily re-sell stolen items and their useability (Clarke, 1995:109). The Sub-Principle related to emotional rewards included the release of negative emotions during times of arousal and disinhibitors such as drugs and alcohol (POPCentre, Sa).

Lastly, the Sub-Principle related to the consideration that 'targets were easy to find' included the Specific Principles of low travel demand and the functions of the built environment, which attracted both criminals and targets to the same locations (Brantingham & Brantingham, 1995:7-8). The final Specific Principle related to instances in which targets were openly displayed (POPCentre, Sa).

The template is presented in tabular form, with separate columns for the Broad, Sub- and Specific principles. The source of each Specific Principle is also indicated. For clarity, the contributing theories were abbreviated as follows:

- Routine Activity Theory (RAT)
- Broken Windows Theory (BWT)
- Crime Prevention through Environmental Design (CPTED)
- Crime Pattern Theory (CPT)
- Situational Crime Prevention (SCP) – with accompanying principle and number (e.g., A 1)

| Table 5: CORF-Opportunity Theories Template | | | |
|---|---|---|---|
| **Broad Principles** | **Sub-Principles** | **Specific Principles** | **Source** |
| **1. Poor Guardianship:** | **1.1) Insufficient Formal Guardians** | A) No/limited formal surveillance | RAT, SCPT B 6 |
| | | B) No access control/screening/identification | SCPT A 2; A 3; B 10 |
| | | C) No control of facilitators like firearms and knives | SCP A 5 |
| | **1.2) Insufficient Informal Guardians** | A) No/Limited natural and surveillance | RAT, SCP B 7; SCPT B 8 |
| | | B) No access control/screening/identification | SCP A 2; A 3; B 10 |
| | | C) Ineffective self-protection/Guardianship not extended | SCP B 9 |
| | **1.3) Insufficient Technological Aids** | A) No surveillance technology– manned and automated | SCPT - B6, B7, B 8 |
| | | B) No access control technology | SCP A 2 |
| | | C) No/insufficient target hardening technology | SCP A 1 |
| | **1.4) Poor Form of built environment limits guardianship** | A) No territoriality | CPTED |
| | | B) Poor Image | CPTED; BWT; SCP D 20 |
| | | C) Poor Milieu | CPTED |
| | | D) Obstructs natural surveillance | CPTED; SCP B 7, B 8 |
| **2. Benefit: Attractive Target** | **2.1) Will Provide Materialistic Reward** | A) High Financial Worth – goods and cash | RTA |
| | | B) Can Easily Re-Sell: Easy market & No ID on goods | SCP C15; SCP C12 |
| | | C) Can easily use goods | SCP C14 |
| | **2.2) Will Provide Emotional Reward** | A) Release of negative emotions i.e., during a dispute, frustration/stress or emotional arousal | SCP D17; SCP D16; SCPT D18 |
| | | B) Psychological disinhibitors – Alcohol, Drugs | SCP E25 |
| | **2.3) Easy to Find** | A) Travel Demand – Close to travel | CPT) |
| | | B) Function of built environment attracts victims during routine activities | RAT, CPT |
| | | C) Displayed - No target removal at risky times & Temptation/Exhibition | SCP C11, SCP C13 |

## 2.6. Conclusion

In conclusion, this chapter delved deeper into the issue of street robberies in South Africa and the relevant risk factors, before it assessed existing crime forecasting methodologies against the country's need for an approach with a wide theoretical base, intuitiveness, affordability, and accuracy. This analysis identified Risk Terrain Modeling as most suitable approach to address these challenges. Subsequently, the Opportunity Theories were presented, and it was found that although they could explain the distribution of street robberies in the USA and UK, it is unclear whether they can achieve this in South Africa due to a dearth of studies. The latter was used as a motivation to formulate the current study's theoretical base, which was called the Opportunity Theories Template. This template utilised Conceptual Integration to consolidate all the relevant Opportunity Theories into a cohesive whole, which addressed the first obstacle to a South African crime forecasting model. Despite its broad nature, this template also allowed for increasing levels of complexity in terms of broad, sub, and specific principles.

# CHAPTER 3: METHODOLOGY

## 3.1. Introduction

The methodology chapter will highlight the ways in which this wide theoretical base, from the Opportunity Theories Template, was incorporated into the Crime Opportunity & Risk Forecasting (CORF) model. This chapter will illustrate that the CORF model was specially formulated to be easily understandable and affordable, in order to achieve the second, third objectives of the study.

The basic premise of the CORF approach was to identify the specific crime opportunities, in the Opportunity Theories Template, that were linked to the actual occurrences of crime incidents. This linkage then effectively elevated the crime opportunities into the status of crime risk factors, which were used to forecast the locations and times of future crimes. The following subsections will illustrate the process linked to this model, which included the selection of a study population, field site, the selection of reference and forecasted-time periods, and the dependent and independent variables. Thereafter, the data collection and analysis processes will be presented. The methods used to process and analyse the contextual street robbery data from the SAPS is subsequently shown, before the ethical considerations of the study are addressed. Finally, the conclusion presents a summary of the CORF model and illustrates that it satisfies the need for an intuitive and cost-effective crime forecasting model, as per the South African context.

## 3.2. Population of the Study

The parameters of the current study's population relate to the 1212 street segments, that formed part of the Johannesburg Central jurisdiction, between March and April 2017. The CORF model did not include sampling from the study's population with the aim to infer the independent variables' parameters due to its inherent complexity. The sampling process could have included various overly technical applications such as simple random sampling, systematic random sampling, stratified random sampling or cluster random sampling (Abu-Bader, 2021:18). Furthermore, the requisite usage of inferential statistics would have made the CORF model exponentially complicated. Indeed, training is needed to understand and apply inferential statistical techniques

such as Pearson's Correlation, t-tests, analysis of variance, regression analysis and nonparametric statistical techniques (Abu-Bader, 2021:19).

Instead of inferring the parameters of variables through inference, the CORF model aimed to measure the actual variables through a census, which was simpler and more accurate (Kish, 1979:101).

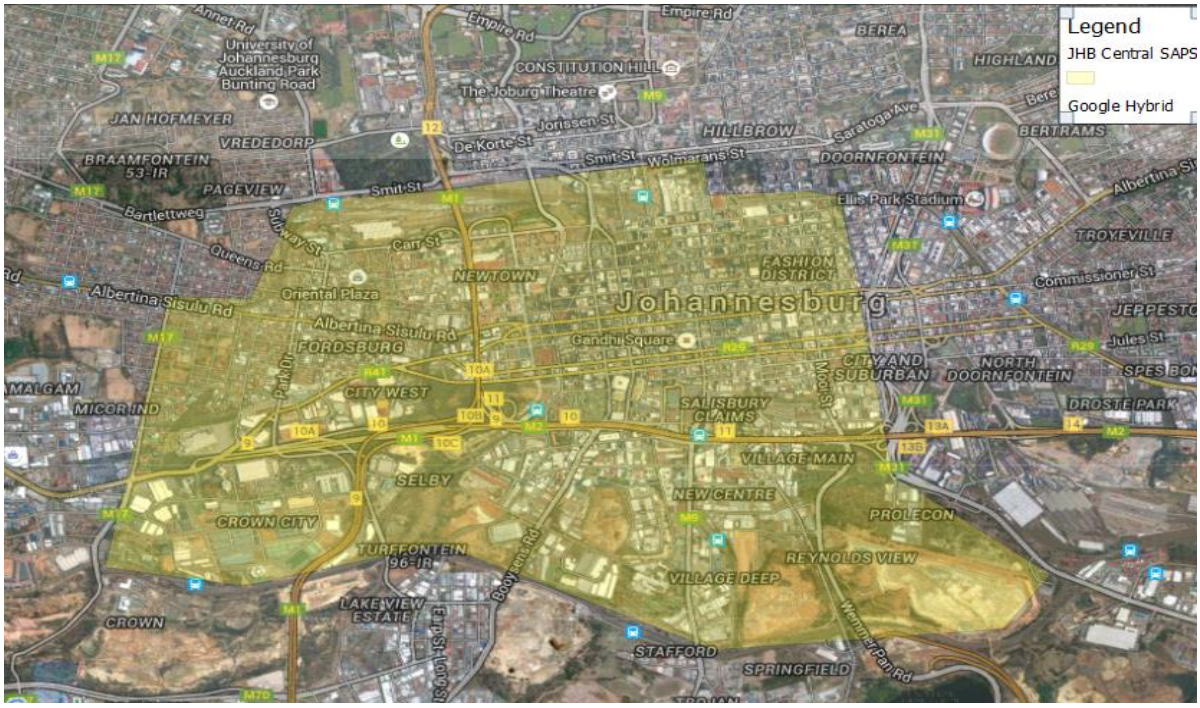
## 3.3. Selection of Field Site

The Johannesburg Central Police Station's jurisdiction was selected because it had the highest number of street robberies during the study's time-period of 2017 (CrimeStatsSa, 2017). The boundaries of this jurisdiction included:

- Northern Boundary: Hancock St, Wanderers St, Wolmarans St. and Smit St
- Western Boundary: Church St
- Southern Boundary: Railway lines marked by Crown, Booysens Stations
- Eastern Boundary: M31 and End St. (CrimeStatsSa, 2018).

The following map illustrated the jurisdiction more clearly:

**Image 1: Johannesburg Central SAPS Jurisdiction**




This image was created through QGIS' polygon function. A new Vector layer was selected and a polygon was created. The 'Toggle Editing' function was selected for this new variable. The Edit feature was selected from the main ribbon and 'Add

Feature' was selected. The actual boundaries of the jurisdiction were then found at CrimeStatssa (2018). The screen was split between the CrimeStatsSa and QGIS pages and the map was drawn.

## 3.4. Selection of Reference – and Forecasted - Time Periods

The following step related to the time period over which the study focused on the field site. In light of the model's goal to forecast incidents of crime, this time period was further differentiated in terms of a reference and forecasted time periods. The former referred to a time period in the field site's history, which was later used to forecast crime in a future time period. Both these time periods had to include the same length of time, such as a week or a month, to facilitate this comparison.

The reference time period for this field site was March 2017. This month was chosen because it was the time at which most of the images from Google Street View were captured. Google's Street View imagery is captured by Google staff who drive in a vehicle with specially mounted cameras that take 360-degree images from streets across the globe. These Google staff members visited the field site sporadically over an 8-year period and the latest available images were from 2017 – no more recent images were available. The subsequent month of April 2017 was selected as the forecasted time period.

## 3.5. Selection and Processing of Dependent and Independent Variables

The dependent and independent variables within the population parameters were selected and processed as described below.

### *3.5.1. Selection of Dependent Variable/Crime Type*

The following step was taken in order to identify the relevant crime type, i.e., street robberies. This crime type was chosen because of its prevalence in the field site (CrimeStatsSa, 2017). As mentioned in the first chapter, the study adopted a definition of street robberies from Monk, Heinonen & Eck, (2010:1) because the definition is comprehensive; it holds the following six characteristics:

- the offender targets a victim.
- the victim was a pedestrian.

- the offender attempted or completed a theft of cash or property.
- the offender used force or the threat of force against the victim.
- the offender used a weapon or the threat of a weapon against the victim.
- the offender may have also grabbed valuable items from the victim without the use of threat/force/weapons.
- the offence occurred in a public place including streets, public parks and abandoned buildings.

The current study's definition, however, differed from the original in terms of characteristic 2, which originally read that the perpetrators could only be strangers. This is due to Leggett's (2003:67) findings that several of the perpetrators in Johannesburg were known to their victims. The current study also added to the definition in the use, or threatened use, of a weapon against the victim, as this was also a common characteristic of street robberies in Johannesburg Central (Leggett, 2003:65). The fifth point of grabbing valuable items without the use of threat/force/weapons were also added to the definition because it occurred often in the area.

Furthermore, the study's definition differed from the original in terms of the sixth characteristic, which spoke to the locations of street robberies. Whereas the current study's definition only included public places, the original definition also related to semi-public areas, such as shared apartment hallways and parking garages. These areas were omitted because Google Street View did not capture them and was therefore not available. The current study added abandoned buildings to this point, due to their prevalence in the area (Van Jaarsveld, et al, 2013:1).

For clarity, the description of street robbery in the study's first chapter did not include the statistics for incidents that fell under the SAPS' 'Common Robbery' crime category. This was due to the fact that the statistics in the first chapter was obtained from the publicly released annual statistics, which did not have the number of street robberies that fell under the 'Common Robbery' crime category.

However, the police's crime registrar provided the student with a detailed Excel spreadsheet for Johannesburg Central, which allowed the student to also include common robberies into the study's crime category.

### *3.5.2. Independent Variables*

The selection and processing of independent variables included the selection of specific principles from the Opportunity Theories Template, their transformation info Crime Opportunity questions and their division into data types.

#### 3.5.2.1. Selection of Corresponding Specific Principles

The selection of street robbery as the study's area of focus directly influenced the Specific Principles that were selected from the CORF model's Opportunity Theories Template. In this sense, all these specific principles related to street-level, as opposed to property-related principles.

#### 3.5.2.2. Transformation of Specific Principles into Crime Opportunity Questions

These Specific Principles from the Opportunity Theories Template were used to compile questions to capture data from the field site. These questions were derived from an investigation in the area and the relevant Criminological literature. At this point in the process, these questions were only indicative of opportunities for crimes that could occur. They were not yet positively linked to the actual crimes.

The questions were phrased in terms of statements that could either be affirmed or denied and implied binary yes/no answers. All the positive answers indicated that the relevant crime opportunity was present in the relevant street. The full data schedule is presented in the appendix.

#### 3.5.2.3. Division of Questions into Data Types

These crime opportunities questions were categorised as either point, or line data. The former represented discrete locations on a map in the form of a point or a set of coordinates. This data type includes factors such as a bar, a broken window or a section of peeling paint (Escobar, et al. Sa:5). Line data was represented by two points on a map and a line connecting them. This data type could not easily be captured

through a point on a map and included crime opportunities along the entire length of a street, such as the absence of a security guard or the absence of an armed response placard (Escobar, et al. Sa:5). The questions linked to these data types had to be differentiated from each other due to this inherent structural difference and the different analyses they required during the analysis phase.

## 3.6. Data Collection

The subsequent steps describe the ways in which this data was captured. This process includes the construction of a data schedule, the selection of data sources and the baseline census of questions.

### *3.6.1. Construction of Data Schedule*

These point and line data questions were captured onto a specifically designed data schedule. This schedule consisted of an Excel spreadsheet, which included all the individual street segments in the area, as rows. The researcher ensured that the entire police jurisdiction was covered.

These street segments contained the relevant street name, the names of the two streets which crossed them and the coordinates at which they crossed. The following table provides an example of the data schedule:

**Table 6: Data schedule excerpt**

| No. | Main Street | Cross Street 1 | Cross Street 2 | 1st Cross street Coordinates | 2nd Cross street Coordinates |
|---|---|---|---|---|---|
| **1** | School St | Polly St | Mooi St | -26.210266, 28.051074 | -26.210218, 28.051675 |
| **2** | School St | Mooi St | Goud St | -26.210228, 28.051879 | -26.210141, 28.052415 |
| **3** | School St | Goud St | Wemmer-Jubilee Rd | -26.210102, 28.052490 | -26.211642, 28.054013 |

The line data questions were included in the columns of the same tab and asked of each one of these street segments. These questions could either be answered ‘yes/no’ to signify their presence or absence in the relevant street segment. In turn, each one of the subsequent point data questions were provided with their own tabs in the spreadsheet, ordered by the relevant numbers of the street segments. These point data questions asked the co-ordinates of the relevant features on the map. Finally,

the spreadsheet also contained a separate tab that captured the co-ordinates and times of the street robberies that took place.

### *3.6.2. Selection of Data Sources*

The independent variable data was captured from Google Street View images, which provided 360-degree views of the 1212 street segments of the field site (Vandeviver, 2014:1). Most of the segments were captured on Google Street View during the selected time-period of the study's population, i.e., March 2017 (69.6%). The other segments were covered during November 2013 (13%), February 2015 (5.9%) and April 2017 (4.2%). The table below provides the percentages of months and years that were available and captured in Google Street View:

| **Table 7: Available Google Street View Data** | | |
|---|---|---|
| **Months** | **Number** | **Percentage** |
| March 2017 | 844 | 69,6% |
| November 2013 | 157 | 13,0% |
| February 2015 | 71 | 5,9% |
| April 2017 | 51 | 4,2% |
| December 2013 | 28 | 2,3% |
| September 2016 | 12 | 1,0% |
| July 2017 | 1 | 0,1% |
| September 2009 | 1 | 0,1% |
| None | 38 | 3,1% |
| Unknown | 9 | 0,7% |
| **Total** | **1212** | **100,0%** |

Street robbery locations were obtained through a perusal of the Johannesburg Central Police Station's case records. This related to all of the robberies that satisfied the definition of street robberies as defined by Monk, Heinonen & Eck, (2010:1) as found in subsection 3.5.1. of this chapter.

### *3.6.3. Baseline Census of Questions*

The Street View images were used to capture all the relevant point and line data crime opportunity questions into the data schedule. This resulted in a large baseline database, which contained the locations of various street robbery opportunities in the area for the reference time period. The locations and times of the street robberies that

took place in this period were also captured in this database. As noted in subsection 3.2 of this chapter, a census was selected because it represented a more intuitive process than sampling. A census also provided more accurate results than inferential statistics (Kish, 1979:101).

## 3.7. Data Analysis

This recorded data was prepared for analysis and thereafter elevated to the status of crime risk factors through their inclusion into vector grids. The details surrounding the latter will be described, before the subsequent processes related to the forecasting, and assessment of results are presented.

### *3.7.1. Data Cleaning*

The baseline data was assessed for any errors to ensure accuracy. One of the errors encountered included the incorrect classification of point data co-ordinates, such as a peeling paint co-ordinate in a drinking tavern subcategory. This issue was addressed through spot checks, which included the pasting of random co-ordinates into Google Maps, and verifying through Google Street View, that the co-ordinate referred to the correct physical feature.

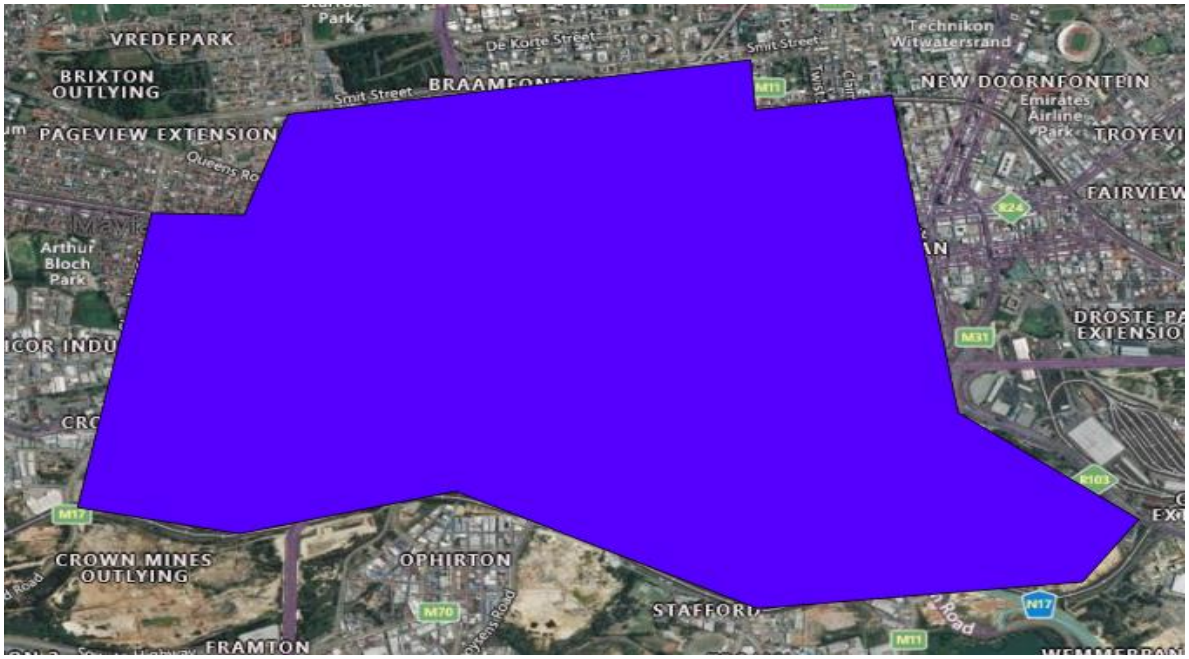
The researcher occasionally, mistakenly, pasted the same set of co-ordinates for two or more different physical features, which meant that these features had incorrect co-ordinates. The ‘Duplicate Values’ tool in Excel was used to highlight these duplicate co-ordinates in red. The researcher then revisited the relevant street segment and inserted the correct co-ordinates.

### *3.7.2. Escalation to Crime Risk Factors through Integration into Vector Grids*

The data was categorised simply as crime opportunities at this point. The integration of the data into Quantum Geographic Information System’ (QGIS) vector grids allowed for the data to be elevated to the status of crime risk factors. QGIS was used in this study as it is an intuitive, free and open-source software program that allows for the analysis and presentation of spatial data (QGIS, 2018). As such, it was an appropriate data analysis program for the purposes of this study.

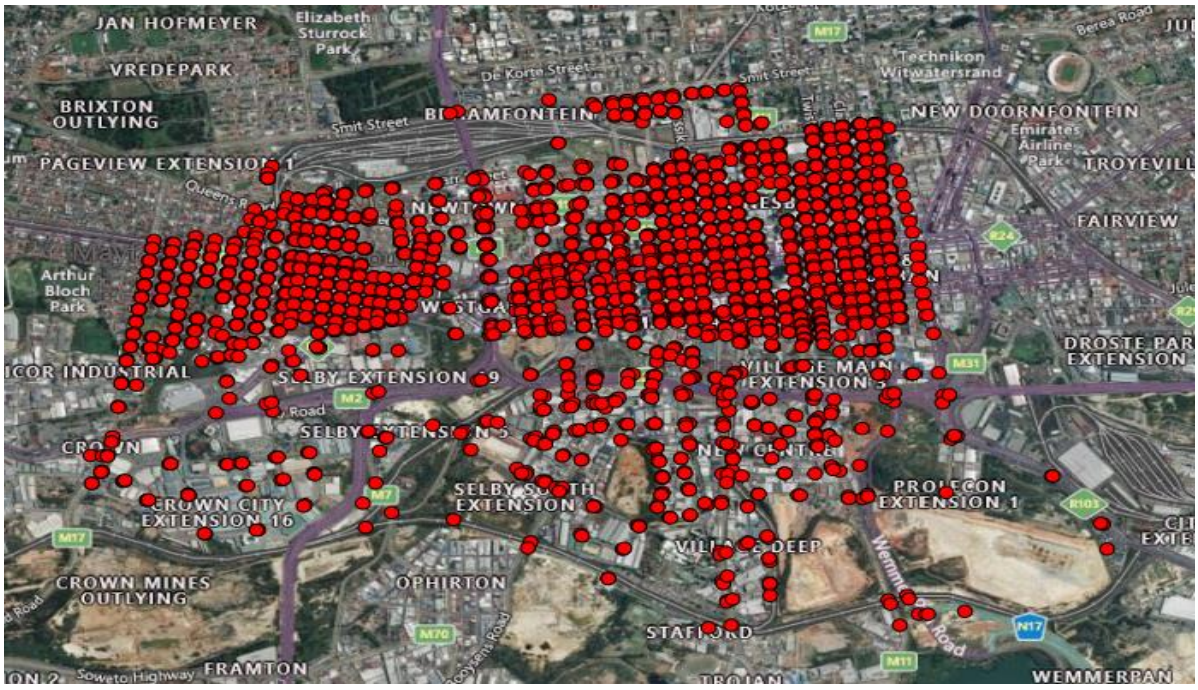
The process started with the superimposition of a polygon over the boundaries of the field site, as discussed in subsection 3.3 (CrimeStatsSa, 2018). The polygon below illustrates:

**Image 2: Polygon Superimposed Over Field Site**




The point data of the street segments were used as the input to create a vector grid over this polygon. The following image presents the street corners of the street segments for the jurisdiction:

**Image 3: Street Corners of Street Segments in Field Site**

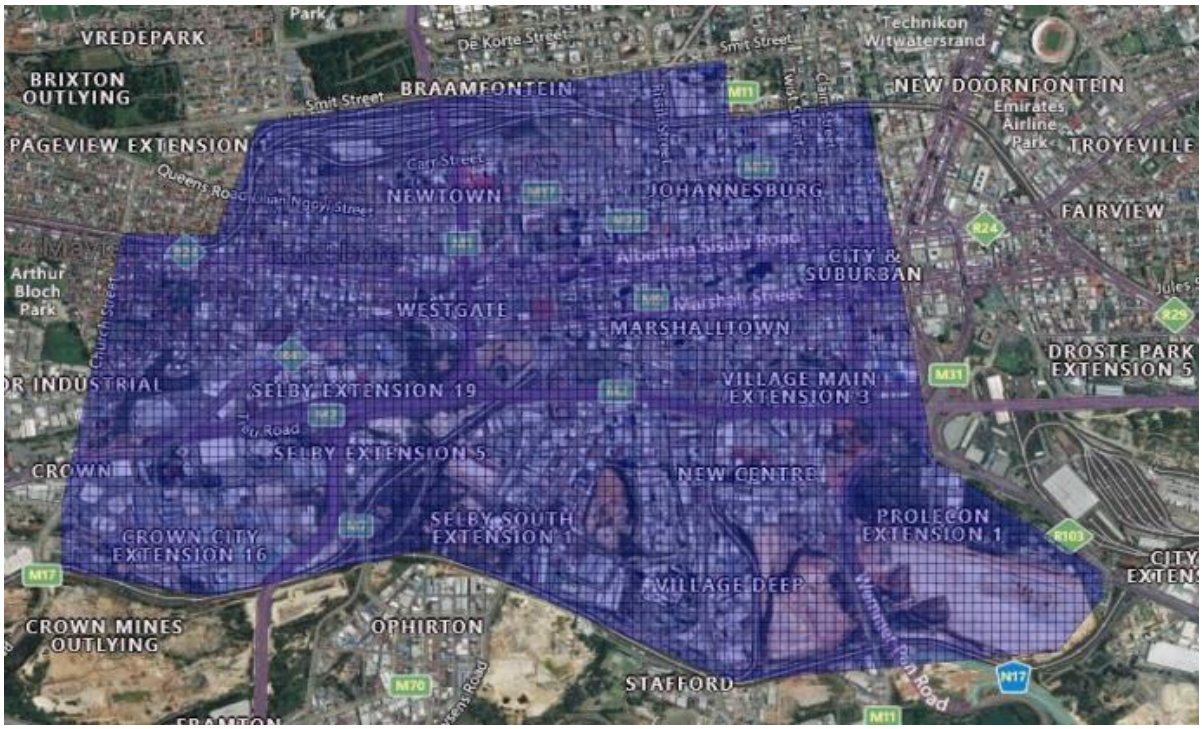


This grid was constructed through the selection of the ‘Vector’, ‘Research Tools’ and ‘Vector Grid’ functions. The street segments were chosen as the input and the ‘Update extents from layer’ option was selected. The parameters for the X were selected for 50 $m^2$. This size was selected because it seemed to loosely fit the size of the city blocks in the jurisdiction. The Lock 1:1 ratio was chosen to make the grids a square shape and the ‘Output grid as polygons’ was selected. The following image presents the unprocessed grid that was created in this manner:

**Image 4: Unprocessed Grid Superimposed Over Field Site**


This grid was clipped in terms of the boundaries of the polygon. This was done through the selection of the functions ‘Vector’, ‘’Geoprocessing Tools’, and ‘Clip’. The Input vector layer was selected as the grid layer and the Clip layer was selected as the polygon of the police jurisdiction. A name was selected for the new file. The following image presents the final grid:

**Image 5: Processed Grids Superimposed Over Field Site**




The point data for the crime opportunities and street robberies in March 2017 were imported. A Points in Polygon analysis was conducted, which effectively divided the points into the relevant grids. This process was followed for each of the crime opportunity point data entries and street robbery data entries from March 2017. The results were then exported to an Excel spreadsheet. Importantly, this allowed all the results to be compared to each other because they were all organised in terms of the rows of the same vector grid.

However, the line dataset was still in a point data format because it only held the two points linked to each line. To transform this into a line data format, each data point for each line was assigned a common questionnaire number. This data was run through QGIS' 'Points2One' function, which used these questionnaire numbers as a common denominator to create line data. The following images provide an example of the conversion of point data to line data:

**Image 6: Points of all Line Coordinates**

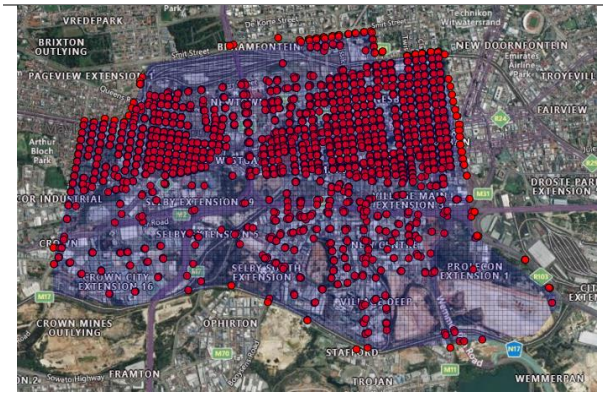
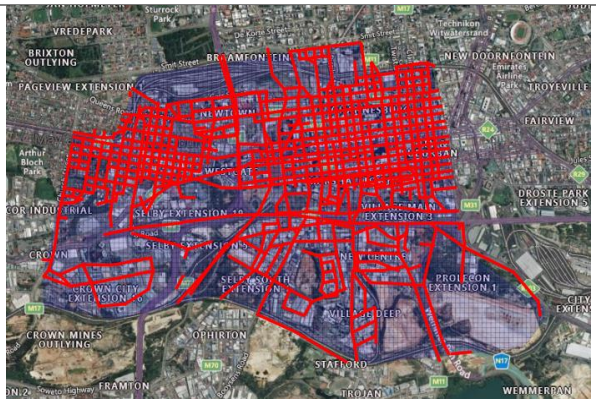



**Image 7: Transformation of Points to Lines**




The Intersect tool was used to identify the grids that intersected the lines of the relevant crime opportunities. This effectively divided the line data entries into the relevant grids. Unfortunately, this process omitted the grids that were not intersected. The results could not, therefore, yet be pasted onto the main spreadsheet, because the line data results did not have the same number of grids.

To address this issue, the line data results, and its grid numbers were pasted underneath a copy of a complete list of the vector grids' numbers. Excel's 'Conditional Formatting' and 'Duplicate Values' function then highlighted in red all the duplicated cells that recorded the same grid number. Thereafter, the grid number column was organised according to cell colour through the 'Custom Sort' function. These duplicated cells were assigned a "1" to identify them as positive rows. The duplicated rows were deleted through the 'Remove Duplicates' function. The result was a list of grid questionnaire numbers as rows, with positive cases as columns that had the exact same grid numbers as the original vector grid. This completed dataset allowed for a spreadsheet with the vector grid numbers as rows and the point and line data headings as columns, with the relevant data organised accordingly.

### *3.7.3. Forecasting*

This spreadsheet was analysed further to assign a risk profile to each grid. To achieve this, the spreadsheet was organised in terms of the grids that recorded crimes. This was done through the 'Sort and Filter' and 'A-Z' functions in Excel. All the rows that had positive entries were converted to "1" and spaces were made underneath to temporarily differentiate the positive rows from the rows that did not record any crimes.

All the crime opportunities that co-occurred within the same grids as these crimes were also identified. Following Tobler's first law of Geography (Tobler, 1970:234), these crime opportunities could be associated with these crime locations due to their proximity. Tobler's First Law of Geography provides a basis from which to gauge the extent to which variables are related. The law states that although all spatial variables are related to each other in some form, variables that are in closer proximity to each other are more related to each other.

These crime opportunities were then weighted to determine the risk attached to each grid. This weighting process started with the conversion of each number in the spreadsheet to a "1". Each crime opportunity's column was summed to get an overall total. These totals were exported and divided by the overall number of street robberies that were recorded in March 2017 to obtain percentages. These percentages were divided by 10 and rounded off to obtain a risk code per crime opportunity out of 10. For example, if 87% of the grids that recorded street robberies also recorded sections of peeling paint, this crime opportunity received a weight of 9 (87%/10 and rounded off). Furthermore, each grid that recorded an incident in March 2017 was automatically designated with a weight of 10.

These weighted codes were pasted in the entire spreadsheet in each relevant crime opportunity's column; the variables not linked to the crimes were deleted from the spreadsheet. All these weighted codes were summed to get an overall total number for each grid. These totals signified the risk profile for each grid. The spreadsheet was organised from the highest to lowest risk profile through the 'Sort and Filter' and 'A-Z functions. Increments of the top 5% were calculated up to the limit of 30%. These segments indicated the grids with the highest risk for street robberies in April 2017 in increasing intervals of 5%. These increments were capped at 30% because it seemed like a reasonable geographical area to cover during police patrols and any larger percentage seemed too large to be useful. The selection of the 30% cut off was selected arbitrarily due to a lack of guidance from the literature regarding the ideal geographical size of policeable hotspots.

These high-risk grids were presented on maps in QGIS, which could facilitate the interpretation of the results, and assist with the planning of prevention efforts. These maps were constructed through opening the grids' attribute table, adding a column, and highlighting the relevant grids. These highlighted grids then appeared in a prominent colour on the map and were superimposed over the street robbery locations of April 2017, to illustrate the extent to which the grids successfully forecasted them.

The forecasting process was repeated on smaller subsets within the database, which included the day- (06:00-17:59) and night-times (18:00-05:59) of the week days during a four-week period in March 2017. The weekends were analysed together in terms of day and night times. This resulted in 10 separate datasets. The following table shows the days that were used for these data sets:

**Table 8: Constitutive Days of Sub-Analysis Datasets**

| | **March** | **April** | **March** | **April** |
|---|---|---|---|---|
| **Week** | **Weekday Daytime & Night-time** | | **Weekend Daytime & Night-time** | |
| **1** | 1, 2, 3, 6, 7 | 3, 4, 5, 6, ,7 | 4, 5, 11, 12, 18, 19, 25, 26 | 1, 2, 8, 9, 15, 16, 22, 23 |
| **2** | 8, 9, 10, 13, 14 | 10, 11, 12, 13, 14 | | |
| **3** | 15, 16, 17, 20, 21 | 17, 18, 19, 20, 21 | | |
| **4** | 22, 23, 24, 27, 28, 29, 30, 31 | 24, 25, 26, 27, 28 | | |

Although some of these variables remained relevant across all the data subsets, some lost its relevance during night times. For instance, the entrances to businesses were not relevant to the night time data sets because they were closed (Clarke & Felson, 1993:2). To ensure the accuracy of the analyses, these dynamic variables were identified through an investigation of the literature and observations at the field site and removed from the night time analyses. The differentiation between static and dynamic variables are presented in the appendix.

### *3.7.4. Assessment of Accuracy*

The following step was to determine the accuracy of the forecasts. This step was important because it allowed the researcher to assess whether the fourth objective of

the study was addressed. The assessment of the model's accuracy was also important for its future applications. Indeed, accurate forecasts could identify areas at risk for crime and assist with prevention efforts. Moreover, inaccurate forecasts could waste valuable human and financial resources.

The first step in this process related to the importation of all the actual crime locations, from April 2017, onto the grids that were forecasted to be high risk. Another Points in Polygon analysis was conducted to determine the number of street robberies that fell within the forecasted high-risk grids. The percentage of these successful forecasts was calculated in terms of the number of grids and incidents in the forecasted time period. These calculations effectively provided an indication of whether the CORF model could accurately forecast the times and dates of street robberies in the Johannesburg Central jurisdiction during April 2017, as per the fourth objective of the study and the hypotheses.

## 3.8. Analysis of Contextual Street Robbery Data

The street robbery data from the SAPS Crime Registrar was analysed for context. These descriptions of street robberies were received from the SAPS in the form of an Excel spreadsheet and contained a variety of information that was analysed. This included the proportions of incidents between March and April 2017, the days of the week, times of day, numbers of perpetrators, numbers of victims, victims' sexes and victims' actions immediately prior to the robbery. It also contained descriptions of weapons, physical violence, injuries, and items that were taken. This information was coded manually, and percentages and totals were calculated.

## 3.9. Ethics

Ethical clearance was applied for the study (Project ID 29032) and obtained from the Monash University Human Research Ethics Committee (MUHREC), as per Appendix-A. In addition, access to the crime data was obtained through the submission of a research proposal to the Crime Registrar at the SAPS Head Office in Pretoria, South Africa, as per Appendix-B.

In this regard, no personal information of the complainants who opened cases at the Johannesburg Police Station were captured to protect their privacy. Furthermore,

these complainants were never contacted at any stage of the research process. In addition, no business names were recorded to protect their reputations and maintain confidentiality (Palys & Lowman, 2000:41).

## 3.10. Conclusion

This chapter showed that the CORF model was intuitive and affordable, as per the second and third objectives of the study. Indeed, the CORF model did not include any complex sampling designs and the corresponding requisite inferential statistics. Instead, the model rather captured data through a census of the dependent and independent variables, which was comparatively simpler. Moreover, only a basic understanding of relatively simple tools in Excel and QGIS were required to perform the data processing, analyses, and forecasts.

The chapter also showed that the CORF model achieved the third objective of affordability because it used QGIS, which was a free and open-source software program. Although Excel was not free, its cost was not exorbitant. Moreover, the same functionality of Excel can be achieved through related free and open-source software programs such as LibreOffice (libreoffice.org). The CORF model itself was not proprietary and was freely available.

Furthermore, the chapter showed that the CORF model's emphasis on intuitiveness and affordability did not compromise its thoroughness and analytical ability, all of which contributed towards the potential for highly accurate crime forecasts. Indeed, the model included an extremely thorough research process, which started with the census of a wide array of independent variables from the Opportunity Theories Template. The thoroughness of the model was also evidenced by detailed data processing and analytical phases. The following chapter will illustrate that this thoroughness resulted in highly accurate crime forecasts.

# CHAPTER 4: RESULTS

## 4.1 Introduction

This chapter will provide some context through a presentation of the results of the street robbery data from the police. Thereafter, the main results from the spatial analysis are presented, which will show that the thorough nature of the CORF model resulted in highly accurate crime forecasts, as per the fourth requirement for the South African context.

## 4.2 Street Robbery Data

The street robbery data from the police was analysed for context and will present the totals, days of the week and times of the day that street robberies took place during the reference and forecasted time periods. Thereafter, the number of perpetrators and victims, the victims' sexes and actions, immediately prior to the robberies, are presented. Finally, the weapons and levels of physical violence are shown before the injuries and losses are presented.

### *4.2.1 Street Robbery Totals*

A total of 306 street robberies were recorded. The month of March 2017 recorded 161 (52.6%) and April recorded 145 (47.4%) of these robberies. Co-ordinates were not available for these street robberies in 32 of the cases (10.5%). The table below provides a summary:

**Table 9: Street Robbery - Totals per Month**

| Month | With Co-ordinates | | Without Co-ordinates | | All Incidents | |
|---|---|---|---|---|---|---|
| | Number | Percentage | Number | Percentage | Number | Percentage |
| **March 2017** | 145 | 52,9% | 16 | 50,0% | 161 | 52,6% |
| **April 2017** | 129 | 47,1% | 16 | 50,0% | 145 | 47,4% |
| **Total** | **274** | **100,0%** | **32** | **100,0%** | **306** | **100,0%** |

### *4.2.2 Days of the Week*

The highest proportion of street robberies occurred over Fridays (18.6%) and Saturdays (16.3%) overall. No significant difference was noticed when the two relevant months were compared.

| Table 10: Street Robbery - Days of the Week | | | | | | |
|---|---|---|---|---|---|---|
| **Days of the Week** | **March 2017** | | **April 2017** | | **Total** | |
| | **Number** | **Percentage** | **Number** | **Percentage** | **Number** | **Percentage** |
| **Mondays** | 21 | 13,0% | 18 | 12,4% | 39 | 12,7% |
| **Tuesdays** | 21 | 13,0% | 20 | 13,8% | 41 | 13,4% |
| **Wednesdays** | 19 | 11,8% | 13 | 9,0% | 32 | 10,5% |
| **Thursdays** | 18 | 11,2% | 29 | 20,0% | 47 | 15,4% |
| **Fridays** | 35 | 21,7% | 22 | 15,2% | 57 | 18,6% |
| **Saturdays** | 27 | 16,8% | 23 | 15,9% | 50 | 16,3% |
| **Sundays** | 20 | 12,4% | 20 | 13,8% | 40 | 13,1% |
| **Total** | **161** | **100,0%** | **145** | **100,0%** | **306** | **100,0%** |

### *4.2.3 Times of the Day*

The hours between 14:00-17:59 (27.1%) and 18:00-21:59 (31.7%) recorded the highest proportions of street robberies overall. The two respective months both showed this same pattern.

| Table 11: Street Robbery - Time of the Day | | | | | | |
|---|---|---|---|---|---|---|
| **Times of Day** | **March 2017** | | **April 2017** | | **Total** | |
| | **Number** | **Percentage** | **Number** | **Percentage** | **Number** | **Percentage** |
| **06:00-09:59** | 28 | 17,4% | 13 | 9,0% | 41 | 13,4% |
| **10:00-13:59** | 28 | 17,4% | 25 | 17,2% | 53 | 17,3% |
| **14:00-17:59** | 39 | 24,2% | 44 | 30,3% | 83 | 27,1% |
| **18:00-21:59** | 51 | 31,7% | 46 | 31,7% | 97 | 31,7% |
| **22:00-01:59** | 6 | 3,7% | 9 | 6,2% | 15 | 4,9% |
| **02:00-05:59** | 9 | 5,6% | 8 | 5,5% | 17 | 5,6% |
| **Total** | **161** | **100,0%** | **145** | **100,0%** | **306** | **100,0%** |

### *4.2.4 Number of Perpetrators*

Most street robberies recorded only 1-5 perpetrators (85%).

| Table 12: Street Robbery - Number of Perpetrators | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | **March 2017** | | **April 2017** | | **Total** | |
| | **Number** | **Percentage** | **Number** | **Percentage** | **Number** | **Percentage** |
| **One - Five Perpetrators** | 139 | 86,3% | 121 | 83,4% | 260 | 85,0% |
| **Six-Sixteen Perpetrators** | 9 | 5,6% | 14 | 9,7% | 23 | 7,5% |
| **Unknown Number of Perpetrators** | 13 | 8,1% | 10 | 6,9% | 23 | 7,5% |
| **Total** | **161** | **100,0%** | **145** | **100,0%** | **306** | **100,0%** |

### *4.2.5 Number of Victims*

The perpetrators typically only robbed one victim (93.5%).

| Table 13: Street Robbery - Number of Victims | | | | | | |
|---|---|---|---|---|---|---|
| **Number of Victims** | **March 2017** | | **April 2017** | | **Total** | |
| | **Number** | **Percentage** | **Number** | **Percentage** | **Number** | **Percentage** |
| **One** | 154 | 95,7% | 132 | 91,0% | 286 | 93,5% |
| **Two** | 6 | 3,7% | 8 | 5,5% | 14 | 4,6% |
| **Three** | 1 | 0,6% | 1 | 0,7% | 2 | 0,7% |
| **Unknown** | 0 | 0,0% | 4 | 2,8% | 4 | 1,3% |
| **Total** | **161** | **100,0%** | **145** | **100,0%** | **306** | **100,0%** |

### *4.2.6 Victims' Sexes*

Furthermore, these victims were typically male (69.6%).

| Table 14: Street Robbery – Victims' Sexes | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | **March 2017** | | | **April 2017** | | | **Total** | | |
| | **Number** | **Percentage** | **Total** | **Number** | **Percentage** | **Total** | **Number** | **Percentage** | **Total** |
| **Male** | 109 | 67,7% | **161** | 104 | 71,7% | **145** | 213 | 69,6% | **306** |
| **Female** | 43 | 26,7% | **161** | 39 | 26,9% | **145** | 82 | 26,8% | **306** |
| **Unknown** | 14 | 8,7% | **161** | 6 | 4,1% | **145** | 20 | 6,5% | **306** |

### *4.2.7 Victims' Actions Immediately Prior to Robbery*

A large proportion of victims were on their way to or from nodes of transport such as taxi ranks, bus and train station (16.3%) before the robberies. The victims were also commonly going to or from work (4.9%) and the shops (4.9%). The SAPS records did not have information related to the actions of victims immediately prior to robberies in a total of 54.9%.

| Table 15: Street Robbery – Victims' Actions Immediately Prior to Robbery | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | **March 2017** | | | **April 2017** | | | **Total** | | |
| | **Number** | **Percentage** | **Total** | **Number** | **Percentage** | **Total** | **Number** | **Percentage** | **Total** |
| **At/To/From a taxi/taxi rank/bus/train station/transport** | 22 | 13,7% | **161** | 28 | 19,3% | **145** | 50 | 16,3% | **306** |
| **To/From work** | 6 | 3,7% | **161** | 9 | 6,2% | **145** | 15 | 4,9% | **306** |
| **To/from shop** | 9 | 5,6% | **161** | 4 | 2,8% | **145** | 13 | 4,2% | **306** |
| **After withdrew/deposit cash at bank ATM/Branch** | 3 | 1,9% | **161** | 9 | 6,2% | **145** | 12 | 3,9% | **306** |
| **To/From residence** | 4 | 2,5% | **161** | 5 | 3,4% | **145** | 9 | 2,9% | **306** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **At an event/concert/party/protest/bar** | 0 | 0,0% | **161** | 9 | 6,2% | **145** | 9 | 2,9% | **306** |
| **Used cell phone on street** | 3 | 1,9% | **161** | 5 | 3,4% | **145** | 8 | 2,6% | **306** |
| **Informal Seller busy selling** | 4 | 2,5% | **161** | 3 | 2,1% | **145** | 7 | 2,3% | **306** |
| **Waited on street for traffic light/friend/rain to stop** | 3 | 1,9% | **161** | 4 | 2,8% | **145** | 7 | 2,3% | **306** |
| **From school** | 3 | 1,9% | **161** | 2 | 1,4% | **145** | 5 | 1,6% | **306** |
| **To/From shopping centre** | 1 | 0,6% | **161** | 4 | 2,8% | **145** | 5 | 1,6% | **306** |
| **To fast food outlet/restaurant** | 3 | 1,9% | **161** | 0 | 0,0% | **145** | 3 | 1,0% | **306** |
| **From college/university** | 1 | 0,6% | **161** | 1 | 0,7% | **145** | 2 | 0,7% | **306** |
| **Collecting owed cash** | 0 | 0,0% | **161** | 2 | 1,4% | **145** | 2 | 0,7% | **306** |
| **Unknown** | 98 | 60,9% | **161** | 70 | 48,3% | **145** | 168 | 54,9% | **306** |
| **Other** | 4 | 2,5% | **161** | 2 | 1,4% | **145** | 6 | 2,0% | **306** |

### *4.2.8 Weapons and Physical Violence*

Most of the street robberies recorded the use of violence and/or weapons (83.3%). The remaining street robberies (16.7%) related to incidents in which this was not the case. More specifically, these incidents included so-called snatch and grab, where the perpetrators simply grabbed valuable items from victims and ran away.

**Table 16: Street Robbery – Weapons and Physical Violence**

| **Description** | **March 2017** | | **April 2017** | | **Total** | |
|---|---|---|---|---|---|---|
| | **Number** | **Percentage** | **Number** | **Percentage** | **Number** | **Percentage** |
| **Weapons and/or violence** | 133 | 82,6% | 122 | 84,1% | 255 | 83,3% |
| **No weapons and/or violence (Bump/Pickpocket/Grab item)** | 28 | 17,4% | 23 | 15,9% | 51 | 16,7% |
| **Total** | **161** | **100,0%** | **145** | **100,0%** | **306** | **100,0%** |

### *4.2.9 Presence of Weapons*

The results further showed that perpetrators used weapons quite often (43.1%).

| Table 17: Street Robbery – Presence of Weapons | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | **March 2017** | | **April 2017** | | **Total** | |
| | **Number** | **Percentage** | **Number** | **Percentage** | **Number** | **Percentage** |
| **Yes** | 69 | 42,9% | 63 | 43,4% | 132 | 43,1% |
| **No** | 74 | 46,0% | 67 | 46,2% | 141 | 46,1% |
| **Unknown** | 18 | 11,2% | 15 | 10,3% | 33 | 10,8% |
| **Total** | **161** | **100,0%** | **145** | **100,0%** | **306** | **100,0%** |

### *4.2.10 Types of Weapons Used*

These weapons typically included knives (56.1%) and firearms (38.6%). Other weapons such as pepper spray and bricks were also used (17.4%).

| Table 18: Street Robbery – Types of Weapons Used | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **March 2017** | | | **April 2017** | | | **Total** | | |
| | **Number** | **Percentage** | **Total** | **Number** | **Percentage** | **Total** | **Number** | **Percentage** | **Total** |
| **Knives** | 37 | 53,6% | **69** | 37 | 58,7% | **63** | 74 | 56,1% | **132** |
| **Firearms** | 34 | 49,3% | **69** | 17 | 27,0% | **63** | 51 | 38,6% | **132** |
| **Other Weapon** | 12 | 17,4% | **69** | 11 | 17,5% | **63** | 23 | 17,4% | **132** |

### *4.2.11 Prevalence of Physical Violence*

Perpetrators also used physical violence regularly during the robberies (32.7%). This violence related to instances in which the perpetrators physically touched their victims with the intent to either injure of subdue them.

| Table 19: Street Robbery – Prevalence of Physical Violence | | | | | | |
|---|---|---|---|---|---|---|
| **Descriptions** | **March 2017** | | **April 2017** | | **Total** | |
| | **Number** | **Percentage** | **Number** | **Percentage** | **Number** | **Percentage** |
| **Yes** | 53 | 32,9% | 47 | 32,4% | 100 | 32,7% |
| **No** | 86 | 53,4% | 80 | 55,2% | 166 | 54,2% |
| **Unknown** | 22 | 13,7% | 18 | 12,4% | 40 | 13,1% |
| **Total** | **161** | **100,0%** | **145** | **100,0%** | **306** | **100,0%** |

### *4.2.12 Types of Physical Violence*

This violence typically took the form of grabs (47%) and strangulations (40%). The latter referred to a carotid choke in which the perpetrators used their forearms to strangle their victims from behind.

| Table 20: Types of Physical Violence | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | **March 2017** | | | **April 2017** | | | **Total** | | |
| | **Number** | **Percentage** | **Total** | **Number** | **Percentage** | **Total** | **Number** | **Percentage** | **Total** |
| **Grabbed** | 25 | 47,2% | **53** | 22 | 46,8% | **47** | **47** | 47,0% | **100** |
| **Strangled** | 24 | 45,3% | **53** | 16 | 34,0% | **47** | **40** | 40,0% | **100** |
| **Pushed** | 3 | 5,7% | **53** | 9 | 19,1% | **47** | **12** | 12,0% | **100** |
| **Threw Down/Tripped** | 5 | 9,4% | **53** | 3 | 6,4% | **47** | **8** | 8,0% | **100** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Punched** | 4 | 7,5% | **53** | 2 | 4,3% | **47** | **6** | 6,0% | **100** |
| **Slapped** | 2 | 3,8% | **53** | 1 | 2,1% | **47** | **3** | 3,0% | **100** |

### *4.2.13 Injuries*

A large proportion of these strangulations resulted in the loss of consciousness (15%). Some incidents also recorded stabbings (7%) and other physical injuries (16%).

| **Table 21: Street Robbery - Injuries** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Description** | **March 2017** | | | **April 2017** | | | **Unknown** | | | **Total** | | |
| | **Number** | **%** | **Total** | **Number** | **%** | **Total** | **Number** | **%** | **Total** | **Number** | **%** | **Total** |
| **Conscious-ness Lost** | 3 | 12,5% | 24 | 3 | 18,8% | 16 | 27 | 67,5% | 40 | 6 | 15,0% | 40 |
| **Stabbed** | 5 | 9,4% | 53 | 2 | 4,3% | 47 | 33 | 33,0% | 100 | 7 | 7,0% | 100 |
| **Other Injuries** | 9 | 17,0% | 53 | 7 | 14,9% | 47 | 36 | 36,0% | 100 | 16 | 16,0% | 100 |

### *4.2.14 Items Taken*

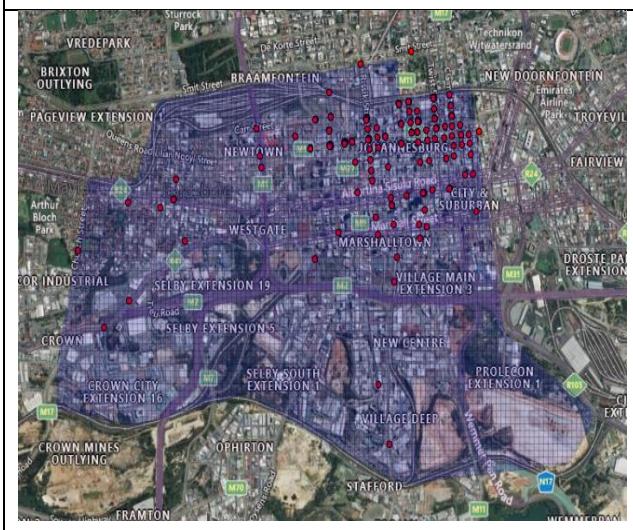
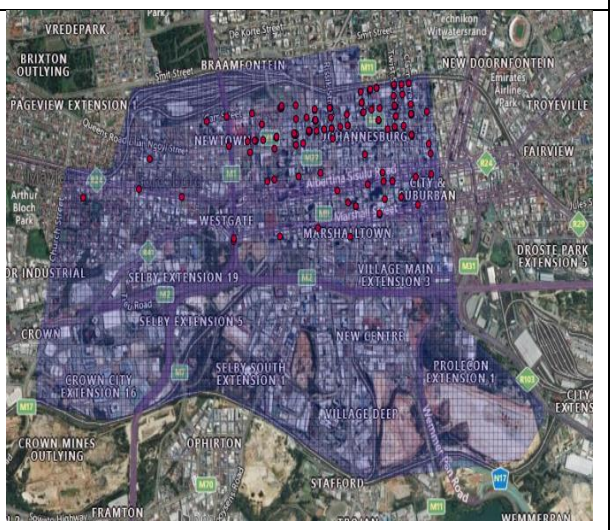
The perpetrators typically took items such as wallets, cash, cell phones, jewelry, laptops and handbags. The results from the spatial analyses are presented below.

## 4.3 Spatial Analysis Results

This subsection will present the locations of these street robberies and the relevant crime opportunities in the police jurisdiction. Thereafter, the results for the analysis of the entire database are presented in terms of the weights that were identified and the successful forecasts. Maps of these successes are also presented. Subsequently, the chapter provides the weights and successful forecasts of the 10 sub-analyses, in addition to a summary of all the results.

### *4.3.1 Street Robbery Locations*

The maps below illustrate that the robberies in both March and April 2017 that took place, mostly in the north-eastern subsection of the field site. Furthermore, the 145 street robberies, with co-ordinates, that took place in March 2017, were recorded in 97 grids. The 129 street robberies, with co-ordinates, that took place in April 2017, were recorded in 87 grids.

| **Image 8: Street Robberies – March 2017** | **Image 9: Street Robberies – April 2017** |
|---|---|
|  |  |

### *4.3.2 Overall Results*

The weights and successful forecasts for the overall results follow.

#### 4.3.2.1 Weights for March 2017

This subsection will now display the 55 crime opportunities that were recorded in the 97 grids that held street robberies during the reference-period, i.e., March 2017. These results showed that a total of 97.9% of the grids that recorded street robberies in March 2017 also held the locations of cash-based services; the entrances to formal businesses were also highly linked (83.5%). The grids with street robberies also typically recorded an absence of security guards linked to specific streets (96.9%) and sites (94.8%), in addition to the absence of car guards (96.9%). Furthermore, street robbery grids often recorded the absence of CCTV cameras (83.5%) and sections of street that were not covered by existing CCTV cameras (94.8%). Other significant risk factors related to the absence of armed response placards (80.4%) and stop streets (96.9%); the presence of sidewalks (97.9%) was also highly linked. The table below provides more information about each of the crime opportunities that fell within the street robbery grids in March 2017:

| Table 22: Overall Results – Weights for March 2017 | | | | |
|---|---|---|---|---|
| **No** | **Question** | **Number** | **Percentage** | **Weight** |
| **1** | 31) There were sidewalk(s) on this street that pedestrians could walk on (Observation). | 95 | 97,9% | 10 |
| **2** | 30) People used cash to pay for services/goods on this street (Bernasco & Block, 2011:35). | 95 | 97,9% | 10 |
| **3** | 12) No security guards were stationed on this street (Welsh, Mudge & Farrington, 2010: 314). | 94 | 96,9% | 10 |
| **4** | 17) There were no stop streets on this street. (Observation). | 94 | 96,9% | 10 |
| **5** | 13) No formal (Welsh, Mudge & Farrington, 2010: 314) or informal (Baker, 2002:41) car guards were present on this street. | 94 | 96,9% | 10 |
| **6** | 20) There were sections on this street not covered by CCTV cameras (Minnaar, 2002). | 92 | 94,8% | 9 |
| **7** | 11) No guards were stationed at a specific site (Willis, 1995). | 92 | 94,8% | 9 |
| **8** | 50) Cars and motorcycles could park on this street (Observation). | 89 | 91,8% | 9 |
| **9** | 19) There were no CCTV cameras on this street (Minnaar, 2002: 175). | 81 | 83,5% | 8 |
| **10** | 33) Locations of entrances to all formal businesses (Irvin-Erickson, 2014:125). | 79 | 81,4% | 8 |
| **11** | 10) No alarm/armed response placard(s) was present on this street (Singh, 2005: 154) | 78 | 80,4% | 8 |
| **12** | 15) This street had 2 or fewer lanes. (Observation). | 67 | 69,1% | 7 |
| **13** | 21) The entrances to any formal land usages with obvious functions were not visible to each other (Observation). | 64 | 66,0% | 6 |
| **14** | 28) The street lights did not provide adequate lighting for any portion of this street (Pease, 1999: 69). | 57 | 58,8% | 6 |
| **15** | 32) Locations of informal businesses such as road-side stalls and other informal traders on this street (Observation). | 53 | 54,6% | 5 |
| **16** | 23) Locations of peeling paint / irregular paint on this street (Van Jaarsveld et al. 2013). | 51 | 52,6% | 5 |
| **17** | 18) Any stalls/informal traders were not visible to each other (Observation). | 42 | 43,3% | 4 |
| **18** | 25) Locations of graffiti on this street (Van Jaarsveld et al. 2013). | 41 | 42,3% | 4 |
| **19** | 58) Multistorey Apartments above Businesses (Observation). | 31 | 32,0% | 3 |
| **20** | 59) Informal housing/shacks (Observation). | 31 | 32,0% | 3 |

| | | | | |
|---|---|---|---|---|
| **21** | 24) Locations of structural damage on buildings on this street (Van Jaarsveld et al. 2013). | 26 | 26,8% | 3 |
| **22** | 26) Locations of razor mesh on this street (Van Jaarsveld et al. 2013). | 25 | 25,8% | 3 |
| **23** | 16) There were no traffic lights on this street. (Observation). | 25 | 25,8% | 3 |
| **24** | 22) Locations of broken window(s) on this street (Van Jaarsveld et al. 2013). | 24 | 24,7% | 2 |
| **25** | 37) Locations of entrances to fast-food outlets on this street (Bernasco & Block, 2011:34) | 23 | 23,7% | 2 |
| **26** | 38) Locations of entrances to restaurants (Bernasco & Block, 2011:34) and coffee shops (Observation) on this street. | 12 | 12,4% | 1 |
| **27** | 39) Locations of entrances to shopping centres on this street (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 62).. | 12 | 12,4% | 1 |
| **28** | 51) Location of entrances to parking lots on this street (Observation). | 12 | 12,4% | 1 |
| **29** | 35) Locations of entrances bars/drinking taverns on this street (Bernasco & Block, 2011:35). | 10 | 10,3% | 1 |
| **30** | 68) Locations of entrances to office blocks and warehouses (Observation). | 7 | 7,2% | 1 |
| **31** | 53) Locations of entrances to bus stops, bus ticket sales offices and bus depots on this street (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 71; https://www.mbus.co.za/index.php/pricing?id=118) | 7 | 7,2% | 1 |
| **32** | 72) Locations of entrances to churches (Observation). | 6 | 6,2% | 1 |
| **33** | 42) Locations of (s)/open spaces on this street (Mohit & Elsawahli 2017: 57). | 6 | 6,2% | 1 |
| **34** | 48) Location of entrances to banks on this street (Thobane (2017:2) | 5 | 5,2% | 1 |
| **35** | 75) Locations of public seating areas and a public gym (Observation). | 4 | 4,1% | 1 |
| **36** | 36) Locations of entrances to liquor stores (Bernasco & Block, 2011:48). | 4 | 4,1% | 1 |
| **37** | 40) Locations of entrances to abandoned building on this street (Van Jaarsveld et al. 2013). | 4 | 4,1% | 1 |
| **38** | 44) Location of entrances to creche/kindergartens on this street (Observation). | 4 | 4,1% | 1 |
| **39** | 49) Location of ATMs on this street (Thobane (2017:2). | 4 | 4,1% | 1 |
| **40** | 57) Multistorey Apartments – No businesses below (Observation). | 4 | 4,1% | 1 |
| **41** | 61) Locations of entrances to hotels/motels on this street (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 69). | 4 | 4,1% | 1 |
| **42** | 62) Locations of entrances to construction sites (Observation). | 3 | 3,1% | 1 |

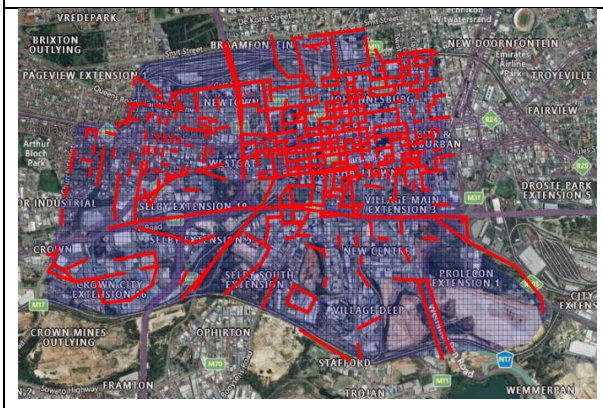
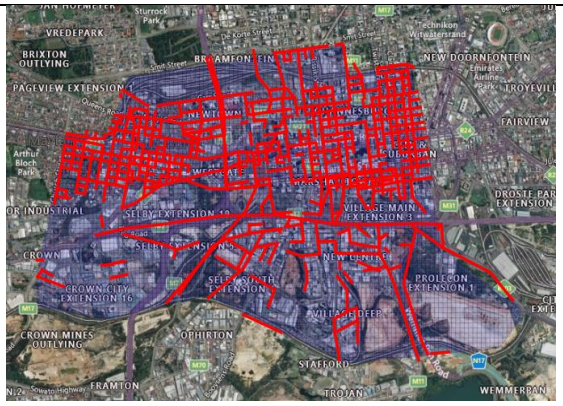
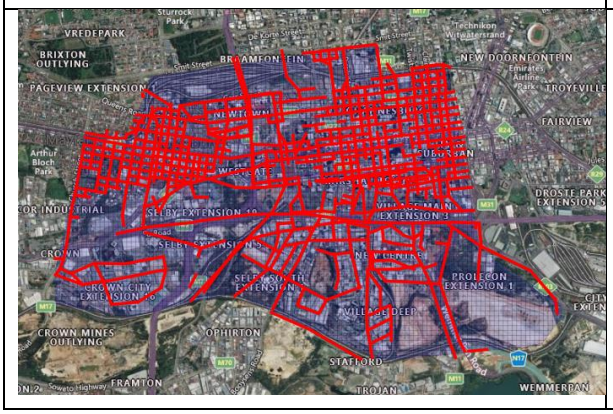
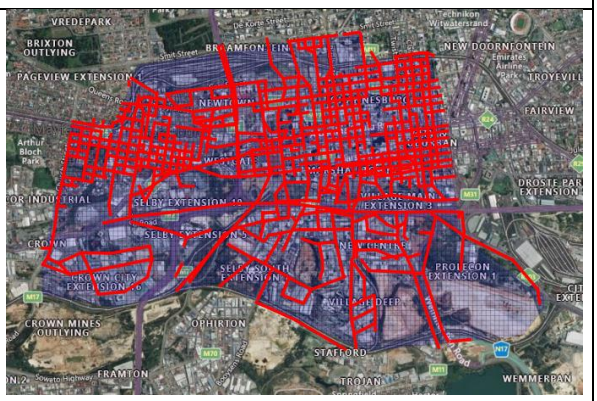
| | | | | |
|---|---|---|---|---|
| **43** | 70) Locations of entrances to medical assistance, including clinics, doctors' offices and dentists – not open 24/7 (Observation). | 3 | 3,1% | 1 |
| **44** | 14) No vehicles drove on this street at all at any time. (Observation) (Observation). | 3 | 3,1% | 1 |
| **45** | 69) Locations of homeless and recycling (not including recycling depots) (Observation). | 2 | 2,1% | 1 |
| **46** | 47) Locations of entrances to universities, colleges, academies and training facilities on this street (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 69). | 2 | 2,1% | 1 |
| **47** | 64) Locations of public telephones (Observation). | 1 | 1,0% | 1 |
| **48** | 66) Locations of postboxes and lockers (not at post offices) (Observation). | 1 | 1,0% | 1 |
| **49** | 67) Locations of entrances to petrol stations (Observation). | 1 | 1,0% | 1 |
| **50** | 27) Location of an alleyway or tunnel on this street. (Observation) | 1 | 1,0% | 1 |
| **51** | 34) Locations of entrances to larger businesses (Irvin-Erickson, 2014:125). | 1 | 1,0% | 1 |
| **52** | 41) Locations of entrances to empty/to-let/sold/auctioned properties (Observation). | 1 | 1,0% | 1 |
| **53** | 46) Locations of entrances to schools for primary and high school / high school students on this street (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 62). | 1 | 1,0% | 1 |
| **54** | 52) Location of entrances to taxi ranks on this street (Observation). | 1 | 1,0% | 1 |
| **55** | 56) House (Mohit & Elsawahli 2017: 60). | 1 | 1,0% | 1 |

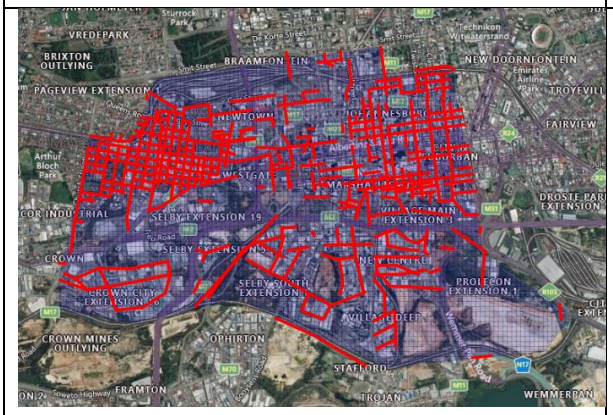
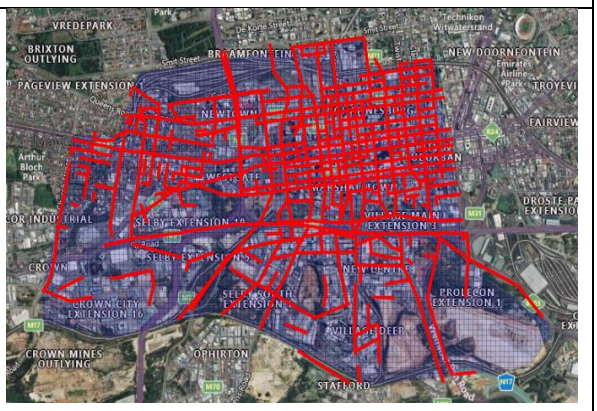
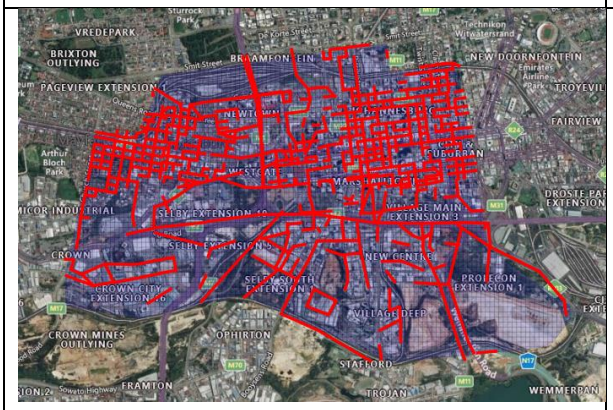
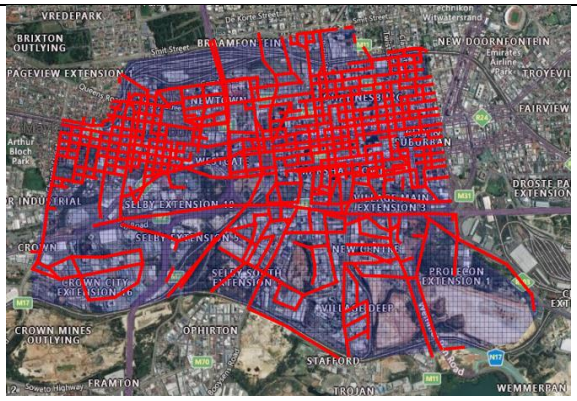
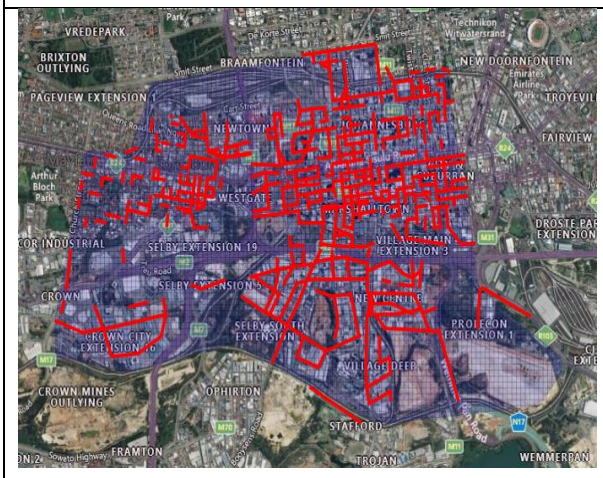
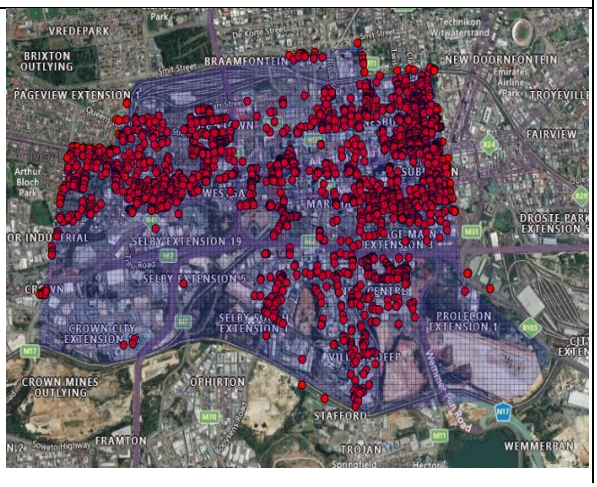
#### 4.3.2.2 Successful Forecasts

The results from the top 10 crime opportunities showed that that top 5% (248 grids/1.2 km$^2$) of these risk-adjusted grids included 47.1% of the grids that recorded street robberies during April 2017. Furthermore, these grids held 50.4% of all the April 2017, street robberies.

The top 10% of the risk-adjusted grids held 63.2% of April 2017's street robbery grids and 69% of all April 2017, street robberies. The top 15% recorded 77% of the relevant grids and 80.6% of the incidents. The reason for the discrepancy between the number of successfully forecasted grids and incidents is that more than one incident took place in some of the grids.

The images below present the spatial distributions of the crime opportunities that were linked to street robberies, in both the overall and sub analyses.

| **Image 10: No alarm/armed response placard(s) was present on this street (Singh, 2005: 154)** | **Image 11: No guards were stationed at a specific site (Welsh, Mudge & Farrington, 2010: 314).** |
|---|---|
|  |  |
| **Image 12: No security guards were stationed on this street (Welsh, Mudge & Farrington, 2010: 314).** | **Image 13: No formal (Welsh, Mudge & Farrington, 2010: 314) or informal (Baker, 2002:41) car guards were present on this street.** |
|  |  |

| | |
|---|---|
| **Image 14: This street had two or fewer lanes. (Observation).** | **Image 15: There were no stop streets on this street. (Observation).** |
|  |  |
| **Image 16: There were no CCTV cameras on this street (Minnaar, 2002).** | **Image 17: There were sections on this street not covered by CCTV cameras (Minnaar, 2002: 175).** |
|  |  |
| **Image 18: The entrances to any formal land usages with obvious functions were not visible to each other** (Observation). | **Image 19: Locations of peeling paint / irregular paint on this street (Van Jaarsveld et al. 2013).** |
|  |  |

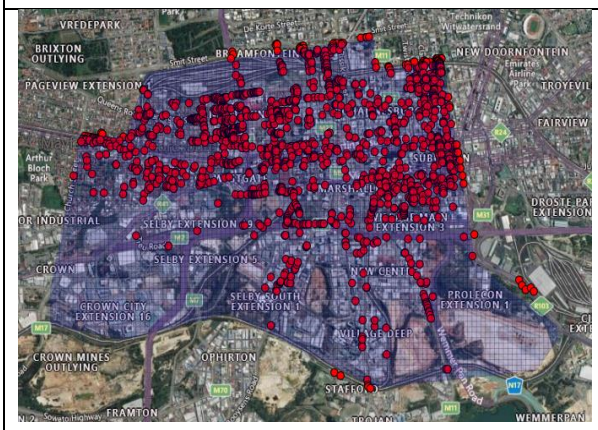
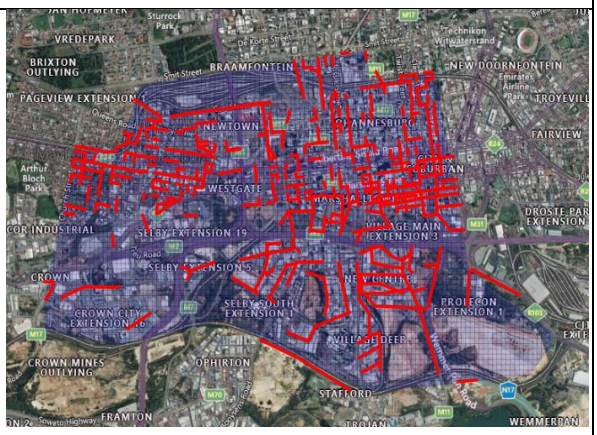
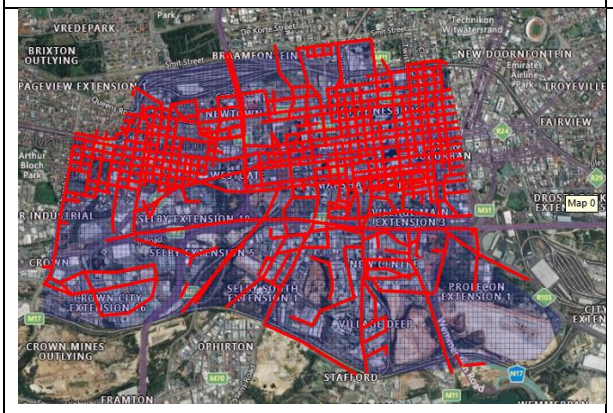
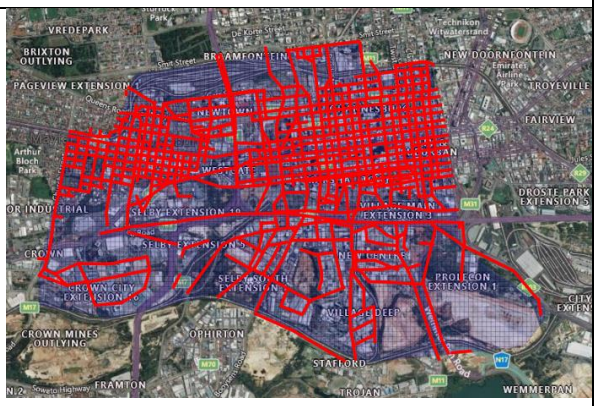
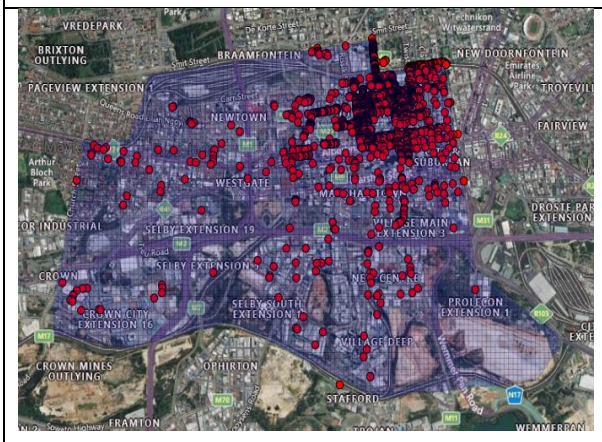
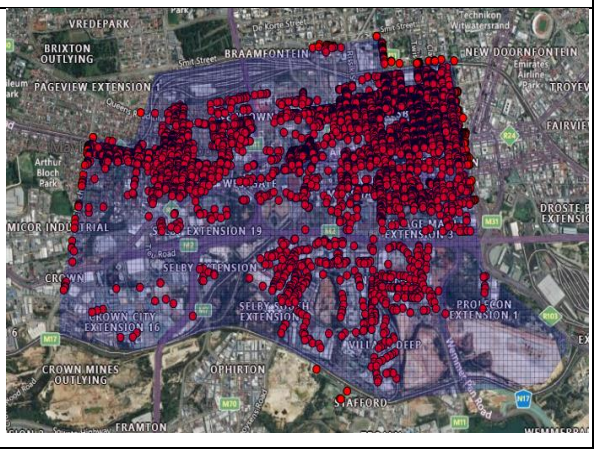
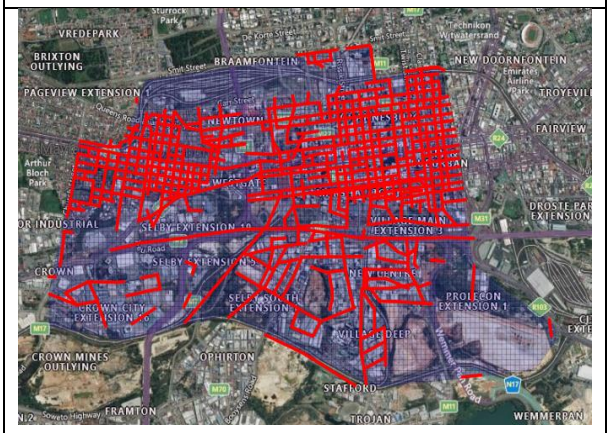
| | |
|---|---|
| **Image 20: Locations of graffiti on this street (Van Jaarsveld et al. 2013).** | **Image 21: The street lights did not provide adequate lighting for any portion of this street (Pease, 1999: 69).** |
|  |  |
| **Image 22: People used cash to pay for services/goods on this street (Bernasco & Block, 2011:35).** | **Image 23: There were sidewalk(s) on this street that pedestrians could walk on (Observation).** |
|  |  |
| **Image 24: Locations of informal businesses such as road-side stalls and other informal traders on this street (Observation).** | **Image 25: Locations of entrances to all formal businesses (Irvin-Erickson, 2014: 125).** |
|  |  |

**Image 26: Cars and motorcycles could park on this street (Observation).**




The table below presents the details of the successful forecasts that the relevant crime opportunities produced, during the overall analyses.

**Table 23: Overall Results – Successful Forecasts, April 2017**

| Affected Area | | | Successful Forecasts: Grids | | Successful Forecasts Incident Counts | |
|---|---|---|---|---|---|---|
| **Percentage of Overall Jurisdiction** | **Affected 50 $m^2$ Grids** | **Affected $km^2$** | **Number** | **Percentage** | **Number** | **Percentage** |
| **5,0%** | 248 | 1.2 $km^2$ | 41 | 47,1% | 65 | 50,4% |
| **10,0%** | 496 | 2.5 $km^2$ | 55 | 63,2% | 89 | 69,0% |
| **15,0%** | 744 | 3.7 $km^2$ | 67 | 77,0% | 104 | 80,6% |
| **20,0%** | 992 | 4.7 $km^2$ | 76 | 87,4% | 115 | 89,1% |
| **25,0%** | 1240 | 6.2 $km^2$ | 80 | 92,0% | 119 | 92,2% |
| **30,0%** | 1488 | 7.4 $km^2$ | 83 | 95,4% | 125 | 96,9% |
| **100,0%** | **Total: 4961** | **24.8 $km^2$** | **87** | **100,0%** | **129** | **100,0%** |

The images of the forecasted grids and the locations of the actual street robberies that took place, in April 2017, are presented below, in terms of the top 5%, 10% and 15% levels.

**Image 27: Top 5% Forecasted Grids**

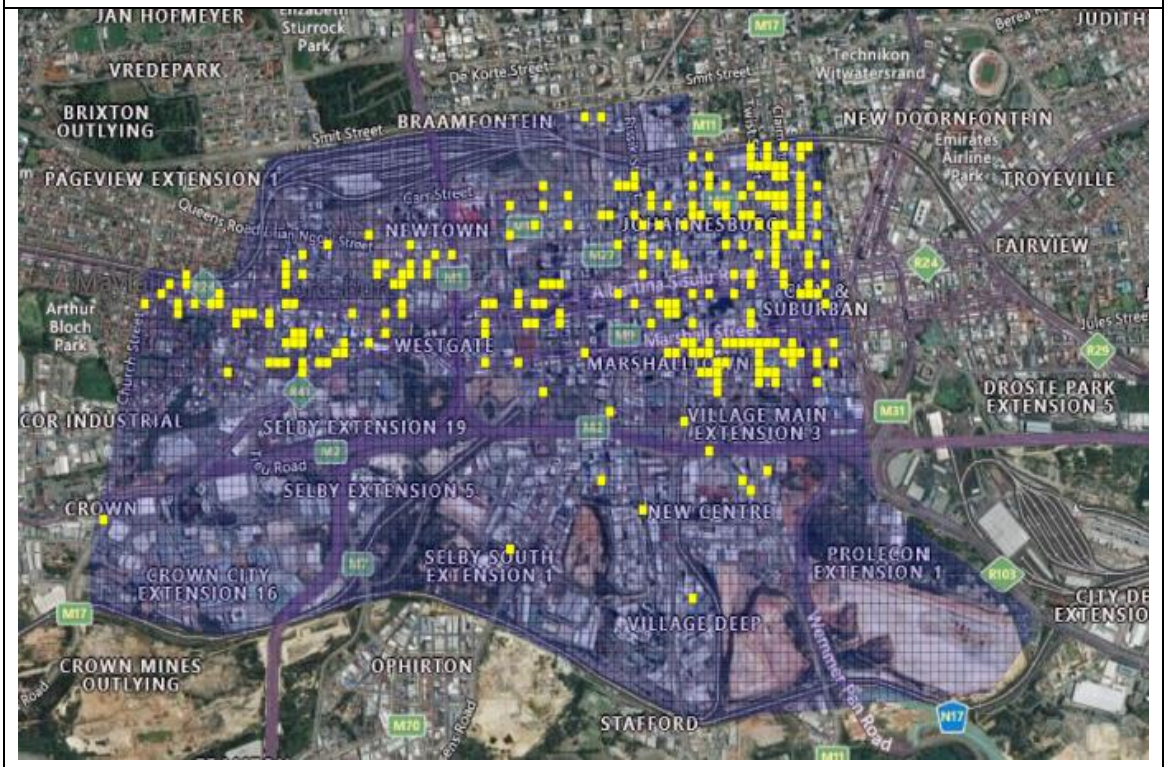



**Image 28: Top 5% Forecasted Grids with April 2017 Robberies**

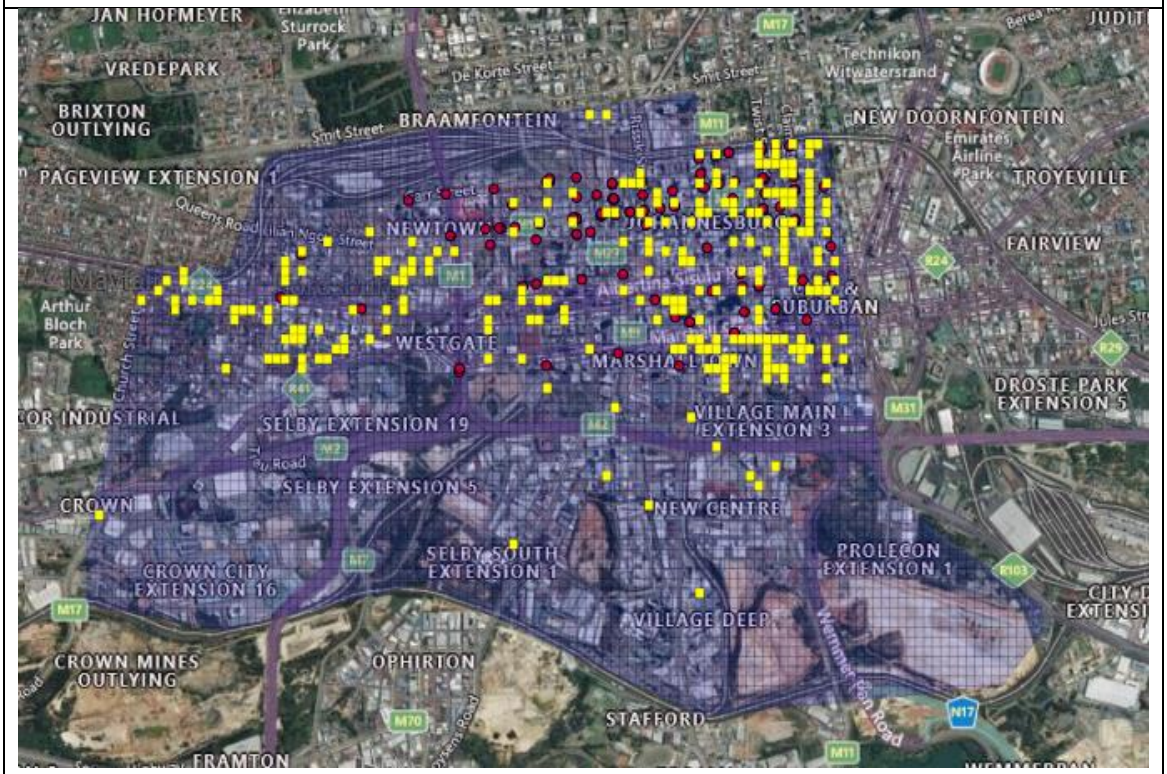


**Image 29: Top 10% Forecasted Grids**

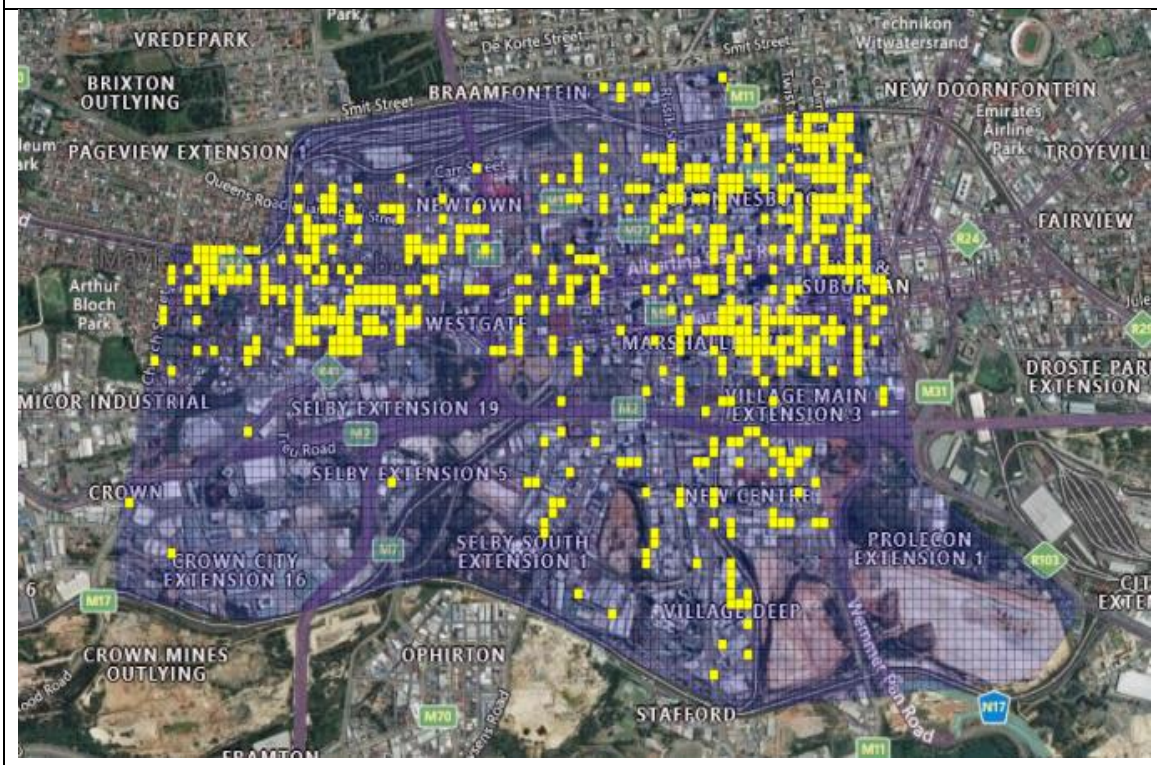



**Image 30: Top 10% Forecasted Grids with April 2017 Robberies**

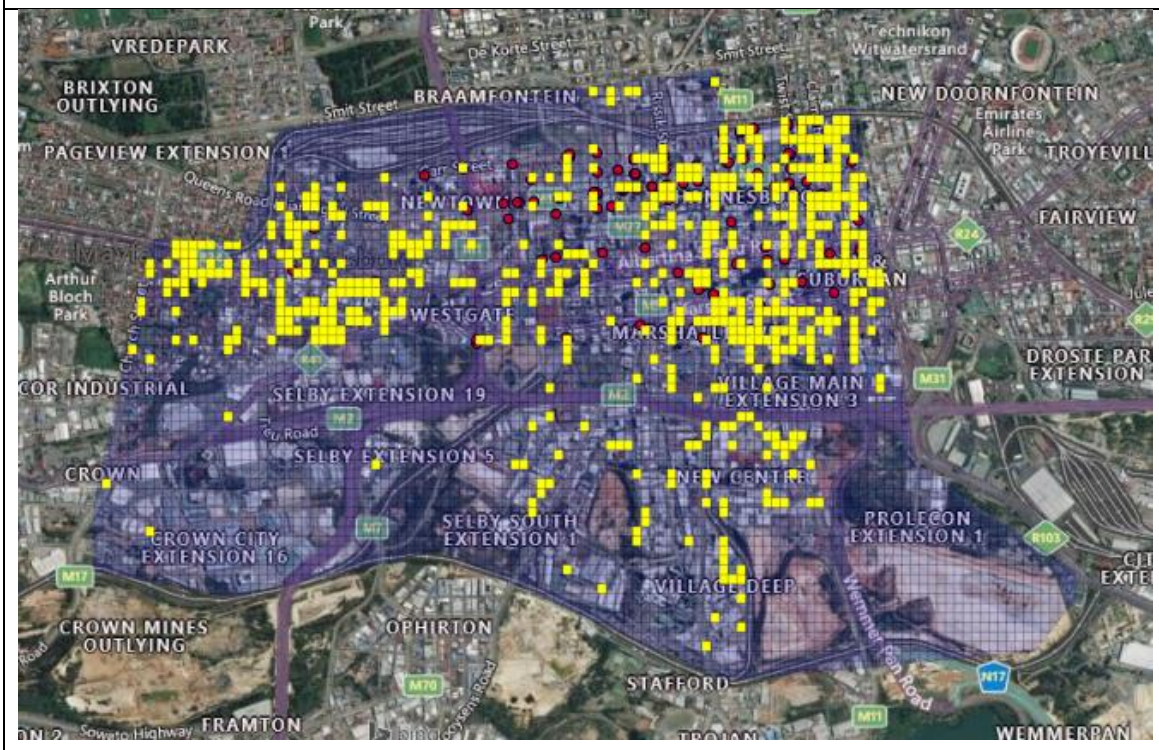


**Image 31: Top 15% Forecasted Grids**

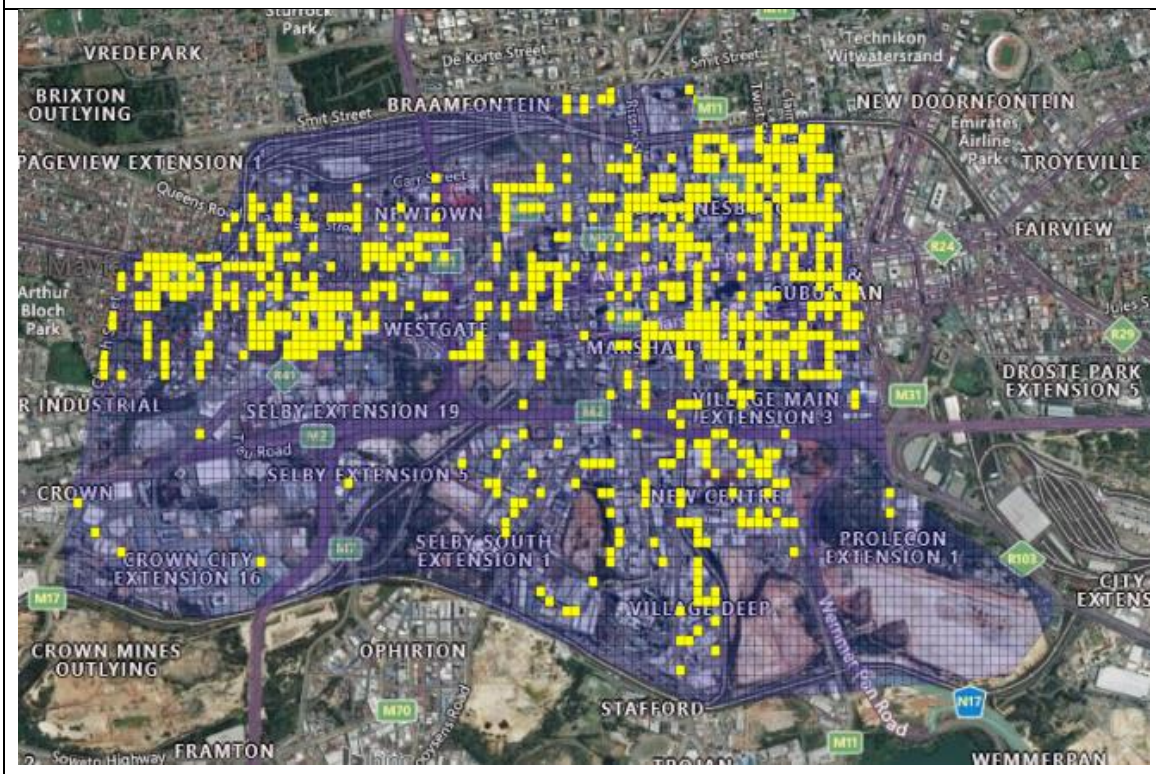
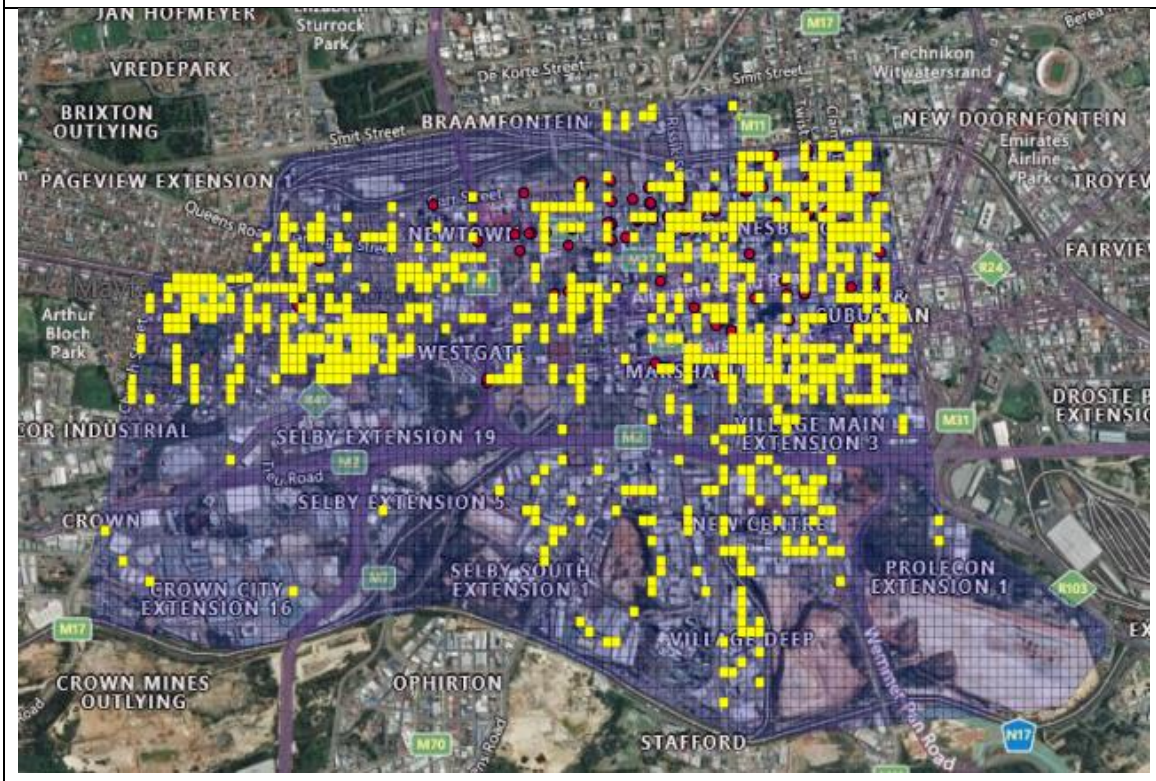



**Image 32: Top 15% Forecasted Grids with April 2017 Robberies**



#### 4.3.2.3 Results for Alternative Methods of Analysis

The results for the top 10 crime risk factors were presented in the previous subsection because it led to the most accurate forecasts, especially in terms of the top 5% of the risk adjusted grids. The same analyses were also attempted with the inclusion of all the linked 55 crime risk factors. A version of the top 20 crime risk factors was also attempted. The following two tables represent the results of these analyses:

| **Table 24: Results – Alternative Method of Analysis – All Risk Factors Included - April 2017** | | | | | | |
|---|---|---|---|---|---|---|
| **Affected Grids** | | | **Grids Successfully Forecasted** | | | |
| | | | **Successful Forecasts - Grids** | | **Successful Forecasts - Incident Counts** | |
| **Affected 50 $m^2$ Grids** | **Affected $km^2$** | **Percentage of Overall Jurisdiction** | **Number** | **Percentage** | **Number** | **Percentage** |
| 248 | 1.2 $km^2$ | 5,0% | 35 | 40,2% | 58 | 45,0% |
| 496 | 2.5 $km^2$ | 10,0% | 56 | 64,4% | 90 | 69,8% |
| 744 | 3.7 $km^2$ | 15,0% | 71 | 81,6% | 109 | 84,5% |
| 992 | 4.7 $km^2$ | 20,0% | 77 | 88,5% | 116 | 89,9% |
| 1240 | 6.2 $km^2$ | 25,0% | 81 | 93,1% | 120 | 93,0% |
| 1488 | 7.4 $km^2$ | 30,0% | 83 | 95,4% | 125 | 96,9% |
| **Total: 4961** | **24.8 $km^2$** | **100,0%** | **87** | **100,0%** | **129** | **100,0%** |

| **Table 25: Results – Alternative Method of Analysis – Top 20 Risk Factors Included - April 2017** | | | | | | |
|---|---|---|---|---|---|---|
| **Affected Grids** | | | **Grids Successfully Forecasted** | | | |
| | | | **Successful Forecasts - Grids** | | **Successful Forecasts - Incident Counts** | |
| **Affected 50 $m^2$ Grids** | **Affected $km^2$** | **Percentage of Overall Jurisdiction** | **Number** | **Percentage** | **Number** | **Percentage** |
| 248 | 1.2 $km^2$ | 5,0% | 39 | 44,8% | 64 | 49,6% |
| 496 | 2.5 $km^2$ | 10,0% | 62 | 71,3% | 96 | 74,4% |
| 744 | 3.7 $km^2$ | 15,0% | 73 | 83,9% | 111 | 86,0% |
| 992 | 4.7 $km^2$ | 20,0% | 78 | 89,7% | 117 | 90,7% |
| 1240 | 6.2 $km^2$ | 25,0% | 81 | 93,1% | 120 | 93,0% |
| 1488 | 7.4 $km^2$ | 30,0% | 83 | 95,4% | 125 | 96,9% |
| **Total: 4961** | **24.8 $km^2$** | **100,0%** | **87** | **100,0%** | **129** | 100,0% |

### *4.3.3 Sub-Analyses Results*

This same process was followed for the day (06:01-17:59) and night times (18:00-06:00) for each respective week of the month. The day and night times of all the weekends were also collapsed and analyzed together. These results will show that the enquiries into more specific time frames achieved more accurate forecasts.

#### 4.3.3.1 Week 1 Daytime

##### 4.3.3.1.1 Weights

The March 2017 crime data for the first week during the daytime (N=20) were most highly linked to the absence of security guards on streets (95%), CCTV non-coverage of some street sections (95%) and the absence of stop streets (95%).

**Table 26: Week 1 Daytime – Weights**

| No | ID | Total | Percentage | Risk |
|---|---|---|---|---|
| **1** | **12)** No security guards were stationed on this street (Welsh, Mudge & Farrington, 2010: 314). | **19** | 95,0% | 10 |
| **2** | **20)** There were sections on this street not covered by CCTV cameras (Minnaar, 2002: 175). | **19** | 95,0% | 10 |
| **3** | **17)** There were no stop streets on this street. (Observation). | **19** | 95,0% | 10 |
| **4** | **31)** There were sidewalk(s) on this street that pedestrians could walk on (Observation). | **19** | 95,0% | 10 |
| **5** | **30)** People used cash to pay for services/goods on this street (Bernasco & Block, 2011:35). | **19** | 95,0% | 10 |
| **6** | **13)** No formal (Welsh, Mudge & Farrington, 2010: 314) or informal (Baker, 2002:41) car guards were present on this street. | **19** | 95,0% | 10 |
| **7** | **50)** Cars and motorcycles could park on this street (Observation). | **18** | 90,0% | 9 |
| **8** | **11)** No guards were stationed at a specific site (Welsh, Mudge & Farrington, 2010: 314). | **18** | 90,0% | 9 |
| **9** | **10)** No alarm/armed response placard(s) was present on this street (Singh, 2005:154) | **17** | 85,0% | 8 |
| **10** | **19)** There were no CCTV cameras on this street (Minnaar, 2002: 175). | **17** | 85,0% | 8 |

#### 4.3.3.1.2 Successful Forecasts

The top 5% of the risk-adjusted grids recorded 76.9% of the, April 2017, street robbery grids and incidents. This percentage jumped to 92.3% in the top 10% of grids.

| **Table 27: Week 1 Daytime, April 2017 – Successful Forecasts -** | | | | | | |
|---|---|---|---|---|---|---|
| **Affected Grids** | | | **Grids Successfully Forecasted** | | | |
| | | | **Successful Forecasts – Grids** | | **Successful Forecasts - Incident Counts** | |
| **Affected 50 m² Grids** | **Affected km²** | **Percentage of Overall Jurisdiction** | **Number** | **Percentage** | **Number** | **Percentage** |
| 248 | 1.2 km² | 5,0% | 10 | 76,9% | 10 | 76,9% |
| 496 | 2.5 km² | 10,0% | 12 | 92,3% | 12 | 92,3% |
| 744 | 3.7 km² | 15,0% | 12 | 92,3% | 12 | 92,3% |
| 992 | 4.7 km² | 20,0% | 12 | 92,3% | 12 | 92,3% |
| 1240 | 6.2 km² | 25,0% | 12 | 92,3% | 12 | 92,3% |
| 1488 | 7.4 km² | 30,0% | 13 | 100,0% | 13 | 100,0% |
| **Total: 4961** | **24.8 km²** | **100,0%** | **13** | **100,0%** | **13** | **100,0%** |

### 4.3.3.2 Week 1 Night-Time

#### 4.3.3.2.1 Weights

The night time Week 1 street robbery data in March 2017 (N=8) were most often linked to the absence of security guards in streets (100%), CCTV non-coverage (100%) and guards linked to specific sites (100%). Three irrelevant crime opportunities were omitted, which included the presence of cash services, car guards, and formal businesses because they were closed during night time.

| **Table 28: Week 1 Night-Time – Weights** | | | | |
|---|---|---|---|---|
| **No** | **ID** | **Total** | **Percentage** | **Weights** |
| **1** | **12)** No security guards were stationed on this street (Welsh, Mudge & Farrington, 2010: 314). | **8** | 100,0% | 10 |
| **2** | **20)** There were sections on this street not covered by CCTV cameras (Minnaar, 2002: 175). | **8** | 100,0% | 10 |
| **3** | **50)** Cars and motorcycles could park on this street (Observation). | **8** | 100,0% | 10 |
| **4** | **17)** There were no stop streets on this street. (Observation). | **8** | 100,0% | 10 |

| | | | | |
|---|---|---|---|---|
| **5** | **31)** There were sidewalk(s) on this street that pedestrians could walk on (Observation). | **8** | 100,0% | 10 |
| **6** | **11)** No guards were stationed at a specific site (Welsh, Mudge & Farrington, 2010: 314). | **8** | 100,0% | 10 |
| **7** | **19)** There were no CCTV cameras on this street (Minnaar, 2002: 175). | **7** | 87,5% | 9 |
| **8** | **23)** Locations of peeling paint / irregular paint on this street (Van Jaarsveld et al. 2013). | **6** | 75,0% | 7 |
| **9** | **32)** Locations of informal businesses such as road-side stalls and other informal traders on this street (Observation). | **6** | 75,0% | 7 |
| **10** | **15)** This street had 2 or fewer lanes. (Observation). | **6** | 75,0% | 7 |

#### 4.3.3.2.2 Successful Forecasts

The top 10% of the risk-adjusted grids recorded 50% of the grids and incidents of April 2017. The top 15% recorded 62.5% of the relevant grids and 75% of the incidents.

**Table 29: Week 1 Night-Time, April 2017 – Successful Forecasts**

| **Affected Grids** | | | **Grids Successfully Forecasted** | | | |
|---|---|---|---|---|---|---|
| | | | **Successful Forecasts – Grids** | | **Successful Forecasts - Incident Counts** | |
| **Affected 50 $m^2$ Grids** | **Affected $km^2$** | **Percentage of Overall Jurisdiction** | **Number** | **Percentage** | **Number** | **Percentage** |
| 248 | 1.2 $km^2$ | 5,0% | 3 | 37,5% | 3 | 37,5% |
| 496 | 2.5 $km^2$ | 10,0% | 4 | 50,0% | 4 | 50,0% |
| 744 | 3.7 $km^2$ | 15,0% | 5 | 62,5% | 6 | 75,0% |
| 992 | 4.7 $km^2$ | 20,0% | 6 | 75,0% | 7 | 87,5% |
| 1240 | 6.2 $km^2$ | 25,0% | 6 | 75,0% | 7 | 87,5% |
| 1488 | 7.4 $km^2$ | 30,0% | 7 | 87,5% | 8 | 100,0% |
| **Total: 4961** | **24.8 $km^2$** | **100,0%** | **8** | **100,0%** | **8** | **100,0%** |

### 4.3.3.3 Week 2 Daytime

#### 4.3.3.3.1 Weights

The Week 2 daytime data for March 2017 (N=12) most often co-occurred with the absence of security guards linked to a street (100%) and a specific site (91.7%). The absence of car guards always co-occurred in the same grids as the relevant robberies (100%).

| Table 30: Week 2 Daytime – Weights | | | | |
|---|---|---|---|---|
| **No** | **ID** | **Total** | **Percentage** | **Risk** |
| **1** | **12)** No security guards were stationed on this street (Welsh, Mudge & Farrington, 2010: 314). | 12 | 100,0% | 10 |
| **2** | **17)** There were no stop streets on this street. (Observation). | 12 | 100,0% | 10 |
| **3** | **31)** There were sidewalk(s) on this street that pedestrians could walk on (Observation). | 12 | 100,0% | 10 |
| **4** | 30) People used cash to pay for services/goods on this street (Bernasco & Block, 2011:35). | 12 | 100,0% | 10 |
| **5** | **13)** No formal (Welsh, Mudge & Farrington, 2010: 314) or informal (Baker, 2002:41) car guards were present on this street. | 12 | 100,0% | 10 |
| **6** | **10)** No alarm/armed response placard(s) was present on this street (Singh, 2005: 154) | 11 | 91,7% | 9 |
| **7** | **20)** There were sections on this street not covered by CCTV cameras (Minnaar, 2002: 175). | 11 | 91,7% | 9 |
| **8** | **50)** Cars and motorcycles could park on this street (Observation). | 11 | 91,7% | 9 |
| **9** | **11)** No guards were stationed at a specific site (Welsh, Mudge & Farrington, 2010: 314). | 11 | 91,7% | 9 |
| **10** | **19)** There were no CCTV cameras on this street (Minnaar, 2002: 175). | 11 | 91,7% | 9 |

#### 4.3.3.3.2 Successful Forecasts

The top 5% of the risk adjusted grids could successfully forecast 72.7%, of April 2017, street robbery grids and 69.2% of the incidents.

| Table 31: Week 2 Daytime, April 2017 – Successful Forecasts | | | | | | |
|---|---|---|---|---|---|---|
| **Affected Grids** | | | **Grids Successfully Forecasted** | | | |
| | | | **Successful Forecasts - Grids** | | **Successful Forecasts - Incident Counts** | |
| **Affected 50 $m^2$ Grids** | **Affected $km^2$** | **Percentage of Overall Jurisdiction** | **Number** | **Percentage** | **Number** | **Percentage** |
| 248 | 1.2 $km^2$ | 5,0% | 8 | 72,7% | 9 | 69,2% |
| 496 | 2.5 $km^2$ | 10,0% | 8 | 72,7% | 9 | 69,2% |
| 744 | 3.7 $km^2$ | 15,0% | 8 | 72,7% | 9 | 69,2% |
| 992 | 4.7 $km^2$ | 20,0% | 10 | 90,9% | 11 | 84,6% |
| 1240 | 6.2 $km^2$ | 25,0% | 10 | 90,9% | 11 | 84,6% |
| 1488 | 7.4 $km^2$ | 30,0% | 11 | 100,0% | 13 | 100,0% |
| **Total: 4961** | **24.8 $km^2$** | **100,0%** | **11** | **100,0%** | **13** | **100,0%** |

#### 4.3.3.4 Week 2 Night Time

##### 4.3.3.4.1 Weights

The Week 2 night time period of the March 2017 (N=7) street robberies most often coincided with the same grids that recorded an absence of security guards linked to a street (100%), CCTV non-coverage for certain sections of a street (100%) and guards linked to a specific site (100%).

**Table 32: Week 2 Night-Time – Weights**

| No | ID | Total | Percentage | Weight |
|---|---|---|---|---|
| **1** | **12)** No security guards were stationed on this street (Welsh, Mudge & Farrington, 2010: 314). | 7 | 100,0% | 10 |
| **2** | **20)** There were sections on this street not covered by CCTV cameras (Minnaar, 2002: 175). | 7 | 100,0% | 10 |
| **3** | **50)** Cars and motorcycles could park on this street (Observation). | 7 | 100,0% | 10 |
| **4** | **17)** There were no stop streets on this street. (Observation). | 7 | 100,0% | 10 |
| **5** | **31)** There were sidewalk(s) on this street that pedestrians could walk on (Observation). | 7 | 100,0% | 10 |
| **6** | **11)** No guards were stationed at a specific site (Welsh, Mudge & Farrington, 2010: 314). | 7 | 100,0% | 10 |
| **7** | **10)** No alarm/armed response placard(s) was present on this street (Singh, 2005: 154) | 6 | 85,7% | 9 |
| **8** | **28)** The street lights did not provide adequate lighting for any portion of this street (Pease, 1999: 69). | 6 | 85,7% | 9 |
| **9** | **19)** There were no CCTV cameras on this street (Minnaar, 2002: 175). | 6 | 85,7% | 9 |
| **10** | **25)** Locations of graffiti on this street (Van Jaarsveld et al. 2013). | 4 | 57,1% | 6 |

#### 4.3.3.4.2 Successful Forecasts

The top 15% of the risk-adjusted grids recorded 66.7%, of the April 2017, street robbery grids and incidents.

| Table 33: Week 2 Night-Time, April 2017 – Successful Forecasts | | | | | | |
|---|---|---|---|---|---|---|
| **Affected Grids** | | | **Grids Successfully Forecasted** | | | |
| | | | **Successful Forecasts - Grids** | | **Successful Forecasts - Incident Counts** | |
| **Affected 50 $m^2$ Grids** | **Affected $km^2$** | **Percentage of Overall Jurisdiction** | **Number** | **Percentage** | **Number** | **Percentage** |
| 248 | 1.2 $km^2$ | 5,0% | 1 | 16,7% | 1 | 16,7% |
| 496 | 2.5 $km^2$ | 10,0% | 2 | 33,3% | 2 | 33,3% |
| 744 | 3.7 $km^2$ | 15,0% | 4 | 66,7% | 4 | 66,7% |
| 992 | 4.7 $km^2$ | 20,0% | 4 | 66,7% | 4 | 66,7% |
| 1240 | 6.2 $km^2$ | 25,0% | 4 | 66,7% | 4 | 66,7% |
| 1488 | 7.4 $km^2$ | 30,0% | 6 | 100,0% | 6 | 100,0% |
| **Total: 4961** | **24.8 $km^2$** | **100,0%** | **6** | 100,0% | **6** | 100,0% |

### 4.3.3.5 Week 3 Daytime

#### 4.3.3.5.1 Weights

The Week 3 day time period of the March 2017 street robbery data (N=8) were very often recorded in the same grids which did not have armed response placards (87.5%), certain sections of street without CCTV coverage and guards linked to specific sites.

| Table 34: Week 3 Daytime – Weights | | | | |
|---|---|---|---|---|
| **No** | **ID** | **Total** | **Percentage** | **Weight** |
| **1** | **10)** No alarm/armed response placard(s) was present on this street (Singh, 2005: 154) | **7** | 87,5% | 9 |
| **2** | **20)** There were sections on this street not covered by CCTV cameras (Minnaar, 2002: 175). | **7** | 87,5% | 9 |
| **3** | **17)** There were no stop streets on this street. (Observation). | **7** | 87,5% | 9 |
| **4** | **31)** There were sidewalk(s) on this street that pedestrians could walk on (Observation). | **7** | 87,5% | 9 |
| **5** | **11)** No guards were stationed at a specific site (Welsh, Mudge & Farrington, 2010: 314). | **7** | 87,5% | 9 |

| | | | | |
|---|---|---|---|---|
| **6** | **30)** People used cash to pay for services/goods on this street (Bernasco & Block, 2011:35). | **7** | 87,5% | 9 |
| **7** | **13)** No formal (Welsh, Mudge & Farrington, 2010: 314) or informal (Baker, 2002:41) car guards were present on this street. | **7** | 87,5% | 9 |
| **8** | **32)** Locations of informal businesses such as road-side stalls and other informal traders on this street (Observation). | **6** | 75,0% | 8 |
| **9** | **33)** Locations of entrances to all formal businesses (Irvin-Erickson, 2014: 125). | **6** | 75,0% | 8 |
| **10** | **12)** No security guards were stationed on this street (Welsh, Mudge & Farrington, 2010: 314). | **6** | 75,0% | 8 |

#### 4.3.3.5.2 Successful Forecasts

The top 5% of the risk adjusted grids successfully forecasted all the incidents for the relevant period in April 2017 (100%).

**Table 35: Week 3 Daytime, April 2017 – Successful Forecasts**

| **Affected Grids** | | | **Grids Successfully Forecasted** | | | |
|---|---|---|---|---|---|---|
| | | | **Successful Forecasts - Grids** | | **Successful Forecasts - Incident Counts** | |
| **Affected 50 $m^2$ Grids** | **Affected $km^2$** | **Percentage of Overall Jurisdiction** | **Number** | **Percentage** | **Number** | **Percentage** |
| 248 | 1.2 $km^2$ | 5,0% | 8 | 100,0% | 8 | 100,0% |
| 496 | 2.5 $km^2$ | 10,0% | 8 | 100,0% | 8 | 100,0% |
| 744 | 3.7 $km^2$ | 15,0% | 8 | 100,0% | 8 | 100,0% |
| 992 | 4.7 $km^2$ | 20,0% | 8 | 100,0% | 8 | 100,0% |
| 1240 | 6.2 $km^2$ | 25,0% | 8 | 100,0% | 8 | 100,0% |
| 1488 | 7.4 $km^2$ | 30,0% | 8 | 100,0% | 8 | 100,0% |
| **Total: 4961** | **24.8 $km^2$** | **100,0%** | **8** | **100,0%** | **8** | **100,0%** |

### 4.3.3.6 Week 3 Night Time

All of the street robberies that took place in the third week of March 2017 during night time (N=12) were recorded in the same grids as grids that did not have security guards linked to a street (100%). These street robberies were also linked to the absence of stop streets (100%) and the presence of sidewalks (100%). The crime opportunities

linked to the presence of cash-based services, car guards and formal businesses were omitted, because they were not relevant during night time.

#### 4.3.3.6.1 Weights

| Table 36: Week 3 Night-Time – Weights | | | | |
|---|---|---|---|---|
| **No** | **ID** | **Total** | **Percentages** | **Weights** |
| **1** | **12)** No security guards were stationed on this street (Welsh, Mudge & Farrington, 2010: 314). | **12** | 100,0% | 10 |
| **2** | **17)** There were no stop streets on this street. (Observation). | **12** | 100,0% | 10 |
| **3** | **31)** There were sidewalk(s) on this street that pedestrians could walk on (Observation). | **12** | 100,0% | 10 |
| **4** | **20)** There were sections on this street not covered by CCTV cameras (Minnaar, 2002: 175). | **11** | 91,7% | 9 |
| **5** | **50)** Cars and motorcycles could park on this street (Observation). | **11** | 91,7% | 9 |
| **6** | **11)** No guards were stationed at a specific site (Welsh, Mudge & Farrington, 2010: 314). | **11** | 91,7% | 9 |
| **7** | **15)** This street had 2 or fewer lanes. (Observation). | **9** | 75,0% | 8 |
| **8** | **10)** No alarm/armed response placard(s) was present on this street (Singh, 2005: 154) | **8** | 66,7% | 7 |
| **9** | **23)** Locations of peeling paint / irregular paint on this street (Van Jaarsveld et al. 2013). | **8** | 66,7% | 7 |
| **10** | **19)** There were no CCTV cameras on this street (Minnaar, 2002: 175). | **8** | 66,7% | 7 |

#### 4.3.3.6.2. Successful Forecasts

The top 10% of the risk adjusted grids recorded 75%, of the April 2017, street robbery grids and incidents.

| Table 37: Week 3 Night-Time, April 2017 – Successful Forecasts | | | | | | |
|---|---|---|---|---|---|---|
| **Affected Grids** | | | **Grids Successfully Forecasted** | | | |
| | | | **Successful Forecasts - Grids** | | **Successful Forecasts - Incident Counts** | |
| **Affected 50 $m^2$ Grids** | **Affected $km^2$** | **Percentage of Overall Jurisdiction** | **Number** | **Percentage** | **Number** | **Percentage** |
| 248 | 1.2 $km^2$ | 5,0% | 3 | 37,5% | 3 | 37,5% |
| 496 | 2.5 $km^2$ | 10,0% | 6 | 75,0% | 6 | 75,0% |
| 744 | 3.7 $km^2$ | 15,0% | 7 | 87,5% | 7 | 87,5% |
| 992 | 4.7 $km^2$ | 20,0% | 7 | 87,5% | 7 | 87,5% |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1240 | 6.2 km$^2$ | 25,0% | 7 | 87,5% | 7 | 87,5% |
| 1488 | 7.4 km$^2$ | 30,0% | 8 | 100,0% | 8 | 100,0% |
| **Total: 4961** | **24.8 km$^2$** | **100,0%** | **8** | **100,0%** | **8** | **100,0%** |

#### 4.3.3.7 Week 4 Daytime

The crimes that took place during the fourth week in the daytime (N=24) were always linked to the absence of security guards on a specific street (100%) and the absence of CCTV cameras at certain sections of the street (100%).

##### 4.3.3.7.1 Weights

**Table 38: Week 3 Daytime – Weights**

| No | ID | Number | Percentage | Total |
|---|---|---|---|---|
| **1** | **12)** No security guards were stationed on this street (Welsh, Mudge & Farrington, 2010: 314). | **24** | 100,0% | 10 |
| **2** | **20)** There were sections on this street not covered by CCTV cameras (Minnaar, 2002: 175). | **24** | 100,0% | 10 |
| **3** | **17)** There were no stop streets on this street. (Observation). | **24** | 100,0% | 10 |
| **4** | **31)** There were sidewalk(s) on this street that pedestrians could walk on (Observation). | **24** | 100,0% | 10 |
| **5** | **30)** People used cash to pay for services/goods on this street Bernasco & Block, 2011:35. | **24** | 100,0% | 10 |
| **6** | **50)** Cars and motorcycles could park on this street (Observation). | **23** | 95,8% | 10 |
| **7** | **11)** No guards were stationed at a specific site (Welsh, Mudge & Farrington, 2010: 314). | **23** | 95,8% | 10 |
| **8** | **13)** No formal (Welsh, Mudge & Farrington, 2010: 314) or informal (Baker, 2002:41) car guards were present on this street. | **23** | 95,8% | 10 |
| **9** | **19)** There were no CCTV cameras on this street (Minnaar, 2002: 175). | **22** | 91,7% | 9 |
| **10** | **10)** No alarm/armed response placard(s) was present on this street (Singh, 2005: 154) | **21** | 87,5% | 9 |

#### 4.3.3.7.2 Successful Forecasts

The top 5% of the risk-adjusted grids successfully forecasted 65.4%, of April 2017, street robbery grids and 69% of all relevant incidents.

| **Table 39: Week 3 Daytime, April 2017 – Successful Forecasts** | | | | | | |
|---|---|---|---|---|---|---|
| **Affected Grids** | | | **Grids Successfully Forecasted** | | | |
| | | | **Successful Forecasts – Grids** | | **Successful Forecasts - Incident Counts** | |
| **Affected 50 $m^2$ Grids** | **Affected $km^2$** | **Percentage of Overall Jurisdiction** | **Number** | **Percentage** | **Number** | **Percentage** |
| 248 | 1.2 $km^2$ | 5,0% | 17 | 65,4% | 20 | 69,0% |
| 496 | 2.5 $km^2$ | 10,0% | 21 | 80,8% | 24 | 82,8% |
| 744 | 3.7 $km^2$ | 15,0% | 21 | 80,8% | 24 | 82,8% |
| 992 | 4.7 $km^2$ | 20,0% | 25 | 96,2% | 28 | 96,6% |
| 1240 | 6.2 $km^2$ | 25,0% | 25 | 96,2% | 28 | 96,6% |
| 1488 | 7.4 $km^2$ | 30,0% | 25 | 96,2% | 28 | 96,6% |
| **Total: 4961** | **24.8 $km^2$** | **100,0%** | 26 | 100,0% | 29 | 100,0% |

#### 4.3.3.8 Week 4 Night Time

The street robberies that occurred during night time in the last week of March 2017 (N=11) always co-occurred with the absence of guards linked to streets (100%) and stop streets (100%). The presence of cash-based services and the absence of car guards were omitted because they were not relevant during night time. This was also the case for crime opportunities linked to the ability of vehicles to park on the street and the entrances to formal businesses.

#### 4.3.3.8.1 Weights

| **Table 40: Week 4 Night-Time – Weights** | | | | |
|---|---|---|---|---|
| **No** | **ID** | **Total** | **Percentages** | **Weights** |
| **1** | **12)** No security guards were stationed on this street (Welsh, Mudge & Farrington, 2010: 314). | 11 | 100,0% | 10 |
| **2** | **20)** There were sections on this street not covered by CCTV cameras (Minnaar, 2002: 175). | 11 | 100,0% | 10 |
| **3** | **17)** There were no stop streets on this street. (Observation). | 11 | 100,0% | 10 |

| | | | | |
|---|---|---|---|---|
| **4** | **31)** There were sidewalk(s) on this street that pedestrians could walk on (Observation). | 11 | 100,0% | 10 |
| **5** | **11)** No guards were stationed at a specific site (Welsh, Mudge & Farrington, 2010: 314). | 10 | 90,9% | 9 |
| **6** | **19)** There were no CCTV cameras on this street (Minnaar, 2002: 175). | 10 | 90,9% | 9 |
| **7** | **10)** No alarm/armed response placard(s) was present on this street (Singh, 2005: 154) | 9 | 81,8% | 8 |
| **8** | **15)** This street had 2 or fewer lanes. (Observation). | 7 | 63,6% | 6 |
| **9** | **28)** The street lights did not provide adequate lighting for any portion of this street (Pease, 1999: 69). | 7 | 63,6% | 6 |
| **10** | **23)** Locations of peeling paint / irregular paint on this street (Van Jaarsveld et al. 2013). | 6 | 54,5% | 5 |

#### 4.3.3.8.2 Successful Forecasts

The top 10% of the risk-adjusted grids could forecast 58.8% of the April 2017 grids and 52.6% of all relevant incidents.

**Table 41: Week 4 Night-Time, April 2017 – Successful Forecasts**

| **Affected Grids** | | | **Grids Successfully Forecasted** | | | |
|---|---|---|---|---|---|---|
| | | | **Successful Forecasts - Grids** | | **Successful Forecasts - Incident Counts** | |
| **Affected 50 $m^2$ Grids** | **Affected $km^2$** | **Percentage of Overall Jurisdiction** | **Number** | **Percentage** | **Number** | **Percentage** |
| 248 | 1.2 $km^2$ | 5,0% | 4 | 23,5% | 4 | 21,1% |
| 496 | 2.5 $km^2$ | 10,0% | 10 | 58,8% | 10 | 52,6% |
| 744 | 3.7 $km^2$ | 15,0% | 13 | 76,5% | 13 | 68,4% |
| 992 | 4.7 $km^2$ | 20,0% | 15 | 88,2% | 15 | 78,9% |
| 1240 | 6.2 $km^2$ | 25,0% | 15 | 88,2% | 15 | 78,9% |
| 1488 | 7.4 $km^2$ | 30,0% | 15 | 88,2% | 15 | 78,9% |
| **Total: 4961** | **24.8 $km^2$** | **100,0%** | **17** | **100,0%** | **19** | **100,0%** |

### 4.3.3.9 Weekend Day Time

#### 4.3.3.9.1 Weights

The incidents that took place during the weekend daytimes (N=20) always co-occurred with grids that recorded the absence of security guards attached to specific streets (100%) and the absence of CCTV footage on certain portions of a street (100%).

| Table 42: Weekend Daytime – Weights | | | | |
|---|---|---|---|---|
| **No** | **ID** | **Total** | **Percentages** | **Weights** |
| **1** | **12)** No security guards were stationed on this street (Welsh, Mudge & Farrington, 2010: 314). | 20 | 100,0% | 10 |
| **2** | **20)** There were sections on this street not covered by CCTV cameras (Minnaar, 2002: 175). | 20 | 100,0% | 10 |
| **3** | **17)** There were no stop streets on this street. (Observation). | 20 | 100,0% | 10 |
| **4** | **31)** There were sidewalk(s) on this street that pedestrians could walk on (Observation). | 20 | 100,0% | 10 |
| **5** | **30)** People used cash to pay for services/goods on this street (Bernasco & Block, 2011:35). | 20 | 100,0% | 10 |
| **6** | **13)** No formal (Welsh, Mudge & Farrington, 2010: 314) or informal (Baker, 2002:41) car guards were present on this street. | 20 | 100,0% | 10 |
| **7** | **10)** No alarm/armed response placard(s) was present on this street (Singh, 2005: 154) | 19 | 95,0% | 10 |
| **8** | **50)** Cars and motorcycles could park on this street (Observation). | 19 | 95,0% | 10 |
| **9** | **11)** No guards were stationed at a specific site (Welsh, Mudge & Farrington, 2010: 314). | 19 | 95,0% | 10 |
| **10** | **19)** There were no CCTV cameras on this street (Minnaar, 2002: 175). | 18 | 90,0% | 9 |

#### 4.3.3.9.2 Successful Forecasts

The top 5% of the risk adjusted grids recorded 65% of the April 2017 grids and 63.6% of all the relevant incidents.

| Table 43: Weekend Daytime, April 2017 – Successful Forecasts | | | | | | |
|---|---|---|---|---|---|---|
| **Affected Grids** | | | **Grids Successfully Forecasted** | | | |
| | | | **Successful Forecasts - Grids** | | **Successful Forecasts - Incident Counts** | |
| **Affected 50 $m^2$ Grids** | **Affected $km^2$** | **Percentage of Overall Jurisdiction** | **Number** | **Percentage** | **Number** | **Percentage** |
| 248 | 1.2 $km^2$ | 5,0% | 13 | 65,0% | 14 | 63,6% |
| 496 | 2.5 $km^2$ | 10,0% | 13 | 65,0% | 14 | 63,6% |
| 744 | 3.7 $km^2$ | 15,0% | 13 | 65,0% | 14 | 63,6% |
| 992 | 4.7 $km^2$ | 20,0% | 19 | 95,0% | 21 | 95,5% |
| 1240 | 6.2 $km^2$ | 25,0% | 19 | 95,0% | 21 | 95,5% |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1488 | 7.4 km$^2$ | 30,0% | 20 | 100,0% | 22 | 100,0% |
| **Total: 4961** | **24.8 km$^2$** | **100,0%** | **20** | **100,0%** | **22** | **100,0%** |

#### 4.3.3.10 Weekend Night Time

##### 4.3.3.10.1 Weights

The street robberies that took place during the night times of weekends in March 2017 (N=19) co-occurred with the grids that recorded the absence of security guards linked to streets (100%) and to specific sites (100%), in addition to the presence of sidewalks (100%). The crime opportunities linked to cash-based services, car guards and formal businesses were omitted because they were not relevant during night time.

**Table 44: Weekend Night Time – Weights**

| No | ID | Total | Percentages | Weights |
|---|---|---|---|---|
| **1** | **12)** No security guards were stationed on this street (Welsh, Mudge & Farrington, 2010: 314). | **19** | 100,0% | 10 |
| **2** | **31)** There were sidewalk(s) on this street that pedestrians could walk on (Observation). | **19** | 100,0% | 10 |
| **3** | **11)** No guards were stationed at a specific site (Welsh, Mudge & Farrington, 2010: 314). | **19** | 100,0% | 10 |
| **4** | **50)** Cars and motorcycles could park on this street (Observation). | **18** | 94,7% | 9 |
| **5** | **17)** There were no stop streets on this street. (Observation). | **18** | 94,7% | 9 |
| **6** | **20)** There were sections on this street not covered by CCTV cameras (Minnaar, 2002). | **17** | 89,5% | 9 |
| **7** | **10)** No alarm/armed response placard(s) was present on this street (Singh, 2005: 154) | **16** | 84,2% | 8 |
| **8** | **19)** There were no CCTV cameras on this street (Minnaar, 2002: 175). | **16** | 84,2% | 8 |
| **9** | **21)** The entrances to any formal land usages with obvious functions were not visible to each other (Observation). | **15** | 78,9% | 8 |
| **10** | **15)** This street had 2 or fewer lanes. (Observation). | **13** | 68,4% | 7 |

##### 4.3.3.10.2 Successful Forecasts

The top 10% of the risk-adjusted grids could successfully forecast 60%, of the April 2017, street robbery grids and 61.8% of all the relevant street robberies.

| Table 45: Weekend Night-Time, April 2017 – Successful Forecasts | | | | | | |
|---|---|---|---|---|---|---|
| **Affected Grids** | | | **Grids Successfully Forecasted** | | | |
| | | | **Successful Forecasts - Grids** | | **Successful Forecasts - Incident Counts** | |
| **Affected 50 $m^2$ Grids** | **Affected $km^2$** | **Percentage of Overall Jurisdiction** | **Number** | **Percentage** | **Number** | **Percentage** |
| 248 | 1.2 $km^2$ | 5,0% | 12 | 40,0% | 13 | 38,2% |
| 496 | 2.5 $km^2$ | 10,0% | 18 | 60,0% | 21 | 61,8% |
| 744 | 3.7 $km^2$ | 15,0% | 23 | 76,7% | 27 | 79,4% |
| 992 | 4.7 $km^2$ | 20,0% | 26 | 86,7% | 30 | 88,2% |
| 1240 | 6.2 $km^2$ | 25,0% | 26 | 86,7% | 30 | 88,2% |
| 1488 | 7.4 $km^2$ | 30,0% | 27 | 90,0% | 31 | 91,2% |
| **Total: 4961** | **24.8 $km^2$** | **100,0%** | **30** | 100,0% | **34** | 100,0% |

#### *4.3.3.11 Summary of Results from Overall and Sub Analyses*

This subsection will present a summary of the results from the overall and sub analyses. As illustrated in the summative table below, the top 15% of the vector grids adjusted by the CORF model held more than 50% of the street robberies recorded in April 2017. In fact, the top 15% level recorded 77%, of the April 2017, street robbery grids and 80.6% of all the relevant incidents. Furthermore, a summary of the results from the sub analyses on the top 15% level showed that grids were successfully forecasted between 62.5% and 100%; the overall number of incidents were successfully forecasted between 63.6% and 100%. In addition, the top 5% of risk-adjusted grids of the overall- and daytime data forecasted in excess of 50%, of the April 2017, street robbery data. Forecasts for night time data at the top 5% level could, however, not reach the 50%. A summary of the results is presented in the table below:

| Table 46: Summary of Spatial Analysis Results and Main Research Question – Top 15% | | | | | | |
|---|---|---|---|---|---|---|
| **Overall** | **Successful Forecasts – Top 15% Grids** | | | **Successful Forecasts – Top 15% Incident Counts** | | |
| | **Number** | **Percentage** | **Total** | **Number** | **Percentage** | **Total** |
| **Overall Results** | 67 | 77% | 87 | 104 | 80.6% | 129 |
| **Week 1 – Daytime** | 12 | 92,3% | 13 | 12 | 92,3% | 13 |
| **Week 1 Night-Time** | 5 | 62,5% | 8 | 6 | 75,0% | 8 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Week 2 Daytime** | 8 | 72,7% | 11 | 9 | 69,2% | 13 |
| **Week 2 Night-Time** | 4 | 66,7% | 6 | 4 | 66,7% | 6 |
| **Week 3 – Daytime** | 8 | 100,0% | 8 | 8 | 100,0% | 8 |
| **Week 3 Night-Time** | 7 | 87,5% | 8 | 7 | 87,5% | 8 |
| **Week 4 – Daytime** | 21 | 80,8% | **26** | 24 | 82,8% | **29** |
| **Week 4 Night-Time** | 13 | 76,5% | **17** | 13 | 68,4% | **19** |
| **Weekend Daytime** | 13 | 65,0% | **20** | 14 | 63,6% | **22** |
| **Weekend Night-Time** | 23 | 76,7% | **30** | 27 | 79,4% | **34** |

## 4.4 Conclusion

These results from the spatial analyses indicated that the CORF model could successfully forecast the times and locations of street robberies that took place during April 2017, as per the fourth objective for the study. These results also identified several key risk factors for street robberies in the field site. These related to the absences of security guards, car guards and CCTV, in addition to the presence of sidewalks, the locations of services that received cash payments and the presence formal businesses. Interestingly, the same crime risk factors were often evident throughout the results of the sub-analyses, with some minor exceptions.

Furthermore, this chapter also presented the results from the police data, which showed that the street robberies selected for this study were most often recorded over Fridays and Saturdays, and that the hours between 14:00 and 21:59, were particularly high risk. Furthermore, most of the robberies recorded between 1-5 perpetrators and only one victim was typically robbed at a time. These victims were usually male and they were quite often in the vicinity of nodes related to transport, work and shopping immediately prior to the robberies. The results further showed that the perpetrators often used weapons such as knives and firearms. Acts of physical violence, such as strangulations were also regularly recorded, and several victims lost consciousness during robberies. Finally, perpetrators typically took valuables such as wallets, cash and cell phones from victims. The following chapter will interpret and assess these results, in conjunction with the preceding chapters, as a cohesive whole.

# CHAPTER 5: INTERPRETATION

## 5.1 Introduction

This chapter will firstly relate the results to the study's literature review. Thereafter, the chapter will assess whether the study's aim and objectives were achieved, and whether the hypothesis was proven. Subsequently, the study's results will be interpreted in terms of the CORF model's Opportunity Theories Template, before the limitations, value and future applications of the study are described. Finally, key recommendations from the study and a summary of the chapter conclude the chapter.

## 5.2. Discussion of the results

Several of the findings presented in this study's literature review corroborated the identified crime risk questions that appeared in the results chapter, their underlying theories and the results from the contextual analysis of the police data. In relation to the latter, Leggett's (2003:66) investigation of street robberies in the Johannesburg Central area also found that single victims were most often targeted. His study's results also corresponded with the current study, in the sense that the perpetrators often used weapons (Leggett, 2003: 65). However, whereas Leggett's study found firearms more prevalent than knives (Leggett, 2003: 65), the current study found the opposite. Nonetheless, the two studies agreed in relation to the prevalence of physical violence and the resulting injuries of victims. Both studies also corresponded on the finding that cash, electronic goods, and jewellery were taken during the robberies (Leggett, 2003: 65 & 67).

The results from the spatial analyses were also echoed by several theories and studies. In this regard, Thobane's (2017: 280-281) dissertation on the robberies of South African victims who withdrew cash from banks and ATMs also successfully used Routine Activity Theory (Cohen & Felson, 1979: 588; Clarke & Felson, 1993:2). Furthermore, and similar to the current study, Geoff & Taylor's (2013: 178) study based in Philadelphia, USA could successfully use Crime Pattern Theory (Brantingham & Brantingham, 1995:5) to explain the distribution of street robberies.

Furthermore, the current study's results on crime risk factors also found support in the literature. In this regard, Bernasco & Block's (2011:35) study in Chicago, USA found that the presence of cash-based services was linked to robberies. In a similar vein, Irvin-Erickson's (2014: 125) dissertation on criminogenic landscape features influences on street robberies in the city of Newark, New Jersey, USA resonated with the current study's identification of formal businesses, as a risk factor.

Furthermore, the current study's results clearly highlighted the importance of monitoring and surveillance in the prevention of street robberies, a finding that was supported by several studies (Baker, 2002:41; Minnaar, 2002:175; Welsh, Mudge & Farrington, 2010:314). In congruence with the current study's findings, these studies' findings read that the absences of formally employed security guards (Welsh, Mudge & Farrington, 2010: 314), in addition to formal (Welsh, Mudge & Farrington, 2010: 314) and informal car guards (Baker, 2002:41) were linked to robberies. Moreover, this was also the case for the absence of CCTV cameras (Minnaar, 2002: 175). Finally, the sub-analyses' findings on the significance of peeling paint and graffiti found support in a study that linked these features to the abuse and robbery of sex workers in the Johannesburg Central police jurisdiction (Van Jaarsveld et al. 2013:1).

## 5.3. Achievement of Research Question, Aim, Objectives and Hypotheses

Furthermore, the study's respective chapters illustrated that the aim and research question, which were to illustrate that CORF was an appropriate crime forecasting model for the South African context, was indeed achieved. This assertion is based on the achievement of the study's four objectives, all of which were geared towards addressing the corresponding four obstacles to the implementation of existing crime forecasting methodologies, in the country.

The first of these obstacles was the narrow theoretical foci of existing crime forecasting methodologies, which precluded the use of a wide theoretical base. This restriction was adequately addressed by the CORF model's Opportunity Theories Template, as detailed in the study's literature review chapter. Not only did this template provide a

wide theoretical base that encapsulated all the relevant Opportunity Theories, the template maintained a high level of detail.

The second obstacle related to the overly complex nature of existing crime forecasting methodologies. To address this challenge, the study's methodology chapter illustrated that the CORF model was specifically designed to steer away from complex sampling methods and corresponding requisite inferential statistics. Instead, the model utilised a census, which was considerably less convoluted. In addition, the only prerequisite for the CORF model's calculations was a basic understanding of relatively simple tools in Excel, such as the Sort and Filter function and the Vector Grids and Points in Polygon analyses in QGIS.

The affordability of these software programs also points to the fact that the CORF model addressed the third obstacle, which was concerned with the high cost attached to existing crime forecasting approaches. Indeed, QGIS was a free and open-source software program, at the time of writing. Although Excel was not free, its cost was not exorbitant. Moreover, the same functionality of Excel can be achieved through related free and open-source software programs such as LibreOffice (libreoffice.org). In addition, the CORF model is not attached to proprietary software and is freely available.

The final obstacle to the implementation of existing crime forecasting methodologies related to the fact that it was unclear whether they could accurately forecast the times and locations of crimes in the country. The study's results chapter showed that the CORF model could, in fact, successfully forecast street robberies that took place in the CBD of Johannesburg. Indeed, these results showed that the CORF model successfully forecasted a substantially higher proportion of street robberies in this area than the requisite 50% stipulated in the related hypotheses.

## 5.4. Spatial Results in Terms of the Opportunity Theories Template

The confirmations of the hypotheses, objectives and aim of the study indicate that the CORF model's Opportunity Theories Template could indeed explain the spatial distribution of street robberies that were committed in Johannesburg Central.

Moreover, due to the multi-layered and detailed nature of the Opportunity Theories Template, the study's results provided a wide array of insights into the decision-making processes that street robbers exhibited. The subsections below will describe these decision-making processes in terms of the Opportunity Theory Template's constituent Criminological Theories, broad, sub and specific principles in addition to the relevant crime risk questions.

### *5.4.1. Criminological Theories*

The most significant crime risk questions that were used to forecast street robberies mostly originated from Routine Activity Theory (70%), Situational Crime Prevention Theory (60%) and Crime Pattern Theory (20%). Although these theories were originally developed and tested outside of the country, their generalizability allowed them to successfully forecast street robberies in Johannesburg Central.

In relation to Routine Activity Theory, the study's results suggested that street robbers conducted cost benefit analyses and purposively selected seemingly 'attractive' victims, in the absence of capable guardians. Situational Crime Prevention Theory's prominence in the study's results effectively continued this line of thought and added that the street robbers' cost benefit analyses were influenced by tangibly practical considerations that were present in the field site. Crime Pattern Theory's prominent presence in the study's results further indicated that the functions of the built environment also influenced the perpetrators' cost benefit analyses.

Furthermore, although the overall results did not include the form of the built environment as a risk factor for street robberies in the field site, the results of some sub-analyses did, in fact, relate to CPTED and Broken Windows Theory. The table below illustrates the percentage which each theory achieved, in terms of their presence in the top 10 risk factors, that successfully forecast street robberies in Johannesburg Central. Take note that the totals of the percentages in the table below exceed 100%, because multiple theories were linked to single crime risk factors.

| Table 47: Results – Criminological Theories | | | |
|---|---|---|---|
| **Criminological Theories** | **Number** | **Total** | **Percentage** |
| Routine Activity Theory | 7 | 10 | 70% |
| Situational Crime Prevention Theory | 6 | 10 | 60% |
| Crime Pattern Theory | 2 | 10 | 20% |
| Crime Prevention through Environmental Design | 0 | 10 | 0% |
| Broken Windows Theory | 0 | 10 | 0% |

### *5.4.2. Broad Principles*

An additional dynamic of perpetrators' cost benefit analyses became apparent when the study's results were abstracted in terms of the Opportunity Theory Template's Broad Principles. This dynamic in the study's results indicated that perpetrators were generally biased towards the avoidance of 'cost' rather than the attraction to 'benefit' during their decision-making processes. Indeed, 60% of the crime risk factors that successfully forecast street robberies in the field site originated from 'cost'-related principles in the Opportunity Theories Template. This result implied that perpetrators rather selected victims in the absence of suitable guardians, than in the presence of attractive targets.

| Table 48: Results – Broad Principles | | | |
|---|---|---|---|
| **No** | **Broad-Principles** | **Number** | **Percentage** |
| **1** | 1. Cost: Poor Guardianship | 6 | 60% |
| **2** | 2. Benefit: Attractive Target | 4 | 40% |
| | **Total** | **10** | **100,0%** |

### *5.4.3. Sub-Principles*

The Opportunity Theories Template provided more specific insights into the nature of the street robbers' cost-benefit analyses when the study's results were considered in terms of the Sub-Principles. In relation to the 'cost' aspect, the study's results indicated that perpetrators often selected targets in situations which included insufficient formal and informal guardians, in addition to a lack of technological aids. The study's results that were related to the 'benefit' aspect indicated that perpetrators also selected

victims who were easy to find and who could reasonably provide some form of materialistic reward.

| Table 49: Results - Sub-Principles | | | |
|---|---|---|---|
| **No.** | **Sub-Principles** | **Number** | **Percentage** |
| **1** | 2.3) Easy to find | 3 | 30% |
| **2** | 1) Insufficient Formal Guardians | 3 | 30% |
| **3** | 1.3) Insufficient Technological Aids | 2 | 20% |
| **4** | 2.1) Will Provide Materialistic Reward | 1 | 10% |
| **5** | 1.2) Insufficient Informal Guardians | 1 | 10% |
| | **Total** | **10** | **100%** |

### *5.4.4. Specific-Principles*

The Opportunity Theories Template provided greater detail of these Sub-Principles when viewed on the level of the Specific Principles. In this sense, perpetrators' 'cost' considerations of guardians and technologies related to the absence of natural, manned and technological surveillance in the field site. Perpetrators' deliberations of the 'benefit' to easily find suitable targets included the functions in the built environment that attracted victims, during their routine activities. Moreover, the benefit of high materialistic rewards related to the presence of goods and cash in the field site.

| Table 50: Results - Specific-Principles | | | |
|---|---|---|---|
| **No** | **Specific Principles** | **Number** | **Percentage** |
| **1** | B) Function of built environment attracts victims during routine activities | 3 | 30% |
| **2** | A) No/limited formal surveillance | 3 | 30% |
| **3** | 10A) No surveillance technology– manned and automated | 2 | 20% |
| **4** | A) High Financial Worth – goods and cash | 1 | 10% |
| **5** | A) No/Limited natural surveillance | 1 | 10% |
| | **Total** | **10** | **100%** |

### *5.4.5. Crime-Risk Questions*

The preceding Criminological Theories, and the addition to the Broad, Sub and Specific Principles of the Opportunity Theories Template, resulted in 10 crime risk questions that were used to successfully forecast street robberies in Johannesburg Central. These crime risk questions indicated that perpetrators' selected areas were

without the surveillance of security guards, attached to a general street, in addition to a specific site. In a similar vein, perpetrators also avoided streets with informal and formal car guards. These results implied that the perpetrators purposively avoided these guardians, to avoid punishment.

The results further indicated that street robbers purposively sought out streets without CCTV cameras and stop signs, possibly for the same motivation, to avoid punishment. Indeed, CCTV cameras are manned by trained controllers who dispatch the SAPS and armed response vehicles from private security companies, when they observe crimes on their monitors (Minnaar, 2012:107). Furthermore, the perpetrators' selection of streets without stop signs might have indicated to perpetrators that motorists were less likely to observe sidewalks and intervene during robberies as they would have when they were stationary.

Indeed, the study's results showed that perpetrators often chose to commit their crimes on the streets that had sidewalks, which speaks to the concepts of 'benefit' and the functionality of the built environment. Certainly, streets with sidewalks naturally attracted pedestrians, which plausibly attracted the perpetrators. The functionality of the built environment also extended to the presence of spaces on the street where motor vehicles and motorcycles could park. Street robbers possibly gravitated towards these areas in the field site with the expectation that motorists would park and exit their vehicles, which would make them more vulnerable to attacks. The results further showed that perpetrators chose to commit street robberies in the close vicinity of cash-based services and formal businesses. This result indicates that these businesses' services attracted victims who held cash, which in turn made the locations attractive to street robbers. The table below provides a summary of these Top 10 crime risk questions that perpetrators in the field site most often considered during their selection of targets:

| Table: 51: Top 10 Crime-Risk Questions | | | |
|---|---|---|---|
| **No** | **Questions** | **Number** | **Percentage** |
| **1** | 31) There were sidewalk(s) on this street that pedestrians could walk on (Observation). | 1 | 10% |
| **2** | 30) People used cash to pay for services/goods on this street (Bernasco & Block, 2011:35). | 1 | 10% |
| **3** | 12) No security guards were stationed on this street (Welsh, Mudge & Farrington, 2010: 314). | 1 | 10% |
| **4** | 17) There were no stop streets on this street. (Observation). | 1 | 10% |
| **5** | 13) No formal (Welsh, Mudge & Farrington, 2010: 314) or informal (Baker, 2002:41) car guards were present on this street. | 1 | 10% |
| **6** | 20) There were sections on this street not covered by CCTV cameras (Minnaar, 2002: 175). | 1 | 10% |
| **7** | 11) No guards were stationed at a specific site (Welsh, Mudge & Farrington, 2010: 314). | 1 | 10% |
| **8** | 50) Cars and motorcycles could park on this street (Observation). | 1 | 10% |
| **9** | 19) There were no CCTV cameras on this street (Minnaar, 2002: 175). | 1 | 10% |
| **10** | 33) Locations of entrances to all formal businesses (Irvin-Erickson, 2014: 125). | 1 | 10% |
| | **Total** | **10** | **100%** |

### *5.4.6. Summative Table: Opportunity Theories Template Results Overview*

The table below provides a summary of these top 10 crime risk questions and their relevant theories, broad-, sub-, and specific-principles from the Opportunity Theories Template:

**Table 52: Opportunity Theories Template Results Overview**

| No | Theories | Broad Principles | Sub-Principles | Specific Principles |
|---|---|---|---|---|
| **1** | *Routine Activity Theory; *Situational Crime Prevention Theory-B6 | 1. Low Cost: Poor Guardianship: | 1.1) Insufficient Formal Guardians | A) No/limited formal surveillance |
| **2** | *Routine Activity Theory; *Situational Crime Prevention Theory-B7 & B8 | 1. Low Cost: Poor Guardianship: | 1.2) Insufficient Informal Guardians | A) No/Limited natural and surveillance |
| **3** | *Routine Activity Theory; *Situational Crime Prevention Theory-B6 | 1. Low Cost: Poor Guardianship: | 1.1) Insufficient Formal Guardians | A) No/limited formal surveillance |
| **4** | *Situational Crime Prevention Theory-B6, B7 & B8 | 1. Low Cost: Poor Guardianship: | 1.3) Insufficient Technological Aids | A) No surveillance technology– manned and automated |
| **5** | *Routine Activity Theory; *Situational Crime Prevention Theory-B6 | 1. Low Cost: Poor Guardianship: | 1.1) Insufficient Formal Guardians | A) No/limited formal surveillance |
| **6** | *Situational Crime Prevention Theory-B6, B7 & B8 | 1. Low Cost: Poor Guardianship: | 1.3) Insufficient Technological Aids | A) No surveillance technology– manned and automated |
| **7** | *Routine Activity Theory; *Situational Crime Prevention Theory-B6 | **2.** Benefit: Attractive Target | 2.3) Easy to find | B) Function of built environment attracts victims during routine activities |
| **8** | *Routine Activity Theory | **2.** Benefit: Attractive Target | 2.1) Will Provide Materialistic Reward | A) High Financial Worth – goods and cash |
| **9** | *Routine Activity Theory; *Crime Pattern Theory | **2.** Benefit: Attractive Target | 2.3) Easy to find | B) Function of built environment attracts victims during routine activities |
| **10** | *Routine Activity Theory; *Crime Pattern Theory | **2.** Benefit: Attractive Target | 2.3) Easy to find | B) Function of built environment attracts victims during routine activities |

## 5.5. Limitations of the Study

Time and financial constraints forced the researcher to apply the CORF model to only a specific contact crime, i.e., the robbery of pedestrians in the CBD of a single city on only a week-by week basis. Indeed, this narrow focus and application certainly detracts from the study's assertion of the CORF model's generalisability.

In addition, not all the crime opportunity data was available from the reference period of March 2017, in the available Google Street View images, as presented in subsection 3.6.2 of the study. This necessitated the occasional use of alternative time periods, which detracts from the accuracy of the results, at least to some extent. In addition, the model's data capturing phase was lengthy and data intensive.

## 5.6. Value of the Study

Nonetheless, the study added substantial value. Indeed, it introduced a new crime forecasting model that was specifically designed for the South African context. This addition addresses, albeit to a limited extent, the current dearth in the literature on crime forecasting in the country. Moreover, the model successfully forecasted 81% of street robberies in the Johannesburg CBD and thus proved the hypothesis. This high proportion of successful forecasts indicates that the study identified key risk factors for street robberies such as the absence of surveillance and the presence of cash-based services, insights which could greatly assist with prevention efforts. These insights become especially significant when considered against the literature review's description of the prevalence and severity of street robberies in the Johannesburg CBD.

Furthermore, the CORF model's Opportunity Theories Template presents a novel means of theoretical abstraction for this set of theories. Indeed, this approach allowed for the simultaneous integration of five distinct theories into a cohesive and complementary whole. This union provided the foundation for an exceptionally broad and multi-layered theoretical structure, which ultimately resulted in a large number of practical street robbery risk factors. Moreover, the structure of Broad, Sub and Specific Principles is indicative of the Opportunity Theories Template's inherent versatility.

Indeed, the Template's principle-based structure allows for it to be molded according to varying contexts, crime types and geographical areas.

## 5.7. Future Applications of the CORF Model

This inherent versatility justifies future applications of the CORF model to other contact crimes such as murder, attempted murder, rape, assault, hijacking and business and residential robbery. The CORF model also lends itself to the forecasting of property-related crimes such as residential and business burglary, general theft, shoplifting and theft out of/of/from motor vehicles.

Furthermore, the model's utility could be tested in CBDs across the country, in addition to informal settlements, suburban and rural areas. Other developing countries with similar obstacles to the implementation of existing crime forecasting methodologies may also find the model useful. Future studies could also test whether the model could forecast crimes in terms of more specific time frames, such as hour blocks with data sets that are large enough to warrant such enquiries.

These future applications of the CORF model could potentially provide several valuable academic and practical contributions. Indeed, the approach could present researchers with a standardised model that could be used to compare results from studies across South Africa and other lower income countries. These results could provide valuable insights into the spatial distributions of crimes across regions, which would address the current lack of research in this area of focus.

In addition to academic gains, the model could be of practical value, in the sense that it could bolster crime prevention efforts in Johannesburg Central specifically, and other areas within South Africa and other lower income countries. This could be achieved when police departments incorporate the CORF model into their policies and place patrols at high-risk grids and their corresponding street corners during relevant high-risk time periods. Other government departments linked to human settlements and public works, in addition to the various municipalities, could also use the CORF model's results to eliminate specific crime risk factors in the built environment.

Moreover, the objectives detailed in this study's first chapter could facilitate this inclusion of the CORF model into governmental departments' policies. The third objective of cost-effectiveness could make the model especially attractive to governments. In addition to the low cost attached to the CORF model's software, as described in subsection 5.1 of this chapter, the implementation of emanating recommendations does not imply exorbitant costs either. Cases in point are in-situ rejuvenation projects which fix broken windows, peeling paint and graffiti. In addition, the model could allow police services to use resources sparingly, by only deploying staff at the relevant high-risk areas, as opposed to the entire jurisdiction. Indeed, the management of the Johannesburg Central police jurisdiction could both save costs and increase their effectiveness when they mostly focus their prevention efforts on the top 15% (3.7km$^2$) of the jurisdiction that the CORF model identified, which also recorded the vast majority of street robberies (81%). Furthermore, the relative simplicity of the CORF model implies a cost saving related to training needs, as the model does not necessitate lengthy complex courses.

The intrinsic non-complexity of the model could also attract governments in and of itself since this characteristic could facilitate the swift and widespread implementation of interventions. Finally, the CORF model's potential to utilise a wide variety of Criminological theories to accurately forecast several crime types, as per the first and final objectives of the study, would be beneficial to governments, as it could assist with the prevention of crimes against their citizens.

## 5.8 Recommendations

The value and possible future applications of the CORF Model described in this chapter leads to recommendations related to the National SAPS, the management of the Johannesburg Central SAPS, government departments and academics. Firstly, the SAPS should investigate the feasibility of the inclusion of the CORF model into their Intelligence structures and processes. The encouraging results of the study showed that the model could potentially significantly contribute towards the prevention of street robberies and various other crime types in the country.

Furthermore, the Johannesburg Central police jurisdiction should focus their prevention efforts on the various grids that the study identified as high risk, in addition to streets that housed the relevant crime risk factors. The police station's management should also conduct CORF-based investigations on the current conditions in their jurisdiction.

Other South African governmental departments and municipalities should also incorporate the CORF model into their processes, as it could assist with the identification and elimination of specific features that are linked to crime. Finally, Academics from South Africa and other lower income countries should further test the CORF model against more crime types and geographical areas. Scholars should also further explore the topic of crime forecasting in the context of South Africa and other lower income countries, to address the current scarcity in the literature.

## 5.9 Conclusion

In conclusion, this chapter illustrated that the study achieved its aim, which was to show that the designed and developed CORF model was an appropriate crime forecasting model for the South African context. The respective chapters provided evidence for this assertion through an alignment with the four objectives of the study. In this regard, the study's literature review illustrated that the CORF Model's Opportunity Theories Template was broad enough to include a wide variety of theoretical foci. Thereafter, the methodology chapter showed that the CORF model was both intuitive and cost effective. Finally, the results chapter clearly indicated that the CORF model could accurately forecast street robberies in the Johannesburg Central police jurisdiction, as per the fourth objective and related hypotheses of the study.

Subsequently, the current chapter explored the insights that were gained from these successful forecasts in terms of the Opportunity Theories Template's constituent Criminological Theories, principles, and crime risk questions. This multi-layered description suggested that the street robbers in Johannesburg Central conducted cost-benefit analyses before they selected their targets. More specifically, the results indicated that perpetrators avoided punishment through a purposive selection of

portions in the field site that were not covered by surveillance in the form of guards, CCTV cameras and motorists. In addition to the perpetrators' avoidance of 'cost', the results further suggested that the perpetrators were attracted to specific locations that could benefit them. In this regard, street robbers most often selected streets that housed land usages such cash-based services, formal businesses, and pavements, which naturally attracted the ideal victim, i.e., pedestrians with cash. Therefore, street robbers in Johannesburg Central did not commit robberies at random locations. Instead, the results indicated that robbers specifically selected locations that could benefit them without any consequences or punishment.

Moreover, the current chapter showed that these findings were supported by the theories and studies in the literature review. This corroboration extended to the nature and extent of street robberies in Johannesburg Central, in addition to the ability of Routine Activity Theory and Crime Pattern Theory to explain the spatial distribution of street robberies. The literature also supported the current study's findings that the absence of surveillance and the presence of cash-based services were linked to street robberies.

Although the CORF model was applied to only a specific contact crime in the CBD of a single city, the successful application in this study and the fact that the model was specifically designed for the South African context certainly warrants future implementations. The value of the study was further illustrated by the CORF model's Opportunity Theories Template, which provided a broad and principle-based theoretical base, that ultimately resulted in the identification of key risk factors for street robberies in the area. In addition, the principle-based nature of the Template would allow future applications to a variety of crime types across various areas, which would address the current dearth in South Africa's Criminological literature regarding crime forecasting. Government departments could also implement the CORF model to proactively prevent crime.

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# Annexure A: MUHREC Approval Letter

ANNEXURE A

MONASH University

**Monash University Human Research Ethics Committee**

**Approval Certificate**

This is to certify that the project below was considered by the Monash University Human Research Ethics Committee. The Committee was satisfied that the proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and has granted approval.

| | |
|---|---|
| **Project ID:** | 29032 |
| **Project Title:** | CRIME OPPORTUNITY & RISK FORECASTING: A NEW PERSPECTIVE APPLIED TO STREET ROBBERIES IN JOHANNESBURG CENTRAL, SOUTH AFRICA |
| **Chief Investigator:** | Mrs Tara Cik |
| **Approval Date:** | 31/05/2021 |
| **Expiry Date:** | 31/05/2026 |

**Terms of approval - failure to comply with the terms below is in breach of your approval and the *Australian Code for the Responsible Conduct of Research*.**

1. The Chief Investigator is responsible for ensuring that permission letters are obtained, if relevant, before any data collection can occur at the specified organisation.
2. Approval is only valid whilst you hold a position at Monash University.
3. It is responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by MUHREC.
4. You should notify MUHREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
5. The Explanatory Statement must be on Monash letterhead and the Monash University complaints clause must include your project number.
6. Amendments to approved projects including changes to personnel must not commence without written approval from MUHREC.
7. Annual Report - continued approval of this project is dependent on the submission of an Annual Report.
8. Final Report - should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected completion date.
9. Monitoring - project may be subject to an audit or any other form of monitoring by MUHREC at any time.
10. Retention and storage of data - The Chief Investigator is responsible for the storage and retention of the original data pertaining to the project for a minimum period of five years.

Kind Regards,

Professor Nip Thomson

Chair, MUHREC

CC: Mr Francois van Jaarsveld

**List of approved documents:**

| Document Type | File Name | Date | Version |
|---|---|---|---|
| Consent Form | SAPS Permission Letter | 16/11/2020 | 1 |
| Supporting Documentation | SAPS Permission Letter | 16/11/2022 | 1 |
| Consent Form | SAPS Permission Letter | 16/11/2022 | 1 |

MONASH SOUTH AFRICA

# Annexure B: SAPS Approval Letter

**ANNEXURE B**

South African Police Service — Suid-Afrikaanse Polisiediens

| Privaatsak: Private Bag X94 | Pretoria 0001 | Faks No. Fax No. | (012) 334 3518 |
|---|---|---|---|

Your reference/U verwysing:

My reference/My verwysing: **3/34/2**

THE HEAD: RESEARCH
SOUTH AFRICAN POLICE SERVICE
PRETORIA
0001

Enquiries/Navrae: **Lt Col Joubert**
**AC Thenga**
Tel: **(012) 393 3118**
Email: **JoubertG@saps.gov.za**

APPROVED

Mr F van Jaarsveld
**MONASH UNIVERSITY OF SOUTH AFRICA**

**RE: PERMISSION TO CONDUCT RESEARCH IN SAPS: CRIME FORECASTING IN THE SOUTH AFRICAN CONTEXT – A NEW PERSPECTIVE APPLIED TO STREET ROBBERIES IN JOHANNESBURG CENTRAL, SOUTH AFRICA : MONASH UNIVERSITY OF SOUTH AFRICA: MASTERS DEGREE: RESEARCHER: F VAN JAARSVELD**

The above subject matter refers.

You are hereby granted approval for your research study on the above mentioned topic in terms of National Instruction 1 of 2006.

Further arrangements regarding the research study may be made with the following office:

The Divisional Commissioner: Crime Registrar:

- **Contact Person:** Col John van der Merwe
- **Contact Details:** (011) 373 3504/082 822 7177
- **Email Address :** vandermerwej3@saps.gov.za

- **Contact Person:** Capt Wepener
- **Contact Details:** (011) 373 3487 /079 895 0770
- **Email Address :** WepenerNico@saps.gov.za

Kindly adhere to paragraph 6 of our attached letter signed on the **2020-09-07** with the same above reference number.

**MAJOR GENERAL**
**THE HEAD: RESEARCH**
**DR PR VUMA**

**DATE:** 2020-11-16

# Appendix

| Table 1: Opportunity Theories Template and Questions | | | | |
|---|---|---|---|---|
| **Broad Principles** | **Sub-Principles** | **Specific Principles** | **Source** | **Questions** |
| | | | | **1)** Question Number |
| | | | | **2)** Main Street |
| | | | | **3)** Street 1 |
| | | | | **4)** Street 2) |
| | | | | **5)** Latitude – First Corner |
| | | | | **6)** Longitude – First Corner |
| | | | | **7)** Latitude – Second Corner |
| | | | | **8)** Longitude – Second Corner |
| | | | | **9)** Date of Google Street View Image |
| **1. Poor Guardianship:** | **1.1) Insufficient Formal Guardians** | A) No/limited formal surveillance | RAT, SCPT B 6 | **10)** No alarm/armed response placard(s) was present on this street (Singh, 2005:154) |
| | | | | **11)** No guards were stationed at a specific site (Welsh, Mudge & Farrington, 2010: 314). |
| | | | | **12)** No security guards were stationed on this street (Welsh, Mudge & Farrington, 2010: 314). |
| | | | | **13)** No formal (Welsh, Mudge & Farrington, 2010: 314) or informal (Baker, 2002:41) car guards were present on this street. |
| | | B) No access control/screening/identification | SCPT A 2; A 3; B 10 | N/A |
| | | C) No control of facilitators like firearms and knives | SCP A 5 | N/A |
| | **1.2) Insufficient Informal Guardians** | A) No/Limited natural and surveillance | RAT, SCP B 7; SCPT B 8 | **14)** No vehicles drove on this street at all at any time (Observation). |
| | | | | **15)** This street had 2 or fewer lanes (Observation). |
| | | | | **16)** There were no traffic lights on this street (Observation). |
| | | | | **17)** There were no stop streets on this street (Observation). |
| | | | | 18) Any stalls/informal traders were not visible to each other (Observation). |
| | | B) No access control/screening/identification | SCP A 2; A 3; B 10 | N/A |
| | | C) Ineffective self protection/Guardianship not extended | SCP B 9 | N/A |

| | | | | |
|---|---|---|---|---|
| | **1.3) Insufficient Technological Aids** | A) No surveillance technology– manned and automated | SCPT - B6, B7, B 8 | **19)** There were no CCTV cameras on this street (Minnaar, 2002: 175). |
| | | | | **20)** There were sections on this street not covered by CCTV cameras (Minnaar, 2002: 175). |
| | | B) No access control technology | SCP A 2 | N/A |
| | | C) No/insufficient target hardening technology | SCP A 1 | N/A |
| | **1.4) Poor Form of built environment limits guardianship** | A) No territoriality | CPTED | **21)** The entrances to any formal land usages with obvious functions were not visible to each other (Observation). |
| | | B) Poor Image | CPTED; BWT; SCP D 20 | **22)** Locations of broken window(s) on this street (Van Jaarsveld et al. 2013). |
| | | | | **23)** Locations of peeling paint / irregular paint on this street (Van Jaarsveld et al. 2013). |
| | | | | **24)** Locations of structural damage on buildings on this street (Van Jaarsveld et al. 2013). |
| | | | | **25)** Locations of graffiti on this street (Van Jaarsveld et al. 2013). |
| | | | | **26)** Locations of razor mesh on this street (Van Jaarsveld et al. 2013). |
| | | C) Poor Milieu | CPTED | N/A |
| | | D) Obstructs natural surveillance | CPTED; SCP B 7, B 8 | **27)** Location of an alleyway or tunnel on this street (Observation) |
| | | | | **28)** The street lights did not provide adequate lighting for any portion of this street (Pease, 1999: 69). |
| | | | | **29)** Locations of overgrown vegetation that a perpetrator could use to hide (Despard, 2012:159). |
| **2. Benefit: Attractive Target** | **2.1) Will Provide Materialistic Reward** | A) High Financial Worth – goods and cash | RAT | 30) People used cash to pay for services/goods on this street (Bernasco & Block, 2011:35). |
| | | B) Can Easily Re-Sell: Easy market & No ID on goods | SCP C15; SCP C12 | N/A |
| | | C) Can easily use goods | SCP C14 | N/A |
| | **2.2) Will Provide Emotional Reward** | A) Release of negative emotions i.e., during a dispute, frustration/stress or emotional arousal | SCP D17; SCP D16; SCPT D18 | N/A |
| | | B) Psychological disinhibitors – Alcohol, Drugs | SCP E25 | N/A |

| | | | |
|---|---|---|---|
| **2.3) Easy to find** | A) Travel Demand – Close to travel | CPT) | N/A |
| | B) Function of built environment attracts victims during routine activities | RAT, CPT | **31)** There were sidewalk(s) on this street that pedestrians could walk on (Observation). |
| | | | **32)** Locations of informal businesses such as road-side stalls and other informal traders on this street (Observation). |
| | | | **33)** Locations of entrances to all formal businesses (Irvin-Erickson, 2014:125). |
| | | | **34)** Locations of entrances to larger businesses (Irvin-Erickson, 2014:125). |
| | | | **35)** Locations of entrances bars/drinking taverns on this street (Bernasco & Block, 2011:35). |
| | | | **36)** Locations of entrances to liquor stores (Bernasco & Block, 2011:48). |
| | | | **37)** Locations of entrances to fast-food outlets on this street (Bernasco & Block, 2011:34). |
| | | | **38)** Locations of entrances to restaurants (Bernasco & Block, 2011:34) and coffee shops (Observation) on this street. |
| | | | **39)** Locations of entrances to shopping centres on this street (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 62). |
| | | | **40)** Locations of entrances to abandoned building on this street (Van Jaarsveld et al. 2013). |
| | | | **41)** Locations of entrances to empty/to-let/sold/auctioned properties (Observation). |
| | | | **42)** Locations of (s)/open spaces on this street (Mohit & Elsawahli 2017: 57). |
| | | | **43)** Locations of entrances to sex worker home bases on this street (Observation). |
| | | | **44)** Location of entrances to creche/kindergartens on this street (Observation). |
| | | | **45)** Location of entrances to primary school on this street (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 62). |
| | | | **46)** Locations of entrances to schools for primary and high school / high school students on this street (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 62). |
| | | | **47)** Locations of entrances to universities, colleges, academies and training facilities on this street (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 69). |
| | | | **48)** Location of entrances to banks on this street (Thobane (2017:2) |

| | | | | |
|---|---|---|---|---|
| | | | | **49)** Location of ATMs on this street (Thobane (2017:2). |
| | | | | **50)** Cars and motorcycles could park on this street (Observation). |
| | | | | **51)** Location of entrances to parking lots on this street (Observation). |
| | | | | **52)** Location of entrances to taxi ranks on this street (Observation). |
| | | | | **53)** Locations of entrances to bus stops, bus ticket sales offices and bus depots on this street (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 71). https://www.mbus.co.za/index.php/pricing?id=118 |
| | | | | **54)** Location of entrances to train stations and train ticket sales offices on this street ((Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 71). http://www.metrorail.co.za/Timetables.html |
| | | | | **55)** Locations of entrances to all residences on this street (Mohit & Elsawahli 2017: 60). |
| | | | | **56)** House (Mohit & Elsawahli 2017: 60). |
| | | | | **57)** Multistorey Apartments – No businesses below (Observation). |
| | | | | **58)** Multistorey Apartments above Businesses (Observation). |
| | | | | **59)** Informal housing/shacks (Observation). |
| | | | | **60)** Single storey Apartments above Businesses (Observation). |
| | | | | **61)** Locations of entrances to hotels/motels on this street (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 69). |
| | | | | **62)** Locations of entrances to construction sites (Observation). |
| | | | | **63)** Locations of entrances to public toilets (Observation). |
| | | | | **64)** Locations of public telephones (Observation). |
| | | | | **65)** Locations of entrances to post offices and post boxes (Observation; https://www.postoffice.co.za/Tools/postofficelocations.html) |
| | | | | **66)** Locations of postboxes and lockers (not at post offices) (Observation). |
| | | | | **67)** Locations of entrances to petrol stations (Observation). |
| | | | | **68)** Locations of entrances to office blocks and warehouses (Observation). |
| | | | | **69)** Locations of homeless and recycling (not including recycling depots) (Observation). |

| | | | | |
|---|---|---|---|---|
| | | | | **70)** Locations of entrances to medical assistance, including clinics, doctors' offices and dentists – not open 24/7 (Observation). |
| | | | | **71)** Locations of entrances to medical services – clinics and hospital – open 24/7 (Observation). |
| | | | | **72)** Locations of entrances to churches (Observation). |
| | | | | **73)** Locations of entrances to Union offices (Observation). |
| | | | | **74)** Locations of entrances to Mosques (Observation). |
| | | | | **75)** Locations of public seating areas and a public gym (Observation). |
| | | | | **76)** Locations of entrances to NPO's, charities and shelters (Observation). |
| | | | | **77)** Location of stairways to another street or underground area (Observation). |
| | | | | **78)** Locations of entrances to Museums (Observation). |
| | | | | **79)** Locations of tourist attractions outside buildings without any business hours (Observation). |
| | | | | **80)** Locations of entrances to associations, councils and societies (Observation). |
| | | | | **81)** Locations of entrances to libraries (Observation). |
| | | C) Displayed - No target removal at risky times & Temptation/Exhibition | SCP C11, SCP C13 | N/A |
| | | | | **82)** Unknown entrances and irrelevant entrances such as fire exits, substations, and delivery entries (Observation). |

| **Table 2: Static and Dynamic Crime Opportunities** | |
|---|---|
| **Questions** | **Static/Dynamic** |
| 1)Question Number | N/A |
| 2) Main Street | N/A |
| 3) Street 1 | N/A |
| 4) Street 2) | N/A |
| 5) Latitude – First Corner | N/A |
| 6) Longitude – First Corner | N/A |
| 7) Latitude – Second Corner | N/A |
| 8) Longitude – Second Corner | N/A |
| 9) Date of Google Street View Image | N/A |
| **10)** No alarm/armed response placard(s) was present on this street (Singh, 2005:154) | Static |
| **11)** No guards were stationed at a specific site (Welsh, Mudge & Farrington, 2010: 314). | Static |
| **12)** No security guards were stationed on this street (Welsh, Mudge & Farrington, 2010: 314). | Static |
| **13)** No formal (Welsh, Mudge & Farrington, 2010: 314) or informal (Baker, 2002:41) car guards were present on this street. | Dynamic |
| **14)** No vehicles drove on this street at all at any time (Observation). | Static |
| **15)** This street had 2 or fewer lanes (Observation). | Static |
| **16)** There were no traffic lights on this street (Observation). | Dynamic |
| **17)** There were no stop streets on this street (Observation). | Static |
| **18)** Any stalls/informal traders were not visible to each other (Observation). | Static |
| **19)** There were no CCTV cameras on this street (Minnaar, 2002: 175). | Static |
| **20)** There were sections on this street not covered by CCTV cameras (Minnaar, 2002: 175). | Static |
| **21)** The entrances to any formal land usages with obvious functions were not visible to each other (Observation). | Static |
| **22)** Locations of broken window(s) on this street (Van Jaarsveld et al. 2013). | Dynamic |
| **23)** Locations of peeling paint / irregular paint on this street (Van Jaarsveld et al. 2013). | Static |
| **24)** Locations of structural damage on buildings on this street (Van Jaarsveld et al. 2013). | Dynamic |
| **25)** Locations of graffiti on this street (Van Jaarsveld et al. 2013). | Static |
| **26)** Locations of razor mesh on this street (Van Jaarsveld et al. 2013). | Dynamic |
| **27)** Location of an alleyway or tunnel on this street (Observation) | Dynamic |
| **28)** The street lights did not provide adequate lighting for any portion of this street (Pease, 1999: 69). | Dynamic |
| **29)** Locations of overgrown vegetation that a perpetrator could use to hide (Despard, 2012:159). | Dynamic |
| **30)** People used cash to pay for services/goods on this street (Bernasco & Block, 2011:35). | Dynamic |
| **31)** There were sidewalk(s) on this street that pedestrians could walk on (Observation). | Static |
| **32)** Locations of informal businesses such as road-side stalls and other informal traders on this street (Observation). | Dynamic |
| **33)** Locations of entrances to all formal businesses (Irvin-Erickson, 2014:125). | Dynamic |
| **34)** Locations of entrances to larger businesses (Irvin-Erickson, 2014:125). | Dynamic |
| **35)** Locations of entrances bars/drinking taverns on this street (Bernasco & Block, 2011:35). | Dynamic |
| **36)** Locations of entrances to liquor stores (Bernasco & Block, 2011:48). | Dynamic |
| **37)** Locations of entrances to fast-food outlets on this street (Bernasco & Block, 2011:34). | Static |
| **38)** Locations of entrances to restaurants (Bernasco & Block, 2011:34) and coffee shops (Observation) on this street. | Static |
| **39)** Locations of entrances to shopping centres on this street (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 62). | Dynamic |
| **40)** Locations of entrances to abandoned building on this street (Van Jaarsveld et al. 2013). | Dynamic |

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| **41)** Locations of entrances to empty/to-let/sold/auctioned properties (Observation). | Dynamic |
| **42)** Locations of (s)/open spaces on this street (Mohit & Elsawahli 2017: 57). | Dynamic |
| **43)** Locations of entrances to sex worker home bases on this street (Observation). | Static |
| **44)** Location of entrances to creche/kindergartens on this street (Observation). | Static |
| **45)** Location of entrances to primary school on this street (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 62). | Static |
| **46)** Locations of entrances to schools for primary and high school / high school students on this street (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 62). | Static |
| **47)** Locations of entrances to universities, colleges, academies and training facilities on this street (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 69). | Static |
| **48)** Location of entrances to banks on this street (Thobane (2017:2) | Static |
| **49)** Location of ATMs on this street (Thobane (2017:2). | Static |
| **50)** Cars and motorcycles could park on this street (Observation). | Dynamic |
| **51)** Location of entrances to parking lots on this street (Observation). | Static |
| **52)** Location of entrances to taxi ranks on this street (Observation). | Static |
| **53)** Locations of entrances to bus stops, bus ticket sales offices and bus depots on this street (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 71). https://www.mbus.co.za/index.php/pricing?id=118 | Dynamic |
| **54)** Location of entrances to train stations and train ticket sales offices on this street (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 71). http://www.metrorail.co.za/Timetables.html | Static |
| **55)** Locations of entrances to all residences on this street (Mohit & Elsawahli 2017: 60). | Static |
| **56)** House (Mohit & Elsawahli 2017: 60). | Dynamic |
| **57)** Multistorey Apartments – No businesses below (Observation). | Static |
| **58)** Multistorey Apartments above Businesses (Observation). | Dynamic |
| **59)** Informal housing/shacks (Observation). | Static |
| **60)** Single storey Apartments above Businesses (Observation). | Dynamic |
| **61)** Locations of entrances to hotels/motels on this street (Kinney, Brantingham, Wuschke, Kirk & Brantingham, 2008: 69). | Dynamic |
| **62)** Locations of entrances to construction sites (Observation). | Dynamic |
| **63)** Locations of entrances to public toilets (Observation). | Static |
| **64)** Locations of public telephones (Observation). | Dynamic |
| **65)** Locations of entrances to post offices and post boxes (Observation; https://www.postoffice.co.za/Tools/postofficelocations.html) | Static |
| **66)** Locations of postboxes and lockers (not at post offices) (Observation). | Dynamic |
| **67)** Locations of entrances to petrol stations (Observation). | Static |
| **68)** Locations of entrances to office blocks and warehouses (Observation). | Dynamic |
| **69)** Locations of homeless and recycling (not including recycling depots) (Observation). | Dynamic |
| **70)** Locations of entrances to medical assistance, including clinics, doctors' offices and dentists – not open 24/7 (Observation). | Static |
| **71)** Locations of entrances to medical services – clinics and hospital – open 24/7 (Observation). | Static |
| **72)** Locations of entrances to churches (Observation). | Dynamic |
| **73)** Locations of entrances to Union offices (Observation). | Dynamic |
| **74)** Locations of entrances to Mosques (Observation). | Dynamic |
| **75)** Locations of public seating areas and a public gym (Observation). | Static |
| **76)** Locations of entrances to NPO's, charities and shelters (Observation). | Dynamic |

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| **77)** Location of stairways to another street or underground area (Observation). | Static |
| **78)** Locations of entrances to Museums (Observation). | Dynamic |
| **79)** Locations of tourist attractions outside buildings without any business hours (Observation). | Static |
| **80)** Locations of entrances to associations, councils and societies (Observation). | Dynamic |
| **81)** Locations of entrances to libraries (Observation). | Dynamic |
| **82)** Unknown entrances and irrelevant entrances such as fire exits, substations and delivery entries (Observation). | Static |