CRIME ANALYSIS AND POLICE STATION LOCATION IN SWAZILAND: A CASE STUDY IN MANZINI

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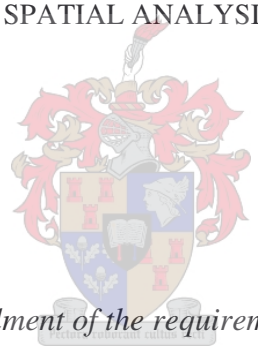

Research report submitted in partial fulfilment of the requirements for the degree Master of Arts (in GIS: Human Geography) at the University of Stellenbosch.

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18 February 2006

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

AUTHOR'S DECLARATION

I, the undersigned, hereby declare that the work contained in this research report is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Signature: .....

Date: .....

SUMMARY

Criminal activity and police station locations have an inherent geography that needs to be understood in order for crime prevention strategies to be reasonably effective. This study analysed the spatio-temporal pattern of crime in the city of Manzini, in Swaziland, for the period of 2004 and determined suitable locations for future police stations.

Four categories of crime were analysed. These were crimes against property, crimes against people, drug related crimes and crimes against public order. Five main analyses were performed namely: overlay analysis, proximity analysis, temporal analysis, morphological analysis, and accessibility analysis.

The findings suggest that crimes against property are the most prevalent category of crime in Manzini with a prevalence rate of 84.2%. This category was followed by crimes against people (11.9%), drug related crimes (3.5%), and crimes against public order (0.4%). Landuses associated with transportation experienced the highest amount (22%) of crime in Manzini. There was a strong relationship between incidents of crime and areas with medium to high population density. The proximity analysis revealed that the highest concentration of incidents of crime was between 50 and 100 metres from alcohol-serving establishments in Manzini. In a similar analysis, the proximity of incidents of crime to educational institutions was concentrated between 500 and 1000 metres whereas the proximity of incidents of crime to the Manzini police station was dominant between 250 and 500 metres. Of all recorded incidents of crime 87% occurred during the day while 13% occurred during the night. In areas of high-crime concentration such as the bus rank and the Manzini market, it was established that the structural layout of these areas promoted criminal activity. The accessibility analysis showed that seven police stations are necessary to ensure that people do not walk more than 30 minutes to the nearest police station in Manzini.

The study concluded that crime prevention strategies would require the intervention of both the police and city planners to be reasonably successful. It also noted that the establishment of accessible police stations would complement the efforts of the police in their endeavour to combat crime in Manzini.

Key words: GIS, overlay analysis, proximity analysis, temporal analysis, morphological analysis, accessibility analysis, and Flowmap.

OPSOMMING

Misdaad-aktiwiteite en die ligging van polisiestasies het ’n inherente geografie wat eers verstaan moet word voordat dit ingespan kan word in effektiewe misdaadsvoorkomingstrategieë. Hierdie studie analiseer die tyd-ruimtelike patroon van misdaad vir die stad Manzini in Swaziland vir die jaar 2004 en bepaal ook geskikte liggings vir toekomstige polisiestasies.

Vier kategorieë van misdaad word geanaliseer, naamlik; geweld teen eiendom, geweld teen mense, dwelmverwante geweld en geweld teen openbare orde. Vyf hoof analises is uitgevoer, naamlik; oorleg-analise, nabyheidsanalise, temporale-analise, morfologiese-analise en toeganklikheidsanalise.

Die studie het bevind dat misdaad teen eiendom die mees algemene misdaad kategorie in Manzini is, met ’n voorkomskoers van 84.2%. Hierdie kategorie word gevolg deur misdaad teen mense (11.9%), dwelmverwante-geweld (3.5%) en geweld teen openbare orde (0.4%). Gebiedens wat verwant is aan vervoeraktiwiteite ondervind die grootste hoeveelheid misdaad in Manzini, nl. 22%. Daar is ook ’n sterk verwantskap tussen gevalle van misdaad en gebiedens met gemiddelde- tot hoë bevolkingsdigthede. Die nabyheidsanalise ontbloot ‘n hoë konsentrasie van misdaad gevalle tussen 50 en 100 meter van alkoholverskaffingsondernemings. In ‘n soortgelyke analise is die nabyheid van misdaad gevalle aan opvoedkundige instellings tussen 500 en ‘n 1000 meter bevind, terwyl die nabyheid van misdaad gevalle aan die Manzini polisiestasie tussen 250 en 500 meter voorkom. Van alle aangetekende gevalle van misdaad, vind 87% gedurende die dag plaas teenoor die 13% gedurende die nag. Daar is ook vasgestel dat die strukturele-uitleg van areas soos die busstasie en die Manzini mark, misdaadaktiwiteite in dié gebiede kan verhoog. Die toeganklikheidsanalise toon dat sewe polisiestasies nodig is in Manzini om te verseker dat mense nie meer as 30 minute na die naaste polisiestasie hoef te stap nie.

Die gevolgtrekking van die studie is dat die ingryping van beide die polisie en stadsbeplanners nodig is vir redelik suksesvolle misdaadsvoorkomingsstrategieë. Daar is ook vasgestel dat die vestiging van toeganklike polisiestasies ’n positiewe bydrae kan lewer vir polisie in hul poging om misdaad in Manzini te voorkom.

Sleutelwoorde: GIS, oorleg-analise, nabyheidsanalise, temporale-analise, morfologiese-analise, toeganlikheidsanalise en Vloeikaart.

ACKNOWLEDGEMENTS

This study has immensely profited from several individuals whom I would like to acknowledge and extend my appreciation. I start by thanking my parents, Dr. and Mrs. Tengbeh, for financial support and spiritual guidance.

Special thanks go to Dr. SLA Ferreira and Professor HL Zietsman (my supervisor and co-supervisor), for their dedication and readiness to always assist me in my thesis. Many thanks go to the staff of the Royal Swaziland Police for facilitating the provision of crime data. Mr Edgar Hillary (Commissioner of Police), Mr. Sithole (Director of Crime), Mr Mgwane Mabuza (Operations Officer) and Constables Sabelo and Zanele Dlamini, your efforts are greatly appreciated.

To Mr Patrick Mkhonta and Mr Esau Dlamini from the Surveyor General's Department in Swaziland, thank you for your assistance with GIS data. To Dr G Peter, from the Department of Geography, Environmental Science, and Planning at the University of Swaziland, thank you for your comments, suggestions, and criticisms even during holidays.

Lastly, I would like to thank the staff of the Department of Geography and Environmental Studies at the University of Stellenbosch for making my stay in Stellenbosch a comfortable and memorable one.

FIGURES

TABLES

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CHAPTER 1
CRIME IN MANZINI

1.1 INTRODUCTION

The rate of crime is on the increase in the city of Manzini. In 1999, the Royal Swaziland Police (RSP) recorded 7231 reported incidents of crime in Manzini (Royal Swaziland Police 1999). By 2004, the number of reported incidents had risen by 26% (9125) with theft and robbery crimes being the most frequently reported (Royal Swaziland Police 2004). This trend suggests that 25 incidents of crime occurred in Manzini everyday and one incident every hour, thus making Manzini a very unsafe city in Swaziland.

Reasons for this high crime rate have been attributed to overcrowding, unemployment, illegal immigrants and street children who have lost their parents to HIV/AIDS (Sihlongonyane 2002; IRIN 2004). The high cost of policing and other pressing budgetary needs of the police implies that the crime situation is unlikely to improve in the near future unless something is done about controlling it now.

Related to the high incidence of criminal activity in Manzini is the inaccessibility of police services by a single police station (Mabuza 2005, pers com). Located in the city centre, the Manzini police station is not accessible (within 30 minutes walking time) to the majority of residents in Manzini. Budgetary constraints appear to be the main limiting factor in the establishment of more police stations. It is essential therefore that when funding is made available for the establishment of new police stations in Manzini, these are located as near as possible so that they are not at great distances from the residents.

According to Murray, McGuffog, Western & Mullins (2001:312) the analysis of criminal activity requires one important item, information on crime occurrence. The most powerful tool today that can assist the police in crime prevention and the optimal location of police stations is information technology (Ahmadi 2003). Mapping crime is the key to understanding its spatial and temporal dimensions (Getis, Drummy, Gartin, Gorr, Harries, Rogerson, Stoe & Wright 2000). It is essential therefore, that the possibilities information technology has to offer the police are explored so that they can be incorporated into crime prevention strategies.

1.2 CRIME: DEFINITION AND CATEGORIES

It is important to start by defining crime as a concept. This will strengthen the conceptual framework for crime analysis and enable an understanding of the realm of crime in which to situate the investigation. The legal definition of crimes is that, it is an act of omission or an omission of an act that is illegal, transgresses/violates formally constituted law, and is thereby prohibited or punishable by law (Munice & McLaughlin 2001; Oc & Tiesdell 1998; Microsoft 2005a). In a non-legal sense, it refers to "acts that violate socially accepted rules of human, ethical, or moral behaviour" (Ahmadi 2003: 5). The focus for this study revolves around the legal definition of crime because it is forms the basis of police operations for preventing crime and apprehending perpetrators.

Crime can be grouped into several categories. Van Steel & Pellenbarg (2000) distinguish between four categories namely:

- Crimes against property,
- Violent crimes against people,
- Devastation and vandalism (crimes against the public order) and
- Traffic crimes

Property crimes consist of various forms of theft, embezzlement, receiving stolen goods and fraud (Van Steel & Pellenbarg 2000). In Swaziland, such crimes account for more than 80% of all crimes. Violent crimes against people refer to offences against people like murder, deliberate wounding, sexual violence, violent theft, and blackmail (Van Steel & Pellenbarg 2000). Crimes relating to devastation and vandalism include damage to buildings, public street signs, discrimination and exhibitionism whereas traffic crimes refer to driving at higher speeds than allowed, ignoring traffic lights, drunken driving and hit-and-run accidents (Van Steel & Pellenbarg 2000).

Morolong (2004) shares more or less the same categorical classification as Van Steel & Pellenbarg (2000) but separates assault and sexual violence from the violent crimes category into crimes of social fabric. She includes a category of commercial crimes where she mentions automatic teller machine (ATM) fraud as an example.

1.3 THE RESEARCH PROBLEM

Criminal activity and police station locations have an inherent geography that needs to be understood in order to develop crime prevention strategies that can be reasonably effective. An analysis of the spatio-temporal pattern of crime and police station location in Manzini can shed light on how the police can effectively implement crime prevention strategies.

Knowledge on where and when certain incidents of crime occur can assist the police to better prevent them from occurring. This is possible because limited police resources can be used in known crime infested areas at times, where the crimes are most likely to be committed. The location of police stations, on the other hand, has an influence on how accessible police services are to people. Providing equal access and better distribution of police resources can be vital in the fight against crime (Green 1998: 3). Not only will it improve visibility of the police but also their reaction time to incidents of crime. This can enable the police to provide greater assistance and build closer relationships with the communities they serve and allows for more effective, preventative and proactive policing programmes to be implemented (Green 1998).

1.4 RESEARCH QUESTIONS

Based on the problem investigated, the following research questions were posed:

1. Where do crime incidents tend to concentrate in Manzini?
2. When do crime incidents occur in Manzini?
3. What is the relationship between these crimes and the physical layout of the areas in which they occur?
4. How many additional police stations should be established in Manzini?
5. Where should these police stations be located?

1.5 RESEARCH AIMS AND OBJECTIVES

The aim of this study is to analyse the spatio-temporal dimension of crime in Manzini for 2004, determine suitable locations for future police stations, and use these outcomes to assist in the further development of crime prevention strategies. This was achieved by:

- Classifying crime incidents that occurred in 2004 in Manzini into four categories

- Mapping crime incidents
- Identifying crime "hotspots"
- Determining suitable location(s) for one or more police stations in Manzini
- Making recommendations on how crime prevention strategies could be more effective.

1.6 RATIONALE FOR THE STUDY

This study is motivated by the need to address crime in Manzini, and ensure that police stations are accessible to the inhabitants. A geographical information system (GIS) package (ArcGIS) was used to help determine where crimes were concentrated in Manzini, why they occurred where they did, and how police services could be located to ensure that people have more equitable access to them.

1.7 LIMITATIONS OF THE STUDY

The focus of this study is limited to reported crime incidents that occurred in 2004 and includes only those that the police could spot and possibly have prevented while patrolling certain areas in Manzini. Such incidents include theft, armed robbery, rape, assault (assault to cause Grievous Bodily Harm (GBH)), and possession of habit-forming drugs (HFD's).

In this study, crimes related to robbery and armed robbery were grouped as one class (robbery). Forms of theft such as shoplifting, and pick pocketing were all grouped as theft. This was because no clear distinction was made between armed robbery and robbery in the Manzini police's crime registry.

The temporal analysis of crime is limited to incidents that occurred during the day (06:00-18:00 hours) and during the night (18:01-06:00 hours). This is because incidents of crime were most accurately recorded within these broad temporal categories.

Population distribution in Manzini with respect to the various townships had to be estimated using several spatial analytical techniques. This is because currently, there were no defined boundaries for townships in Manzini. Furthermore, enumeration area data overlapped two and sometimes three townships. This made the task of determining the relationship between incidents of crime and population density within these townships difficult.

CHAPTER 2
SPATIAL PERSPECTIVES ON CRIME

2.1 INTRODUCTION

This chapter presents a literature review on the spatial perspectives of crime, indicators, and approaches used in the analysis of crime and the spatial optimization of service locations. The review begins with an overview of the geography of crime and environmental criminology. It then proceeds to examine the data sources used for the environmental analysis of crime. The following section focuses on traditional and contemporary techniques employed to analyse crime while the last section deals with spatial optimization of service locations.

2.2 THE GEOGRAPHY OF CRIME AND ENVIRONMENTAL CRIMINOLOGY

The geography of crime refers to the study of the spatial manifestation of crime incidents and their outcomes (Georges-Abeyi & Harries 1980). It seeks to describe and determine the implications of the distribution of crime in detail (Young (1991). The geographic distribution of crime offences is not random and varies considerably from place to place. This draws the interest of the geographer (Shaw & McKay 1942; Bottoms & Wiles 2002) who possesses the descriptive and analytical tools (maps) (Association of American Geographers 2005; Fellman 1999; and Microsoft 2005b) to make useful contributions to the social science of crime in gaining a better understanding of the nature and causes of crime.

Environmental criminology on the other hand is the study of crime, criminality, and victimization as they relate to particular places and the ways in which individuals and organizations shape their activities spatially (Bottoms & Wiles 2002: 620). Morolong (2004) observes that environmental criminology encompasses the geography of crime but focuses on criminal acts and the places in which they occur.

History teaches us that the involvement of professional geographers in crime studies is a recent phenomenon whereas criminological research dates back over some two centuries (Herbert 1982). The significance of the complementary fields of the geography of crime and environmental criminology is that they both represent the final (fourth) and current stage in the evolution of the spatial and ecological perspectives on crime (Lawman 1986), the stage at which the first attempts by professional geographers to enter the arena of crime research occurred (Ahmadi 2003).

The three preceding stages included, the nineteenth century cartographic school of criminology, the Chicago ecological school of the 1920s and 1930s and the factor analytical school of the 1950s and 1960s (Lawman 1986: 81). The naming of the Chicago cartographic school of criminology was a result of the frequent use of maps to depict regional and seasonal variations in the pattern of crime (Ahmadi 2003). According to Herbert (1982), exponents of this school such as Tobias and Mahew were among the first to isolate cities as the focus of their study. They observed that areas exist within cities where more crimes occur than in others. Other exponents like Guerry who focussed on urban-rural differences in crime occurrence observed different seasonal patterns in crime and found that crimes against property were more frequent in winter in the north of France while in the south there were more incidents of crime against a person during summer (Herbert 1982).

The Chicago ecological school represented a transition from an aereal to an ecological analysis of crime (Lawman 1986). Exponents such as Clifford Shaw and Henry McKay developed the spatial ecology of crime at the Chicago school of criminology during this era (Herbert 1982). They contributed empirical research to criminology by mapping residences of juveniles with dot maps to show actual distributions and crime rate maps to show aereal variations in delinquency residences (Bottoms & Wiles 2002; Davids 1996; Herbert 1982). They recorded a relationship between delinquency residences and the physical and social environments in which they were located (Ahmadi 2003).

The factor analytical school resurged interest in the spatial perspectives of crime, which has carried through to present times (Lawman 1986). Lawman (1986) views it as the third phase in the evolution of the spatial perspective on crime. Herbert (1982) on the other hand views it differently, as an extension of the methodology of the spatial ecologists. Citing the factor analysis work on crime of Lander (1954) in Baltimore, he observed that this study drew similar conclusions to that of the spatial ecologist's approach and therefore fell within the realm of the ecological school.

2.3 QUANTITATIVE AND QUALITATIVE INDICATORS OF CRIME

This section discusses official crime statistics together with the crime and victimization surveys as respective quantitative and qualitative indicators of crime. Emphasis shall be placed on their use and the limitations of their use for crime analysis.

2.3.1 Crime statistics

Official crime statistics produced by the police, prisons, and courts are the main quantitative indicators of crime that are commonly available in most societies (CLEEN 2004). Such statistics are based on crimes reported to the police by the public and members of the police themselves. In Swaziland, crime offences are recorded (manually) in books such as the "Register of Crimes and Contraventions Investigated" at the local police stations. These documents are bulky and can accommodate data on crimes committed for as many as five months at a time, depending obviously on the frequency of incidents reported. In these registers, some of the information recorded includes:

- Record number of incident
- Type of crime committed
- Location of occurrence
- Date of occurrence
- Time of occurrence (estimated)
- Date reported
- Time reported

This information is very important especially information on the location of occurrences. Zietsman and Lochner (1998) point out that for any meaningful spatial analysis of crime to take place, information on crime locations should be available. Once this information is available the mapping of the statistics can be done either by geocoding (see Ratcliffe 2004a), using collected GPS data on crime incidents or by manually plotting the places where the crimes occurred using a computer. Software such as ArcGIS and ArcInfo has proven to be useful in this endeavour (Craglia, Haining & Wiles 2000; Morolong 2004).

In general, crime statistics do have weaknesses (CLEEN 2004) and this is becoming common knowledge (MacDonald 2002). References to these limitations date back as far as the early 80s. Authors such as Herbert (1982:3) argue that official statistics on crime data sources do not reflect the true crime situation and should be regarded with "scepticism" and "mistrust".

Some of the reasons given are related to the under representation of crime and the "representativeness" of recorded crime. Herbert's (1982) justification is made clear by Davids (1996) who explains that in terms of the representation of crime, crime statistics represent only a fraction of the number of crimes actually committed. In terms of the representativeness of recorded crimes, they argue that the public have their own biases when reporting crimes. Maguire (1997) also alludes to this and points out that official statistics are socially constructed. People decide which crimes they want to report because of certain stereotypes they have against certain offences and offenders. They do not report most crimes to the police in many countries. As a result, accurate crime statistics are difficult to obtain (Stephens 2003; Brand & Price 2000).

Lewis (1989) in MacDonald (2001) suggests reasons why individuals do not report crimes to the police. Lewis (1989) argues that demographic and socio-economic factors have a role to play in influencing individual reporting behaviour. The view held is that higher income groups, particularly older people, tend to be more insured than lower income people or those who are unemployed and consequently are far more likely to report a crime incident (Davids 1996; Lewis 1989).

MacDonald (2002) suggests that individual attitudes are also likely to influence reporting behavior. For instance, if a victim perceives the police to be ineffectual, or has a negative experience of the police, then that person is probably more reticent to contact the police about an incident than they would otherwise be the case.

Other limitations of crime statistics are related to the "intentional underreporting and manipulation of data so that the statistics look good" (Stephens 2003: 42). Police agencies in the United States and elsewhere have fallen victim to such practices. Ways of accounting for this "missing" information are necessary if one wants to have a complete understanding of the actual crime situation.

The fact that people do not report certain crimes is an indication that these incidents are not reflected when the overall analysis and interpretation of the crime situation is considered. However, while striving to overcome their limitations, it is still worth the effort to use crime statistics for crime analysis because their insight though incomplete can shed light on crime trends which can speak to certain nation's successful crime reduction strategies and encourage others to do more (Stephens 2003).

2.3.2 The victimization and crime surveys

The victimization survey is used to measure the extent and pattern of victimization in a community, among members of groups (CLEEN 2004). It differs from the crime survey which is used to obtain data on the extent and pattern of crimes committed by members of society. Both approaches to determining the level and dynamics of crime seem to have developed because of dissatisfaction with official crime statistics produced by criminal justice agencies such as the police.

The methodology followed by the victimization survey entails asking people questions concerning their perception of crime and safety as it affects them in the area where they live (Roberts 2001; Kifer 2004). Responses are numerically coded and quantitatively summarised to determine how many people are saying what and where (Kifer 2004).

The literature provides us with some common questions posed in such surveys. These are exemplified by the following:

- Are there anywhere in your neighbourhood that you are afraid to walk at night? (Roberts 2001)
- How safe do you feel walking in your neighbourhood during the day and during the night? (Kifer 2004)

In comparison, the crime survey involves asking a sample of the population questions with regards to the types and number of incidents of crimes they have committed or been victims to, usually during the past year- whether or not detected or reported to the police (CLEEN 2004). Its focus therefore, is more on factual information rather than perceived indicators of crime.

Victimization research has shown that people with certain socio-economic characteristics have higher levels of fear of victimization/crime when compared to others. Collins (1990) argues that this is particularly so for groups such as the elderly. Earlier work by Thomas & Hyman (1977) corroborates this and adds that blacks, females, those with a low socio-economic status in terms of income, education, and occupational prestige were more concerned with crime and more fearful of being victimized. McGarrell, Giacomazzi & Thurman (1997) supports this result with their own finding that lower income respondents have higher levels of fear. More recent work by Acierno, Rheingold,

Resnick and Kilpatrick (2004) strengthens the findings of Thomas and Hyman (1977), McGarrell *et al* (1997) and others. Acierno *et al*. (2004) also found that being female, non-Caucasian, and having low income is indicative of negative perception of fear outcomes in European societies.

Research by Collins (1990) found that citizens are more fearful than they would normally be when they hear about crimes in the media. He points out that regardless of where people are, they are exposed to the media and are quick to hear about fear provoking incidents occurring in their neighbourhoods. This leads them to think that there is more crime in an area than what actually exists and that most of the incidents are violent and serious.

More recent work (CLEEN 2004: 18) supports this view and points out that that the concentration of the electronic and printed media of mass communication which report daily incidences of crime in an area "can engrain in the consciousness of a population's perception of increasing crime rates as well as fear of crime". Therefore, the effect of the media should not be overlooked when trying to understand the reasons why people fear crimes.

Several limitations are attributed to the victimization and crime surveys. CLEEN (2004) argues that the victimization survey suffers from an inability to report incidents accurately during the course of the survey. Research by Farrall & Gadd (2003) suggests that it may raise over-estimated levels of concern due to the format of the questions. In other words, poorly posed questions can be misleading and therefore extra care needs to be taken when posing certain questions so that accurate responses are recorded (Elfers 2003; Smeenk 2002).

In comparison to the victimization survey, CLEEN (2004:10) argues that questionnaires used in the crime survey "tend to contain more questions on minor crimes with which the respondents are more comfortable" such as theft and much less on rape or questions on sexuality. Secondly, respondents do not always recall all their criminal activities. Thirdly, respondents tend to underreport serious crimes that they might have committed due to the fear of prosecution.

The weaknesses of both surveys are important to consider when evaluating the overall accuracy and relevance of a survey for the fulfilment of particular objectives. When compared to official statistics, they offer a subjective view of the crime situation and are not always the best indicator of crime to use.

However, despite their shortcomings they both can avoid the pitfalls of under-reporting and under-recording of crimes (Altbeker 2005) and provide a coherent view of the extent of public perception of crime and criminal law enforcement in society (CLEEN 2004; United Nations 2005).

2.4 APPROACHES TO MAPPING CRIME

This section seeks to familiarise the reader with traditional and contemporary approaches to the analysis of crime and the factors that motivated the transition to better ways of analysing crime over the years. The first part discusses the traditional approach of pin mapping and its limitations. The second part investigates the contemporary approach of desktop mapping.

2.4.1 Traditional approaches: Pin mapping

Pin mapping refers to the marking of crime locations with pins on a cartographic interface such as a paper map of the area where the crime incident took place (McCullagh & Ratcliff 2001). In the past, before computers became widely used, and even today in developing countries such as Swaziland this is the most evident technique used to map crime by the police.

Pin maps are usually placed on a wall or on large tables for display and analysis. Canter (1997) observes that to analyse crimes, pins have to be placed at an accurate location on the map. This usually requires a map at an appropriately large scale (e.g. 1:10000) in order to place a pin against a street address of the crime locations (Harries 1999).

Harries (1999) points out that pin maps are useful for showing where crimes have occurred but have serious limitations. Firstly, as they are updated prior crime patterns disappear and while the raw data can be archived, the maps cannot, except by photographing them of course. Secondly, pin maps are static and therefore, cannot be queried. For example, it would be difficult to track a series of crimes for durations such as a week or a month. The third limitation observed by Harries (1999) is that pin maps are difficult to read especially when several types of crime, represented by different colours, are mixed together. Fourthly, they take up considerable space. Harries (1999) gives an example where Canter (1997) suggested that to make a single wall map of 610 square miles of Baltimore County in the United States, 12 maps had to be joined covering 70 square feet. Pin maps also lack interactivity (McCullagh & Ratcliff 2001). If the map has to be shown to many people, they all have to come and see the map. As a result, pin maps are very difficult to work with.

Maps that are difficult to read or query pose serious limitations for analysis and the amount of information that can be obtained from them. The trouble of having to go through stacks of archived crime data can be time consuming. Losing such data is even worse. It causes problems when strategic decisions dealing with on-going crime need to be made quickly. Such limitations are the main reasons for the eventual demise of pin maps for crime analysis and the development of better approaches to analysing crime.

2.4.2 Contemporary approaches: Desktop mapping

During the course of the past decade, the manual approach to pin mapping has given way to desktop mapping (Harries 1999). The widespread availability and use of computers with quicker processing speeds, lower costs, and improved crime mapping software functionality has place crime mapping firmly in the grasp of law enforcement agencies (Paulsen 2004; Craglia, Haining & Wiles 2000).

This leap forward in the development of computer technology has stimulated the considerable development of techniques for analysing and helping to explain the occurrence of criminal activity (Murray *et al* 2001). One of the most influential computer based tools thus far that have facilitated the exploration of the spatial distribution of criminal activity has been GIS (Murray *et al.* 2001). At the same time one of the rapidly growing areas of GIS research is in the analysis of crime (Ratcliffe 2004a)

2.5 GEOGRAPHICAL INFORMATION SYSTEMS (GIS) FOR CRIME ANALYSIS

A GIS is "a computerised mapping system that permits information layering to produce detailed conditions of situations and analyses of relationships among variables"……. therefore, strictly speaking, "any system that permits the representation and analysis of geographical information is a GIS" (Harries 1999:92).

GIS is not a new technology (Harries 1999; Tomlinson 1998). In fact, the technology is linked back to the 1960s and 1970s. However, early GIS efforts were limited by older computer systems that lacked memory and speed (Tomlinson 1998). According to Weisburd & McEwen (1997), police departments typically lacked the computer resources and the digital maps necessary to support a GIS operation. Such constraints limited the attractiveness of GIS technology to law enforcement agencies (Tomlinson 1998).

This is arguably true even for the Royal Swaziland Police Service today where a GIS is not in existence to support crime prevention operations. Neither is the software, hardware nor the expertise to manage the technology available. Harries (1999) is of the view that the operational costs of setting up a GIS are prohibitive for its adoption. This appears to be another limitation, because discussions with senior officials of the Royal Swaziland Police Service suggest that some level of awareness of the technology is present especially in as far as how it is used by the South African Police Services (SAPS).

Today, GIS is an increasingly sophisticated technology which enables police officers to work better and make the best use of scarce resources (Stephens 2003; Ratcliffe 2004b). There are several capabilities of a GIS which are applicable to crime analysis. The most obvious of these, after the displaying of spatial information, is probably overlay analysis. In this approach, layers of information such as crime locations, roads and landuse types are stacked as layers on top of each other and displayed in a GIS (see Harries 1999). The order in which they are stacked reflects how they appear in reality. For instance, a road layer would appear on top of a landuse layer and not the other way around. Overlaying in GIS enables us to see the relationships between information layers in a manner not so evident with other approaches such as pin mapping.

Another capability of a GIS is temporal analysis. This refers to analysis of the time or period in which a spatial event such as a crime occurs. According to Ratcliffe (2004b) very little research has gone into analysis of the temporal dynamics of crime patterns. Some examples of research on the temporal analysis of crime includes work that has examined temporal changes in the seasonality of crime (Block 1984), long term changes (LeBeau 1992) and day and night variations (Zietsman & Lochner 1998).

Proximity analysis is another example. Murray *et al.* (2001) describes it as an approach to relate spatial information layers in terms of their distance from one another. Kumar & Waylor (2002) used proximity analysis to determine the relationship between incidents of crime and their distance to alcohol-serving establishments in Savannah, Georgia and in Athens, Greece. This analysis enabled them to draw the conclusion that the density and probabilities of all types of crimes investigated decline exponentially with increasing distance from alcohol services.

Morphological analysis is another capability of GIS that is applicable to crime analysis. It investigates the structural characteristics of an area that make it susceptible to particular crimes. Zietsman &

Lochner (1998) used this type of analysis in their study of crime in Paarl, South Africa. They hold the view that a morphological analysis of the crime environment can make an important contribution to optimal policing. This is because crime is inextricably linked to the place where it is committed (Landman & Liebermann 2005). In cities, they are often associated with the physical or morphological layout of urban space (Morolong 2004; Pacione (2005). This shows us, as Landman & Liebermann (2005) observe, that many incidents of crime are not spontaneous or opportunistic but that offenders select certain places because they lend themselves to criminal activity. Criminals due to their routine use of those spaces (Haining 2003) usually know these areas.

One approach Zietsman & Lochner (1998) used in their morphological analysis was to create a fifty-metre buffer around streets in their study area where robbery occurred chronically. The buffer was then overlayed on a land use map. This approach enabled them to determine that areas where industrial and duplex housing are present, the risk of robbery is high. The use of buffers in this study also shows that for a morphological analysis to be meaningful some reasonable spatial extent, preferably around areas where crime is concentrated, should be specified. This eliminates the tendency to interpret isolated incidents of crime as being characteristic of certain environments and enables us to focus on the areas of high criminal activity. Other related work in this regard includes Council for Scientific and Industrial Research (CSIR 2000), Kruger, Landman & Liebermann (2002) and Loukaitou-Sideris (1999).

The link between crime and place is very important and means that professionals that are working with land management and development are central to the local crime prevention efforts (Landman & Liebermann 2005).

Of all the capabilities discussed, one of the most important uses of GIS technology relates to its ability to extract specific information and display it on a map. With respect to incidents of crime, questions such as: “How may incidents of robbery have occurred in Manzini in the past month/week/hour?” or, “Where in Ngwane Park have incidents of rape occurred in the last week/day/hour?”, can easily be answered by simply querying the crime database.

When compared to pin maps, querying cannot be done as efficiently as with a GIS because pin maps are static. The ability of a GIS to query spatial information is important especially in instances when the analyst wants to focus on particular incidents of a distribution and wants to do so quickly.

2.6 SPATIAL OPTIMIZATION OF SERVICE LOCATIONS

The location of services such as police stations is important as far as crime prevention and crime reporting is concerned. The extent to which police resources can effectively be distributed to areas of population concentration is dependent upon their location.

One of the main reasons why many people do not report crimes is because police stations are not within their reach. This is especially true for petty crimes. The Council of Scientific and Industrial Research (CSIR 1997) argue that in South Africa for example, many low-income residential areas have a poor level of macro-accessibility because of their peripheral location in relation to major job complexes and major public facilities such as police stations, hospitals, courts etc.

In Manzini city, the same can be said for the location of the only police station which is quite a distance from most of the resident population of Manzini. Not only may this hinder people from reporting crimes but it can also affect the response times of the police to incidents of crime. This can have a negative effect on the overall crime prevention strategy. It must be ensured therefore, that future police stations are planned for in ways that improve equity and accessibility.

2.7 GIS SOFTWARE

Service location models offer an objective solution to the problem of inaccessibility. With detailed information on population (supply), services (demand) and road data of an area, various scenarios can be modelled and an optimal location for a new service can be allocated, expanded upon, relocated, or closed down.

One computer program that provides a suitable modelling environment for this kind of analysis is Flowmap. This program was written by Professor Tom de Jong of the Faculty of Geographical Sciences at the University of Utrecht in the Netherlands in the early 1990s. Flowmap is a product for geographical analysis that specialises in among other things, accessibility analysis (Van der Zwan, Van der Wel, De Jong & Floor 2005). Flowmap offers several service location models, which support the location and allocation of private, and public sector services. Among these are the coverage model, the expansion model, relocation model and the reduction model.

Coverage models find solutions to questions like: how many locations are minimally required to meet a minimum level of service? (Van der Zwan *et al* 2005: 140). Flowmap provides the Spatial Pareto method to solve such problems. This procedure emphasises the efficiency of an allocation of selected locations while reducing the number of permutations that can satisfy the objective stipulated. Variables such as travel time or maximum reach distance need to be incorporated in the model to ensure that only those locations which are efficient in this regard are selected.

One disadvantage of this model is that the computational effort in determining optimal locations for many sites requires more processing time than it would be for fewer locations. This is important to note especially when a large-scale application is undertaken and the number of optimal locations necessary for a whole country like Swaziland is required quickly. In such a case, one solution would be to divide the country into much smaller and manageable geographical blocks. This may be useful if one wants to reduce search space and save processing time.

The expansion model is similar to the coverage model in that it also provides answers to the question of how many different locations are required to meet a minimum level of service? It differs from the coverage model because it expands on existing services (Van der Zwan *et al* 2005). It also provides the user with model alternatives to arrive at a solution but requires start locations to be specified. The alternatives it offers are:

- Maximise customer coverage
- Maximise individual market share
- Minimise overall average distance
- Minimise overall worst-case distance.

Van der Zwan *et al* (2005) observe that when we maximise customer coverage we strive to add additional service centres at locations where the highest market share will be realized. In this case, spatial rationality is assumed in that people will make use of the nearest possible service or activity. Minimising overall average distance involves the systematic removal of service centres that will have a minimal effect on the increase in average distance (Van der Zwan *et al.* 2005). This differs from minimising overall worst-case distance in that the service centre that has the least impact on the increase in worst-case distance is removed. The final alternative maximises the individual market share

by maximising the overall increase in customer coverage by removing service posts that have the least impact on the decrease in the number of covered customers.

Relocation models do exactly what they say they do. They optimise a given set of service locations by relocating them. They usually follow the "solution" of the set coverage problem. The relocation model in Flowmap offers several model alternatives namely:

- Minimise average distance
- Minimise worst-case distance
- Maximise spatial competition.

Reduction models are the exact opposite of expansion models. While expansion models strive to improve accessibility by adding new sites on an existing situation, reduction models strive to improve accessibility by eliminating locations that have the least effect on accessibility or individual market share. The alternatives Flowmap provides for reduction models are:

- Remove worst market position
- Least effect on average distance
- Least effect on customer coverage
- Least effect on worst-case distance.

It is important before modelling service locations to be clear about the objective these services strive to achieve so that the model solutions can be realistic. Wambugu (2000) observes that private sector services have a different objective from public sector services. She notices that the objective of the private sector is to minimise transport costs and maximise efficiency. Therefore, alternatives such as the "maximise spatial competition" or "maximise individual market share" offered by the relocation and expansion models respectively would apply. Public sector services on the other hand, like police stations, are supposed to provide equitable services while maximising efficiency (Wambugu 2000). Therefore, alternatives like "least effect on worst-case distance" and the Spatial Pareto method offered by the reduction and coverage models are applicable.

It is also important to note that as much as the service location models discussed tend to improve the current accessibility status of service locations, they are difficult to implement in practice due to political, bureaucratic, environmental, and other reasons. They are therefore, a useful guide for planners in their decision making process so that they become aware of the accessibility implications of not adhering to the model solution.

2.8 CONCLUSION

It is clear from the literature that crime analysis has undergone a revolution that truly improved the way in which we analyse crime and thus facilitate its prevention. The involvement of geographers and their analytical mapping skills through the use of GIS will push this development further by facilitating better ways of analysing and preventing crimes in a way that will optimise the use of scarce police resources. Service location models will complement the efforts of crime prevention by making services more accessible to people. This in turn can improve the relationship between communities and the police and the overall crime situation.

CHAPTER 3
CRIME ANALYSIS AND POLICE STATION LOCATION

3.1 INTRODUCTION

This chapter describes the manner in which the study was conducted and the results obtained to achieve its aim. The chapter begins with a description of the study area. Figure 3.1 is the research design while Figure 3.4 indicates a summary of the research methodology.

The first step of the research process was to conduct a literature review on the spatial dimension of crime, the spatial optimization of service locations, and the adequacy of approaches, data sources, and techniques for the analysis of crime. From the literature, the research problem was formulated. This revealed that criminal activity and police station locations had an inherent geography that required understanding in order for crime prevention strategies to be effective. A broad aim was formulated to address this problem in Manzini. This entailed analysing the spatio-temporal dimension of crime in Manzini for 2004, determining suitable locations for future police stations, and explaining how these outcomes could be used to assist in the further development of crime prevention strategies.

3.2 DESCRIPTION OF THE STUDY AREA

The study area for this research is Manzini city. It is situated in the Kingdom of Swaziland (see Figure 3.2), a small (17,363 sq. Km) independent monarchy in Southern Africa bordered by Mozambique to the east and South Africa to the north, southeast, west and east (Thwala 2004).

Manzini (see Figure 3.3) is the commercial centre of Swaziland. It is also the largest town in the country (Central Statistics Office 1999; Masina 2003). According to Hall (2000), Manzini is also the area where the first commercial activity originated in Swaziland. It is located in the southwestern part of Swaziland in the Manzini region, one of the four administrative districts in Swaziland with the others being Hhohho, Shiselweni and Lubombo.

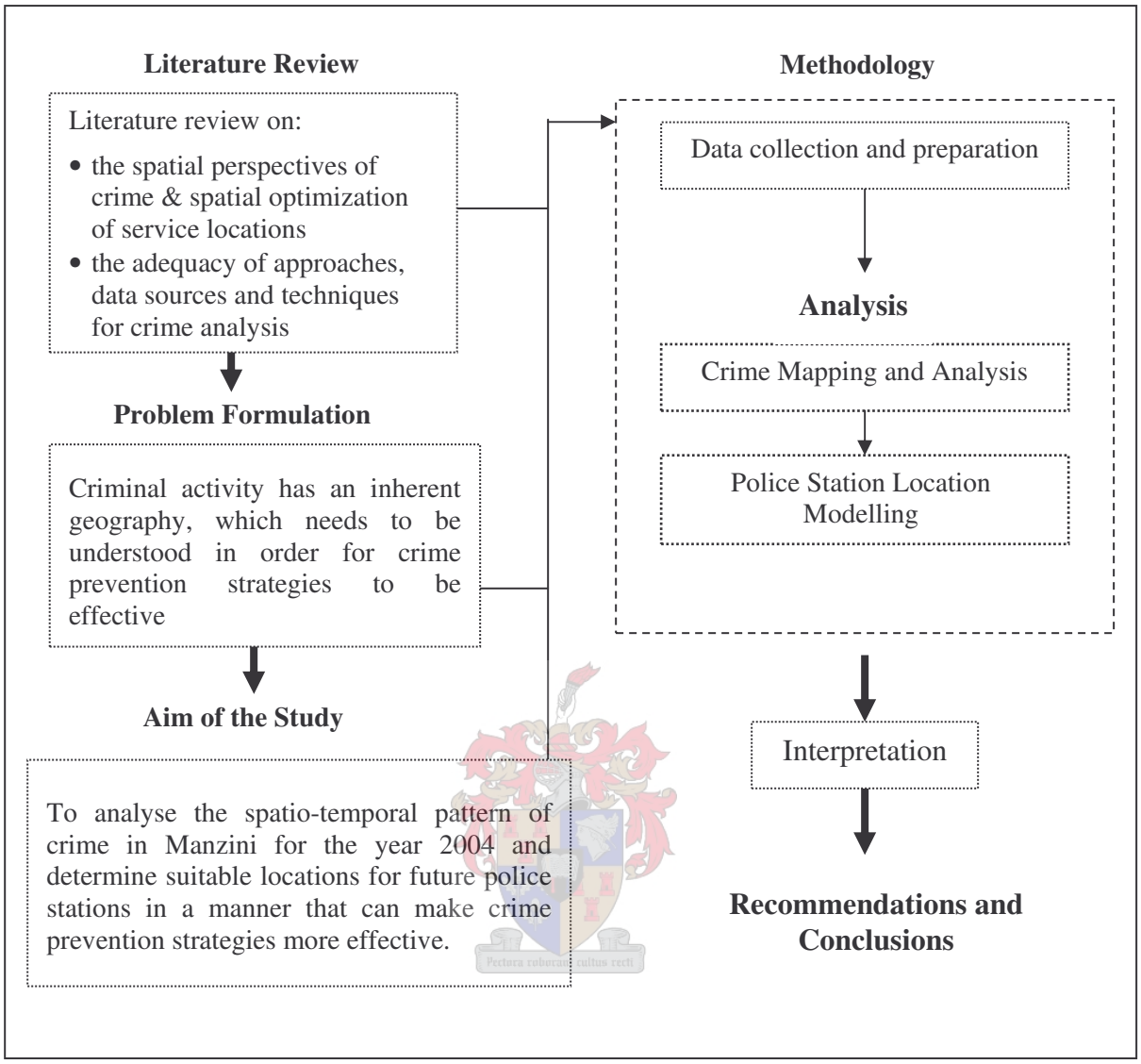

Figure 3.1: The research design.

With a resident population of 25,571 people (Central Statistics Office 1997), Manzini, houses a population of about 120,000 people during the day (Central Statistics Office 1999). Due to its centrality, it commands Sziland's road networks, radiating them outwards to the rest of the country and thus giving the city an image of an overcrowded and congested nerve centre of the country (Hall 2000).

The decision to choose Manzini as the study area is based on the researcher's familiarity with the area, the relatively high level of crime encountered there and the availability of crime data.

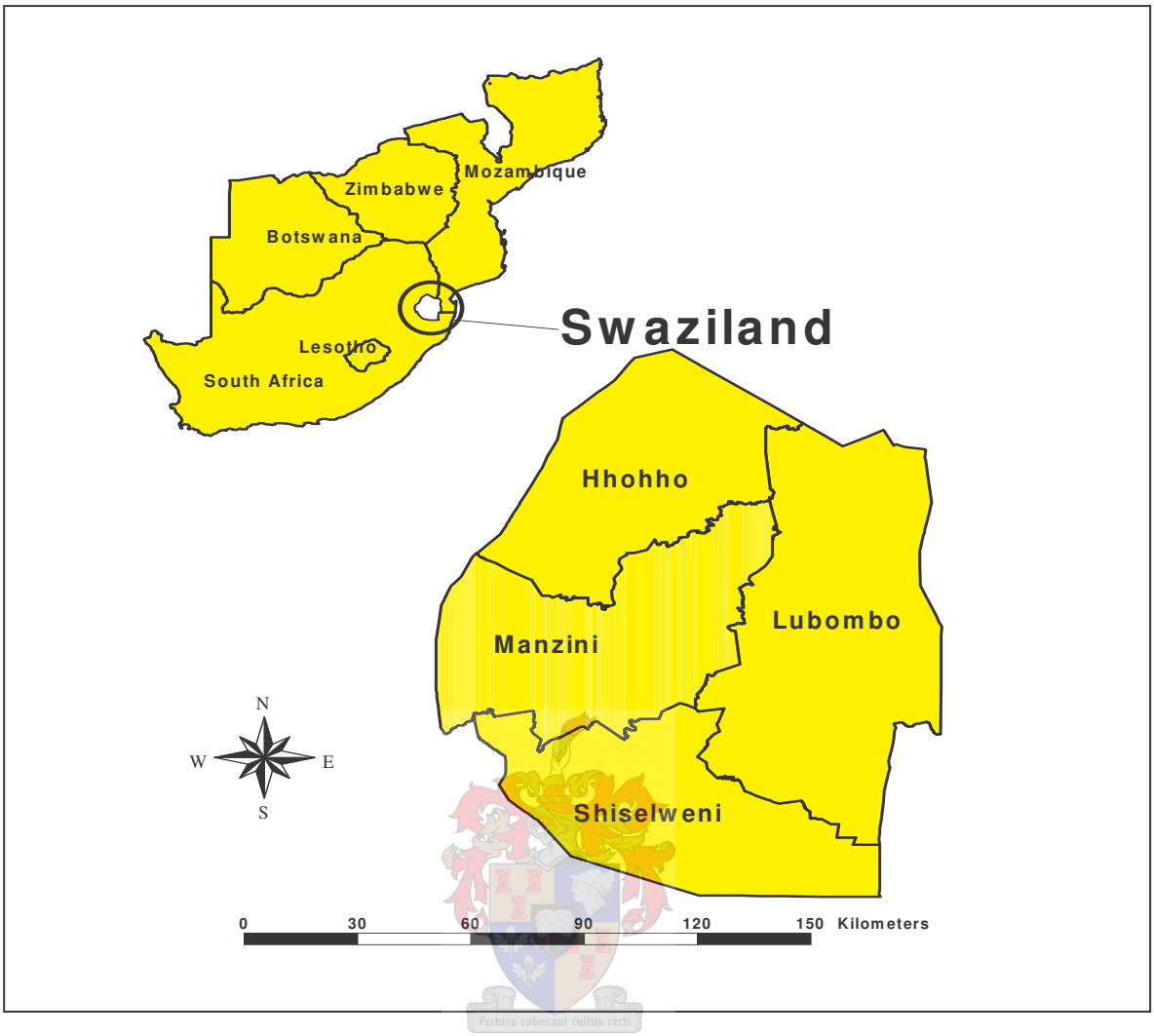

Figure 3.2: Swaziland and its administrative regions [Source: Surveyor General's Office 1995a].

3.3 DATA REQUIREMENTS

Both raw and derived data were required for this study. The raw data collected by the researcher included:

- Digital building data - This was a digitized layer of all building footprints in Manzini. It was used with available population census data to estimate the number of people living in each township in Manzini.

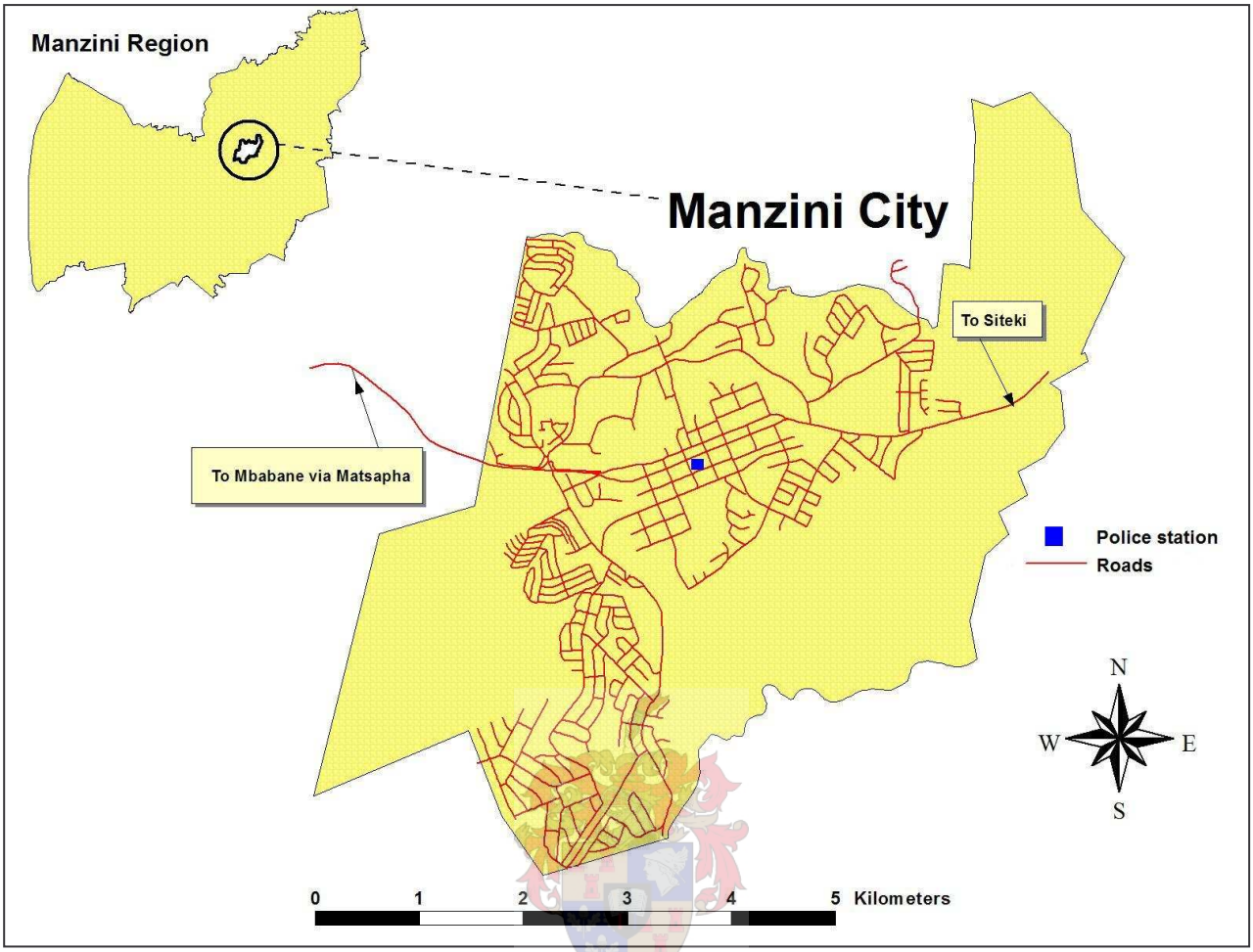

Figure 3.3: Manzini city [Source: Surveyor General's Office 1995b].

- Landuse map of Manzini - This data layer was created by the researcher from available digital orthophotos, topographical maps, and street guides of Manzini. It was used to determine the relationship between crime incidents and landuse in Manzini.

- Population distribution map of Manzini - This was created from available orthophotos, population census and digital building data.

- Police station, educational and alcohol-serving establishment location data - These were manually plotted by the researcher using an available orthophoto. These establishments were used to determine their proximity to areas of crime concentration. The police station location was integrated with population data to determine (a) suitable site(s) to locate a new police station(s).

The derived data for the study included:

- Official crime statistics - This was obtained from the Manzini police station's Register for Crimes and Contraventions Investigated. It comprised data on the type of crime incidents, location, date, and time (day/night) of occurrence for 2004. This information was mapped using an orthophoto backdrop.

- Road centreline data - This was obtained from the Surveyor General's Department in Mbabane in Swaziland. It was used to determine accessible locations for new police stations in Manzini.

- Orthophoto (1:10 000) of Manzini city - The main purpose of this was to determine the relationship between crime incidents and the physical layout of Manzini. It was also collected from the Surveyor General's Department

- Digital population census data - It was collected from the Central Statistics Office in Mbabane. This was integrated with road data and police station locations to determine the most suitable site(s) to locate a new police station(s).

3.4 THE RESEARCH METHODOLOGY

The manner in which the data analysis was conducted is summarised in Figure 3.4. ArcGIS, ArcView, Microsoft Excel, and Flowmap were the three software packages used in this study. ArcGIS and ArcView were used to capture, analyse, and display the results of the analysis. Microsoft Excel was also used to capture crime data whereas Flowmap was used to determine the optimal location for police services.

The first step in this research was to classify crimes according to four categories. As stated earlier, only crimes that the police could spot and possibly prevent while patrolling were selected. Such crimes constituted many types. These were grouped to facilitate analysis. Table 3.1 shows the categories of crimes used and their constituent types.

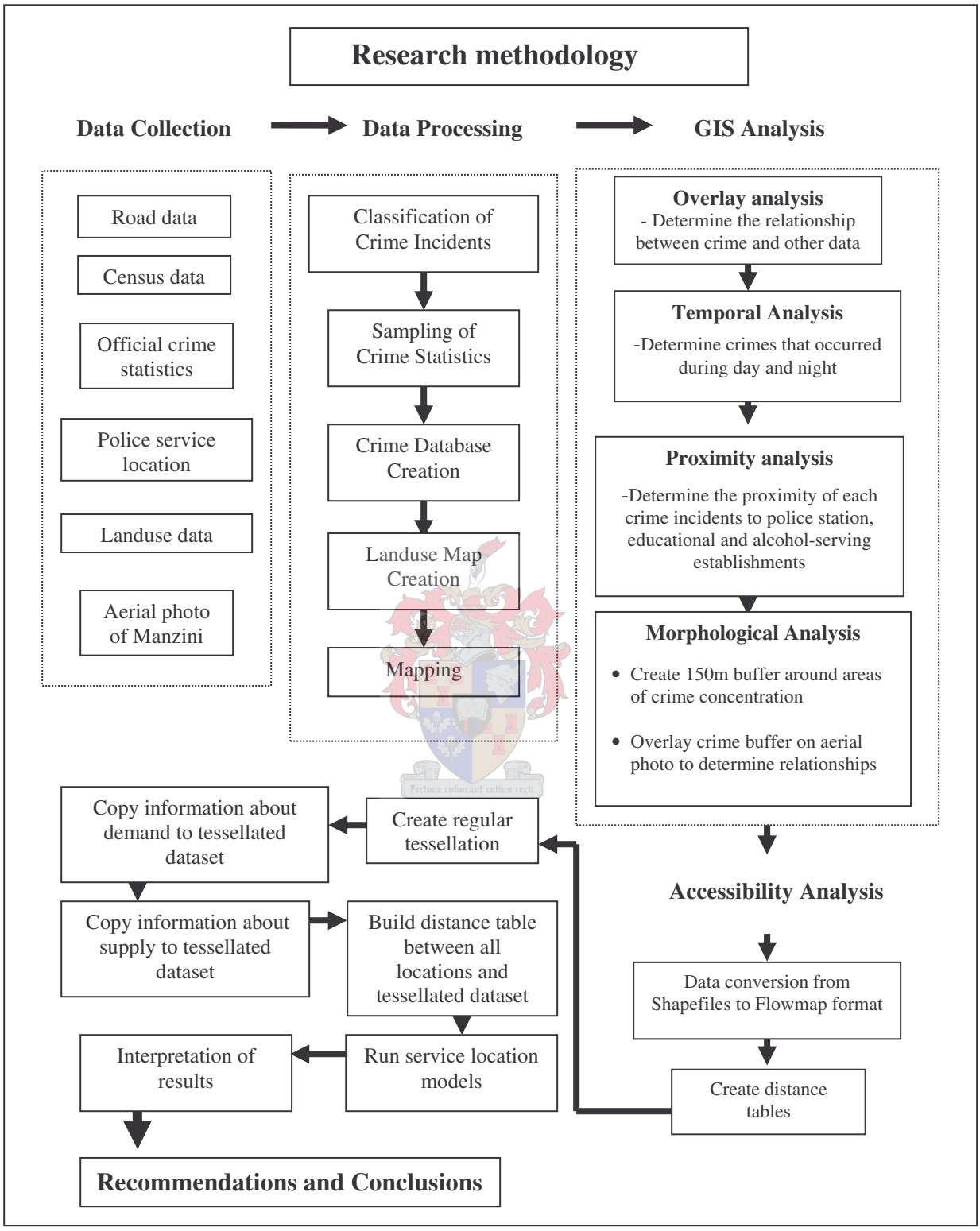

Figure 3.4: The research methodology.

Table 3.1: Categories of crime used.

Category of crime	**Types of crime**
Crimes against property	Housebreaking, robbery, shoplifting, motor-vehicle theft, armed robbery, Malicious injury to property (MIP)
Crimes against people	Rape, common assault, assault to cause grievous bodily harm, theft under false pretences
Drug related crimes	Trading, possession of illegal substances: e.g., dagga (marijuana), cocaine, heroin etc
Crimes against public order	Public disturbance, public indecency, gambling

In 2004, the Manzini police recorded 9125 incidents of crime in the Register for Crimes and Contraventions Investigated (Royal Swaziland Police 2004). Out of these incidents, 8293 (90%) could be spotted by police and possibly prevented while patrolling. This constituted the sample frame. The other 10% comprised of crimes such as murder, domestic violence, fraud, and corruption.

Using this sample frame, the proportion of each category of crime was determined by manually counting the total number of crime incidents for each category. The purpose of this was to determine the most appropriate way to sample the incidents. Table 3.2 shows the results of the count. From this count, it was established that crimes against property had the highest prevalence rate (84.2%). These were followed by crimes against people (11.9%), drug related crimes (3.5%), and crimes against public order (0.4%). Based on this prevalence pattern, a 20% systematic sample was drawn from the crime data where for each category; every fifth incident was selected on the basis of its prevalence.

The sampled crime data was entered into a crime database by the researcher using the Microsoft Excel spreadsheet processing software package. This database was constructed by entering the location of occurrence, the time and date of crime incident occurrence. Table 3.3 shows what a section of the database looked like.

Table 3.2: Prevalence of crime in Manzini in 2004 and sample size.

Category of crime	**Total number of incidents in 2004**	**%**	**Total number sampled (20%)**
Crimes against property	6981	84.2	1396
Crimes against people	986	11.9	197
Drug related crimes	293	3.5	58
Crimes against public order	33	0.4	7
Total	8293	100	1658

Table 3.3: The crime database.

Record No.	**Type of crime**	**Location**	**Time**	**Date**
107	Theft	Bus rank	1700	06-01-04
307	Robbery	Salesian high school	1550	14-01-04
8345	M/V Theft	Manzini motor spares	1330	06-12-04

3.4.1 Overlay analysis

After creating the crime database, the location of all crime incidents was noted and plotted by category using an orthophoto in ArcGIS. The crime database was joined with the attribute table of crime locations in ArcGIS. The number of crimes per location was summarised and displayed in a graduated symbol map showing the distribution of crime in Manzini in terms of the number of occurrences per location. Figure 3.5 shows the distribution of crime in Manzini.

Crimes against property were, spatially, the most widely distributed category of crime in Manzini. Crimes against people were moderately distributed while drug related crimes and crimes against public order were least widely distributed, occurring mainly at the bus rank. Ngwane Street, the main street that enters Manzini, linking the city with other places (Mbabane, Matsapha, and Siteki), together with Meintues street were notorious as many crimes occurred along and in close proximity to them (see Figure 3.6).

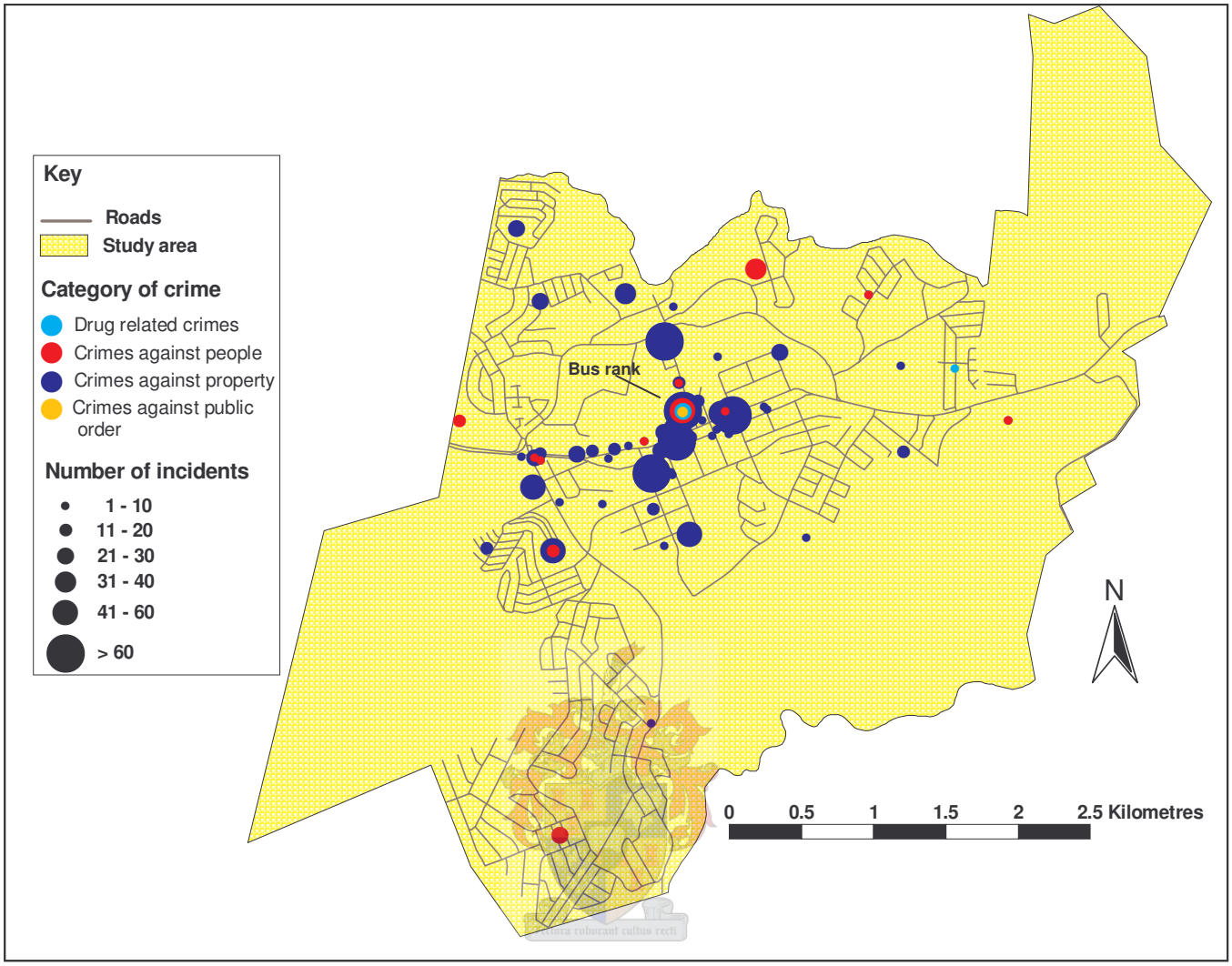

Figure 3.5: The distribution of crime in Manzini in 2004.

The results show that there was a high concentration of crime in the CBD of Manzini. The CBD constitutes the area highlighted in Figure 3.6. It is demarcated by the overhead walking bridge next to Rontanya Flats to the east, the traffic circle along Ngwane Street (next to the Conference of Churches building) to the west, the intersection of Meintues Street and Palm Beach Road to the north and Esselen Street to the south. Figure 3.6 shows the distribution of crime in the CBD. Crime in this area accounted for 57% (945 incidents) of all incidents of crime in Manzini. All four categories of crime occurred in the bus rank which recorded the highest level of crime in Manzini, accounting for 22% (366 incidents) of all crime incidents that occurred in Manzini in 2004.

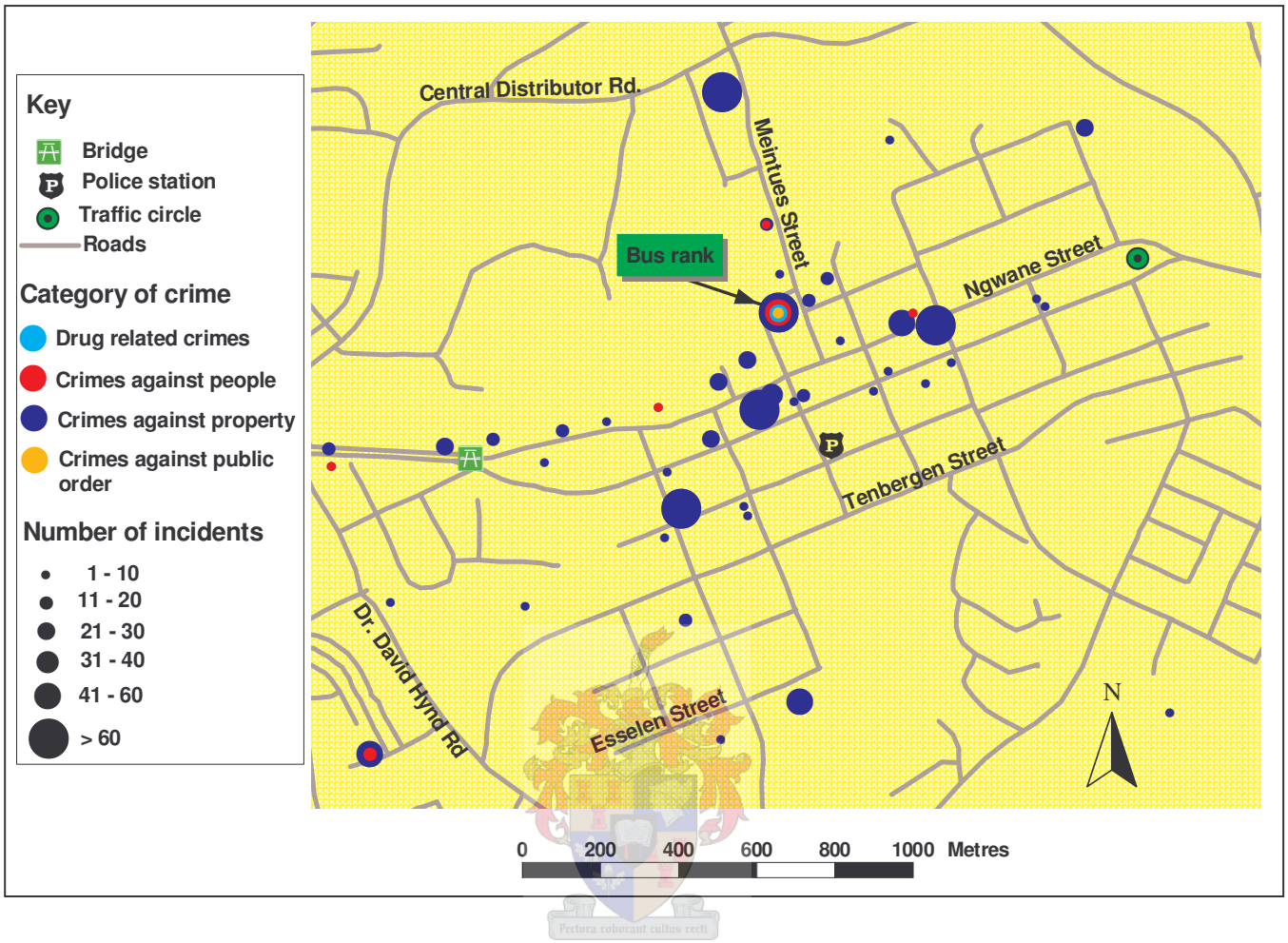

Figure 3.6: The distribution of crime in the CBD of Manzini.

The distribution of crime was analysed in more detail. This was accomplished by creating a landuse map of Manzini and overlaying it with the constituent types of each category of crime. This enabled determining whether any relationship existed between crime locations and landuse. Various forms of information were consulted for the preparation of the landuse map. These included topographical maps, digital street guide maps, aerial photographs, and direct field observations. The landuse classification system of Sabins (1987) as presented by Arnold (1997) was used in this study. Appendix I provides a detailed description of the classes used. Using a level II classification, the city of Manzini was divided into nine landuse classes, namely:

- Utilities
- Industrial
- Open space
- Residential
- Institutional
- Recreational
- Mixed urban
- Transportation
- Commercial and services

Figure 3.7 shows the distribution of landuse classes in Manzini. As illustrated, Manzini has a diverse landuse distribution, with most of the land as open space, farmland, undeveloped or under some unknown form of development.

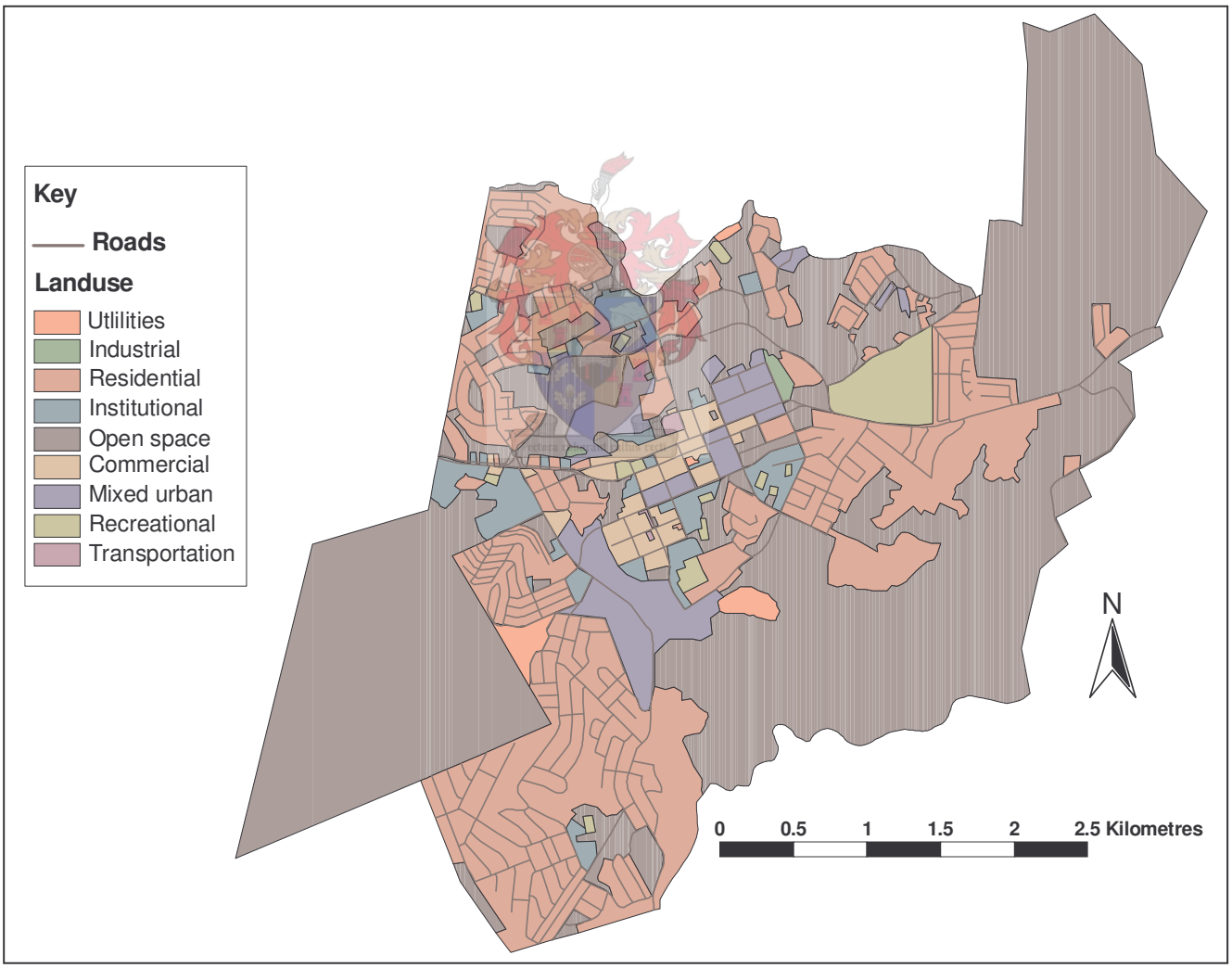

Figure 3.7: Landuse in Manzini.

Table 3.4 shows the relationship between crime and landuse types in Manzini. As illustrated, commercial areas were the most affected areas of crime in Manzini. These areas recorded 492 (30%) of all crime incidents in Manzini. Other landuse types that were mainly affected by crime included transportation, residential, institutional, and mixed urban areas. These recorded 366 (22%), 311 (19%), 245 (15%) and 134 (8%) respectively. Theft was the most prevalent type of crime in Manzini. It accounted for 814 (50%) of all incidents of crime. The prevalence of robbery, assault, housebreaking and theft and motor vehicle theft was also relatively high. These recorded 298 (18%), 160 (10%), 123 (7%) and 122 (7%) of all the sampled incidents respectively.

Table 3.4: The relationship between crime and landuse type in Manzini.

Landuse Class	**RAP**	**ROB**	**ASLT**	**ABD**	**Theft**	**M/V**	**H/B**	**MIP**	**PDST**	**HFD**	**FALS**	**Total**
Utilities	0	0	0	0	0	0	0	0	0	0	0	0
Industrial	0	5	0	0	18	7	0	0	0	0	0	30
Residential	15	71	46	0	55	43	42	19	0	20	0	311
Open space	4	27	5	0	2	15	21	0	0	0	0	74
Institutional	0	57	41	0	89	6	46	6	0	0	0	245
Commercial	5	83	15	0	352	30	7	0	0	0	0	492
Mixed urban	0	7	0	0	105	15	7	0	0	0	0	134
Recreation	0	6	0	0	0	0	0	0	0	0	0	6
Transportation	0	42	53	5	193	6	0	14	7	38	8	366
Total	**24**	**298**	**160**	**5**	**814**	**122**	**123**	**39**	**7**	**58**	**8**	**1658**

Key

Abbreviation	**Type of crime**	**Abbreviation**	**Type of crime**
ABD	Abduction	MIP	Malicious injury to property
ASLT	Assault	M/V	Motor vehicle theft
FALS	(FALSITAS) Theft under false pretences	PDST	Public disturbance
H/B	Housebreaking and theft	ROB	Robbery
HFD	Possession of habit forming drugs		

Table 3.5 and Figure 3.8 show the percentage of all the types of crime analysed per landuse class. Landuses associated with transportation (mainly the bus rank) experienced the highest amount of crime and most variability in the types of crime committed than any other landuse. Nine out of the 11 types of crime investigated were recorded at the bus rank. Residential, commercial, open space and institutional landuses also experienced a variety of crime whereas landuse areas associated with utilities experienced none.

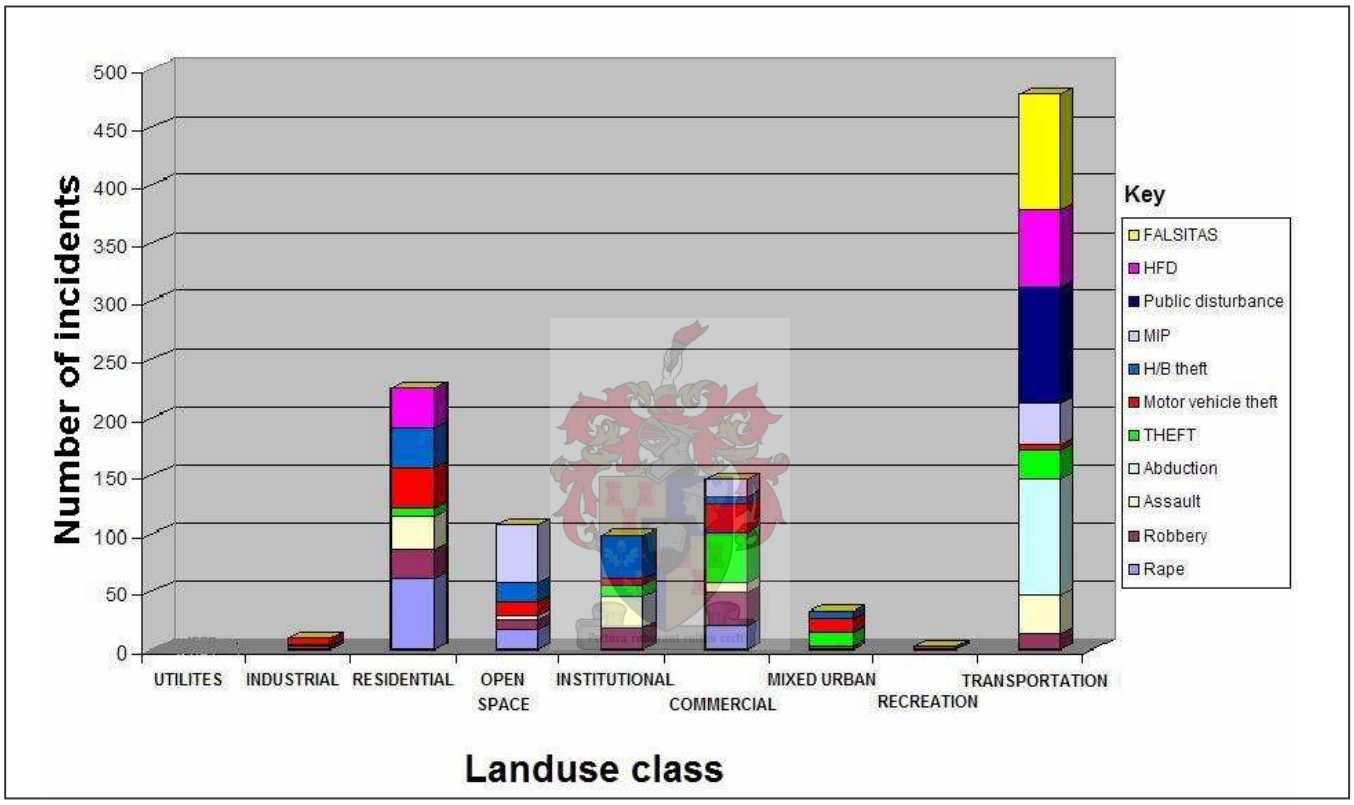

Figure 3.8: The percentage of crime by landuse class.

Table 3.5: The percentage of crimes by landuse.

Landuse Class	RAP (%)	ROB (%)	ASLT (%)	ABD (%)	Theft (%)	M/V (%)	H/B (%)	MIP (%)	PDST (%)	HFD (%)	FALS (%)
Utilities	0	0	0	0	0	0	0	0	0	0	0
Industrial	0	2	0	0	2	6	0	0	0	0	0
Residential	62	24	29	0	7	35	34	49	0	34	0
Open space	17	9	3	0	0	12	17	0	0	0	0
Institutional	0	19	26	0	11	5	37	15	0	0	0
Commercial	21	28	9	0	43	25	6	0	0	0	0
Mixed urban	0	2	0	0	13	12	6	0	0	0	0
Recreation	0	2	0	0	0	0	0	0	0	0	0
Transportation	0	14	33	100	24	5	0	36	100	66	100
Total (100 %)	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Crimes against property were overlayed on the landuse map (see Figure 3.9). A spatial relationship existed between housebreaking and theft in residential areas associated with educational establishments. These were an extension of institutions such as St. Michaels, William Pitcher, Salesian, and Ngwane Park high school. Residential areas such as Fairview North, Zakhele, and Ngwane Park were the most affected.

Theft occurred mainly in retail areas of the city where there is a free exchange of money and a high concentration of people during the day. Areas mainly affected by theft in Manzini were the bus rank, the Manzini market, Spar, JetMart, Bhunu mall (especially shops like Clicks, Sales House, and Shoprite Checkers), Salesian High School, Louis Bar, and Palm Beach Supermarket.

Motor vehicle theft occurred in the centre of town, along major roads like Ngwane Street and Meintues Street. Robbery, like motor vehicle theft also occurred in close proximity to these roads. There were however, more incidents of robbery than motor vehicle theft. Crimes related to MIP were the least reported crimes against property and occurred mainly in the bus rank and at Two Sticks.

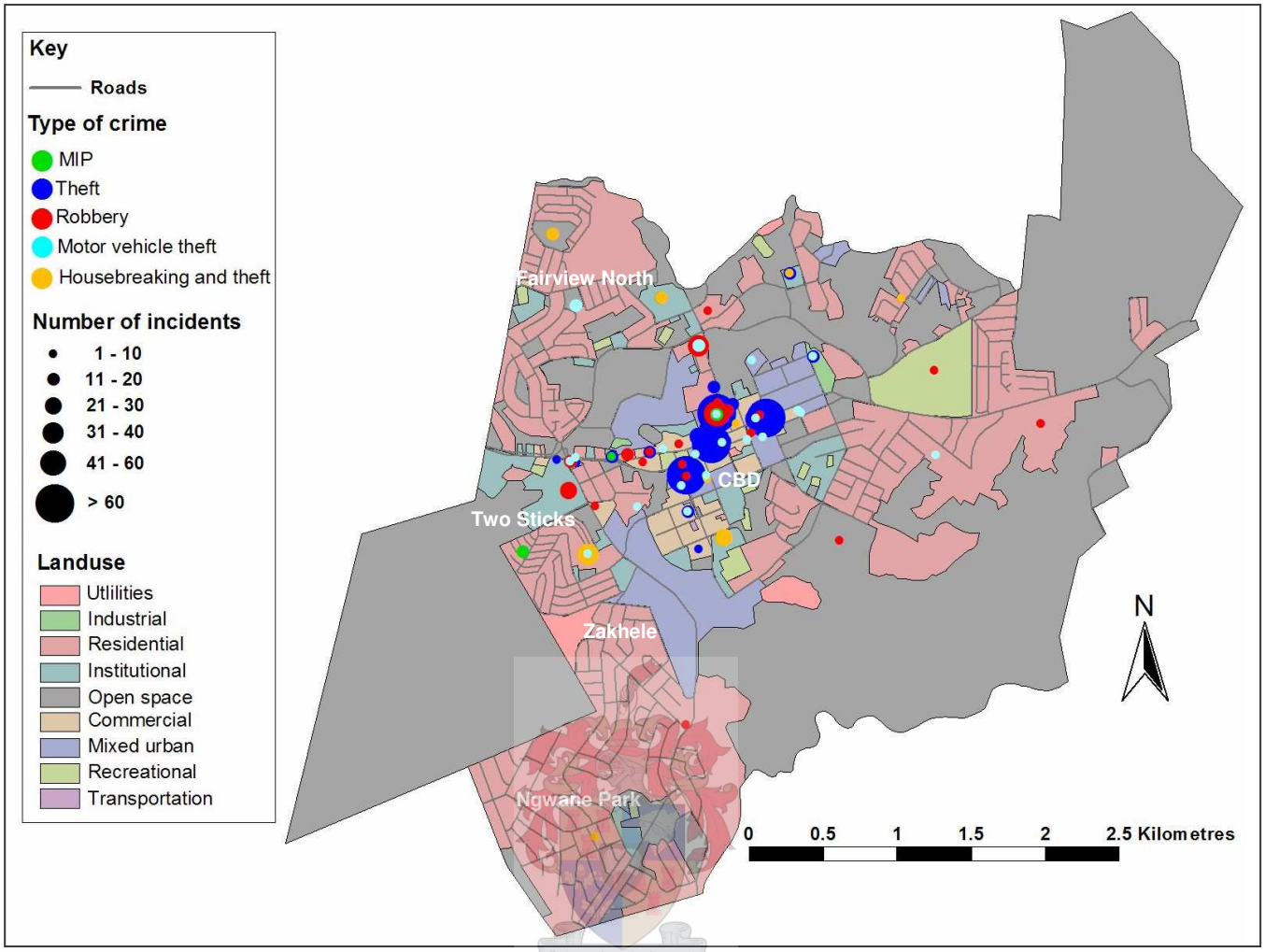

Figure 3.9: The distribution of crimes against property in Manzini.

Figure 3.10 shows the distribution of crimes against people. This category constitutes rape, assault, FALSITAS (theft with false pretences), and abduction. Assault was the most reported crime against people in Manzini. The spatial pattern shows no resemblance to any particular landuse type. The bus rank, Raleigh Fitkin Memorial (RFM) hospital, Woodmasters, Sobhuza Flats, and St. Michaels were the most affected areas by crimes against people. The exact location of more serious crimes like rape was difficult to locate accurately in residential areas because they were recorded according to the townships in which they occurred. They were however, reported to occur in Moneni, Madonsa, Zakhele, and Ngwane park townships.

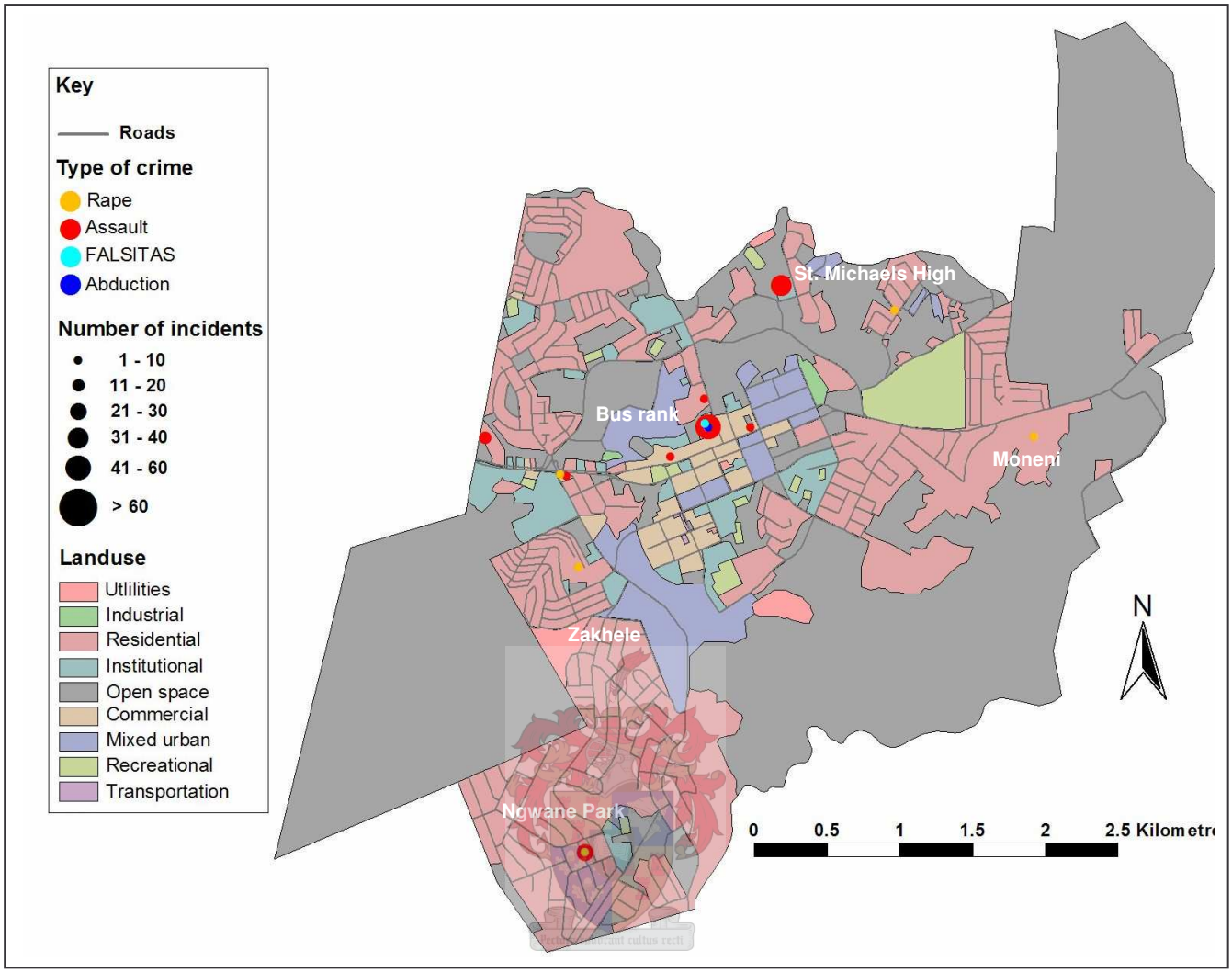

Figure 3.10: The distribution of crimes against people in Manzini.

Very few incidents of FALSITAS and abduction were reported. Those that were reported were located at the bus rank. The same could also be said for drug related crimes and crimes against public order (see Figure 3.11). These crimes exhibited the least number of occurrences in 2004 and occurred mainly in the bus rank.

The relationship between crime and population density in various townships in Manzini was also examined. This was accomplished by overcoming two major problems. The first problem was that there were no defined boundaries of townships in Manzini and therefore it was difficult to determine the townships in which crime was high or low with respect to population density.

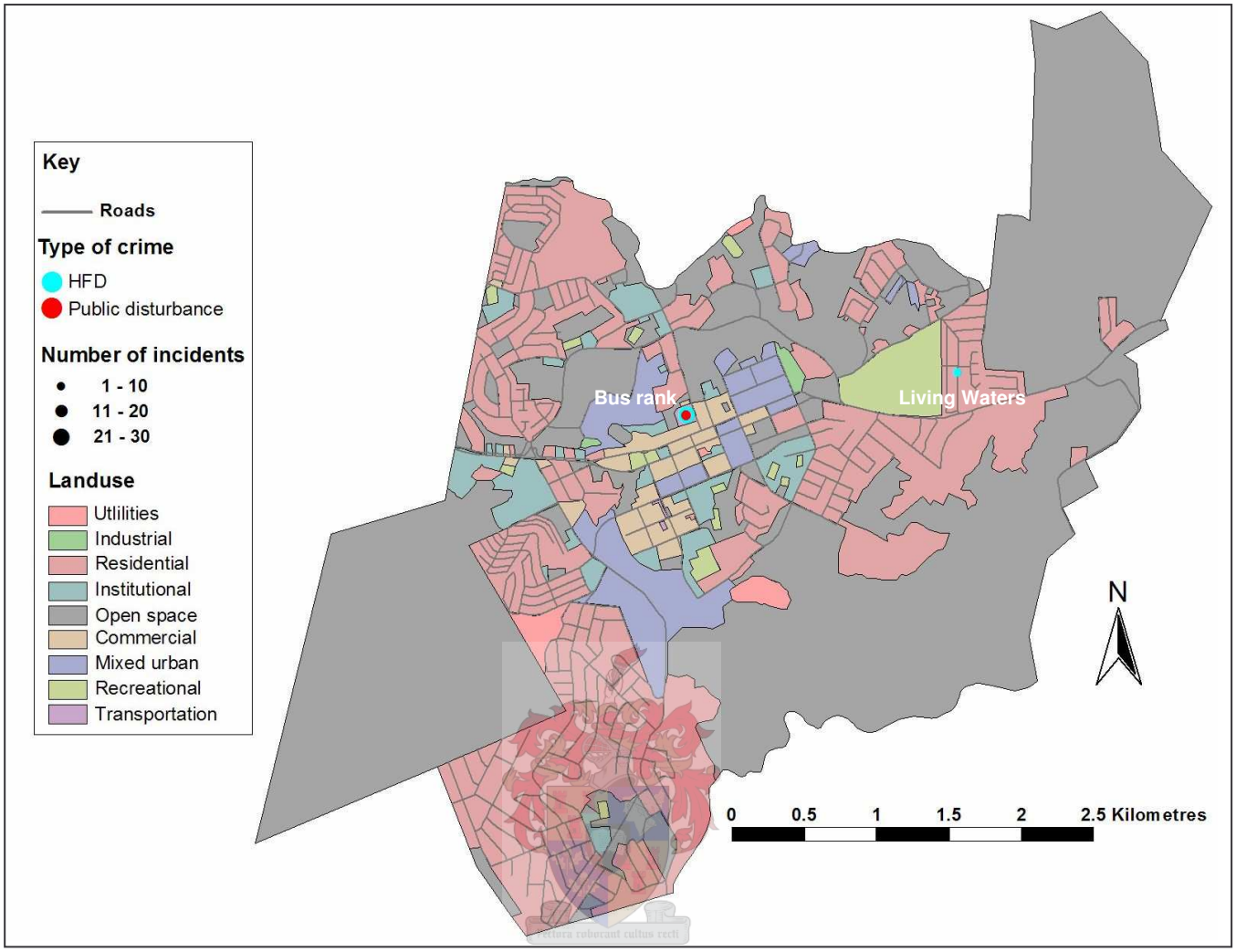

Figure 3.11: The distribution of public order and drug related crimes in Manzini.

This difficulty was overcome using the researcher's knowledge of the study area, orthophotos, topographic maps, and census data. With these, the spatial extent of the various townships in Manzini was roughly demarcated and digitized accordingly in ArcView.

The second problem was related to the fact that the boundaries of some of the enumeration areas from the population census data overlapped two and in some cases three townships. This made the task of assigning population values to some of the created township areas difficult. To address this, a residential building layer of information was created (in ArcView) by digitizing all building footprints in problematic areas and classifying them according to the number of levels (storeys) they had. The area (floor space in square metres) of each building was calculated by executing an AVENUE (object-

oriented) programming language script (CalcArea) in ArcView. The calculated areas of the various buildings were multiplied by the number of storeys each building had.

The next step followed a theme-on-theme-selection of the township boundary layer and the residential buildings layer. In essence, this entailed determining the number of residential buildings that were completely within certain township boundaries and their total area. After this, the total area of buildings in each township was divided by the total area of buildings for the enumeration area they were in. The total population for the enumeration area then multiplied the proportion obtained from this calculation. The result was an estimate of the population in each township.

The area of each township was calculated and the estimated population for each township was divided by this area (in km^2) to determine population density. This made it possible to compare the townships spatially and determine the relationship between crime and population. Figure 3.12 shows the resultant map. The map shows a strong relationship between areas of medium to high population density and high crime. Areas that stand out in this regard are Zakhele, Two Sticks, Fairview North and South, Sterkstroom, Phumula, Moneni and the CBD.

3.4.2 Proximity analysis

Of concern to this study was also the proximity of incidents of crime from alcohol-serving establishments, and educational institutions, to the Manzini police station. The focus was on the proximity of crimes against property and crimes against people. This is because these were the most prevalent categories of crime in Manzini.

Extra layers of information were digitized to show the precise location for each of the alcohol-serving establishments analysed. Proximity breaks were used to show how close these services were to crime locations in Manzini. Table 3.6 and Figure 3.13 show the relationship between categories of crime and their proximity to alcohol-serving establishments. In general, most incidents of crime (56%) occurred between 50 and 100 metres from alcohol-serving establishments in Manzini. The highest concentration of crimes against people was between 100 and 150 metres. Within this distance, 36% (71 incidents) were recorded. Crimes against property were concentrated between 50 and 100 metres from alcohol-serving establishments. Within this distance, 893 incidents (64%) were recorded.

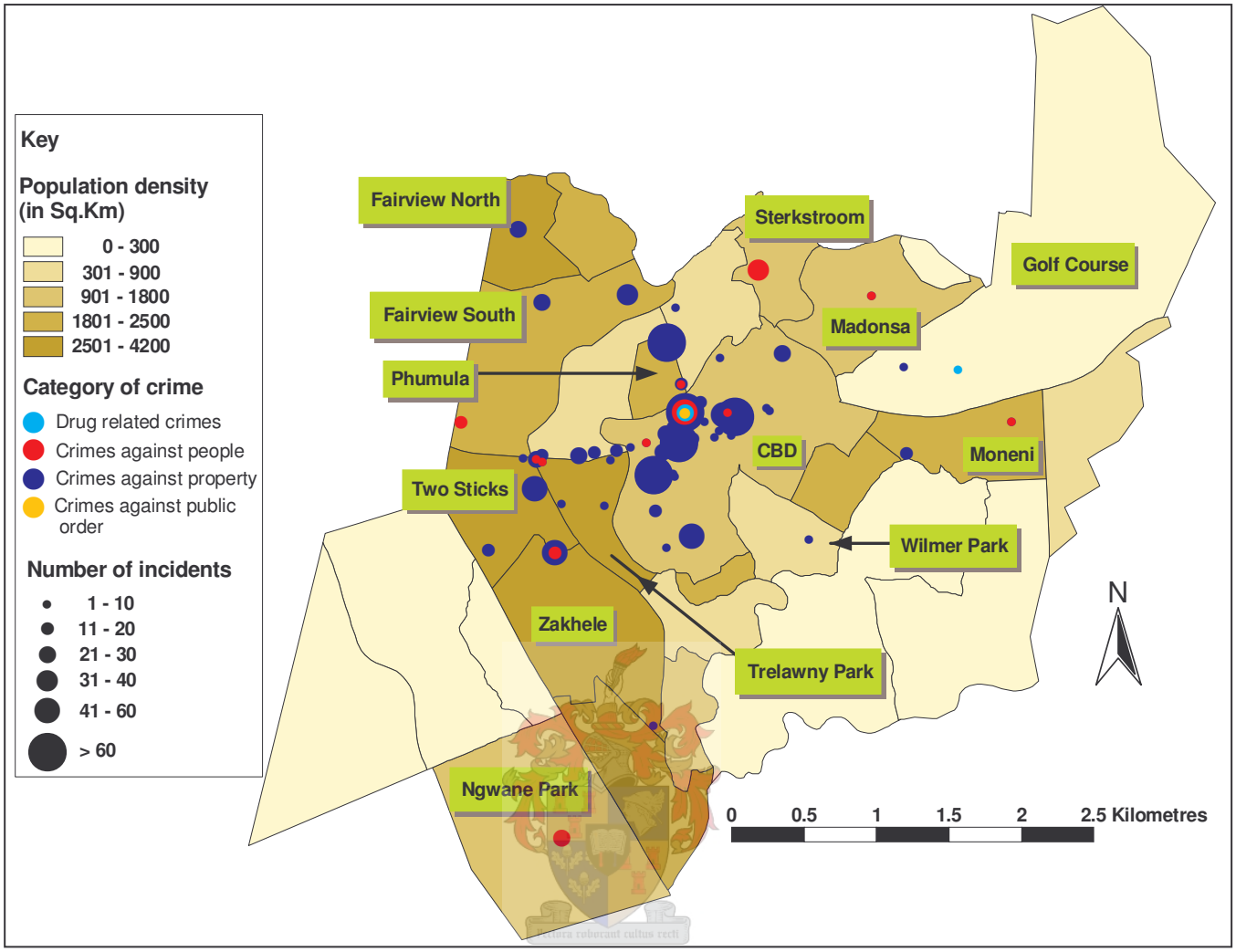

Figure 3.12: The relationship between incidents of crime and population density in Manzini.

Table 3.6: Categories of crime and proximity to alcohol-serving establishments.

Proximity to alcohol-serving establishments (in metres)	**Crimes against people**	**Crimes against property**	**Total**
0 - 50	9	199	208
50 - 100	7	893	900
100 - 150	71	76	147
150 - 200	0	20	20
200 - 250	9	30	39
250 – 500	15	130	145
500 - 1000	53	31	84
1000 – 2000	33	17	50
Total	**197**	**1396**	**1593**

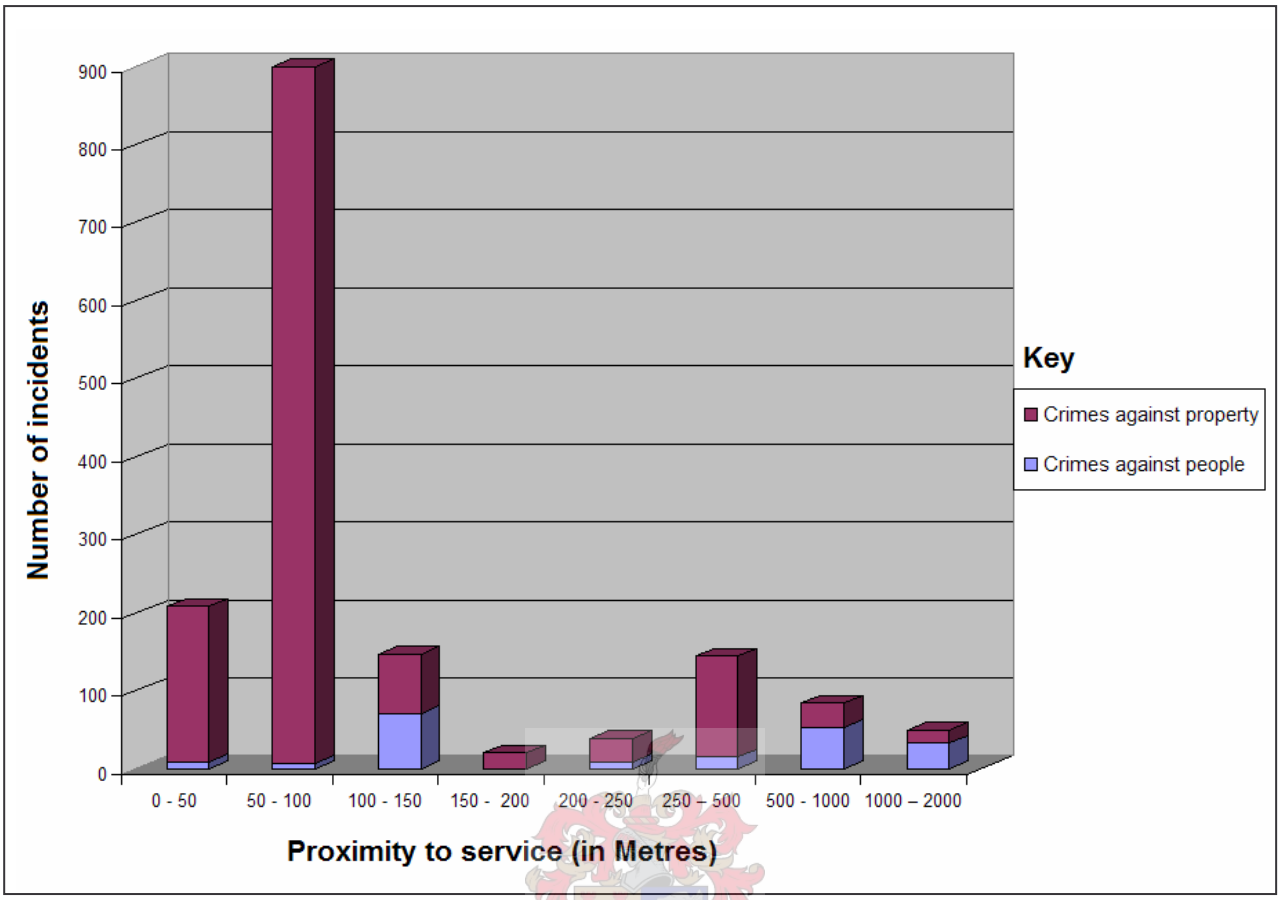

Figure 3.13: Categories of crime and proximity to alcohol-serving establishments.

Figure 3.14 and 3.15 show the relationship between crimes against people and crimes against property to alcohol-serving establishments in Manzini respectively. The proximity of crimes against people to alcohol-serving establishments in residential areas was weaker than in the city centre. At least four locations where crimes against people occurred in the centre of town were within 50 metres of alcohol-serving establishments whereas the proximity decreased to approximately 250 metres in residential areas.

When compared to crimes against people, the proximity of crimes against property to alcohol-serving establishments in the centre of town was much stronger. Over 60% of all crimes against property occurred within 50 metres of alcohol-serving establishments in the city. The proximity of crimes against property also decreased when residential areas are considered but to a lesser extent than for crimes against people.

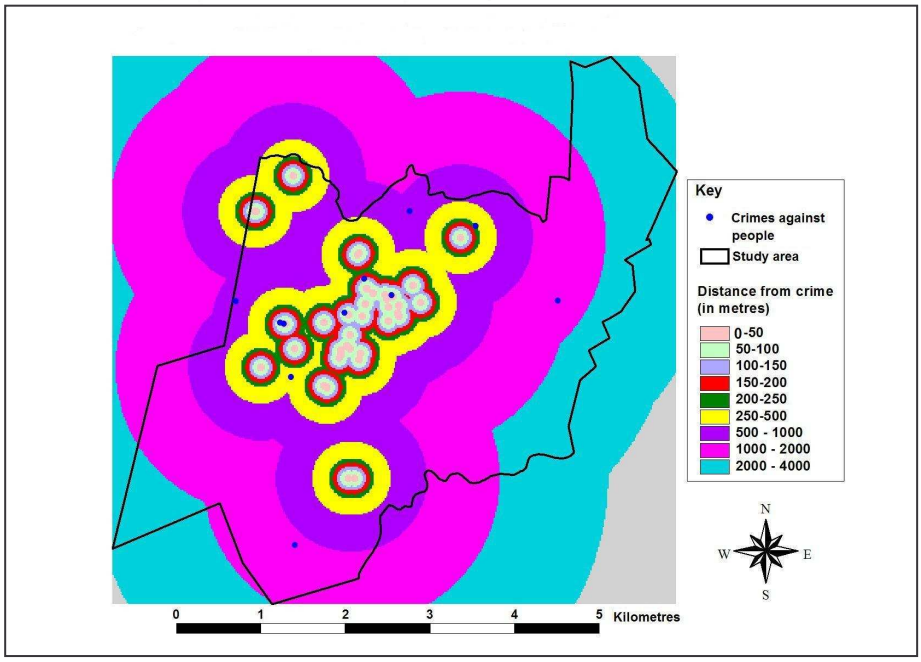

Figure 3.14: Crimes against people and location of alcohol-serving establishments.

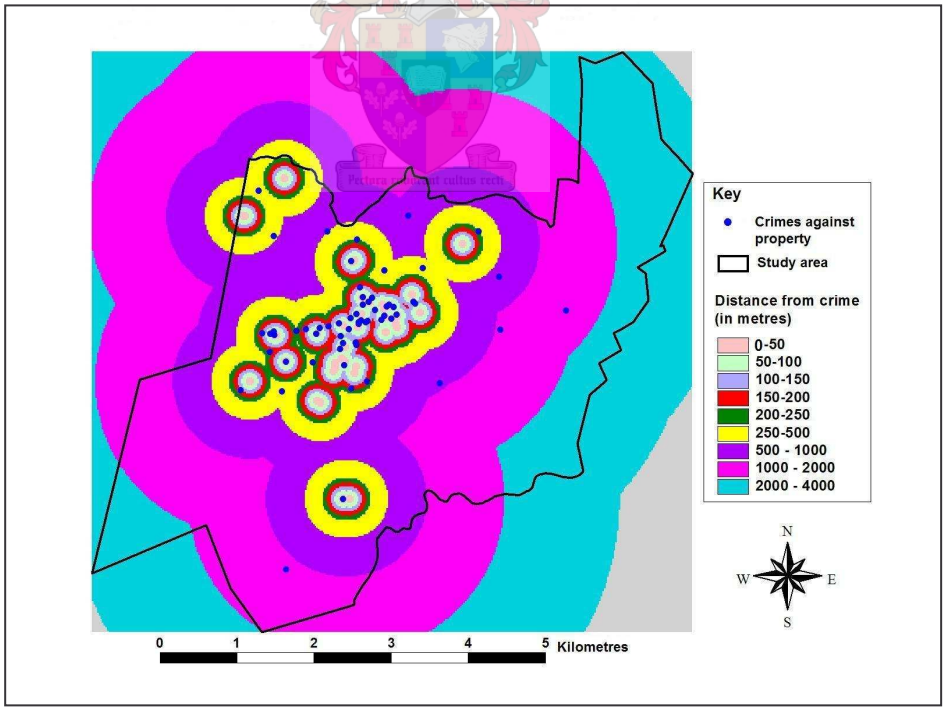

Figure 3.15: Crimes against property and location of alcohol-serving establishments.

The proximity of crimes against people and crimes against property to educational institutions was also examined. The results are shown in Table 3.7 and Figure 3.16. Most crimes occurred between 500 and 1000 metres from educational institutions. Within this distance, 52% (829 incidents) were recorded. Crimes against people together with crimes against property were concentrated between 500 and 1000 metres from educational institutions. Within this distance, 40% (79 incidents) of crimes against people were recorded, whereas 54% (750 incidents) of crimes against property were recorded.

Table 3.7: Categories of crime and proximity to educational institutions.

Proximity to educational institutions (in metres)	**Crimes against people**	**Crimes against property**	**Total**
0 - 50	0	59	59
50 - 100	0	0	0
100 - 150	42	131	173
150 - 200	0	0	0
200 - 250	11	46	57
250 – 500	56	401	457
500 - 1000	79	750	829
1000 – 2000	9	9	18
Total	**197**	**1396**	**1593**

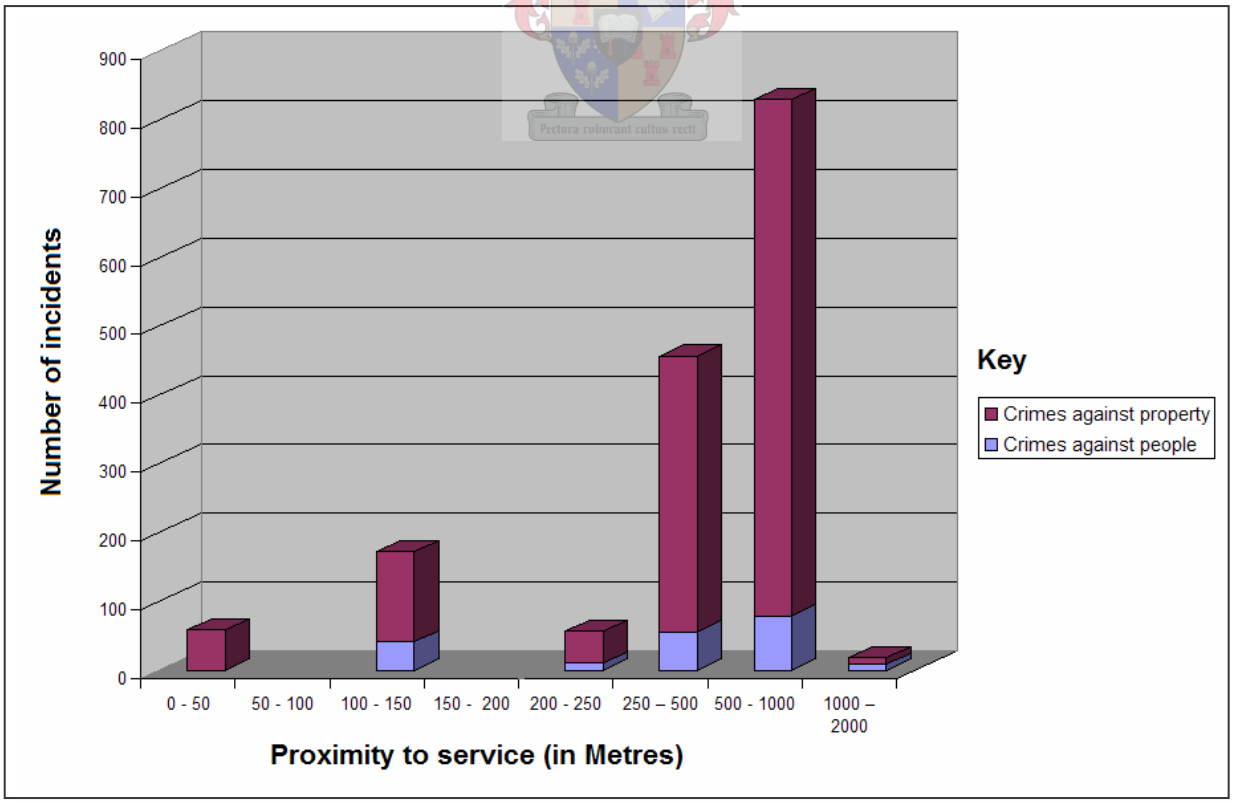

Figure 3.16: Categories of crime and proximity to educational institutions.

Figure 3.17 and 3.18 show the proximity of crimes against people and crimes against property to educational institutions in Manzini. Both maps associate certain institutions as being in close proximity to these categories of crime. This is especially the case with crimes against property. Institutions with a strong proximity to crimes against property (housebreaking and theft) were William Pitcher College, Salesian High, and Manzini Central High. St Michaels High school was the nearest associated institution (100 to 150 metres) to crimes against people (assault).

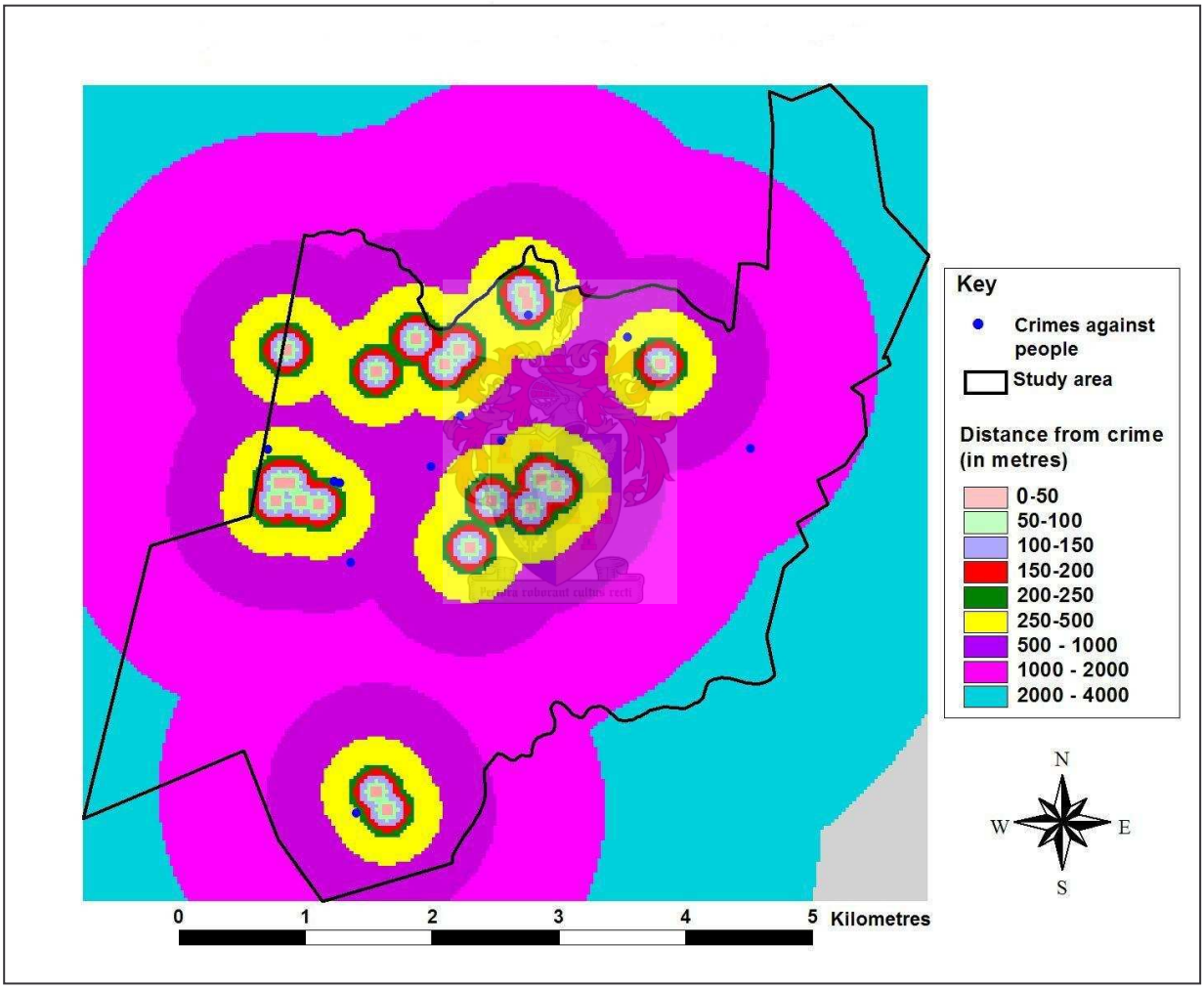

Figure 3.17: Crimes against people and location of educational institutions.

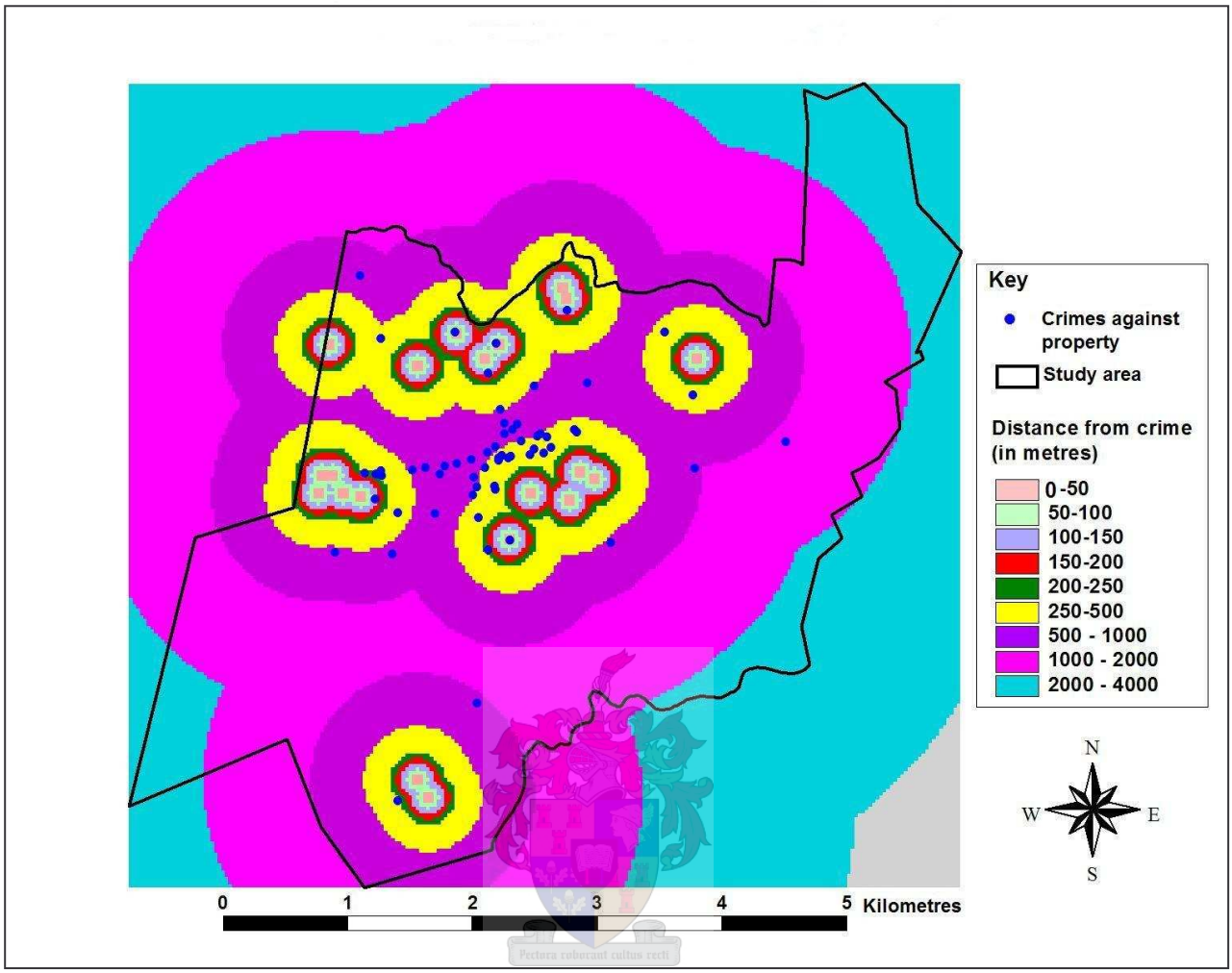

Figure 3.18: Crimes against property and location of educational institutions.

The final proximity analysis examined the proximity of crimes against people and crimes against property to the Manzini police station. Table 3.8 and Figure 3.19 show the result. In general, no incidents of crime were recorded between zero and 150 metres from the Manzini police station. Most incidents of crime (43%) occurred between 250 and 500 metres from the station. Crimes against people together crimes against property were also mainly prevalent within this distance. Between 250 and 500 metres, 42% (82) of all incidents of crimes against people were recorded whereas 598 incidents (43%) were recorded for crimes against property.

Table 3.8: Categories of crime and proximity to Manzini police station.

Proximity to Manzini police station (in metres)	Crimes against people	Crimes against property	Total
0 - 50	0	0	0
50 - 100	0	0	0
100 - 150	0	0	0
150 - 200	0	46	46
200 - 250	0	135	135
250 – 500	82	598	680
500 - 1000	5	323	328
1000 – 2000	72	238	310
2000 - 4000	38	56	94
Total	**197**	**1396**	**1593**

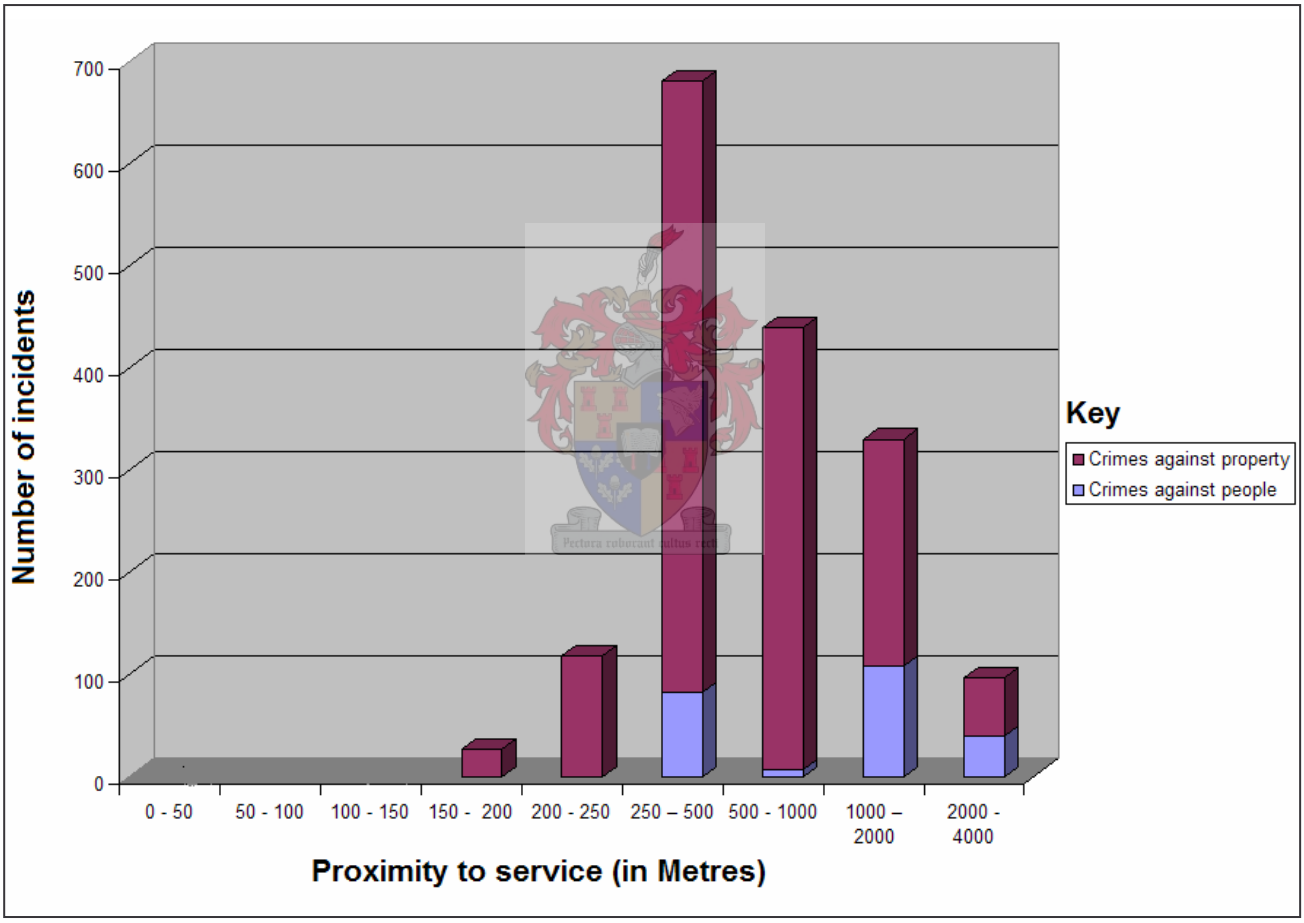

Figure 3.19: Categories of crime and proximity to Manzini police station.

Figures 3.20 and 3.21 show certain crimes and their proximity to the Manzini police station. Crimes against property (Figure 3.21) reveal a much stronger proximity relationship than that of crimes against people. Crimes against people are more sparsely distributed than crimes against property which are more clustered.

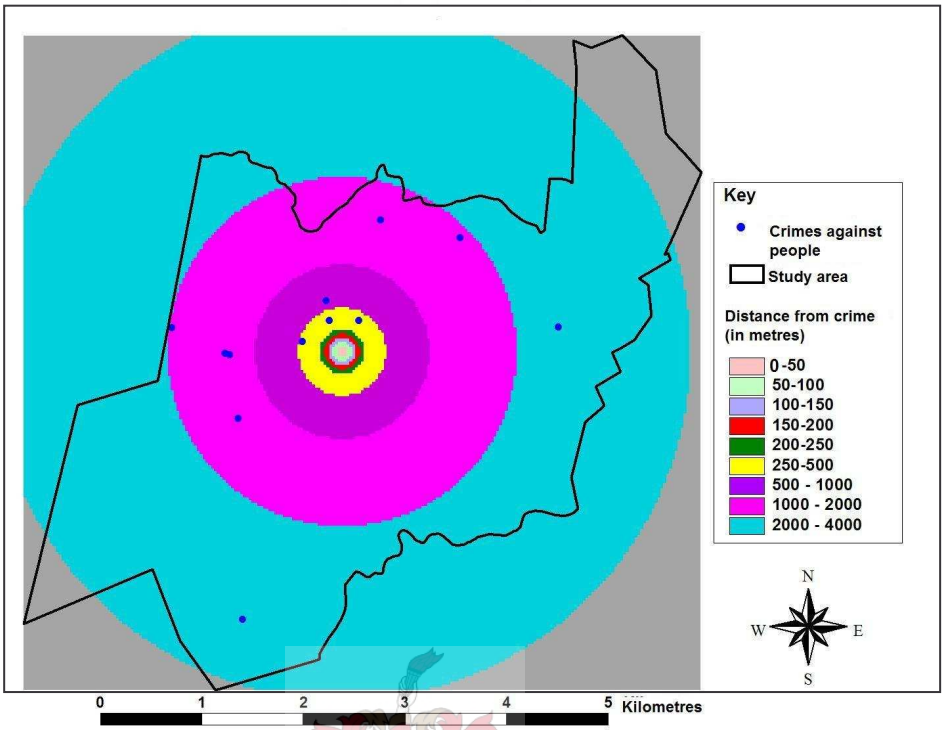

Figure 3.20: Crimes against people and location of Manzini police station.

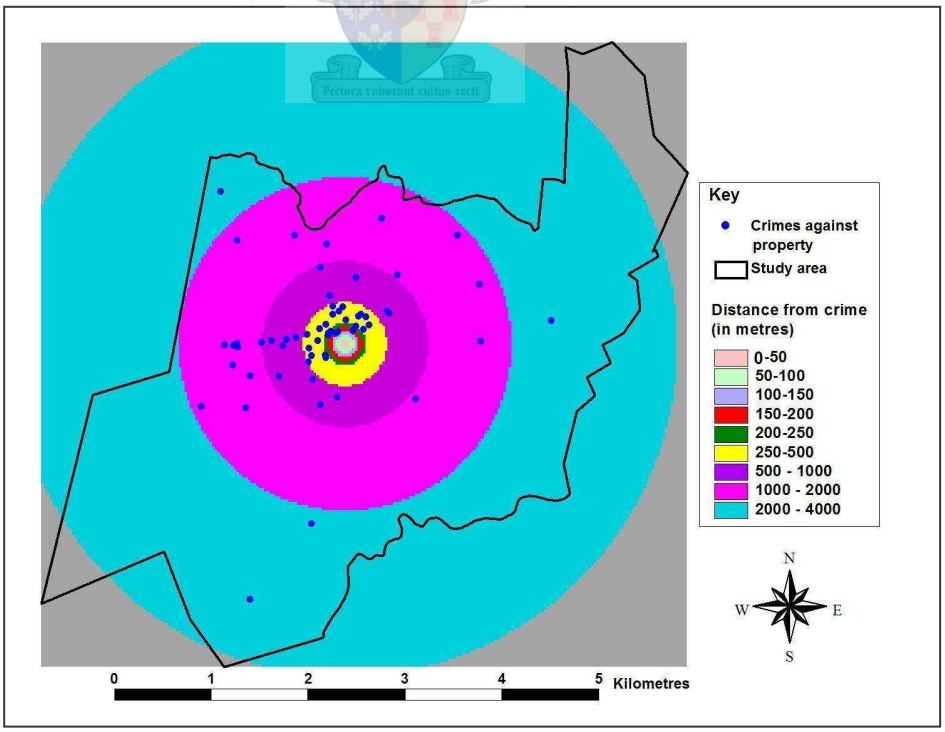

Figure 3.21: Crimes against property and location Manzini police station.

3.4.3 Temporal analysis

The purpose of this task was to determine the temporal pattern of crime in Manzini using the same categories of crime described earlier. These were analysed according to whether they occurred during the day or during the night. Day crimes were those that occurred between 06:00-18:00 hours whereas night crimes were those that occurred between 18:01 to 06:00 hours.

Figure 3.22 and 3.23 show the temporal distribution of crime in Manzini during the day and during the night respectively. Most crimes (87%) occurred during the day rather than during the night (13%). All categories of crime occurred during the day in Manzini. This however, was not so for crimes occurring during the night. Of all categories of crime, only crimes against property and crimes against people occurred during the night while drug related crimes and crimes against public order occurred during the day.

Crimes that occurred during the day were concentrated in the CBD. At night, however, there was a significant drop in the number of incidents of crime in this area. This was especially so for troubled areas such as the bus rank, Bhunu mall, JetMart and the Manzini market. Residential areas also experienced a drop in the number of incidents of crime at night. Areas such as Fairview South experienced a complete drop in the number of crimes against property whereas areas such as Moneni experienced a slight rise in the number of crimes against property.

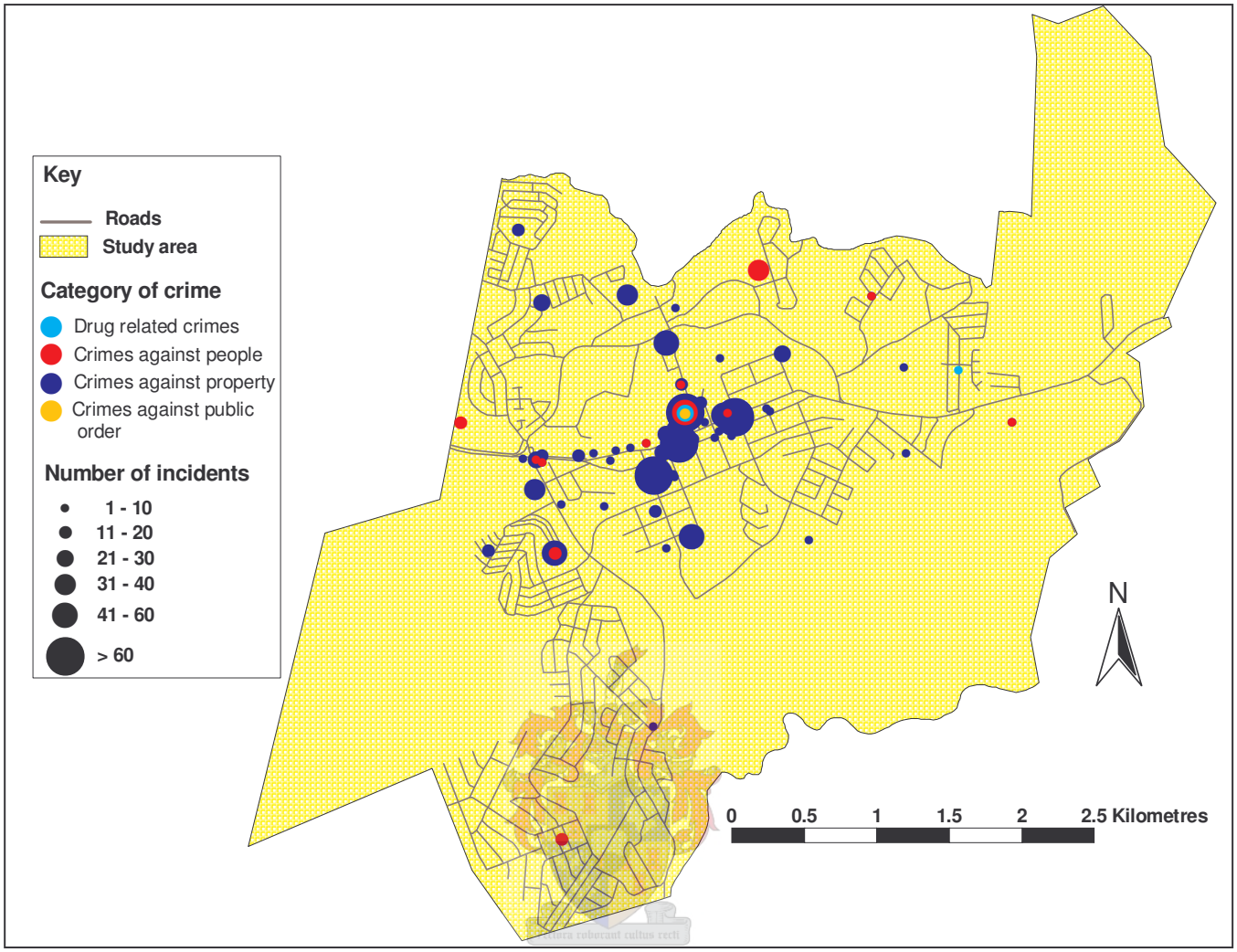

Figure 3.22: The distribution of crimes during the day.

3.4.4 Morphological analysis

The structural layout (morphology) of areas where incidents of crime were high was investigated. These areas were mainly the bus rank, Jet Supermart and the Manzini market. Each area accounted for approximately 22%, 5%, and 5% (4.7%) respectively of all incidents of crime in Manzini in 2004. A 150-metre buffer was overlayed on an orthophoto of Manzini and placed around these crime locations to facilitate the morphological analysis.

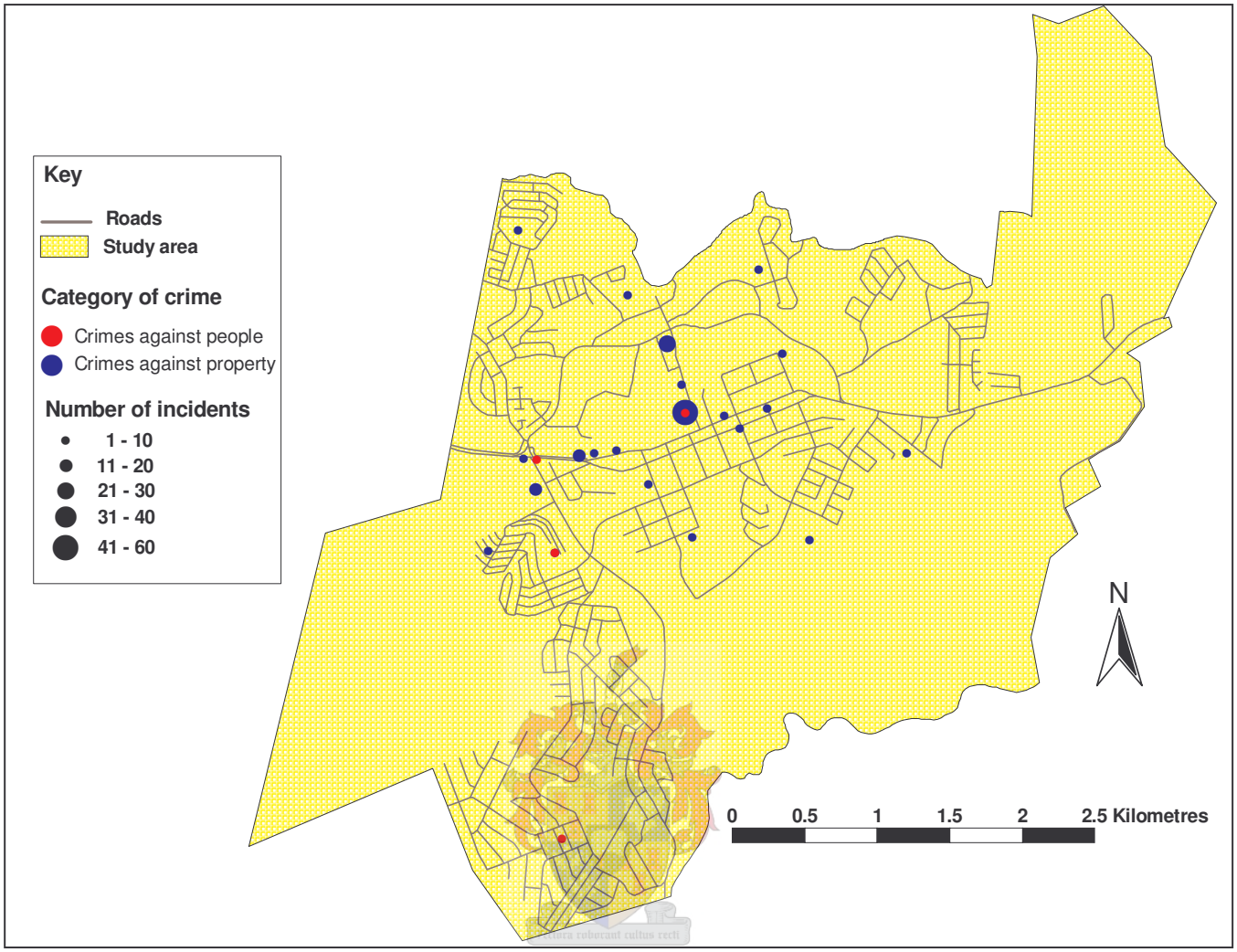

Figure 3.23: The distribution of crimes during the night.

Figure 3.24 shows an aerial view of the Manzini bus rank. The physical features that could contribute to crime there were identified. One of those identified features were exit routes. The bus rank is not enclosed, fenced, or barricaded. It has numerous exit routes that would-be-thieves can use to steal, sell drugs, assault people, and easily escape without being caught. Most of the exit routes lead to adjacent access roads like Ngwane Street and Meintues Streets.

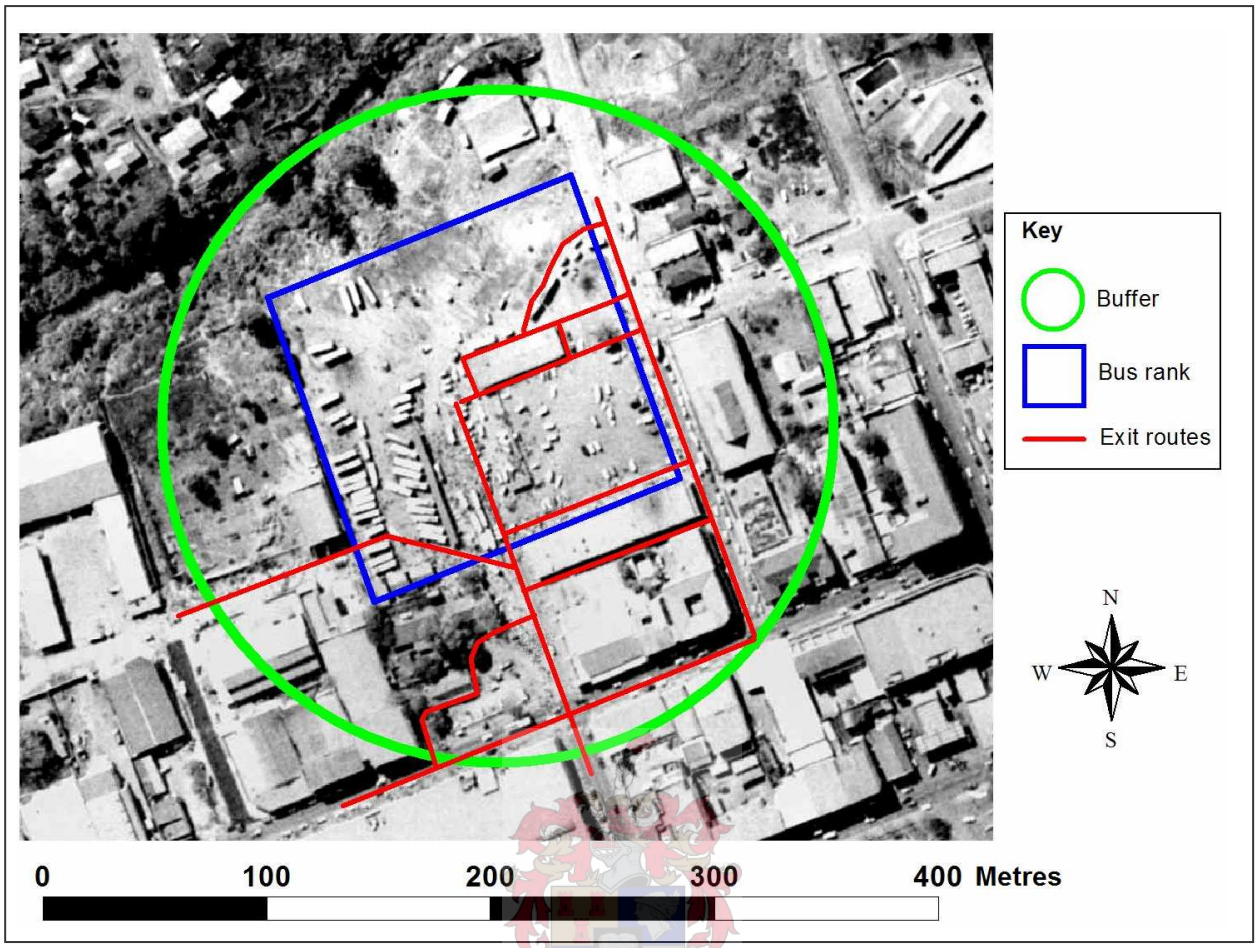

Figure 3.24: An aerial view of the Manzini bus rank.

Another physical aspect has to do with size. The bus rank is not large enough to provide an efficient transport service for the large population that uses it. This is probably best seen by the congested nature of the bus rank with people, buses, and taxis during the day. Figures 3.25 and 3.26 illustrate the congested nature of the bus rank on supposedly quiet day (Sunday afternoon 24th July 2005).

Figure 3.27 shows an aerial view of the JetMart store. As with the case of the bus rank, the location of this store presents criminals with a number of routes to escape after successfully evading the security guards at the entrance.

Figure 3.25: Commuters at the Manzini bus rank.

Figure 3.26: Public transport at the Manzini bus rank.

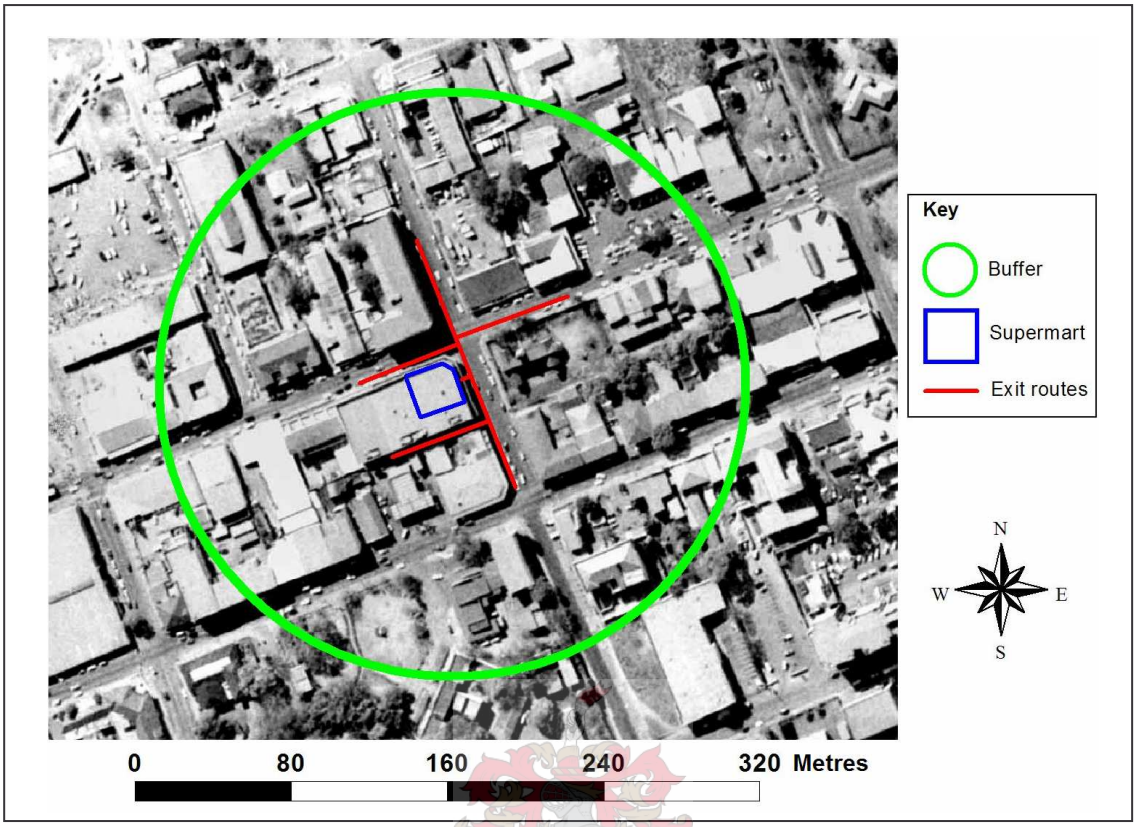

Figure 3.27: An aerial view of JetMart store.

The assistant store manager of JetMart granted the researcher permission to take photos inside the store for use in this study. An inspection of the internal structure of the store revealed that JetMart, like the bus rank is capable of accommodating large numbers of shoppers and can thus get crowded. It was noted that there are a variety of goods sold in this store. An inquiry was made into a theft registry in the store to determine which good were stolen most often. It was established that compact discs (CDs), digital video discs (DVDs) and stationary (see Figures 3.28 and 3.29) were the most targeted goods in 2004 by criminals. Despite the security guards, cameras, and security features on CDs/DVDs in place this store still experienced high incidences of theft.

Figure 3.30 shows an aerial view of the Manzini market place. Like the bus rank and JetMart, the Manzini market can also get extremely crowded during the day (see Figure 3.31). A variety of goods from fruits and vegetables to clothes and jewellery are sold at the market. Most of these goods appeal mainly to low income earners who form the bulk of the shoppers.

Figure 3.28: CD and DVD stalls at JetMart.

Figure 3.29: Stationary stalls at JetMart.

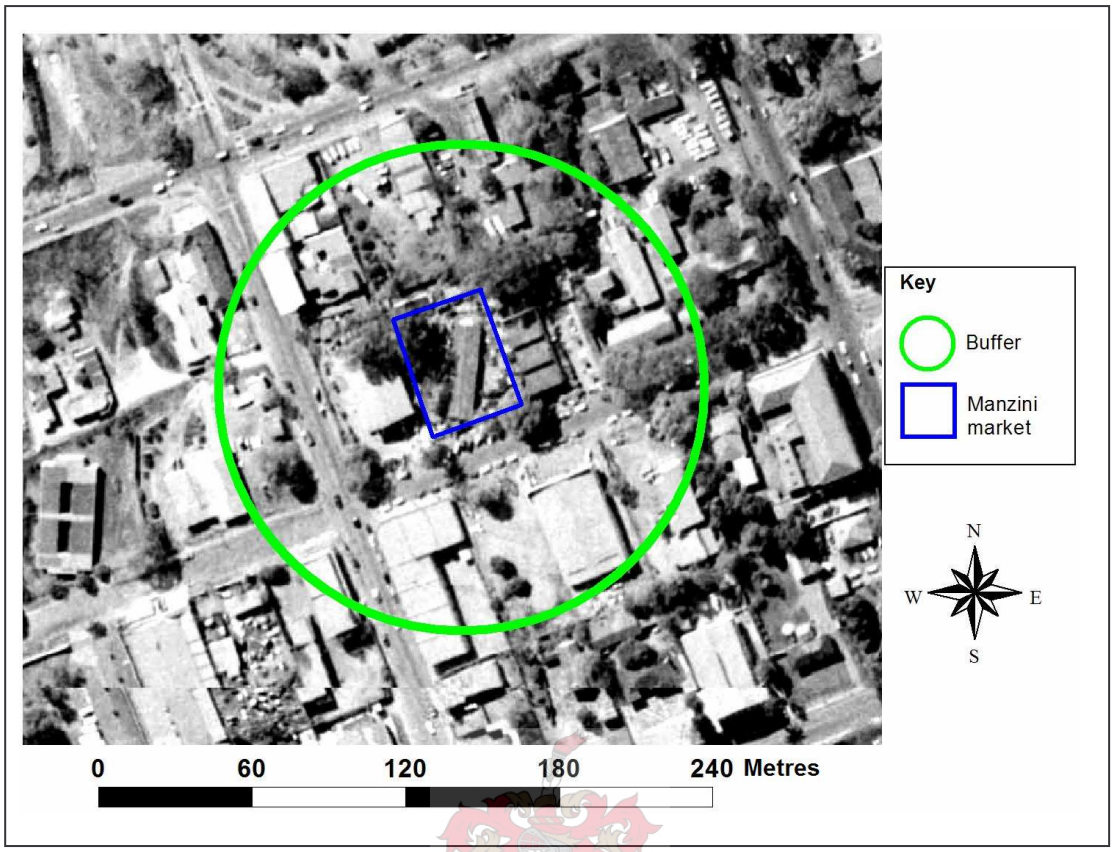

Figure 3.30: An aerial view of Manzini market.

The market place also has multiple entry and exit points. Almost nothing separates the lines of market stalls around the main market building from each other. Their alignment tends to obscure other areas in the market thus making surveillance very difficult. The large number of stalls (Figure 3.32) is a reflection of the large number of people that shop at the market and the available opportunities to steal from there.

Figure 3.31: Congestion in the Manzini market area.

Figure 3.32: Stalls at the Manzini market.

3.4.5 Accessibility analysis

The final task in this study was to determine suitable location(s) for future police station(s) in Manzini. The service-location modelling functionality of Flowmap was used to achieve this objective. To perform accessibility analysis in Flowmap, at least two important requirements need to be satisfied. Firstly, there is a need to specify an origin and a destination. The origin represents supply or the location of the facility that supplies a service to a given "population".

The destination on the other hand represents the locale of demand for a particular service. For this analysis, origins (supply) and destinations (demand) were specified as police stations and the population of Manzini respectively. These were linked via a distance table known as an origin-destination matrix (ODB Matrix).

Secondly, since most people have access to activities though a transport network, as De Jong (2005) observes, the Manzini road network was used in our analysis. The road network was processed in ArcInfo to ensure that it had no disconnected line segments and topological errors. Disconnected line segments in a road network make most network analyses fail because they are based on some form of shortest path algorithm which cannot function when origin and destination locations are in disconnected parts of a network (De Jong 2005). The third requirement was a boundary of Manzini to show the spatial extent of the study area.

Having satisfied the data requirements, the next step was to prepare the data for accessibility analysis. The first step in this endeavour was to create a regular tessellation of the study area. This divided the study area into smaller ones so that it was possible to display geographical differences within a sub area (Van der Zwan *et al* 2005). Figure 3.33 shows a hexagonal tessellated map of Manzini with an edge-length of 150 metres with at least one of the vertices inside the study area.

The next step in the analysis was to copy information about demand to the new tessellated data set. This task is necessary since the tessellated area represents the area for potential supply. According to De Jong (2005), the most accurate way to fulfil this objective is to follow a four-step procedure by:

1. Dividing all data by area (size) to express the information as density
2. Building a distance table between all original demand and supply locations on the one hand and the new tessellated locations on the other
3. Allocating each original location to the nearest tessellated location
4. Reconstructing the numbers by multiplying the densities with the new area sizes

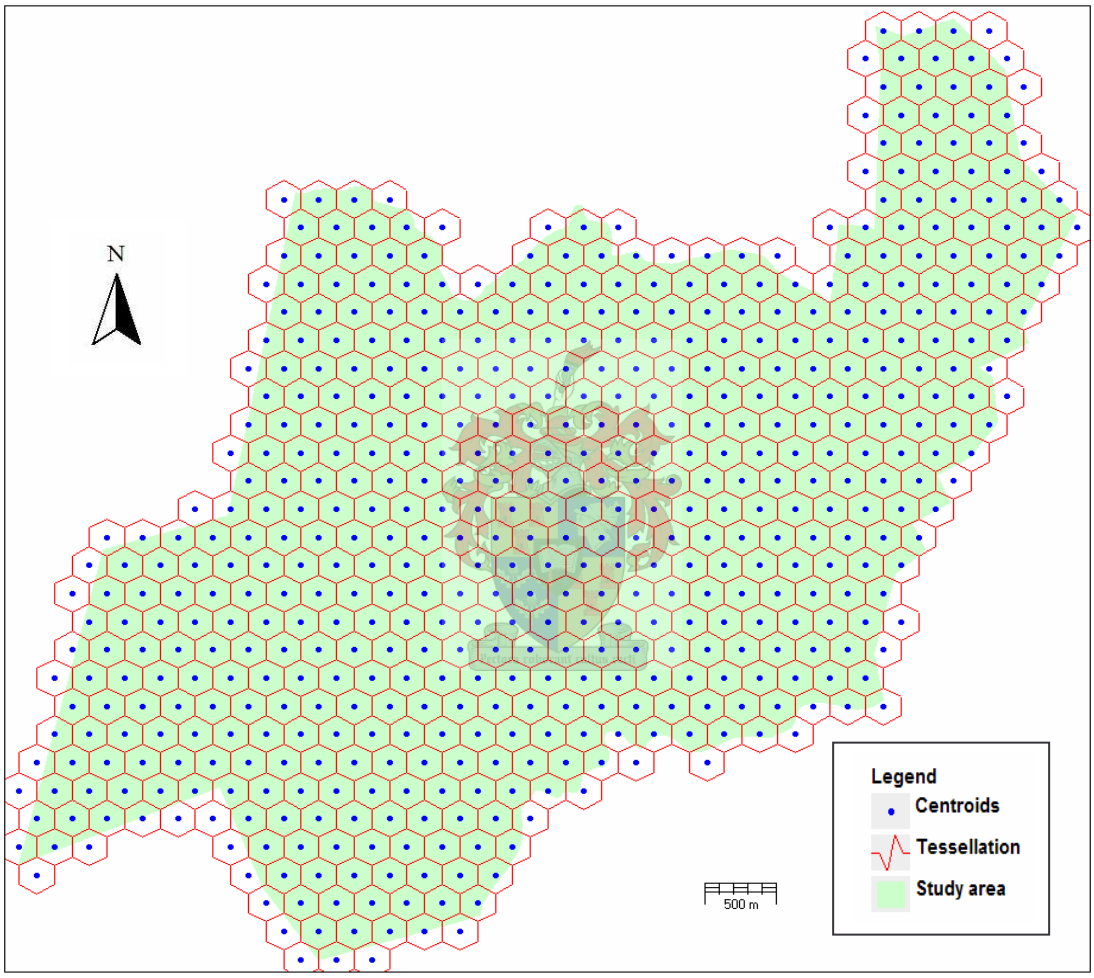

Figure 3.33: A regular tessellation of Manzini.

After copying information about demand to the tessellated data set, supply related information was copied to the tessellated data set. This step was a bit more complicated than the previous task. It required the following procedure to be completed:

1. Split all the information about services into separate attribute fields
2. Create a new variable for each type of service containing capacity
3. Copy the new variable to the tessellated data set

The building of a distance table between all locations in the tessellated dataset was the final step in the preparation of the data for accessibility analysis. According to De Jong (2005), for accessibility analysis distances based on an actual transport network must be used because airline distances do not take obstacles like rivers, lakes, or steep hills into account. Distances based on the road data were used and the average travel time through each type of road segment was estimated for transportation by foot. This form of transport was used because it was reasoned that most people would prefer that police stations be within reasonable walking distance from where they reside. A recommended average walking speed of two metres per second was used.

The parameters available in the "network distance matrix creation" window of Flowmap were used to build a distance table between all locations in the tessellated dataset. All locations (origin and destination) were then snapped to the road network. This concluded the preparation of the data for accessibility analysis.

The accessibility analysis commenced by posing several questions namely:

1. How many police stations are required to ensure that people do not travel more than 30 minutes to the nearest police station in Manzini?
2. How can the distribution of these police stations be optimised?
3. Where are good locations for three additional police stations in Manzini?
4. What is the optimal location for the current police station in Manzini?

To answer the first question, the coverage model (Spatial Pareto method) in Flowmap was used. Because the distance unit of travel time in our distance tables was set to seconds, the distance range for this task was set to 1800 seconds (30 minutes). Figure 3.34 shows the result. As illustrated, to ensure that people do not walk more than 30 minutes to the nearest police station, seven police stations are required in Manzini. Table 3.9 describes the locations for these proposed sites.

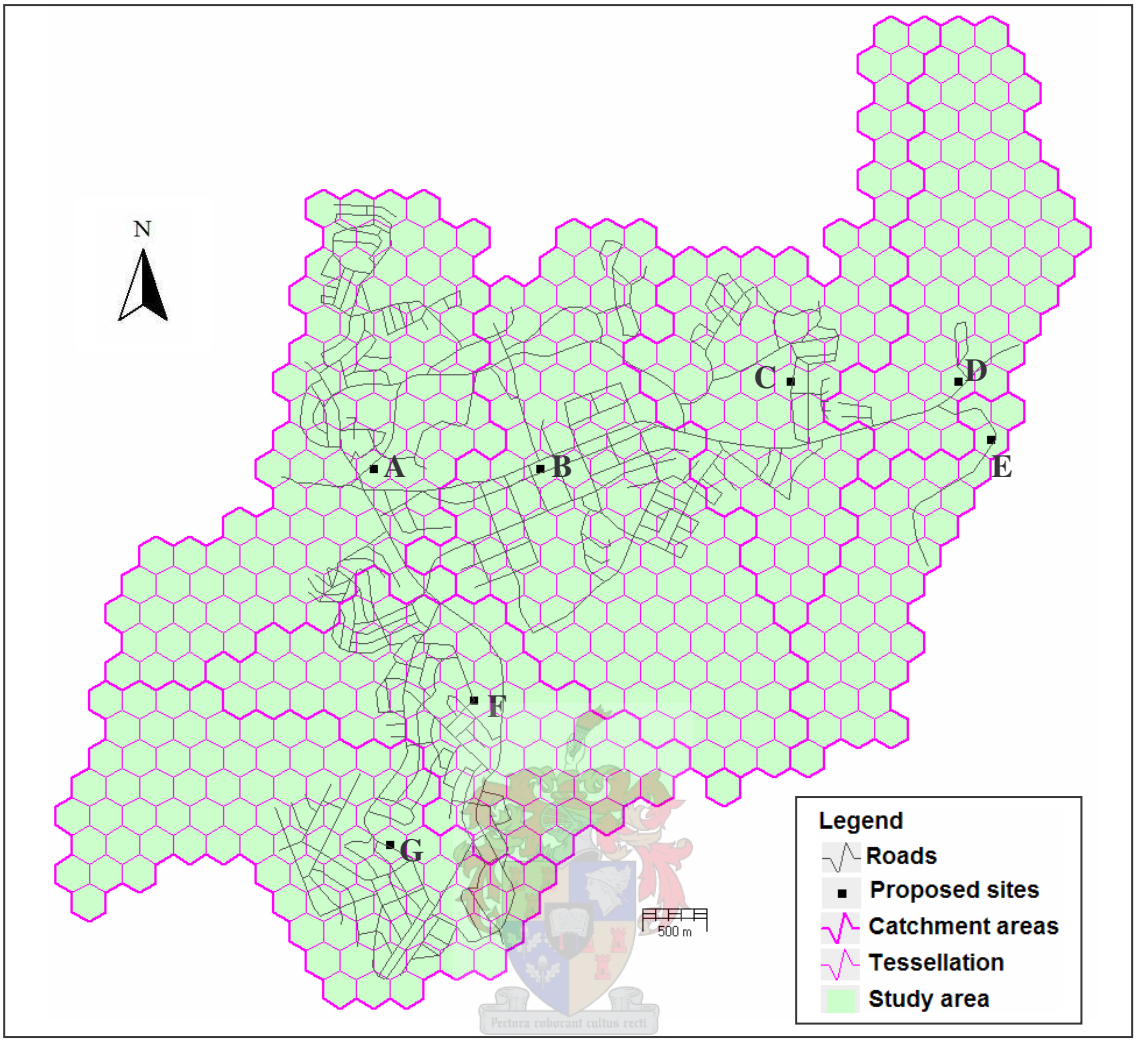

Figure 3.34: Police stations required for 30 minutes walking time in Manzini.

Table 3.9: The locations for proposed sites.

Station	Location
A	At the corner of Ngwane Street and Central Distributor Rd in Helemisi
B	At Swazi Bank between Ngwane Street and Nkoseluhlaza Street
C	Near the intersection of Logwaja Street and Indlovu Street in Golf Course township
D	At south eastern edge of Golf Course township, north of Ngwane Street (road to Siteki)
E	On eastern edge of Moneni township, approximately 600 metres south east of Station C
F	At the corner of Lishongololo and M'thombothi Street in Zakhele township
G	Along Stanley Street between the intersections of Thomas and Moira Street in Ngwane Park

The second question for accessibility analysis required the use of the relocation model in Flowmap. This strived to improve the efficiency of police station locations by optimizing the results of the coverage model. The model alternative to "minimize worst-case distance" was used in this endeavour.

Figure 3.35 illustrates the findings of the accessibility analysis. Almost all police station locations (apart from station A) are relocated to ensure that the worst-case distance travelled to the nearest police station is minimized with a reduction from an initial worst-case travel time of 1797.9 seconds (29.97 minutes) to 1737.15 seconds (28.95 minutes). The average worst-case distance travelled is reduced from 1758.12 seconds (29.3 minutes) to 1433.5 seconds (23.89 minutes). Table 3.10 gives a general description of where the proposed optimised sites are located in Manzini.

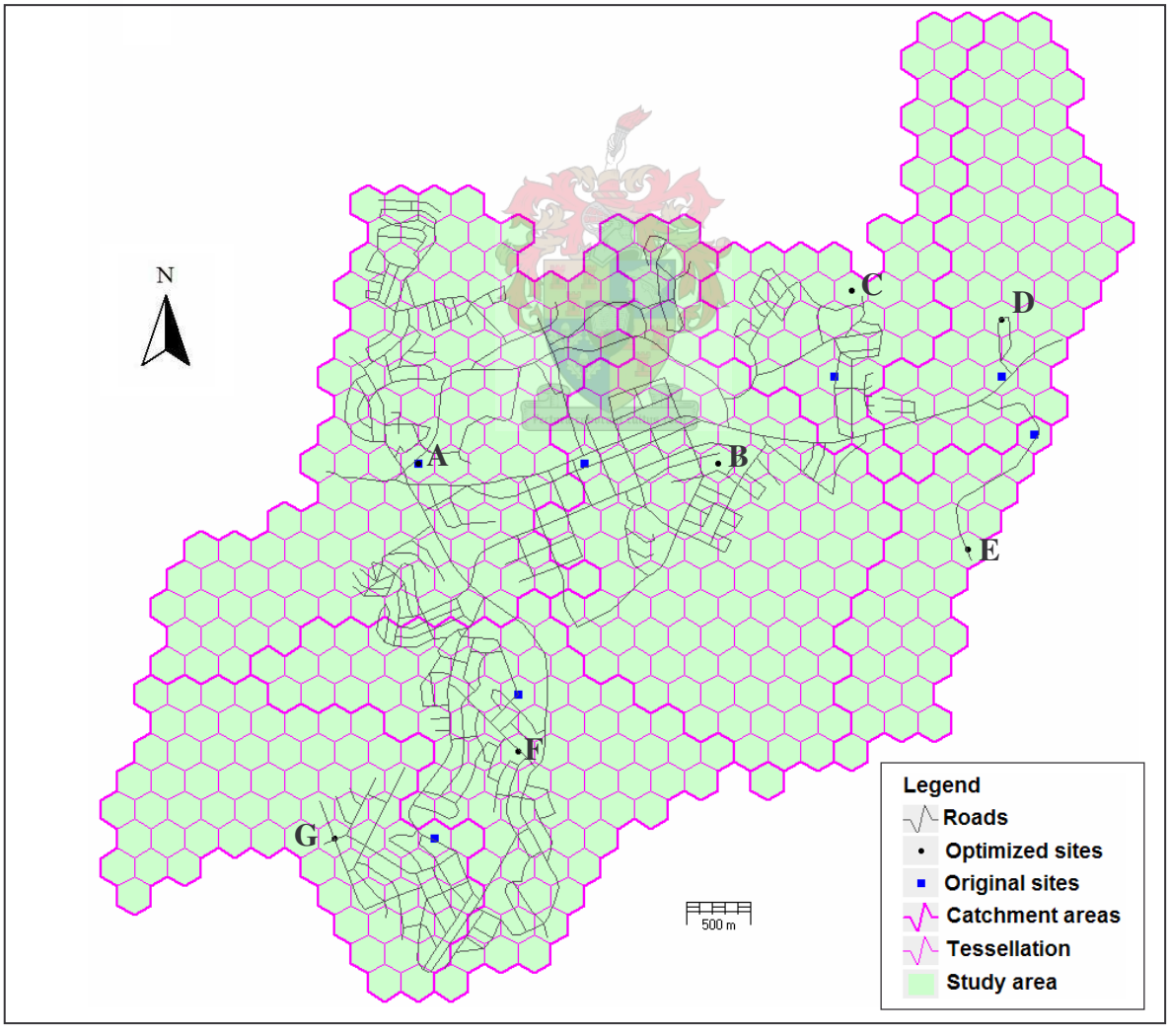

Figure 3.35: Optimised locations for minimized worst-case distance.

Table 3.10: The locations of the proposed optimised sites.

Station	Location
A	At the corner of Ngwane Street and Central Distributor Road in Helemisi
B	Near the intersection of Jacaranda Close and Jacaranda Avenue in Coats Valley township
C	At the corner of Phephemphetwane and Imboma Street In Thomsdale township
D	Along Imfene Street in Golf Course township
E	In south eastern corner of Moneni township
F	Near the corner of Mantayi and Kashali Street In Zakhele township,
G	At the intersection of Ingwenyama and Barry Street in Ngwane Park township

A catchment area analysis was performed to determine the population demand allocated to each of the proposed police station location sites. This gives an indication of how much resources each police station would require to operate efficiently. Figure 3.36 illustrates the findings. The police station in the centre of Manzini and the one to the immediate west of it (in green) require more resources than other stations because they have relatively large catchment/service areas. Stations in the north east, east and southeast on the other hand would require the least amount of resources to operate.

An attempt was made to determine the distance between all origins and their nearest destination using a catchment profile. This made it possible to determine whether many origins were relatively far from their nearest destination or relatively close. The result is shown in Figure 3.37. As illustrated, the catchment profile was convex meaning that more people were nearer rather than further from their nearest police station.

Flowmap's expansion model answers the third question whose objective is to improve accessibility by expanding upon existing police station locations. Since there is one police station in Manzini, the best three additional police stations should be located to maximize customer coverage. Figure 3.38 shows the result. Because there are fewer police stations than previously illustrated, there has been an increase in the service area for each police station. Also in this analysis the location of the current police station has been taken into consideration. This was not the case in the previous illustrations. Table 3.11 describes where the best three proposed sites are located in Manzini.

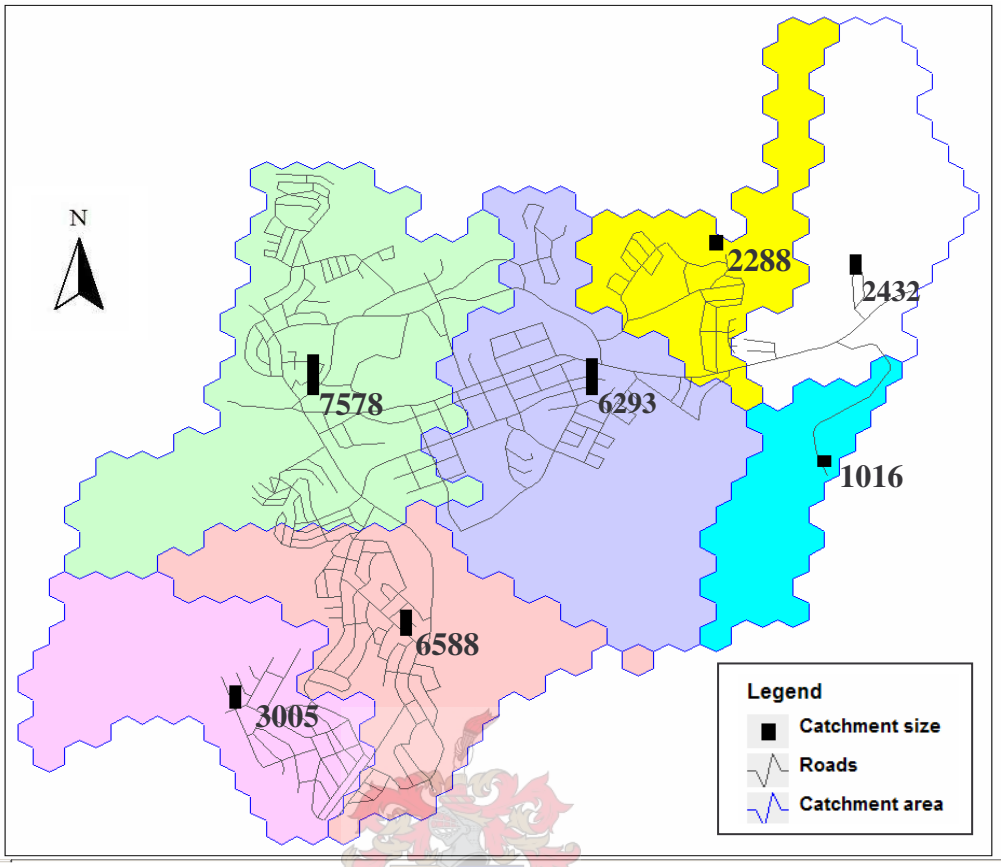

Figure 3.36: Number of people allocated to proposed police stations in Manzini.

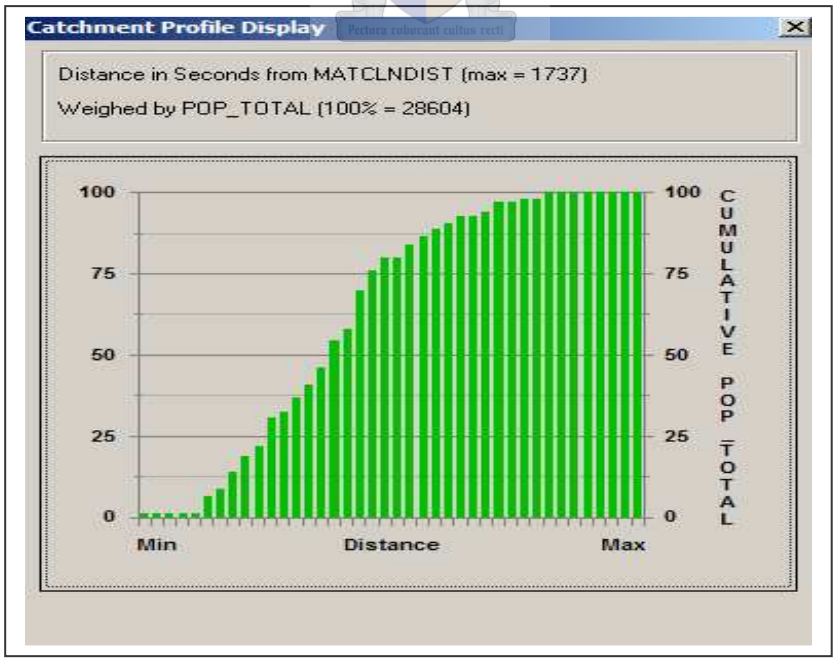

Figure 3.37: Service area profile of proposed police service locations in Manzini.

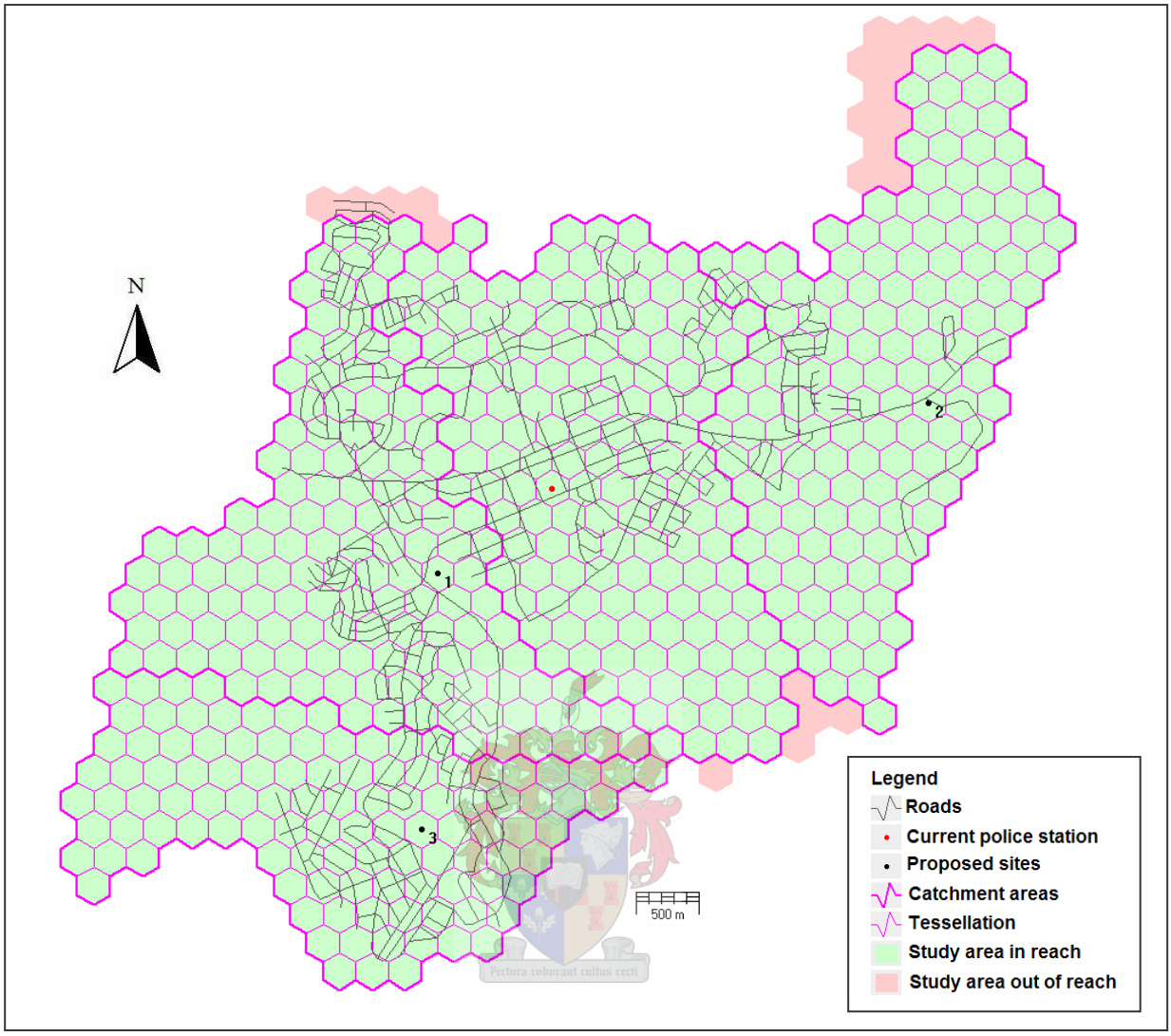

Figure 3.38: The best three locations that maximise resident coverage in Manzini.

Table 3.11: The locations of the proposed best three sites.

Station	Location
1	At the corner of Tenbergen Street and Dr. David Hynd Road, near Zakhele
2	At south eastern edge of Golf Course township, north of Ngwane Street
3	At Ngwane Park High School

The final task was to optimise the location of the current police station in a manner that would minimize average distance travelled. Figure 3.39 shows the result. The proposed optimised location of the current police station in Manzini is at the Zakhele remand prison.

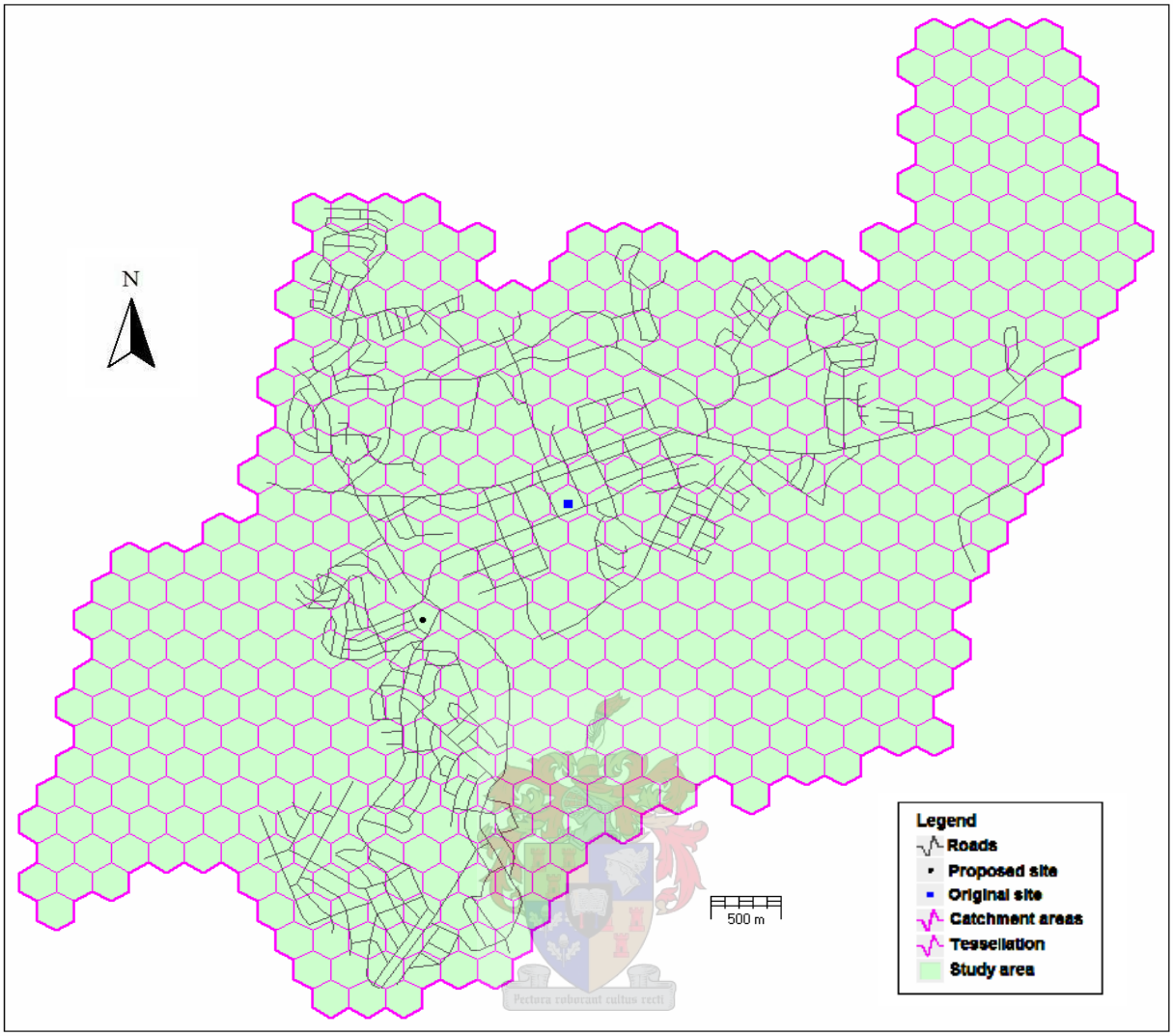

Figure 3.39: Best single location to minimize average distance.

CHAPTER 4
INTERPRETATION OF FINDINGS

This chapter discusses the findings of this study and explains how they can assist in the development of crime prevention strategies in Manzini. The initial results of the study show that Manzini is a city that is impacted by crimes against property. The fact that almost 60% (57%) of all crimes incidents occur in the CBD is an indication that more police resources should be concentrated in this part of town for crime prevention strategies to be more effective. With most crimes against property occurring in the CBD, visitors are more likely to be victims of theft, or robbery in the CBD of Manzini than in any other place. In addition, the fact that the bus rank has an exceptionally high record (22%) of crime incidents in Manzini, which cuts across all the crime categories used in this study, is an indication of where people in the CBD are most likely to be victims of crime.

The strong presence of criminal activity along roads like Ngwane Street, and Meintues Street is a good indication that such streets need to be monitored closely by patrolling officers. In residential areas, Ngwane Park Township and St Michaels High School may need special attention, as they recorded relatively high incidents of crimes against people. Fairview, Zakhele and the RFM Hospital which reported relatively high incidents of crimes against property require a stronger presence of police that can respond to such crimes.

The evident relationship between all categories of crime and retail areas in the CBD suggests that these areas are attractive for criminal activity in Manzini. This is especially so for those crime incidents against property such as theft. The influx of people visiting these parts of town during the day, presents opportunities for those individuals who intend to commit crimes. This is due to the increased possibility of distracting victims and “disappearing” in the crowd without being noticed or caught.

Nagle (1995) and Zietsman & Lochner (1998) had similar findings associating high incidents of crime with commercial areas of cities. Zietsman & Lochner (1998) found that more crime occurred in the CBD than in any other landuse zone in Paarl, South Africa. Nagle (1995) ascribed his similar findings to the fact that the CBD attracts crime from a wider area and that criminals are usually familiar with the CBD because they either work or socialise there.

The concentration of drug related crime incidents in the Manzini bus rank are indicative of several things. Firstly, that drug dealers are taking advantage of the concentration of people coming from all over Swaziland so that they can market and sell their drugs to them there. Secondly, it may be that drug dealing is well organized in other parts of the city like residential areas such that it manages to avoid the police's attention. Thirdly, it could mean that drug related crimes are not a problem in most residential areas in Manzini and that police need to focus their resources exclusively in the bus rank. Of all these possibilities, the latter is least plausible. If hearsay on how easy it is to obtain illegal drugs such as cocaine and marijuana in different areas of Manzini is anything to go by, then the police should note residential areas around places like Living Waters, which featured least prominently in this regard, with suspicion.

This study has shown that there is a relationship between areas of medium to high population density and crime in Manzini. Although areas such as the CBD appear to have medium population density values, it must be understood that such values only take into consideration the number of people living in these areas. As a regional centre, there is a concentration of people in the CBD of Manzini from all corners of Swaziland and beyond. As a result, the density of population in the CBD increases drastically during the day and becomes the highest populated area in Manzini. When using population census data, this relationship between crime and population density in the CBD of Manzini is not so evident. Therefore, caution must be taken when liking population concentration to the distribution of crime.

Several authors have identified the relationship between population and crime (see Chamlin & Cochran 2004; Fischer 1995; Van Steel & Pellenbarg 2000). According to Chamlin & Cochran (2004), the increase in population size in an area promotes various social interactions including criminal victimization. This is because it reduces the physical distance between members of a community while simultaneously increasing the number of potential associates within that community. Consequently, areas with higher urban population densities are expected to experience more criminal activity than those with lower population densities (Fischer 1995; Chamlin & Cochran 2004).

The proximity analysis shows that there is a relationship between crimes against property and alcohol-serving establishments. This suggests several things for crime prevention strategies. Firstly, it is an

indication, especially for those in the CBD, that these establishments are an apparent problem that needs special attention from the police.

Secondly, most alcohol-serving establishments that have a strong proximity relationship to crimes against property occurred along Ngwane Street and Meintues Street. The high number of incidences of motor vehicle theft along these streets can be attributed to the numerous parking opportunities along them. These streets, once again, need to be cautiously monitored.

Although proximity to alcohol-serving establishments was not as strongly associated with crimes against people as with crimes against property, it could be that the level of reporting for such crimes in these areas is not as well motivated. A need therefore exists to encourage people to report such crimes.

The findings of the proximity analysis are partly in line with those of Kumar and Waylor (2002). They found that the density and probability of all types of crime declines exponential with increasing distances from alcohol-serving establishments in Savannah, Athens. This study established that in Manzini the findings of Kumar and Waylor were only applicable for crimes against property and to a certain extent drug related crimes and crimes against public order. The slight difference in the findings of this study corroborates the observations made by Kumar and Waylor (2002) that we must be careful when drawing the conclusion that alcohol-serving establishments cause crime. This is because crime is a multifaceted problem and several socio-economic, political, demographic factors may affect the probability of crimes occurring besides distance from alcohol-serving establishments.

The proximity of crimes to educational establishments, although not strong, suggests that institutions like St Michaels High, William Pitcher College, Salesian High, and Manzini Central High need attention. St. Michaels was associated with assault related crimes. Known for its occasional bashes and late night functions these crimes can be attributed to such gatherings. The visibility of the police during these functions might help prevent assault from occurring there.

Areas close to educational institutions that were associated with housebreaking and theft have several similarities. Firstly, these institutions are located in very quiet neighbourhoods. During the day these institutions get very busy with students and other people. Workers at these institutions leave their

homes for work during the day. This makes it difficult for them to monitor their homes and serves as an opportunity for thugs to break in and steal their property.

The proximity of crimes to the Manzini police station suggests that the operational efforts of the police need to be focussed beyond 150 metres from the police station. Any concentration of police resources within this distance may not be in the best interest of crime prevention. The close proximity of incidents of crime to the Manzini police station is also an indication that locating police stations in areas where crime is high may not have any significant influence in reducing crime there.

The findings of the temporal analysis indicate that Manzini is a safer place at night than during the day. This is so for all categories and types of crime. It is also a reflection of the daring nature of criminals operating in Manzini and an indication of how temporal crime patterns can change there. In previous years, it was common to hear about most crimes occurring during the night, but today they tend to occur during the day. The main reason for this is that most people leave the CBD after five o'clock in the afternoon and therefore there are less opportunities for crime to occur. In residential areas, the same trend tends to occur, especially for crimes against property. During the day when most residents are at work, criminals seize the opportunity of invading their homes.

The significance of all this, as far as crime prevention strategies are concerned, is that the police should mobilize significantly more resources for crime prevention during the day than during the night. This mobilization however, must have spatial emphasis in the CBD in Manzini where residents and visitors are concentrated and are at a greater risk of being victims of crime. In this endeavour, emphasis should be placed on visible policing instead of undercover policing. This will create an atmosphere that can prevent criminals from committing crimes. Undercover policing on the other hand may increase the number of criminals being caught by the police and the number of prisoners in jail but may not necessarily prevent the crimes from occurring.

The morphological analysis shows that although factors like population concentration contribute to criminal activity in areas such as the bus rank and the Manzini market, so do the layout of these areas. The numerous noted exit and entry points and the absence of a barricade enclosing these areas are an indication that these areas cannot effectively defend themselves against crime in Manzini. The fact that

it is difficult to provide complete surveillance from at least one place in these areas also makes monitoring crime an even more difficult task for the police.

The findings of Loukaitou-Sideris (1999) suggest that bus stops like the bus rank which are adjacent to liquor stores and have many entry and exit points can promote criminal activity. These alleys serve as hiding places for criminals and can serve as important escape routes for them. Landman & Lieberman (2005), Loukaitou-Sideris (1999), and Jeffrey (1971) observed that the crime prevention strategy with the greatest potential involves heavy reliance on design and physical changes that can help reduce criminal opportunities in the environment. In the case of the bus rank and the market place, a solution to the crime problem should also entail a restructuring of this area. This would require that the bus rank and the market place be fenced with one entry and one exit point. This would introduce some control over those entering and leaving these areas, something impossible in the current situation. It would also enable the police to engage in surveillance that is complete and more meaningful.

The morphological analysis of JetMart store suggests that criminals are taking advantage of the limitations of the security provided there. CDs/DVDs which were the most targeted goods had a security feature that was linked to an alarm system which detects all CDs/DVDs that leave the store without being paid for. The limitation of this security feature is that it can easily be removed from a disc. Once this is done, the CD/DVD can be concealed and can not be detected by the alarm system when taken out of the store.

In addition, the fact that JetMart is a large and relatively new store that sells goods which appeal to a variety of consumers, also makes it vulnerable to crime because it has to gradually "learn" to defend itself from crime. Information obtained from officials at JetMart shows that most incidents of theft occur when the shop is actually least busy. This appears to be because criminals fear being spotted and reported by other customers when stealing at the time the store is full. Furthermore, when the store is least busy, the security guards may have a tendency to be least suspicious and more relaxed since there are fewer people to monitor. This serves as a perfect opportunity for thugs to take advantage of and steal.

The high dependency on security television cameras, instead of workers for security does not appear to do the JetMart much good. There are limits on the mental concentration of limited security guards

viewing television screens to monitor the movements of people in such a large store. Therefore, a more visible presence of security guards may reduce the possibility of people taking chances to steal from there.

Accessibility analysis indicates how the police, from a GIS service-location planning point of view, can better serve people. From a crime prevention point of view, accessible police stations are supposed to facilitate crime reporting and ensure improved police visibility. In this study, the location of suitable police service was determined, using the Coverage Model in Flowmap. Seven police stations are required to ensure that people do not walk more than 30 minutes to the nearest police station in Manzini. This kind of application is useful when the police want to disregard the current police station location in their planning and identify new sites that would be more accessible to residents of a particular area. An attempt to optimise this result using a Relocation Model reflects the desire to improve this accessibility situation even further.

In situations where the police would like to determine additional sites for police stations, while considering the location of current or existing stations, the results of the Expansion Model would apply. Where resources are limited but a will exists to improve the accessibility of only one police station, the Relocation Model can also be used.

The findings of the accessibility analysis revealed that a number of the proposed sites for police station location are in close proximity to Ngwane Street. In the light of the relatively high concentration of crime along this street, such findings are intuitively sensible.

CHAPTER 5
RECOMMENDATIONS AND CONCLUSION

The purpose of this research was to analyse the spatio-temporal pattern of crime in Manzini for the year 2004 and determine suitable locations for future police stations in a manner that can assist in the development of crime prevention strategies.

This study has shown that combating crime in Manzini is an activity that will require intervention from law enforcement agencies and planners for it to be completely successful. The future planning and design of Manzini should be seen as an activity that plays a crucial role in crime prevention. For areas of crime concentration like the bus rank, the market place and JetMart, investment in security barriers together with an increased presence of law enforcement officers would be an effective approach to crime prevention in Manzini.

The findings of the accessibility analysis are an indication of the financial commitment that the Royal Swaziland Police needs to consider to ensure that it serves the residents and visitors to Manzini efficiently. Improved accessibility to police stations will complement the efforts of the police and the Manzini City Council in their endeavour to combat crime in Manzini.

The main problems encountered in this study are not only limitations for this study but are also applicable to the analysis of crime and the implementation of crime prevention strategies in general for the whole of Swaziland. The first problem and probably the most important one is related to the police's lack of spatial emphasis when geo-coding incidents of crime. Only the locations of crime incidents that were recorded for areas in the CBD of Manzini were done so accurately. This was mainly because there was, for instance, only one bus rank, one Bhunu mall, one Clicks, Shoprite Checkers and Sales House store in Manzini. However, as the location of crimes entered residential areas, the resolution at which they were recorded became unacceptable for proper crime analysis. Almost all recorded crime locations in residential areas were merely associated with the residential area itself rather than the actual location of the incident. This made it impossible to map the spatial pattern of incidences of crime in these areas accurately.

The problem of not specifying the actual location of incidents of crime in any area is that it limits the ability of the police to target resources exactly where they are required. Instead of patrolling certain

streets where crime is a problem, an entire area could be patrolled for the mere fact that the statistics show that the whole area is affected by crime. This wastes resources and time and does not make crime prevention strategies effective. This is particularly important for residential areas in Manzini which recorded a relatively high number of incidents of crime in this study.

It is recommended therefore that the Manzini police place more emphasis on exactly where crimes occur when they record this information. Furthermore, they should do so consistently. This can be achieved by recording crime locations using cadastral information, street addresses (see Ratcliffe 2004a), or global positioning systems (GPS) with the aid of a GIS to present a more precise indication of where crimes are occurring. Although the latter approach is a more expensive approach, it has the potential to improve crime analysis in Swaziland due to its higher accuracy result.

Another problem experienced in this study was related to the inconsistencies in the way in which the temporal dimension of crime was recorded. In some cases, the actual time an incident of crime occurred was recorded while in others the specification was according to whether the crime occurred during the day or during the night. This forced the analyst to use the broader categories of day or night and compromised the temporal accuracy of the analysis. It therefore should be ensured that there is greater consistency of recording in the crime databases the police use.

The third problem experienced during this study extends beyond the bounds of this study and raises serious concerns for the extent to which population planning can be effective. Up to now no data exists in Swaziland to show the spatial extent and the population of the various townships in Manzini (Dlamini 2005a, pers com). According to Dlamini (2005b, pers com), the Manzini city council has no accurate indication of what the population size in the various township actually is and this makes planning problematic. Township boundaries and enumeration area boundaries in Manzini do not coincide. This makes the task of determining the relationship between townships and crime or demographic data very laborious and time consuming. It goes without saying therefore, that the Ministries responsible in Swaziland should either formally make use of the township boundaries and population data created during this study or embark on a mission to define the spatial extent of townships in Manzini and the Swaziland at large. This will improve population planning at the local municipal levels.

The fourth problem was that crime statistics were not readily available in a digital spatial format. Instead, they were manually documented in crime registers. This was a problem because it slowed down the data capturing process and thus forced the researcher to resort to sampling the data. Having a complete digital database enables the researcher to make full use of GIS's capability of handling large volumes of data. This speeds up analyses, permits the in-depth investigation of crime, and strengthens the reliability of findings of a crime investigation. A prospect like this can help the police make quicker and well-informed decisions.

It is therefore important that the relevant staff of the Royal Swaziland Police are trained to capture and analyse crime related information using a GIS and that hardware (computers) and software (programs) be made available to facilitate this. GIS expertise can be hired to facilitate the training of police officers on a consultancy basis at least until training is completed.

In conclusion, there is a need for future research on crime in Swaziland. This can only be to the benefit of the country. Although this study was conducted for 2004, it would be useful to widen its temporal scale to see how the spatial crime patterns have changed over the years. This can help the police in crime forecasting, an activity that can improve the distribution of police resources with a long-term focus in mind. A comparative study of crime in other locations can also give the police a broader understanding of why spatial-temporal patterns of crime differ or are similar from one location to another. From a GIS service-location-planning point of view, it would also be useful to know where police posts (temporary police stations) could be located to improve the response time of the police to crime scenes. This can help ensure that the police are on time especially when people's lives depend on their quick response.

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APPENDIX 1

Landuse classification system by Sabins (1987) in Arnold (1997): Level II

Category	Description
1 Residential	- Single unit dwellings of low, medium and high density, - Multiple dwellings of low/high-rise (2/3 stories or more) - Mixed residential areas
2 Commercial and services	- Retail sales/wholesales and services - Trucking and warehousing - Office and professional services - Hotels and motels - Cultural and entertainment - Mixed commercial and services
3 Industrial	- Light industrial - Heavy industrial - Extractive - Industrial under construction
4 Transportation	- Parking areas - Bus and truck terminals - Major roads and highways
5 Utilities	- Sewage treatment facilities - Water supply/treatment plants - Energy facilities (electric and gas) - Solid waste disposal facilities
6 Institutional	- Educational facilities: Schools, universities, colleges - Religious facilities - Medical and health care facilities - Military facilities - Government, administration, and service facilities - Cemeteries
7 Recreational	- Golf courses - Parks, Zoos - Stadiums, fairgrounds, race tracks
8 Mixed urban	– Mixture of all some or all landuse types
9 Open land	- Undeveloped land within urban areas - Land being developed intended use unknown