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**A SPATIAL ANALYSIS OF ASSAULT PATTERNS IN
ENTERTAINMENT AREAS THROUGHOUT THE
WAIKATO USING GEOGRAPHIC INFORMATION
SYSTEMS**

**A thesis
submitted in fulfillment
of the requirements for the degree of
Master of Social Science
at
The University of Waikato
by
By Geoff Hughes**



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Abstract

Alcohol related violence has long been a matter of social concern. Recent studies investigating the association between assaults and alcohol have found that there are certain places and locations including bars, which are more commonly associated with assaults than other places. Using different spatial analysis techniques accommodated within a Geographic Information System (GIS) including point and choropleth density, Euclidean based distance measures, clustering analysis and geographically weighted regression, this study examines the association between bars and assaults in the Waikato region. It also seeks to explain the assault patterns around bars by various theories, namely the “Social Disorganisation Theory”, “Routine Activity Theory” and the “Crime Potential Theory”.

The study determined that for the two year period (2008-2009) in the Waikato Police district there was clear evidence of higher assault levels being associated with areas of higher bar densities. In Hamilton’s CBD there was a particularly strong relationship between assaults and bars where around 25% of all assaults took place within 10 metres of a bar and approximately half of all assaults took place within 50 metres of a bar. Over the study period, one meshblock in Hamilton’s CBD recorded approximately 45 assaults per square kilometre per week. Elsewhere in the Waikato, the study showed a reasonably strong relationship between assaults and bars at the coastal resorts of Whitianga, Raglan and Coromandel township. In these townships, there was a discernable, but lesser relationship to that of the Hamilton CBD, with around 15-25% of assaults taking place within 10 metres of a bar. The assault density in the centre of these coastal townships, as well as other townships throughout the Waikato was generally lower, recording 3-4 assaults per square kilometre per week. Suburban areas in Hamilton City showed similar assault densities to that recorded in the centre of townships throughout the Waikato.

The study findings were found to be generally consistent with the Routine Activity and Crime Potential theories by conclusively demonstrating that **place**, in

this instance, bars, and their location, influences the distribution of assaults. The study examined **population characteristics** only in respect of population density and its proxy, road density, but these variables were not found to be particularly accurate in predicting the distribution of assaults.

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Geoff Hughes

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Chapter 1: Overview

1.1 Introduction

The ongoing problem of crime has been recognised and addressed in many different ways by different societies over time. Recent technological advancements have meant there has been an increased ability by both public and private organisations to map crime patterns and as a result an increased awareness and understanding of criminal activity has been achieved. Advances in geographic information systems (GIS) and spatial analysis have coincided with a desire on the part of both private and public sector agencies in New Zealand and overseas to assemble more comprehensive spatially related information on various aspects of their functions. Internationally, this analysis has been partly driven by strengthened statutory requirements, such as provided for under the Crime and Disorder Act (1998) in the United Kingdom which mandates audits and complementary analysis by police and associated local partnerships such as local government (Hirschfield and Bowers 2001). So too, considerable academic research has also been undertaken by central governments to study the effects and impact of crime in areas of special social, cultural or economic significance (Jochelson 1997).

Recent studies of areas that have particular significance to a country have highlighted the fact that there are locations or 'hot-spots'¹ of crime where there is shown to be higher rates of crime as distinct from other areas. These studies have also shown that the impact of crime is found to have a negative impact not only on the victim, but also on the criminal justice system and public health authorities (Finney 2004). The tangible effects of assault related crime are the financial cost of this activity which was estimated to be AUS\$1.4 billion or AUS\$1,800 per assault per year (Mayhew 2003). The intangible effects of crime (including violence related crime) are often evidenced in declining tourism business that results from negative publicity and media reporting (Bloom 1996).

¹ Hot-spots are defined by Sherman (1995 36) as "small places in which the occurrence of crime is so frequent that it is highly predictable, at least over a one-year period".

The 1997 study by Jochelson also found that 20% of all arrests in the survey period came from three licensed premises including a bar and restaurant, a bar/nightclub and a bar/strip club in Kings Cross, Sydney (Jochelson 1997 21). The significance of these studies was raised by Sherman(1995) who confirmed by reference to a study by Wolfgang, Figlio and Sellin (1972) that “crime is six times more predictable by address of the occurrence than by the identity of the individual, why aren't we thinking more about wheredunit, rather than just whodunit” (Sherman 1995 37). It is therefore fundamental to much crime analysis that the importance of place is recognised.

An increased public awareness of the continued problems of violence and disorder associated with entertainment venues and facilities has led many community representatives to query the relationship between alcohol, entertainment facilities and violence. Increasingly, it appears that the need for research on the influence of alcohol on violence is important given the conclusions of prior research (such as the conclusions reached by Jochelson). The importance of such research is important to New Zealand given the significance of such events as the upcoming 2011 Rugby World Cup and the social and financial repercussions of violent crime. The possibilities of increased rates of violent crime during this time at venues and land uses associated with the event may well have a negative impact on the tourist industry of New Zealand and affect tourist perceptions of this country.

To date, much of the research investigating links between alcohol outlet density and violence in New Zealand has been on the social impacts of alcohol outlet density. Studies such as “The impacts of liquor outlets in Manukau City” (by Cameron, Cochrane, McNeill, Melbourne, Morrison and Robertson, 2010) have examined these social impacts by reference to alcohol outlets throughout Manukau City. However, there is little evidence of research to date on the *spatial* distribution of assaults around bars and associated land uses elsewhere in New Zealand including the Waikato. Analysing the spatial distribution between bar and assaults using geographic information systems will provide insights into opportunities for crime as determined by the characteristics of

assault distributions around bars and other land uses. The current knowledge gap regarding the spatial distribution of assaults around bars in the Waikato certainly provides an opportunity for further research in this area with the possibility of extending the study methodologies to a national level.

1.2 Research Aim

The aim of this research is to develop and apply a geographic information system to analyse assault patterns around licenced bars, nightclubs and sports clubs throughout the Waikato. The results of the analysis will provide an insight into the spatial geography of crime throughout the Waikato and, among other outcomes will assist the police in determining resource allocation with a view to reducing assault offences throughout the district.

1.3 Research Objectives

There are four objectives in this research.

1. Testing the hypothesis that there are increased densities of violent crime (assault) around bars and associated land uses.
2. Finding out if assault patterns around bars can be explained by well established crime theories such as the Routine Activity Theory and Social Disorganisation Theory and other recently developed theories including the Crime Potential Theory.
3. Comparing assault patterns in this study with those found in other studies so as to determine whether there are any similarities of patterns found in other parts of the world where similar research has been conducted.
4. Comparing spatial analysis techniques and investigating the benefits and limitations of these techniques of each approach in the analysis of assault and bar data.

1.4 Thesis Organisation

The first section of the thesis provides the background to the research by briefly reviewing the geographical location of the study area and the background to the

history of alcohol related legislation in New Zealand. This is followed by definitions of terms used in this thesis, namely those of “assault” and “entertainment precincts”.

The second section of the thesis first explores theories on the relationship between alcohol and assault, then crime theories with reference to assault, and finally, that of contemporary spatial analysis theories. These theories provide a conceptual framework to analyse the spatial distribution of assaults with a particular focus on bars and associated land uses.

The third section of the thesis explores the research design, followed by data collection and limitations of the data collection process.

Attention is then turned to the analysis of data that apply the theoretical concepts defined previously. The application of a variety of different techniques is applied to the data including the more commonly used density analysis techniques, as well as Euclidian-based distance techniques and the recently developed geographically weighted regression technique. The next section includes a summary of the results from the analysis, followed by the study conclusion including opportunities for future research.

The appendix comprises a decision matrix with the strengths and limitations of each spatial analysis function and the weighting given to each function in the first section (Appendix A). The second section (Appendix B) includes a map of the wards located in the Waikato region. The third section of the appendix (Appendix C) includes the models used to automate the spatial analysis process.

Chapter 2: Background

2.1 Geographic Scope of the Research

The research investigates the spatial relationship between bars and assaults in the Waikato, a region situated in the northern part of the North Island of New Zealand. The urban centres in the region have historically developed primarily to service the agricultural and mining sector (King and Morrison, 1993). The decline of the mining sector in some areas has been complemented by the rise in tourism in places such as the Coromandel Peninsula. In 2006, 382,716 people lived in the Waikato region (Environment Waikato, 2010 a) and of this demographic, 129,249 lived in Hamilton city (Environment Waikato, 2010 b).

Although the majority of people in the district are concentrated in Hamilton City, there are significant concentrations of people to be found in the urban settlements of Cambridge, Otorohanga, Te Awamutu, Thames, Huntly, Coromandel township, Matamata, Morrinsville, Raglan, Whitianga and Te Kuiti. Townships that serve the agricultural sector have stable populations throughout the course of the year whereas other towns have a large influx of holiday makers due to their potential as holiday “hotspots”.

The results of a survey conducted by Thames-Coromandel District Council show that the population of the district can increase from 26,000 throughout the year to 135,000 during the summer period (Thames Coromandel District Council, 2010). The significance of these data is that any temporal and spatial variation influences the distribution of people and that of assault patterns. The association between population distribution and assault will be explored further in the thesis.

Elsewhere, the Waikato region is sparsely populated with a mix of lifestyle blocks and large pastoral holdings. The area is well served with a network of roads – state highways and local arterial routes that afford fast links between urban centres and rural areas.

The boundaries and main towns of the Waikato police district are given below:



Figure 1: Boundaries of Waikato police district (source New Zealand police website)

2.2 The Legislative Framework for Alcohol Control in New Zealand

In New Zealand, liquor licensing has been dictated by the Licensing Act (1881) and subsequent legislative reforms through the Sale of Liquor Act (1989). Significant legislative changes regarding alcohol licensing in New Zealand for regulation purposes have been first, simplification of existing legislation making it easier to apply for a license; second, lowering of the minimum purchase age from 20 to 18 in 1999; and third, increased powers transferred to local authorities to control the consumption of alcohol in local areas through the introduction of the Local Government Act (2002) (The Law Commission, 2009). Just under half (30) of New Zealand's 72 district councils now have permanent year round liquor bans and 15 councils have introduced seasonal bans at beaches, holiday spots and festivals (Webb, Marriott-Lloyd and Grenfell 2004). In

the Waikato, permanent liquor bans are now in force in a number of public areas throughout the region through enforcement of the Local Government Act 2002.

The implementation of legislation in New Zealand controlling the sale of liquor has seen timely and relevant audits accounting for the ways District Licensing Authorities are managing their liquor licensing responsibilities. Results of an audit by the office of the Control and Auditor General (2009) found that compliance by District Licensing Authorities was adequate however procedures were not always followed and documentation was not always provided. Overall, it appears as though progress has been made in terms of refining alcohol related legislation to better reflect community norms and expectations, it must be recognised that this is a controversial area of law which is continually under review. In this regard, the minimum purchase age will probably attract ongoing debate.

2.3 Defining the Entertainment Precinct

Humans are social beings and it is the interaction of people with each other, it is argued, that drives processes (Haralambos, van Krieken, Smith and Holborn 1996) and gives rise to development and change in society. In Western society, the development of leisure time or “the time that is left over after basic survival needs have been met” (Sayre and King 2003 3) has been one of these changes. The requirement for leisure time has given rise to the growth of activities, such as the pub experience that was traditionally the domain of the working class male whose leisure culture has now become more “domestic and private” (Sumner and Parker 1994 26) due to the changing socio - economic environment. The “homogenisation” of the class based society (Winlow and Hall 2008) and higher disposable incomes have contributed to larger numbers of younger people drinking earlier than previously (Sumner and Parker 1994). It is clear that the social characteristics of today’s leisure scene are closely related to changing social structures and dynamics. Increased personal mobility is a major factor which has enabled the growth of coastal resorts and entertainment facilities at a range of urban and rural locations.

Given the influence of different factors that define today's leisure scene there are several pertinent questions that must be addressed in an attempt to define what land use is included as an "entertainment precinct".

Scale of settlement: In larger urban centres, including Hamilton, there is often a concentration of entertainment facilities making the definition of a precinct relatively easy. In smaller towns with one or perhaps two pubs and no night clubs, it is more difficult to ascribe "entertainment precinct" to these premises even though they may form the social centre of the town.

Zoning issues: There is no defined planning zone set aside for any entertainment precincts in any District Plan throughout the Waikato region. In Raglan, for example, the locations of drinking establishments are located in the wider "Business Zone" or "designated areas" as defined in the Operative Waikato District Plan. Likewise, the predominance of bars and nightclubs situated in the "City Centre" of Hamilton City (as defined in the Hamilton City Council District Plan) are split between a "City Centre" zone north of Hood Street; and a "Commercial Service" zone to the south and east of Hood Street (Hamilton City Council, Proposed District Plan November 2001). This pattern is repeated throughout the Waikato District, and as a result definition of entertainment precincts by this method remains problematic, although there is a general pattern of entertainment areas being located in business or city centre zones.

More recently, the function of zoning using New Zealand cities as an example has changed considerably, from that of "exclusivity" of use to emphasizing a particular aspect or activity, such as "Maximising vehicle and pedestrian access to the core"(Hamilton City Council, Proposed District Plan, September 2009, City Centre zone Rule 4.3-1) which has been reflected in "increased provision for inner city living, visitor accommodation and educational/cultural facilities in the central area" (Hamilton City Council, Proposed District Plan, September 2009. City Centre zone Rule 4.3-1). As generic as this statement is, the inference is one of promoting a variety of activities within an area and highlighting environmental concerns, rather than one exclusive activity. This applies across a range of business and residential zones which in recent years have undergone a change in

function from single purpose to multiple activities governed by performance standards.

Zoning patterns reflect existing groupings of activities which have evolved over time. They do not determine these grouping but a zoning can either reinforce or weaken particular groupings. In some situations, local authorities can 'zone out'; particular activities for environmental reasons; more commonly, they seek to ensure that 'like activities' are grouped together and managed through carefully drawn performance standards governing such matters as traffic generation, noise, hours of operation, *etc.* (refer Hamilton City Council, Proposed District Plan, September 2009). Thus today, most bar/nightclubs and off licences whether in a central or suburban location are within general business zones with retail, offices and the like determining the geographic extent and character. In the main they enjoy a degree of buffering from residential areas and are often located on main routes with high levels of access and car parking.

Land Use Category: It would seem that there is no statutory definition of an "entertainment precinct" through zoning alone as this activity is found in a range of zonings including business, industrial and even residential. Thus the research has therefore included places that are primarily used to drink alcohol when socialising, akin to what is used in a study by Roncek and Maier (1991). Places with a licence category of "bar", and "tavern" have been included as have those places with "sports club "or" lodge" licences. Lodges are considered retreats often used for weddings and other social events. Restaurants and cafes have been excluded from the study as these places are not primarily associated with the consumption of alcohol. A total of 323 (successfully geocoded) places of entertainment have been identified throughout the Waikato region with a significant number of these places (30% or 98 bars and related activities) located in Hamilton's CBD.

2.4 Defining Assault

An assault may be defined, according to the Crimes Act (1961 section 2), as "the act of intentionally applying force to the person of another, directly or indirectly,

or attempting or threatening by any act or gesture to apply such force to the person of another, if the person making the threat has, or causes to believe upon reasonable grounds that he has present ability to affect his purpose” (Spiller and Hinde 2005 23). In New Zealand, criminal assault is defined according to the degree to which assault has been perpetrated on a victim. There is a scale depending on the severity of assault, ranging from a maximum of one year’s imprisonment for assaults where there is no injury resulting or intended; to a maximum of 14 years for wounding or maiming with intent to cause grievous bodily harm. (Newbold 2000).

Chapter 3: Theory

A theory is defined as “a judgement, conception, proposition or formula (as relating to the nature, action, cause or origin of a phenomenon or group of phenomena) found by speculation or deduction or by abstraction and generalisation from facts” (Gove 1993 2371).

This chapter examines various perspectives which have been developed to explain various elements of and the interaction between, alcohol use, crime, place, and more specifically, violent behaviour. There follows a review of different relevant contemporary spatial analysis theories developed to analyse and represent a range of social interactions including the association of assault patterns around bars.

3.1 Theory on the Relationship between Alcohol Consumption and Aggression

Alcohol use in Western society today has been recognised as being “part of the normal socialisation process” (Deehan 1999 3). However, it has been acknowledged that the excessive consumption and misuse of alcohol is a widespread problem in many societies throughout the world. There is a consensus that there is a robust correlation between alcohol use and aggressive behaviour (Lau, Pihl and Peterson 1995; Valdez, Kaplan, Curds, and Yin 1995; Wiley and Weisner 1995). Some researchers conclude that violence stems from episodes of acute drinking or from patterns of use including binge drinking (White 1993). Therefore understanding the mechanisms by which alcohol use contributes to violence is deemed important.

Several theories have been postulated to explain *why* people become more violent through the consumption of alcohol. These theories, according to Graham (1980) may be categorised as 1) “direct cause” 2) “indirect cause” 3) “indirect cause conditional on motive for drinking” and 4) “predisposition/situational”. They cite environmental, social, or a combination of

physiological or social factors in influencing human behaviour (Bushman and Cooper 1990).

In the first category of theories, the “direct cause” theory, the physiological disinhibition theory recognises that alcohol is regarded as a “disinhibitor” by anaesthetising the centre of the brain that normally inhibits aggressive responding. With the second theory, “indirect cause” theory, increased consumption of alcohol facilitates aggressive behaviour “by causing certain cognitive and physiological changes that increase the probability of aggression” (Bushman and Cooper 1990 342). The third set of theories, the “expectancy” theory hypothesises that “men drink primarily to feel stronger” (McLelland, Davis, Kalin and Wanner 1972 334) and the influence of like minded individuals may reinforce this sense of power (Deehan 1999; Raistrick, Hodgson and Ritson 1999; Homel, McIlwain and Carvoth 2001). The final theory relates to how situational factors affect aggression. In this theory the relationship between alcohol and aggression as postulated by “Direct cause” theorists is considered to be rather tenuous and that the role of environment in influencing aggressive behaviour is a more important determinant than alcohol.

The predisposing factors that are hypothesised to influence aggressive behaviour include first, the nature of the individual in a suitable setting that assists in premeditating aggression (Boyzatis 1975). Second, the psychological effects of alcohol are expected to increase aggression (Lang, Goeckner, Adesso and Marlatt 1975) and third, and perhaps the most commonly held view that the risk of aggressive behaviour increases in environments that typically have “poor ventilation and smoky air, inconvenient bar access, inadequate seating, and high noise level and crowding.” (Homel *et al.*, 2001 724). Homel argues that these factors relating to the flow of people (flow models) are “plausible” (Homel *et al.*, 2001 724) in increasing the likelihood of assaults or aggressive behaviour taking place between intoxicated or irritable patrons.

While theories explored previously have been developed to explain the relationship between assault and the effects of the bar-room environment, there have been few theories that have been developed to explain the variation in

assaults that may exist between different bars. More recently, it has been contended by Gruenewald (2007) that the variation in assaults at each establishment is due to niche marketing and the “character of clientele” (Gruenewald 2007 875) that are present at each drinking establishment. Here the needs and services of the establishment adapt to the needs of the drinker and a supply-demand flow between consumer and commercial interest is created. The segmentation that evolves as a result of these processes may mean that some establishments may be more at risk or more prone to violence than others. Some of the research that has developed therefore appears to have made not only an association between aggressive behaviour and environment, but also a link between aggression, environment and commercial interests.

To date, testing the influence of alcohol in the bar-room environment remains problematic. While the results of experimental, controlled studies testing the effects of alcohol support the expectancy theory (e.g Pihl 1983); observational studies have only been able to conclude that certain patterns of drinking including binge drinking (8-10 drinks per session) increase the risk of assault either as an offender or victim (Shepherd 1994; Shepherd and Brickley 1996). According to Finney (2004), there does not appear to be any conclusive evidence to suggest that drinking in the “Night time economy” (i.e. the night time entertainment industry) will lead to violence.

The theories that have been developed to explain the relationship between assault and alcohol conclude that societal and environmental factors are important. While it is acknowledged that societal norms differ from culture to culture, there appear to be certain similar environmental and social “triggers” that increase the probability of aggressive behaviour. The need to further study these interactions within the context of the entertainment scene will continue to be a focus of research.

3.2 Crime Theories

3.2.1 Social Disorganisation Theory

The central premise to Social Disorganisation Theory is that community breakdown and reduction in informal controls lead to increases in crime rates Jensen (2003). The theory was developed in the early 20th Century by sociologists within the auspices of Chicago School of Ecology at the University of Chicago to explain “the interdependence of recurrent patterns of behaviour in society” (Palen 2008 73). Large scale immigration to the United States affected social patterns of behaviour during this period. Since the earliest years of the 20th Century, different crime measures have been applied to explain variations in crime at the neighbourhood level. Variations in crime are tested through the use of demographic, economic, social or familial indices (Andresen 2006), including population density, income, employment, and ethnic heterogeneity.

Appropriate use of variables to test levels of social disorganisation has been subject to considerable debate. Heitgerd and Bursik (1987) suggest that traditional ecological studies are not suited to an examination of the informal networks of social structure due to an over reliance on census data. There has also been criticism levelled by Sampson and Groves (1989) of typical indices used to measure levels of social disorganisation such as income and employment that are argued as not adequately explaining the relationship between delinquency and community structure. Instead, Sampson and Groves propose that the relationship between the two factors are more appropriately measured using levels of local friendship groups, community participation and unsupervised peer groups.

Other measures including “collective efficacy” (Sampson, Raudenbush and Earls 1997) have been proposed to assess levels of informal control in the neighbourhood by looking at levels of adult guardianship. Alternative qualitative methodologies to measure levels of social disorganisation have been proposed including ethnographic research that provides “rich descriptive accounts of community processes central to theoretical concerns” (Sampson and Groves

1989 775). However there has been some criticism of these methodologies in that ethnographic studies often provide limited tests of theories as they focus on single communities or a cluster of neighbourhoods (Reiss 1986).

There has been considerable recent research on the relationship between neighbourhood violence and bars. (Alaniz, Cartmill and Parker 1998; Gorman, Labouvie, Speer and Subaiya, 1998; Speer, Gorman, Labouvie, and Ontkush, 1998; Scribner, Cohen, Kaplan and Allen, 1999; Stevenson, Lind and Weatherburn, 1999; Gorman, Speer, Gruenewald and Labouvie, 2001; Lipton and Gruenewald, 2002; Gruenewald, Friesthler, Remer, LaScala and Treno, 2006; Livingston, 2008). The research concluded that there is a correlation between alcohol outlet density and assault density at the neighbourhood level.

Other research by Friesthler (2004) focuses on the association specifically between youth maltreatment and access to control and findings show that neighbourhoods with higher poverty, female headed households, Hispanic residents, population loss and greater densities of bars have higher rates of assault. Friesthler (2004) suggests there has been a recent focus on limiting access to alcohol outlets through intervention in those environments that are seen as being vulnerable to an increased likelihood of assault. Other testing of social disorganisation within a neighbourhood has typically been undertaken using population characteristics such as socio economic deprivation, family disruption, itinerant poor, or immigrant levels (Andresen 2006).

There has been some criticism levelled at the use of the Social Disorganisation Theory to test assault levels in that the measurement indices used in testing social disorganisation are not typically related to offender motivation (Brantingham and Brantingham 1981). There also appears to be limitations in the geographic extent of research as well; to date research on the influence of bars on assault rates at the neighbourhood level has been mainly limited to the United States. While these studies have shown there to be broadly similar associations between assault and bars, similar research in other parts of the world may come to other conclusions as a result of the influence of local social and economic factors.

Another limitation of the Social Disorganisation Theory concerns studies that measure collective characteristics at the neighbourhood at the neighbourhood or other aggregate levels. Such aggregate measures “mask” variability in independent variables (i.e. social indicators) across a unit of study such as a meshblock. Evidence tends to indicate spatial variability even within a unit of study (Taylor and Gottfredson 1986) and further empirical research is required at a sub-neighbourhood level to explore any variation at that level.

The role of the neighbourhood has been explored in explaining variations in assault and violent crime. Accounting for limitations in the use of social disorganisation, this theory that uses the neighbourhood as its basis offers a popular and well acknowledged perspective from which to analyse the association between bars and assaults. A particular advantage is that the “Social Disorganisation” approach is reflective of the local characteristics of a population.

3.2.2 Routine Activity Theory

The results of research into the relationship between bars and assaults at the neighbourhood level based on the Social Disorganisation Theory would suggest that the more well off society is, the lower the level of crime. However, a report by the National Commission on the Causes and Prevention of Violence² showed that even though indicators of well-being improved throughout the 1960’s decade, crime rates actually increased (Felson and Cohen 1979). This paradox was recognised by Marcus Felson and Laurence Cohen who proposed that reduced guardianship, motivated offenders and suitable targets were definitive elements that gave rise to criminal opportunity in place and time; these findings provided the foundation for the “Routine Activity Theory”. Recent amendments to this theory have recognised that there must be an absence of controllers who have direct formal authority of people, including handlers (Felson 1986) as well as guardians, teachers or coaches (Eck and Weisburd 1995). The Routine Activity

² The National Commission on the Causes and Prevention of Violence was an advisory body formed in United States in 1968 by United States President Lyndon Johnson.

Theory hypothesises that potential offenders are more likely to commit crimes when there is reduced guardianship, increased motivation or suitable targets.

The main differences between the Social Disorganisation and Routine Activity Theory are that whereas the Social Disorganisation Theory emphasises neighbourhood population characteristics as influencing crime rates, including that of external influences; the Routine Activity Theory gives greater importance to place and the confluence of opportunities for people in place and time for crime and the personal circumstances of offenders.

The convergence of criminal activities in place and time has developed from the Ecological Theory of Hawley (1950) that treats “the community not simply as a unit of territory but rather as an organisation of symbiotic and commensalistic relationships”(Felson and Cohen 1979 589). The Routine Activity Theory was originally developed to focus on the routine activities of people, but research by Felson(1987) recognised the potential of the theory when applied to place. Spring and Block (1988) and Sherman, Gartin and Buerger (1989) studied the criminogenic potential of place by locating crime “hot-spots” using spatially referenced data. Sherman explained the potential for crime in places due to varying patterns in predatory crime rates in the same location in Minneapolis. The studies concluded that certain crime “hot-spots” were more likely to be associated with some places than others. The Sherman *et al.*, (1989) study found that hot spots may account for up to 50% of police calls and recognised that 10 out of 42 hotspots contained bars (Broidy, Willits and Denman 2009). The other places which were crime hot-spots were seen as attractors for low guardianship (Lipton, Gorman, Wiczorek and Gruenewald 2003).

Since the 1980’s there have been several studies testing the role of place as opposed to neighbourhood population characteristics in explaining assault and crime patterns around bars (Roncek and Bell 1981; Roncek and Pravatiner 1989; Roncek and Maier 1991; Block and Block 1995). All of the studies investigated as part of this research project into the relationship between assault and bars support the findings that place influences crime rates and more specifically, where there are bars there is a greater likelihood of crime.

The study by Roncek and Pravatiner found that where bars are found on a block, there is an increase of 3 1/3 crimes per bar. Likewise, the results from the Roncek and Maier (1991) study clearly show that there were higher rates of crime on residential blocks with taverns than on other areas. However, the land use with the most crime happened to be a large public housing project. The findings of the studies clearly demonstrate the relevance of the Routine Activity Theory in “reaffirming the importance of place and facilities” (Roncek and Maier 1991 749).

As with “Social Disorganisation” theories, there has been much debate with the Routine Activity Theory as to what variables are used in *explaining* variations in crime. Miethe, Stafford and Long (1987) suggests that common tests of routine activity theory “lack independent measures of the lifestyles in question and substitute presumed demographic correlates for them” (Miethe *et al.*, 1987 185). This suggests there is no apparent suitable measure of the day to day activities that individuals engage in, and are substituted with commonly applied variables such as female headed households and percentage overcrowding. (Roncek and Maier 1991; Andresen 2006).

Much of the criticism levelled at the Routine Activity Theory is that the ideas presented by Felson and Cohen in 1979 were a re-working of ideas acknowledged in the differential opportunity theory proposed by Cloward and Ohlin in 1960 (Felson 2008). While it is true that there is reference made to earlier sociological theories, the theory was deemed worthy for publication and has been applied in crime research since this time with particular significance to this research area (e.g Roncek and Maier 1991; Andresen 2006).

There have been some recent tests of the Routine Activity Theory that have also used population based measures (such as population density) as a spatial unit of analysis to measure levels of guardianship, however it has been argued by Fitzgerald, Wisesener and Savoie (2004) that these measures are less effective when there is not a large residential population in a given area, as is often the case in central business districts. To account for these shortcomings, the “population at risk” measure (Wikstrom 1991; Oberwittler 2005) has been

developed to explain the population in an area being at risk of assault or violent crime. Definitions of “population at risk” include the total number of people entering a given neighbourhood on public transport (Oberwittler 2005), or the number of people working in a given neighbourhood (Wikstrom 1991). The study by Fitzgerald *et al.*, (2004) compares rates of assault between residential population and residential population at risk. When standardising the results for population at risk (population employed and residential population per meshblock) the results show a more dispersed pattern around the city centre than when only violent crime per head of population is considered.

Other recently developed measures of population density include “road length” used in a study by Lipton *et al.*, (2003). This measure is considered a more accurate assessment of population distribution through consideration of physical features of urban development as opposed to the social measure of population density. Here, road length has an advantage over population density as this measure remains stable over time as opposed with population density which exhibits significant temporal variation on an hourly, daily, weekly or monthly basis. To date, however road length has not been widely used as a proxy measure of population distribution in assault related crime studies.

Other theories such as Environmental Design theory have paralleled the Routine Activity Theory in looking at the crime event and precipitators to the crime event rather than the external socio-economic factors influencing the neighbourhood. Jeffery (1971) and Newman (1972) suggested that the designs of public housing estates conspired to attract criminal activity without any fear of arrest. It may also have contributed to the attention which is given to minimising personal risk in new urban development through the appropriate design of public areas and communal space. Newman’s research was instrumental in the cessation of tower block housing construction in many parts of the world (Clarke n.d. 2).

The recent research relating to place suggests that the role of place in crime research is now more widely acknowledged than in earlier studies. The notion that place dictates rates of crime must be tempered by the realisation that no crime would be committed if there were no people in a given place at any one

time. The two factors of place and population are therefore inextricably linked, which has given rise to the development of theories that look at both population characteristics and place in influencing crime rates.

3.2.3 Integrative Theories

Recently, there have been attempts to integrate various crime theories to explain the distribution of crimes across places. The Crime Pattern Theory (Brantingham and Brantingham 1993) “explores the interactions of offenders with their physical and social environments that influence offenders' choices of targets” (Eck and Weisburd 1995 6). The Crime Potential Theory (Brantingham and Brantingham 1993; 1999) suggests that “crime will be exhibited in an area as a function of various ecological features” (e.g. population and place) (Gruenewald *et al.*, 2006 2).

The integration of social and environmental theories to explain crime has recently been explored in studies by Gruenewald *et al.*, (2006) and Andresen (2006). The 2006 study by Gruenewald *et al.*, reviewed the association between population, place and violent crime. The results of the study showed that violence was found to be associated with particular places but also, the rate of violence around bars varied according to neighbourhood characteristics. The study also found that there was a higher likelihood of assault in areas of higher deprivation, population and with higher immigrant (Hispanic) communities. The findings of the research also highlighted that only off-licence premises as a place characteristic were statistically associated with assault. Other place characteristics including bars, retail outlets, and vacant housing were not statistically associated with increased assault.

Other research by Andresen (2006) has considered different variables to test if population and place characteristics influence crime rates in Vancouver, Canada. At a census tract level, the study concluded that unemployment, population density and proportion of youth populations (Andresen 2006) are significant predictors of violent crime. The results of the studies conclude that rates of

violence are not influenced by places or external social or economic factors alone but by a wide range of factors including demographic characteristics.

In conclusion, the development of integrative theories now complements previously acknowledged formative theories of Social Disorganisation to explain the causes of crime. The more recent theories (Routine Activity Theory, Crime Pattern Theory, and the Crime Potential Theory) have been developed in an attempt to analyse crime patterns using indicators that are seen as a more accurate measure of human behaviour in their association with different places. This is not to say that the Social Disorganisation Theory is not relevant in contemporary crime research, as it is argued by Lipton *et al.*, (2002) that social characteristics (hence that of neighbourhoods) have an indirect influence on assault levels. Rather, it enables one set of factors to be set in a broader evaluation context.

Overall, the integrative theories that consider both population and place seeks to take account of aspects of both the Routine Activity and Social Disorganisation Theories appears to offer the most comprehensive theoretical approach to analyse and explain criminal activity.

3.3 Spatial Analysis Theory

The development of different crime theories to explain crime patterns has been complemented with the recent development of different spatial analysis techniques to represent and visualise crime patterns. Spatial analysis is defined by Haining (1994) as “the analytical technique of geographical data based on the spatial distribution of geographical objects” (Xiang and Han 1997 28).

Crime research conducted in the early 20th Century recognised the value of spatial analysis in finding spatial patterns in data. Since this time, highlighting location, distance, direction and patterns are considered to be the most important considerations when mapping data (Harries 1999). These factors have been categorised by Chainey and Ratcliffe(2005) as spatial heterogeneity, spatial dependency and centrophobic statistics. Spatial heterogeneity is displayed as variation in crime patterns from place to place, spatial dependency relates to the

influence of one (e.g. assault) on another variable (e.g. bar) and centographic statistics illustrate the spatial tendencies of data. In this study, the influence of bars on assault events and displaying bar and assault location are central to the research objectives. Therefore, using spatial analysis that analyses variation or the location in crime patterns and the dependency of variables on each other using distance based analysis techniques, is an essential element of the research.

This section reviews different spatial analysis theories commonly applied in crime research to highlight the influence of bars on assault patterns, displaying variation in crime patterns and also, the spatial tendencies of crime. First, density based theories including vector and raster density theories are examined as measures of spatial heterogeneity in illustrating assault event and bar data. Second, distance based theories, geographic weighted regression theories and clustering theories are explored as measures of spatial dependence to highlight the influence of bars on assaults. Finally, centographic theories are explored that highlight the spatial disposition of data.

3.3.1 Locational Theories

3.3.1.1 Vector Based Density Theories (Choropleth Mapping)

In vector based models, features are represented as discrete events including lines, areas or events. Each feature is represented firstly, physically as a shape that is defined by x and y locations in space. Secondly, each feature is symbolised as a row in a table (Mitchell 1999). To date, maps using vector based models have been applied in crime research in the form of choropleth mapping techniques.

Some methods in crime research consider and present the aggregate characteristics of data. Choropleth mapping is commonly used to map enumeration data at the aggregate level by shading or patterning in proportion to an analysis variable (Dent 1990). An example of an analysis variable commonly used in choropleth mapping is population density. Recently, choropleth techniques have been used to map crime data at a variety of areal units including zip code (e.g. Lipton *et al.*, (2003); Friesthler(2004), Gruenewald *et al.*, (2006),

meshblock (Thornley 2004), census tract (Andresen 2006), census area unit (Thornley 2004), and also basomrade³ (Ceccato, Haining and Signoretta, 2002) to illustrate associations between crime and social disorganisation. Other studies (Lipton *et al.*, 2003; Gruenewald *et al.*, 2006) have used aggregate data to illustrate a positive association of crime, such as assault with population and/or place (e.g. bars and similar land uses).

The benefit of using data at the aggregate level is that it enables the geographic comparison of like data across the study area. This enables broad patterns to be readily established by the reader. It is suggested by Dent (1990) that particular attention should be given to scale and phenomena when representing the data.

In previous research, choropleth analysis techniques have been applied at the countrywide and urban level. As an example, a study by Turner (2010) uses choropleth mapping techniques to represent distributions of health insurance cover at the state and county wide level in the United States. The results of mapping were displayed at a state and county level and resulted in visualisations that highlighted the highest proportion of counties where uninsured individuals are located in the states of Texas and Montana. These broad patterns contrast with studies by Lipton *et al.*, (2003) and Andresen (2006) and Ceccato *et al.*, (2002) that analysed data distributions at a city level and resulted in highlighting crime hotspots in and near the CBD.

The contrasts in the two studies emphasise differences in the application of choropleth mapping at different aggregate units, whether it be state or census area unit. Of interest is the variation in results shown at these differing aggregations. When analysing and displaying data at different scales one should acknowledge the effects of the Modifiable Area Unit Problem (Openshaw 1984) and Ecological Fallacy (Robinson 1950) where data aggregated in a smaller unit is considered more representative of local characteristics than data which is aggregated to larger units. With the Modifiable Area Unit Problem, data may be

³ Basomrade is a geographical unit used by Swedish authorities including Stockholm County Police and Utrednings och Statistik Kontoret (USK) in the analysis of police and census data respectively. The size of these geographical units range from 300 to approx. 9000 people (Ceccato *et al.*, 2002).

arbitrarily defined to geographical boundaries that do not coincide with the general characteristics of local populations. These two problems are closely related to one other and are commonly acknowledged in research of a geographical nature. Given these limitations, representing data at a variety of scales (countrywide, state, county or township level) is still recognised as being a highly effective function of choropleth mapping. This research will seek to explore assault and bar densities throughout the Waikato by the effective use of choropleth mapping techniques at a variety of scales.

Aggregating and mapping data at the meshblock level also allows for the testing of well established crime theories, particularly the Social Disorganisation Theory. In New Zealand, the Social Deprivation Index and Score (White *et al.*, 2008) are useful measures of social and economic well being at the neighbourhood level. This measure is used to recognise those suburbs and neighbourhoods that are socially or economically deprived. This research seeks to establish whether increased assaults occur in areas associated around bars in areas associated with social deprivation or across all socio-economic groupings. If clear patterns emerge, this would lead one to conclude that certain places are associated with violence, and that bars could have different functions according to their location (as hypothesised by Gruenewald *et al.*, (2006). For these associations to be established, there needs first to be a sufficient concentration of bars in residential neighbourhoods and second, one must identify the socio-economic characteristics of these neighbourhoods. This research established at an early stage that the first precondition is not present in the study area and accordingly further analysis into a possible relationship between bars and socio-economic characteristics was not undertaken.

In contrast to the Social Disorganisation Theory, effective testing of the Routine Activity Theory is less well suited to choropleth analysis, as measures such as population density which are commonly used in Routine Activity Theory are based commonly based on meshblocks or larger enumeration units that mask the variation from place to place. As has been shown, choropleth analysis

techniques mask the spatial distribution of data and do not effectively highlight where crime converges in place and time.

3.3.1.2 Raster Based Density Theories

In contrast to line based vector techniques, raster based techniques “offer(s) a practical method for storing land characteristics with digital values of a parameter on grid square elements” (Julien, Saghafian and Ogden 1995 523). Different raster based methods have been applied in crime research, including kernel and point density analysis. These techniques have been applied in a range of different settings in crime research, including crime prediction, (Groff and LaVigne 2001; Bowers and Johnson 2004) crime perception (Ratcliffe and McCullagh 2001) and hot-spot analysis (Fitzgerald, Wisener and Savoie, (2004); Eck, Chainey, Cameron, Leitner and Wilson (1995); Savoie, Bedard and Collins (2006); Savoie (2008) and Charron (2009). The studies of Fitzgerald *et al.*, (2004); Eck *et al.*, (1995); Savoie *et al.*, (2006) and Charron(2009) all employ the kernel density technique to visualise data patterns. Quadrat analysis is another density based analysis technique however this technique has not been widely acknowledged in crime research to date and its use and application will not be explored in this thesis.

The study by Groff and LaVigne(2001) used raster based methods to conduct spatial analysis on data to identify locations that provide increased opportunities for burglary in Charlotte, North Carolina. The study utilised a binary coding system to highlight places and locations at and adjacent to those places at greater risk of burglary. The research concluded that burglary rates were higher where there were more opportunities for crime. Furthermore, the model used in the research was more accurately able to analyse areas of less crime than those where there was more crime. A similar methodology to that used in the Groff and LaVigne study could possibly be used to highlight those areas where the opportunity for assault are greater than others. Other research by Ratcliffe and McCullagh (2001) use raster based methods to highlight police officers perception of crime areas compared with actual hotspots of crime. The study

highlighted that there was significant variation in results on perceived versus actual crime from place to place.

In comparison to the choropleth analysis techniques which are used at a variety of scales, the raster based density analysis methods are most widely used at the city wide scale. This is evidenced in the studies of Fitzgerald, *et al.*, (2004); Charron (2009), where the emphasis is on highlighting crime “hot-spots” in different city suburbs. There are both benefits and limitations in representing assault and bar densities through raster based techniques at larger scales. Using a density analysis method at a region wide level could effectively illustrate any spatial variation (such as an urban-rural dichotomy) in bar or assault distribution. However, it would be difficult to represent the detail of any localised hot-spot activity at a region wide level through this technique. It is therefore appropriate that raster based hotspot activity is best represented at a city or at the neighbourhood level.

It is considered that application of raster as opposed to vector-based analyses are dictated by the purpose of the research and by the ability through the **functionality** that the respective vector or raster based technique has in meeting the research objectives. In formulating a GIS framework to measure urban sprawl, Harris (2000) applies raster over vector data techniques to find the total land area of newly developed areas. Even though the amount of urban sprawl is often modelled using vector techniques, these methods use proximity and neighbour analyses which are only available using raster based techniques.

The benefits of applying this raster based method are that it accounts for the characteristics of neighbouring areas and the influence that these areas may have on the subject area. For this reason, raster based techniques such as kernel and point density have been employed in this study as they serve to illustrate “hot-spots” in assault patterns.

3.3.1.2.1 Kernel Density Theory

The kernel density estimation method is applied primarily to explore “the natural distribution of point data across neighbourhood boundaries” (Fitzgerald *et al.*,

2004 19). This method visualises data by converting “discrete point objects to continuous density estimates” (O’Sullivan and Unwin 2003 85); and the resulting maps display an isopleth style, “weather pattern” map defining those areas of higher and lower activity densities. (Williamson *et al.*, 2001).

The kernel density technique is applied by moving a window across a fine grid of locations defined by points on a grid (Bailey and Gatrell 1995).

$$f_h(x) = 1/nh \sum K(x-x_i)$$

(modified from Bailey and Gatrell 1995 85)

x represents a general location in area A of the kernel density function and $x_1, x_2, x_3, \dots, x_n$ are the locations of n assault events

h is the bandwidth and influences the level of smoothing

where x = locations from an independent and identically distributed sample

K = bivariate probability function, known as a kernel density function

Estimating the density of data using a kernel density method involves calculating the total number of point data or n assault events falling around a central sample location x . The surface value is highest at the location of the sample location x and diminishes with increasing distance from this point, reaching zero at the search radius distance from the sample location. The argument that this weighting system is consistent with Tobler’s First Law of Geography, in that “Everything is related to everything else, but near things are more related than distant things” (Tobler 1970 236) has some merit here. With the Kernel Density method, a higher weighting is accorded to those points closer to the sample location x , and accordingly, a lower weighting is accorded to those points further away from sample location x . Raster cells are created using the Kernel Density method in the surface area A . The density at each output raster cell is calculated by adding the values of all the kernel surfaces where they overlay the raster cell centre.

It has been suggested by Bailey and Gatrell (1995) that the ideal choice for bandwidth of a kernel function selected is:

$$h = 0.68n^{-0.2} \text{ (Bailey and Gatrell 1995 86)}$$

where n is the number of observed events in the study area A .

The kernel density method has been applied in several previous crime studies, including the studies of Fitzgerald *et al.*, (2004), Savoie *et al.*, (2006), Eck, *et al.*, (1995) and Charron (2009). In these studies the kernel density method is seen as useful in highlighting areas of high violent crime and property crime rates in the city centre. The research by Fitzgerald *et al.*, (2004) showed that the density of violent crime was concentrated in areas associated with the “urban core” of Winnipeg. Similarly, the use of the kernel density method in the Savoie *et al.*, (2006) study showed that the downtown suburbs of Verdun and Mercier-Hochelaga-Maisonneuve suffer more from violent crime than other areas on the island of Montreal.

Whereas the kernel density technique is recognised as a useful visualisation tool to analyse crime patterns, problems associated with the technique concern the choice of bandwidth which is often applied arbitrarily (O’Sullivan and Unwin 2003 87) and may result in excessively smoothed or spiky graphs. Using large bandwidths results in overly smooth graphs and may lead one to the conclusion that a particular area has crime related activity when in fact it does not. Conversely, spiky graphs that sample areas close to the sample point fail to test areas further away from the observation point. Therefore, a limitation of the kernel density technique is that it can misrepresent the essential characteristics of data by excessively smooth or spiky visual representations of data. Alternatives to the kernel density technique such as the point density technique rely on the summary characteristics of neighbouring data rather than using a weight to calculate the relationship of data to a sample point.

3.3.1.2.2 *Point Density Theory*

The point density technique for visualising patterns of data uses the characteristics of data surrounding a sample location, known as the “neighbourhood focus” (ESRI Help Menu, 2008). A neighbourhood may be defined using rectangles, circles, annuli or wedges that may be different sizes according to the study cohort (Mitchell 1999) and the density characteristics of a neighbourhood including focal maximum, focal minimum, focal sum, focal product, and focal mean are limited to those areas immediately joining the focus area. A search radius is applied on the data that measures the influence of the study cohort (Mitchell 1999).

The application of filters on some operations results in outputs that may soften or accentuate transitions in space. According to Tomlin (1990), values are generated atypical of immediate neighbours, such as Focal Minimum or Focal Maximum which tend to be more accentuated outputs, whereas Focal Sum, Focal Majority, Focal Mean and Focal Product tend to be softer or smoother outputs. Recent research by Corcoran, Wilson and Ware (2003) has applied point density as a starting point to highlight crime hotspots, followed by cluster analysis, modelling and crime prediction based on results of the cluster modelling.

The recent development of point and kernel density techniques allows for an effective visualisation by “smoothing” data through the use of neighbourhood statistics and kernel density estimators. There are perceived limitations recognised in the inaccurate or misleading representation of data whether it be the masking of data using choropleth mapping or excessive smoothing as is the case using kernel or point density techniques. The evolution in visualisation strategies such as choropleth, kernel and point density techniques has been augmented by clustering analysis techniques that provide analysis through the **quantification** of the spatial characteristics of data. Quantifying patterns of data through clustering analysis complements the different visualisation strategies to provide a rich narrative for analysis.

3.3.2 Spatial Dependence Theories

3.3.2.1 Clustering Analysis Theory

As the name suggests, data clustering, according to Jacquez (2008 2) is “an excess of events in geographic space”. Clustering analysis may either take place at locations that are composed of discrete features throughout a region, or summarized at the local level at a census tract or meshblock unit (Mitchell 2005). Many clustering tests, such as Moran’s I statistic (Moran 1948) and the “nearest neighbour” test (Clark and Evans 1954) have evolved by comparing the results of an observed set of distances with an expected set of distances to calculate the degree to which data clusters (Chainey and Ratcliffe 2005). The practical application of clustering analysis is commonly conducted by testing a null hypothesis of complete spatial randomness versus an alternative hypothesis that describes the spatial pattern that the test is trying to detect (Jacquez 2008). Jacquez (2008) has argued that using a null hypothesis of “Complete Random Sampling” is not appropriate for the complex systems that are encountered in the physical and social world.

The measure to which clustering indices are statistically significant (assuming the data is normally distributed) is determined by evaluating Moran’s I statistic, Moran’s Z score and p value (ESRI 2010). Moran’s I statistic is a measure of clustering. Moran’s I statistic *typically* range between -1 and +1, results that range towards -1 are dispersed, 0, random, and +1 being clustered (Goodchild 1986).

Moran’s I statistic is calculated using the following formula:

$$I = \left[\frac{\sum_{i=1}^n \sum_{j=1}^n W_{ij} z_i z_j}{S_0} \right] / \left[\frac{\sum_{i=1}^n z_i^2}{n} \right]$$

(from: Anselin, Griffiths and Tita 2008 111)

w_{ij} = spatial weighting matrix

$S_0 = \sum_i \sum_j W_{ij}$ = sum of weights

n = number of regions

$$z = (y_{i,j} - \text{mean}(i,j))$$

Z_i^2 = deviations from the mean

n = number of spatial units of observations

areas i and j = adjacent areas

$$\text{Moran's } Z \text{ Score} = (I_O - I_E) / SD_{IE}$$

Where I_O = observed Moran's coefficient

I_E = expected Moran's coefficient for a random distribution

SD_{IE} = Standard Deviation for expected Moran's coefficient

(from Mitchell 2005 124)

Moran's Z score and associated p values are measures to which any assault clustering pattern "is simply not due to chance" (Mitchell 2005 124). Areas that are not randomly distributed will typically have high p values, Z scores with standard deviations greater than 1.95 from the mean and p values of less than 0.01. (Mitchell 2005). Arc software uses 2.5 standard deviations as a critical score (ESRI 2010 Help menu). Hence, a large negative or positive Z score of greater than 2.5 standard deviations and low p values of <0.001 illustrates that there is significant randomness or clustering found in the data respectively. Results in this research are presented as standard deviations of Moran's Z score as Moran's I statistics for assault clustering exceed the value of 1.

A variety of test statistics used to test for data "clustering" includes the Nearest Neighbour statistic (Clark and Evans 1954); Getis-Ord's " G " statistic (Ord and Getis 1995), Ripley's K statistic (Ripley 1977); and Moran's I statistic (Moran 1948). A complete explanation of cluster tests is presented by Jacquez (1996). Moran's I coefficient that is used as a measure of clustering and Geary's C coefficient are also commonly used tests for spatial autocorrelation between similar neighbours. The various test statistics exhibit different characteristics even though they are used to illustrate the spatial dependence of data on each other.

The nearest neighbour statistic is calculated using the following formula:

$$\text{Mean}(d)_{\min} = \sum_{(i=1)}^n d_{ij} / n$$

(Chainey and Ratcliffe 2005 126)

Where d_{\min} = minimum mean distance

d_{ij} = distance between i and j

n = total number of events in data set

i = event number

Expected values for the mean nearest distance are:

$$F_{(e)} = 0.5 / \sqrt{A/n} \quad (\text{From Robinson 1998 268})$$

A = area of study region

n = number of points

And suggested that the ratio R or nearest neighbour statistic for calculating clustering is calculated by:

$$R(\text{NNI}) = r_o / r_e$$

Where r_o = total mean observed distances

r_e = total mean expected distances

Results from this test statistic suggest that zero indicate a clustering pattern, while values tending towards 2.1491 shows a lack of clustering.

The Getis-Ord statistic (Ord and Getis 1995), or G statistic is indicated by:

$$G_i(d) = \sum_j w_{ij}(d) x_i x_j / \sum_{ij} x_i x_j, \quad j \neq i \quad (\text{Getis and Ord 1992 194})$$

$w_{ij}(d)$ is a spatial weighting matrix

$\sum_{ij} x_i x_j$ = sum of observations calculating distance between i and j

i = data point i

j = data point j

d = distance from point i to j

The nearest neighbour statistic (Clark and Evans 1954) is a distance based statistic for point data that compares the closest point to another point in the study area. The average statistics are compared with expected statistics that is based on the number of events and the size of the study area. The Getis-Ord (G) statistic (Getis Ord 1995) is used to “measure the degree of local association for each observation in a data set” (Anselin 1996 114). The G statistic “is useful in the detection of like (high or low) values in an area of interest” Anselin (1996 114).

The measure of clusters using the G statistic is applied by weighting data within a certain distance of each other. Variations on the G statistic include the F statistic that measures the distance between a random point (i) in the study region to a data point (j) rather than measuring the distance between two data points (Bailey and Gattrell 1995 89). Ripley’s K statistic differs somewhat from other clustering patterns as the technique allows for clustering patterns based on the distance from all points in a data set. To date, the use of various test statistics has been used to test for spatial dependence in a variety of disciplines, including forest ecology (Dixon 2006); crime (Anselin Griffiths and Tita 2008; Ratcliffe and McCullagh 2001; Ceccato *et al.*, (2002)) and employment patterns (Ceccato and Persson 2002).

The value of significance tests is highlighted in a study by Anselin (1995); who uses various parameters (I statistic, p -value and standardised Z score) to highlight spatial variations in conflict levels for countries in Africa. The test assumes data is normally distributed (Anselin 1995). The study reveals that there are significant (at 95% level of confidence) levels of conflict in countries around the horn of Africa (East Africa), with less levels of conflict recorded around West Africa.

It appears as though alternative clustering statistics are useful in different situations. The scale of the study area, the type of data and the purpose of study dictate what tests are appropriate for a certain situation. For example, global

statistics (e.g Moran's I statistic) are useful in measuring how patterns cluster at the regional level but local statistics (Local Moran's I statistic) can account for local variations in data that is not possible using global statistics. Likewise, visualising high or low clusters of data is perhaps more appropriate using the Getis-Ord statistic rather than Moran's I statistic. To date there is no evidence in research that density based spatial statistics has been used to explore measures of spatial association between bars and assault, whether at an individual or aggregate level. However, visualising and quantifying the spatial patterns through clustering techniques at a relevant enumeration level, such as "basomrade" as has previously been conducted in research through studies by Ceccato *et al.*, (2002) may highlight an association between crime event (i.e. assault) and land use.

3.3.2.2 Distance Analysis Theory

Distance based research has been developed to test if crimes exist where practical opportunities for crime are greatest. The opportunity-based research has developed as a response to the social based neighbourhood studies of Shaw and McKay (1969). It was argued that the research by Shaw and McKay did "not distinguish between areas of crime occurrence and offender origin" (Capone and Nichols 1975 45). Carrying out distance based research by measuring the distance between crime and offender is therefore one way of quantifying opportunities for crime at a given location.

The usefulness of distance based methods for crime analysis has been acknowledged in studies by Capone and Nichols (1975); Frisbie, Fishbine, Hintz, Joelsons and Nutter (1977); and Lundringan and Czarnomski (2006). The studies review the relationship between offenders home and offence point using different crime indices such as burglary (Capone and Nichols 1975; Frisbie *et al.*, (1977) and sexual assault patterns (Lundringan and Czarnomski 2006). Strong "distance decay" patterns were found in that many more offences occurred closer to home than further away. The results from the Frisbie *et al.*, (1977) study showed that more than "50% of residential burglary suspects travelled less than 0.5 miles to their target (0.8 km)" (Harries 1999 29).

Similar results were found in other distance related crime studies. The results of the Capone and Nicholls (1975) survey demonstrate that one-third of robberies took place within one mile (1.6 km) of an offenders address (Capone and Nichols 1975 47). With sexual assault, the median distance travelled was 3 km and over half (52%) of assaults were committed less than 3 km from the offender's base (Lundringan and Czarnomski 2006 224). These patterns support Morris's (1957) hypothesis that "crimes tend to be committed where practical opportunities are greatest" (Capone and Nichols 1975 45) as more crimes are committed closer to home with increasing distance being seen as a constraint to criminal behaviour.

The distance between an assault and the nearest bar may be calculated using straight line, or Euclidean geometry. This method stores (in a GIS) co-ordinates for each point and the distance between the two points (Mitchell 1999).

The distance between two points is given by the following equation:

$$\text{Distance between two points} = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

Where (x_1, y_1) is co-ordinate 1

(x_2, y_2) is co-ordinate 2

From Mitchell (1999 123)

Distance based analysis is considered relevant to this study in that the establishment of a "distance decay" relationship between assault location and the nearest bar could suggest that there are opportunities for assaults presented by bars and associated land uses that are not present with other land uses.

3.3.2.3 Geographically Weighted Regression Theory

It has been argued that some regression techniques such as "Ordinary Least Squares Regression" do not adequately explain local variations occurring in space (Fotheringham *et al.*, 2002). "Ordinary Least Squares" regression methods assume independence among observations which violates assumptions of spatial dependence inherent in all spatial data.

Geographically weighted regression (Brundson, Fotheringham and Charlton 1998) has been proposed as an improvement on previous regression techniques, to “examine spatial variation in associations between dependent and explanatory variables” (Hay, Whigham, Kypri and Langley 2007 2).

Geographically weighted regression accounts for spatial variation from place to place and the process produces a separate model at regression points representing each assault observation or, in the case of areal data, the regression point is a polygon centroid and “the distance between points is calculated as the distance between polygon centroids” (Mennis 2006 172). The geographically weighted regression technique to date has been applied in research using socio-economic data that is commonly aggregated to enumeration units such as meshblocks (Mennis 2006). The local model created at each observation point (in this case, the meshblock centroid) provides estimates of $\beta_k(u_i, v_i)$ for each variable k (e.g. bar), by considering data around each assault point i (Brundson *et al.*, 1998).

The geographically weighted model is thus represented as follows:

$$Y_i = \beta_0(u_i, v_i) + \sum_k \beta_k(u_i, v_i) x_{ik} + \varepsilon_i$$

(Fotheringham *et al.*, 2002 52)

Where Y_i = regression model at point (u_i, v_i)

β_0 = Y intercept when $x_{ik}=0$

β_k = unknown parameter estimates (Bars)

Where u_i, v_i = coordinates of the i th point in space

$\beta_k(u_i, v_i)$ = realisation of continuous function $B_k(u, v)$ at point i .

x_{ik} = value of k th variable at point i

ε_i = residuals at point i

In the geographically weighted regression process r -squared and t -value statistics are statistics of significance in that they allow for the measure in the strength of relationship between variables of interest. Furthermore, calculation of parameter estimates enables an estimate of the number of assaults given the

number of bars per areal unit. A local r-squared statistic is calculated for each meshblock. The formula for r_i^2 is as follows:

$$r_i^2 = (TSS^w - RSS^w) / TSS^w$$

$$TSS^w = \sum_j w_{ij} (y_j - \text{mean}(y))^2$$

Where TSS^w = geographically weighted total sum of squares

$$RSS^w = \sum_j w_{ij} (y_j - \text{pred}(y))^2$$

and RSS^w = geographically weighted residual sum of squares

(Fotheringham *et al.*, 2002 215)

Where w_{ij} = weight of data point j at regression point i

\sum_j = sum of all data points

y_j = dependent variable (assault) at data point j

$\text{mean}(y)$ = mean value of dependent variable (assault) from regression model

$\text{pred}(y)$ = predicted value of dependent variable (assault) from regression model.

The use of geographically weighted regression has been applied to a diverse range of topics including employment growth dynamics in the United States (Partridge, Rickman, Ali and Olfert 2006) and relationships between rainfall and altitude in Great Britain (Brunsdon, McLatchey and Unwin (2001). However, of particular relevance to this study has been the use of geographically weighted regression to look at the association between alcohol and violence (Waller, Zhu, Gotway, Gorman, and Gruenewald 2006), and the effects of spatial variation on access to alcohol and deprivation in New Zealand (Hay, Whigham, Kyprri and Langley 2007).

The Hay *et al.*, (2007) study highlighted spatial variation in parameter estimates by mapping t-values of parameters including social deprivation and urban/rural meshblock status as independent variables and distance to nearest bar as the dependent variable. The results of the study highlighted that population distribution most influences distance travelled to local bars. However the study also suggests a relationship between alcohol access and deprivation which is apparent in both urban and rural areas, despite the lack of association between

rural areas and access to alcohol in previous research. The study also shows that using geographically weighted regression results in a model that better explains the local relationships between distance to nearest bar and deprivation than traditional regression methods.

There have been acknowledgements in geographic weighted regression to date that there is no standardised approach by which to map or display results generated from geographically weighted regression analysis. Mennis (2006) argues that the need for a more economic approach to represent the large amount of data that is generated through the application of geographically weighted regression. Several possibilities have been explored, including presentation of both t-values and parameter estimates and the use of divergent colour schemes to represent any spatial variation in the data. Clearly, geographically weighted regression has been recognised as a useful technique for studying the spatial variation between two variables at a local level (i.e. meshblock level). However, it is evident that this technique has not been widely utilised in crime research or indeed mapping relationships between variables of interest. It seems likely that due to the functional benefits in modelling at a spatial level, geographically weighted regression will be applied further in a wide range of research in the future.

3.3.3 Centrographic Analysis Theory

Research by Levefer (1926) recognised the use of centrographic analysis methods by which to measure both the deviation and spread of data from a point of interest. The use of such a measure, known as the “Standard Deviational Ellipse” was a favoured technique for “hot-spot analysis” during the mid 1990’s (Canter 1995; Block and Block 1995) . The use of the standard deviation ellipse in these studies found that the density of liquor outlets is not by itself an accurate indicator of criminal activity. The research by Block and Block concluded that tavern related crime was more likely to be associated with main streets and the corners (diagonals) of well established commercial streets of towns with or without a liquor outlet.

Other centographic strategies used in crime analysis to date includes the use of the “Mean centre statistic” and “standard distance” statistic. The two measures are often used in conjunction with each other to measure the geographical centre of crime in the area and the dispersion of crime around that given point. To date, the mean centre statistic has been limited to use in studies of geographical profiling of serial crimes (Paulsen 2004) through comparison with other similar spatial statistics. An analysis of vandalism in Lincoln, Nebraska (Chainey 2002) employed a “standard distance” technique to highlight the distribution and spread of data from a point of interest.

While there are recognised benefits such as providing “general” indicators of activity in employing centographic strategies, the use of such techniques for spatial analysis appears to be limited to place specific research, such as geographic profiling. Its use for defining crime “hot-spots” is limited as the method designates areas within the ellipse as a hotspot and those areas outside as not being a “hot-spot”. Also, the study data in the assessment of mean centre statistic may be spatially skewed and centographic strategies may not adequately represent characteristics found in data. Finally, local geographies of crime are much more complex than a broad generalisation would allow.

3.4 Conclusion – Theory Section

In conclusion, a review of different spatial theories has established the variation, versatility and limitation of each technique. Geographically weighted regression may be a useful predictor of local variation between assault and bar variables, however its application at the aggregate level means that the variability of data within each meshblock or areal unit is “masked”, like that of choropleth analysis techniques. Notwithstanding these limitations, it can be argued that using a variety of vector based, raster based, distance-based, clustering analysis and geographically weighted regression techniques can together effectively explain both the nature of the relationship between assault events and bars and the spatial variation evident from place to place throughout the region.

In the context of this research, it is important to first, utilise the different techniques to assess the relationship between bars and assault, and second, to consider how relevant the different crime and spatial analysis theories can assist in explaining the distribution of assaults around bars and associated land uses.

Thus far, the research has investigated the different types of techniques to usefully explain and understand the relationship between bars and assaults. It is also necessary having regard to the review of crime theory in Chapter 3 to briefly examine the usefulness of crime theories to explain the relationship between bars and assault. The application of the Routine Activity Theory to this analysis requires knowledge of environmental and social factors such as, percentage overcrowding, youth or elderly population numbers, vacant units, *etc.* (refer Roncek and Maier 1991) as well as population density (Andresen 2006).

Although some familial and housing indices such as number of people per household, number of rooms per household and population per meshblock are contained in a Statistics New Zealand Census dataset⁴, a lack of other appropriate data means there is limited opportunity (apart from population density at the meshblock level) to test the applicability of the Routine Activity Theory in this research.

Variables used to test the Social Disorganisation Theory to explain the association between assault and bars include income, employment, social deprivation, *etc.* (refer Andresen 2006). As with the Routine Activity Theory, there are difficulties in testing the Social Disorganisation Theory in this study. However, the difficulties in testing are not limited to lack of appropriate data as is the case when testing the Routine Activity Theory. For the Social Disorganisation Theory, there are two main shortcomings relating to changes in the social and economic characteristics of the population of some settlements throughout the year. This is most apparent at holiday resorts, such as Raglan and Whitianga. Second, as the strongest association between bars and assaults is typically in the centre of the region's urban areas where there is a low residential

⁴ Website reference:
<http://www.stats.govt.nz/Census/2006CensusHomePage/MeshblockDataset.aspx?tab=Download>, 2 February 2011

population, there is no opportunity to test socio-economic characteristics that apply to residential populations.

In conclusion, it is considered that a number of spatial analytical and crime techniques are relevant and should be used to explore and explain the relationship between bars and assault levels in the Waikato. Of these, choropleth mapping, and the point and kernel density techniques are most useful in highlighting the locational aspects of the assault and bar data. Choropleth mapping is especially useful in that, by the use of standardised enumeration units, it enables a consistent interpretation to be given to area and population. The particular value of the point and kernel density methods is that they allow a “natural” representation of data. Clustering analysis using distance-based relationships is also relevant and has been used as an additional “locational” technique. Distance based techniques are also relevant to this study, notably the Euclidian-straight line technique and geographically weighted regression that seeks to establish relationships between assault and bar distributions. Centographic analysis techniques are not considered sufficiently accurate to analyse the spatial relationships between bars and assault distributions and accordingly have not been applied in this study. The precise weighting or role of these techniques is outlined in the following sections.

Chapter 4: Research Methodology

The following chapter describes the methodology used to achieve the research objectives defined in Chapter 1. The use of an appropriate model in which to incorporate the methodology should “guide the planning process” (Punch 1998 41). According to Punch (1998) the empirical part of the research process includes design, data collection, data analysis, and results that answer the research questions. The following chapter will review each part in turn.

4.1 Research Design

The type of research design determines how the analysis is carried out. Denzin and Lincoln (1994) describes “design as situating the researcher in the empirical world and connecting the research question to the data”(Punch 1998 66). The study uses mainly a quantitative approach to answer questions outlined in the objectives. A quantitative approach is preferred to a qualitative approach due to the statistical nature of the data used in the research. The data being spatially referenced allows for a wide range of spatial analysis resulting in map production and the possibilities of regression based analysis.

The approach that will be used here is similar to that used in research by Lipton *et al.*, (2003) as this study takes a quantitative approach to analysis as contrasted with a more qualitative approach that might explore social contributors to violence. The study includes the use of choropleth mapping and clustering analysis to establish the spatial patterns of assaults around the bars throughout the Waikato region. The use of distance and density techniques as well as geographically weighted regression, although not acknowledged in the study by Lipton *et al.*, will add to the other analytical techniques in providing a source of information for analysis that assists in meeting the research objectives.

There are several considerations in developing a research strategy. It is important to consider any inherent bias that could arise from one’s own beliefs or preconception as it would be comparatively easy to seek to make an inference or derive a causative relationship from these beliefs. The use of geographic

information systems using ArcGIS tools and complemented by other software such as Microsoft Excel will ensure a positivist, bias-free outcome which reduces the likelihood of interpretation errors. Recognition should also be given in the research design to practical considerations, financial resources and time constraints (Hedrick, Bickman and Rog 1993). These considerations have determined the scope and nature of this research.

4.2 Research Framework

The conceptual framework of the research involves the process of decision making starting with problem recognition and ending with recommendations (Malczewski 1999). The framework considers “how” the research design is going to be carried out based on a sequence of steps (Malczewski 1999). In GIS-based research, according to Malczewski (1999) attention should be given to data acquisition, storage, retrieval, manipulation, analysis and also capabilities for aggregation. Deciding upon the most appropriate research design strategy in light of the research objectives is not an arbitrary process but one that follows guidelines and rules. The process is illustrated below:

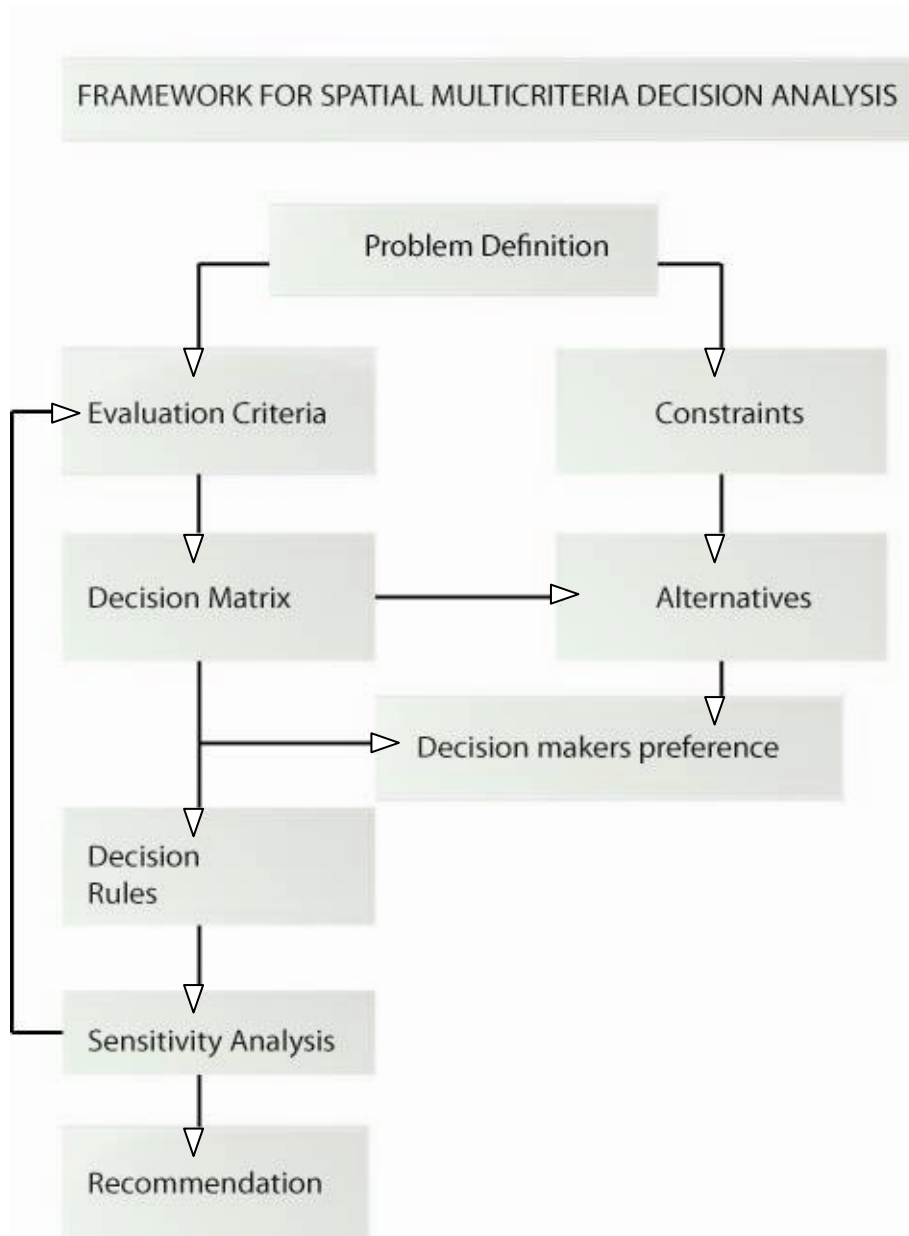


Figure 2: Framework for Spatial Multicriteria Decision Analysis (from Malczewski 1999 96)

Permission to reproduce graphic granted (John Wiley and Sons, 2011)

According to Malczewski (1999) there are two considerations of critical importance for decision analysis. The first is the geographic information system's capabilities for data acquisition, storage, retrieval, manipulation and analysis and second, its capabilities for aggregating geographical data. The decision matrix (based on decision rules) considers how each measure provides for the various processes involved in the data analysis processes by weighing up the benefits and shortcomings of each spatial analysis measure. The decision matrix for each

spatial analysis technique reviewed in the theory section of this thesis is included in Appendix A.

The results of the decision matrix explain the benefits and drawbacks of each analysis function. Overall, the decision matrix highlighted that distance and density based techniques were most appropriate as methodologies to follow in this research. This is mainly due to the aggregation, manipulation and analysis capabilities of the geographic information system when set against the research objectives.

The decision matrix shows that each spatial statistic function has benefits and limitations that demonstrate that no one spatial theory is perfect in describing the relationship between assaults and bar distribution. It is contended here that one spatial analysis technique complements each other so as to build a broad yet accurate picture of the spatial variation exhibited in the relationship between assaults and bars throughout the Waikato.

Chapter 5: Data Collection

In accordance with the research objectives and hypotheses, spatially referenced data on assault and bars has been collected. Commonly, data in crime research comes from four main sources; police; National Statistics agencies, corrections or probation agencies and local government sources (Chainey and Ratcliffe 2005). This research makes use of several different data sources including data sourced from a central police database; local government data sources, government agencies and tertiary institutions (refer Table 1 below).

Raw data	Source	Raw data format	Derived data format	Usage
Assault dataset	New Zealand Police	Tabular data set with x and y coordinates for all assault events	Point layer with spatially referenced data	Defines location of assault events
Bar dataset	Local government authorities	Tabular data set with address information on all entertainment facilities for geocoding	Point layer with spatially referenced data	Defines location of bars and other entertainment facilities
Census dataset	University of Waikato	Area/polygon layer attached with tabular data	Area/polygon layer attached with tabular data	Defines meshblock and ward layers with applicable enumeration data for further analysis. Assault and bar data spatially referenced for analysis
Census dataset	Statistics New Zealand	Tabular alpha/numeric data	Tabular alpha/numeric data	Size of each meshblock unit provided in density analysis using choropleth mapping
Physical and social features dataset	University of Waikato	Point and line feature class	Spatially referenced point and line feature class	Defines NZ coastline and district boundaries; highway and road data

Table 1: Dataset used in the spatial analysis of bar and assault data

Information on assaults was obtained from the following New Zealand police databases: the Police Business Objects Universe database and the INCOFF Offence Calendar Detail Universe. The original source of these databases was the National Intelligence Application (Cinco pers. comm. 2011)⁵. The data collection, scope and procedures of the research were determined by the police and were not able to be influenced by the researcher. However, the available information relating to assault provided by the police is considered sufficient for detailed spatial statistical analysis.

The data collection process is as follows:

First, the geographic location of assaults and information relating to minor, grievous and serious assault was obtained over a two year period from 2008 to 2009. For each recorded assault, the following variables were provided in a raw dataset provided by New Zealand Police:

1. Year
2. Month
3. Offence date (YYYYMMDD format)
4. Offence description
5. Offence code
6. Offence day of week
7. Offence hour
8. Day of month
9. Easting and Northing attributes (X and Y coordinates)
10. Scene Description

Second, the location of bars were 'geocoded' to a spatial reference using local government data sourced from the local territorial authorities in the Waikato district (namely Hamilton City Council, Waikato District Council, Thames

⁵ E-mail correspondence between researcher and Obert Cinco, Senior Statistics Officer, Organisational Performance Group, New Zealand Police Headquarters, 10 January 2011

Coromandel District Council, Matamata-Piako District Council, Otorohanga District Council and Waipa District Council).

The geocoding process is as follows:

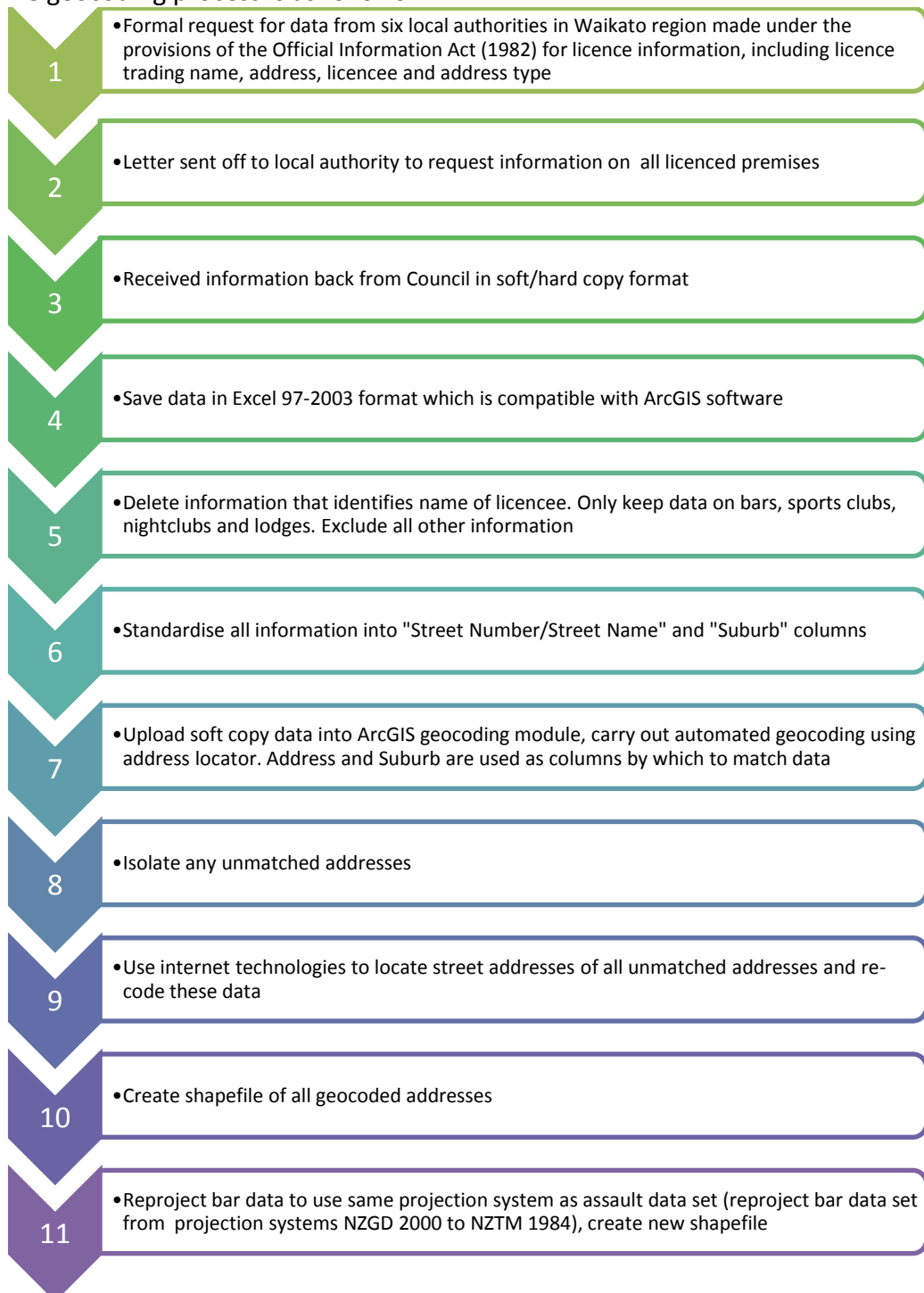


Figure 3: The geocoding process for bar data

There was a wide range in the geocoding success rate. A success rate of 100% was achieved for locations in the Otorohanga District. However, only 43% of all locations in the Waitomo District were successfully geocoded. There was an overall geocoding success rate of 79% for the 409 bars, taverns and nightclubs within the Waikato. Where data was not able to be geocoded automatically, subsequent manual geocoding took place to match a location with an address found in the geocoding database. Any data received that was not a bar, nightclub, tavern or lodge was discarded from further analysis. The “cleaned” geocoded information was then merged into a single file using Model Builder module in ArcGIS and saved as a new shapefile for further analysis.

Lastly, a spatial dataset containing census information was provided by the University of Waikato. The data set contains census data with enumeration information at the meshblock, census area unit, ward level and territorial authority levels. The set contained useful information on population structure, land use characteristics and socio-economic data throughout the district that allows for a wide range of analysis.

5.1 Data Collection - Limitations

Problems associated with data collection relate to the recording and collection of data. First, when recording assault information, time stamping a crime event may be difficult as the exact time of a crime event is sometimes not known precisely. To overcome any temporal bias associated with recording, data has been allocated to hour-long “windows”. Second, some assaults may not be reported to the police and for that reason there is an inherent source of bias in the data set. Some researchers have used assault discharge figures from hospitals as a data source (e.g. Gruenewald *et al.*, 2006) as opposed to police records. However, recent advice from the New South Wales Crime Research Bureau suggests there is no particular advantage in using assault discharge data from hospitals as opposed to official police sources due to lack of reporting assault events from

members of the public (Holmes pers. comm. 2011)⁶ There have also been changes acknowledged in (New Zealand) police recording practices and IT systems (Knight, pers. comm. 2010)⁷ that means that the length of the study is effectively restricted to a comparatively short time period between 2008 and 2009 extending over a 24 month period. This time frame is considered sufficient to provide a representative supply of information and draw conclusions.

The range and type of data gathered demonstrates the positivist, quantitative approach to analysing the relationship of assaults around bars. It should also be recognised that the range of analyses is dictated by the data available whether it be enumeration data, official police data or licensing information. It is true that this information changes according to location or over time, so an exact comparison with other studies of this nature will always remain problematic. Nevertheless there remains the opportunity for a wide range of useful spatial analysis which will be explored further in the following section.

⁶ Email correspondence between researcher and Jessie Holmes, Information Officer, New South Wales Crime Research Bureau, January 24, 2011

⁷ Email correspondence between researcher and Gavin Knight, National Statistics Officer, May 28, 2010

Chapter 6: Analysis

6.1 Analysis Overview

The process used to analyse the data differs according to the strategy for each underlying method applied. There are however similarities in the type of software which is applied. These processes involve geocoding bar data, spatially referencing assault data, and then finally, undertaking spatial analysis using most of the theoretical approaches outlined in Chapter 3. The analysis involved creating models using the Model Builder facility in ArcGIS software version 10 to automate different spatial analysis processes.

A definition of a model is: “A description, a collection of statistical data or an analogy used to help visualise – often in a simplified way something that cannot be directly observed” (Gove 1993 1451). In the geographical context, models have spatial attributes and may be categorised as scale, conceptual or mathematical models (Steyaert 1993). The models that are formulated in this research are considered to be conceptual models in that the different components of the system are represented by flowcharts that are connected by linkages that constitute the processes and interactions between the various components of the system.

In the context of this research, the geocoding of bar data, the spatial referencing of assault data and other analyses are integrated into a model that conceptualises the inputs, processes and outputs as objects. The **aim** of the model is to develop a dataset of aggregate statistics on bars, assaults and other variables used in the analysis of information to better understand the spatial relationship between bars and assaults.

The first stage of the model resulted in an output of a shapefile of spatially referenced assault and bar data containing summary statistics for each meshblock. Summary statistics include the number of assaults, bars and total road length calculated per meshblock. A dataset of aggregate statistics on bars and assaults was compiled using the results from the outputs of the models. The

outputs of the models (number of assaults and bars) are also standardised per area of each meshblock in data preparation for mapping the data.

The second step in the analysis involved mapping the outputs of the data set from the results of the additional spatial analysis conducted at the first stage. These maps provide a picture of assault and bar densities throughout each city, township, and through the region as a whole. Regression analysis was also performed on the dataset to gain further insights into the relationship between assaults and bars. Data mapping in ArcGIS and the regression analysis in Microsoft Excel produces meaningful sets of information to provide evidence that helps support or disprove the research objectives.

6.2 Initial Analysis of Bar, Assault and Road Length Shapefile Data

The purpose of the analysis process involved assigning spatially referenced bar and assault data to enumeration units. The results of the analysis process resulted in sets of statistics including information on bar and assault data aggregated at the meshblock, census area unit and ward level for the different analyses.

6.2.1 Analysis of Bar Data Process

The purpose of the bar data analysis was to spatially reference entertainment facilities to a geographic location and relevant meshblock for comparison with assault data using choropleth mapping techniques. Summary statistics containing the number of bars in a particular meshblock were calculated in preparation for mapping bar density (e.g bar number per hectare or square kilometre). The steps are as follows:

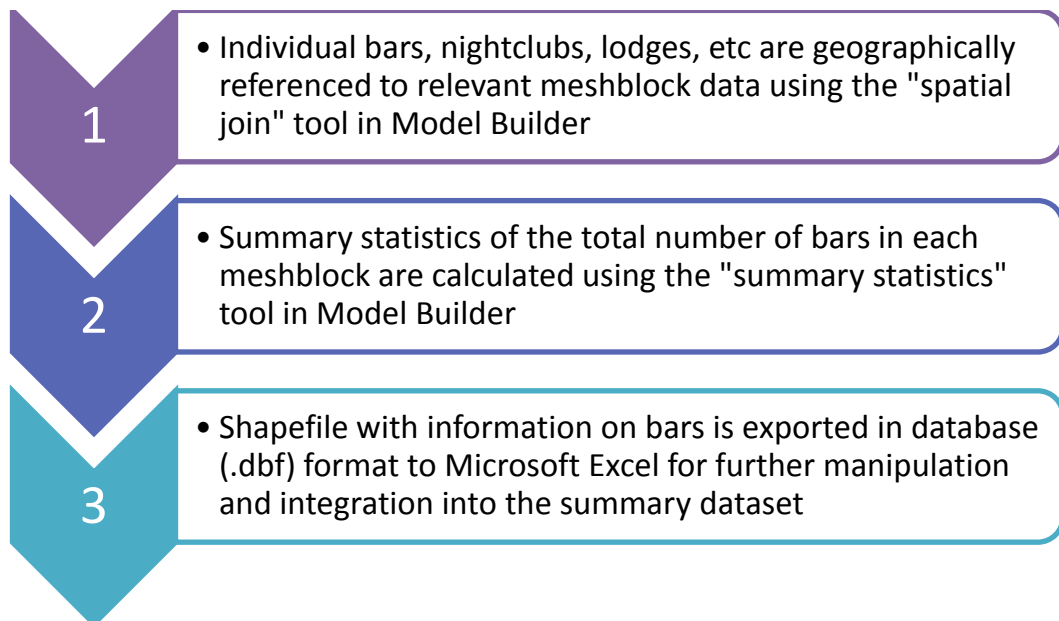


Figure 4: Spatial analysis process for bar data

6.2.2 Analysis of Assault/Road Length Data Process

The assault data set was provided by the New Zealand Police in Microsoft Excel spreadsheet format and supplied with Eastings and Northings (x and y coordinates respectively) for each assault event. The purpose of the assault analysis process through automating procedures in Model Builder was to geographically reference the assault data in a point format to the census shapefile data that is vector data in the form of a polygon. First, summary statistics containing the number of assault events falling within a meshblock unit were calculated in preparation for mapping assault density (e.g assault number per hectare or square kilometre). Second, summary statistics on the length of road per meshblock were then calculated in preparation for further regression analysis. The process in automating assault data is as follows:

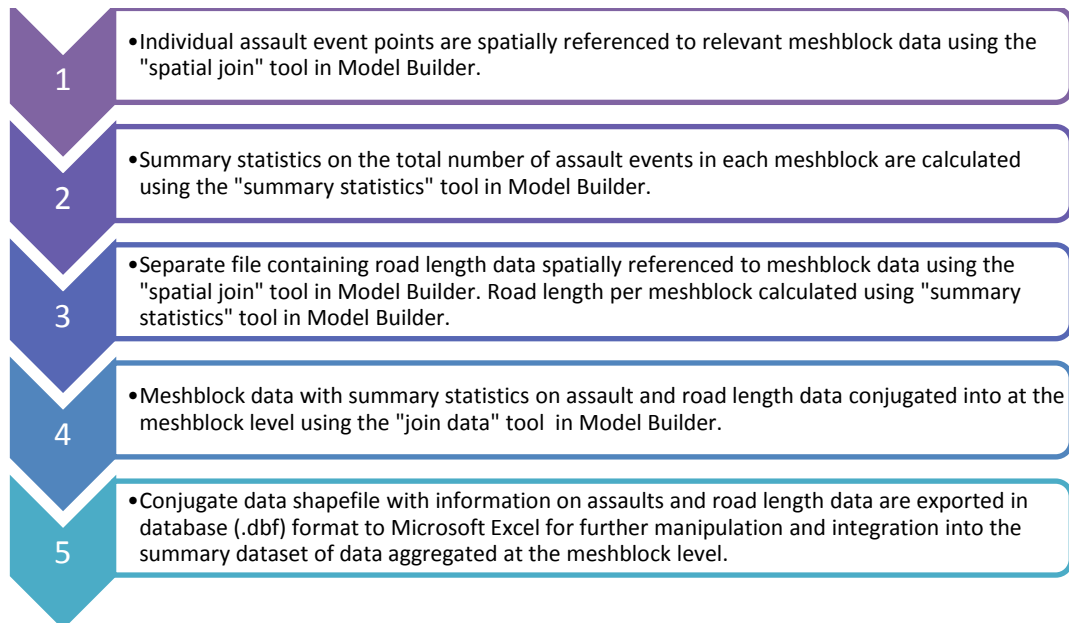


Figure 5: Spatial analysis process for assault and road length data

6.3 Distance-Based Analysis Processes

6.3.1 Straight-Line Analysis Process

By establishing the distance between assault and nearest bar it is possible to accurately describe the level of influence that distance has on assault distributions around bars. The distance between assault event and nearest bar is measured by calculating the "straight-line" or "Euclidian" measurement from assault to nearest bar rather than by using the length of road between assault and nearest bar. "Euclidian" distance is considered to be a practical solution when the distance between bars is short. Most people are within walking distance of a bar and people are likely to be on foot. There are still limitations in the use of this measure at short distances as it does not consider the effects of dwellings on the movement of people. It could also be argued that using road length rather than a "straight line" measure of distance between assault and nearest bar (at short distances) is a more accurate measure as many assaults are close to roads. However, there are some assaults that do not occur on roads and hence distance calculations of these data using road length remains problematic. At longer distances, the "Euclidian" distance measure under represents distance in rural areas, where longer distances necessitate the use of a car. The process in

Model Builder for calculating distance summary statistics on assault and nearest bar is detailed in the following graph:

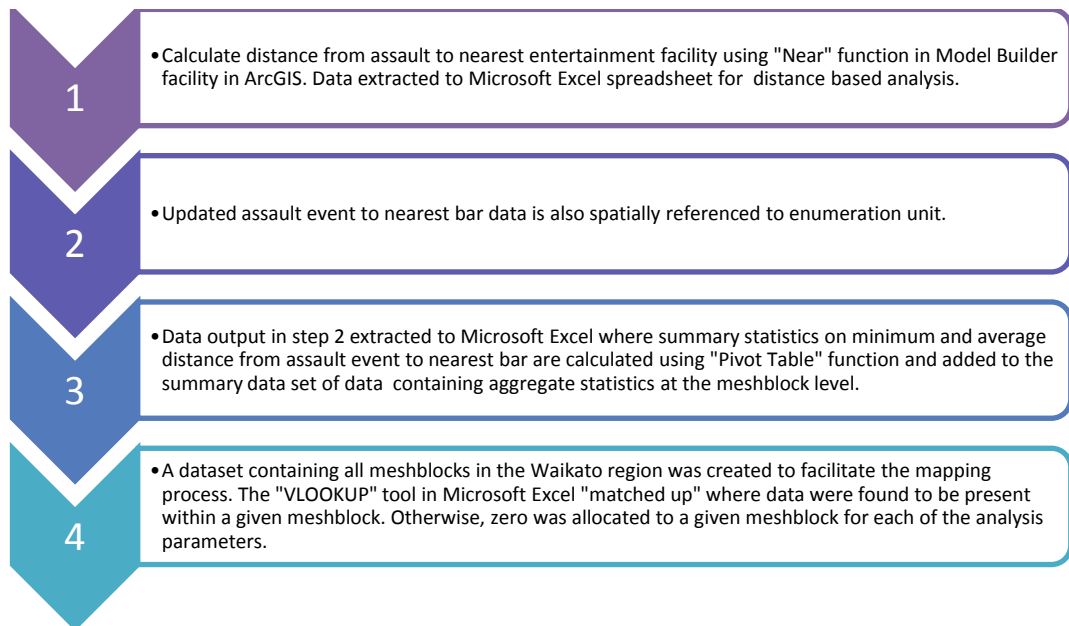


Figure 6: Process for calculating distance from assault to nearest bar/entertainment facility

For mapping assault to nearest bar statistics, the analysis process shown below was followed:

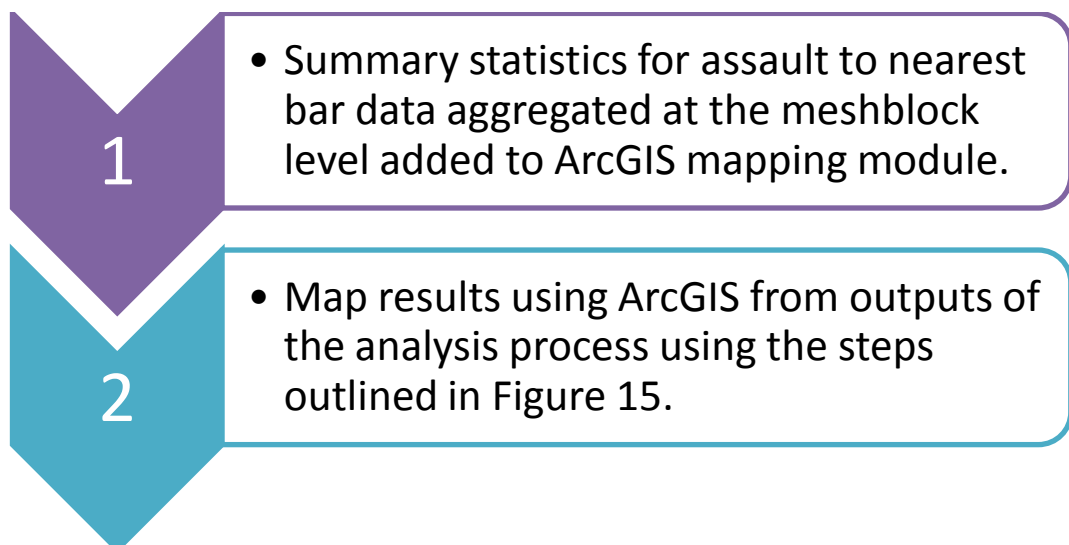


Figure 7: Process for mapping assault to nearest bar statistics

Spatial analysis of distance statistics serves to emphasise any spatial variation evident in "assault to nearest bar" statistics. Illustrating the spatial patterns is problematic at an individual level, and as a result the data is aggregated to the smallest enumeration unit (e.g at the meshblock level).

For distance-based regression analysis, the following process is applied:

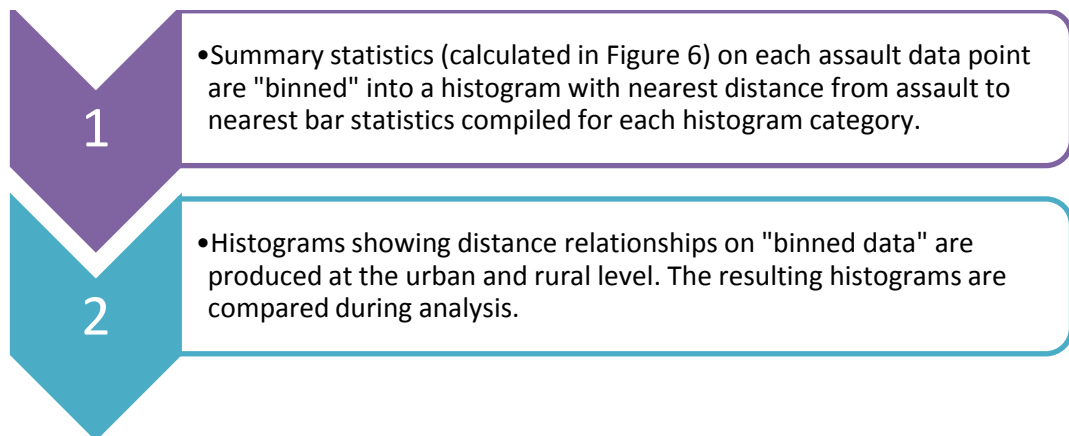


Figure 8: Process for developing frequency histograms showing distribution of assaults from closest bar

It is common for aggregate data illustrating distance relationships in crime to be represented using both histograms (Van Koppen and De Keijser 2006) and line graphs (Capone and Nichols 1975). The use of histograms is a form of univariate density estimation and “can give valuable indication of features such as skewness and multimodality in the data” (Silverman 1986 7). The histograms show whether the assault data at a ward or Census Area Unit level is “skewed” in its distribution when applied to distance statistics.

First, data from the outputs of Figure 6 are binned into categories to highlight any evidence of a distance decay pattern occurring in the assault to nearest bar data. Data binning of assault to nearest bar events into distance categories is applied to each assault event data using a nested IF function in Microsoft Excel. To show the distance decay pattern, the data are binned into categories of 100 metres for urban data and 500 metres for rural data. A rural or urban categorisation for each meshblock was obtained in soft copy from Statistics New Zealand. The number of assaults per bin category (e.g <500 m, between 501-1000m etc) are summarised using the COUNTIF function in Microsoft Excel. The assault numbers per category are plotted and a “line of best fit” is added to the data to show a regression line where applicable. The results are displayed for urban, rural as well as for all data. Second, the same data from the outputs of Figure 6 are separated into wards and the distance data are binned into different categories. These categories are 10 metres, 50 metres, 100 metres, 500 metres,

and 1 kilometre. Binning data into the closest category of 10 metres illustrates the level of assault in the immediate proximity of a bar in a relevant area, whereas the categories of 500 metres or 1 kilometre illustrate the levels of assault in distances further from the nearest bar. The same process as for the distance decay wards where a nested IF statement is used to “bin” data at the ward level and a COUNTIF statement is applied to aggregate the binned data.

6.3.2 Geographically Weighted Regression Analysis Process

Data that is analysed using geographically weighted regression should initially be analysed using “Ordinary Least Squares” regression (Mitchell 2005) as “Ordinary Least Squares” regression explores the strength of relationship between two variables. Where a close relationship is found between variables of interest using Ordinary Least Squares regression, geographically weighted regression is then applied in analysing the spatial variation in the relationship between these variables. The process for conducting geographically weighted regression analysis on bar and assault data thus is as follows:

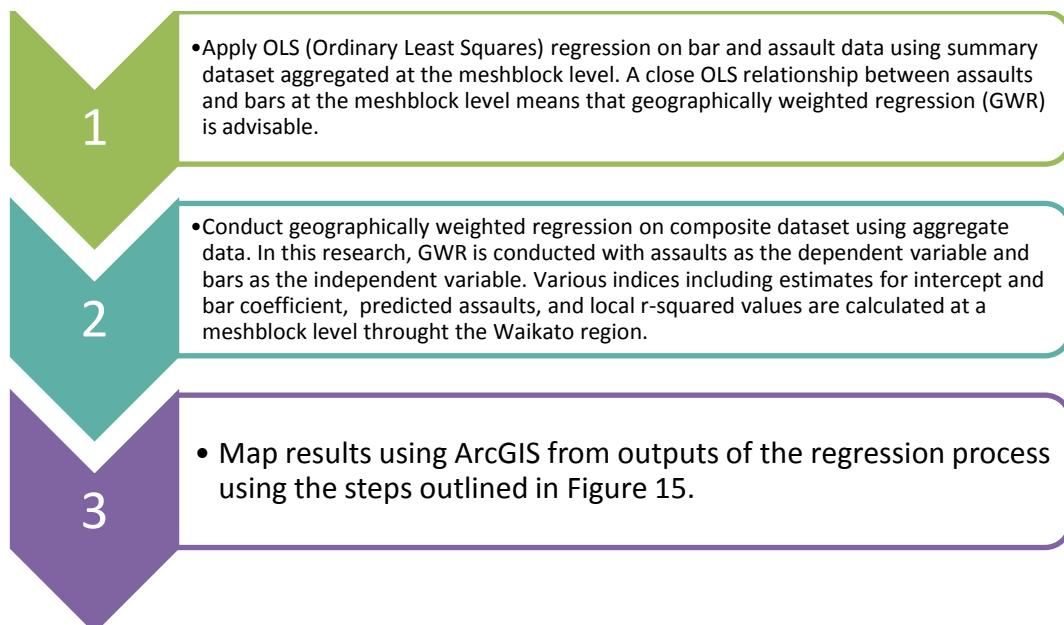


Figure 9: Process of conducting geographically weighted regression on data set

6.4 Location-based Analysis Process

6.4.1 Choropleth Analysis Process

Choropleth mapping is a commonly utilised technique in crime research for mapping crime statistics at the census level, as shown in the previous studies of Lipton *et al.*, (2003) and Gruenewald *et al.*, (2006). The spatial association between bars and assaults can be developed through a range of useful statistical indices including assault density, bar density, distance from assault to nearest bar. By aggregating data at the meshblock level, there is an opportunity for mapping the spatial distribution and densities of bars and assaults without disclosing the individual location of assault events and bars. The following process was followed to create a dataset including assault, bar, population and road lengths for mapping and regression analysis after standardising for area.

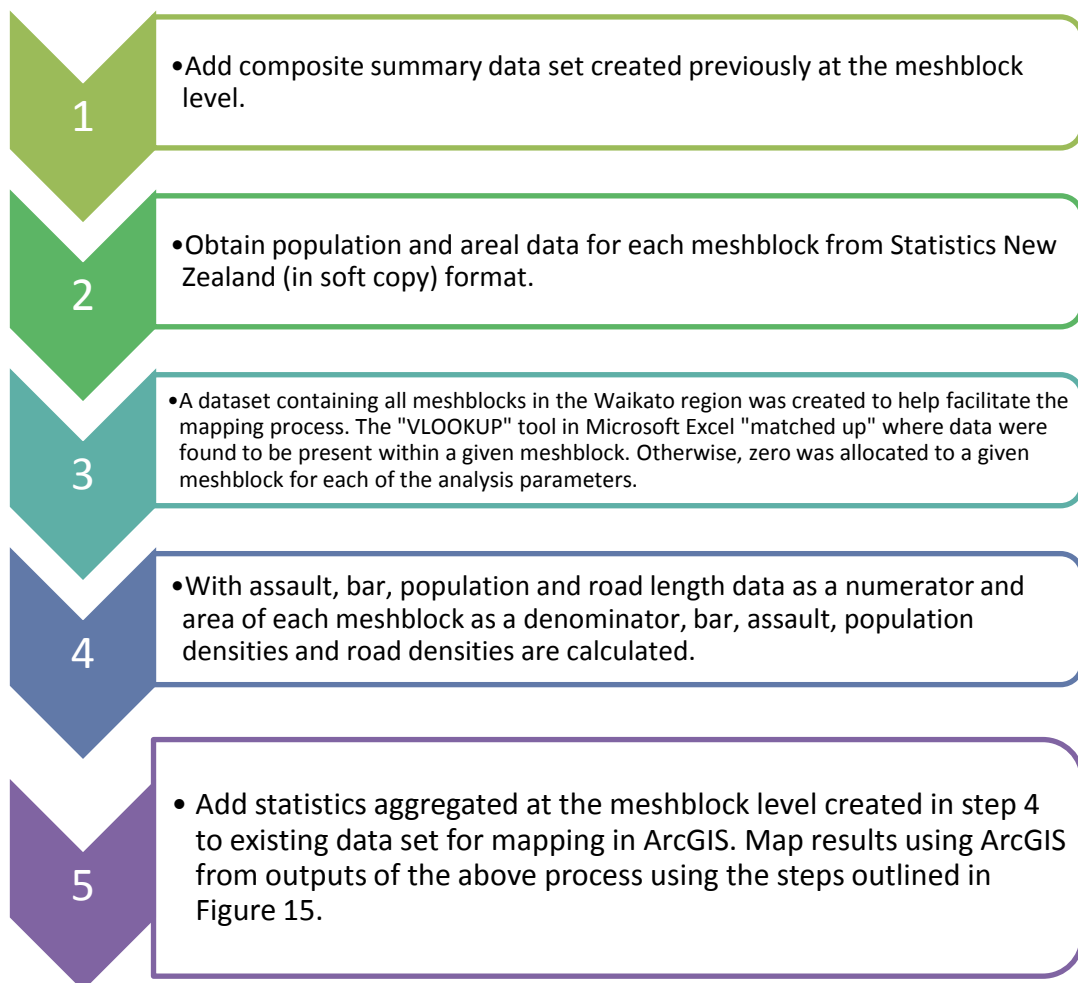


Figure 10: Process in calculating statistics for choropleth based density mapping

6.4.2 Clustering Analysis Process

Clustering analysis serves to supplement the assault density analysis and can assist in measuring the degree of association that assault distributions have with bars, nightclubs and sports clubs. The clustering analysis focuses only on the distribution of assaults and does not seek to attribute the resultant pattern to bars alone. As such, there may be other land uses that influence assault levels. The application of this type of analysis to this study is particularly useful at a small urban area level such as a meshblock to highlight particular land uses including bars, open parks, reserves, hospitals and schools which are regarded as “crime opportunity” areas. Clustering is not intended as a primary analytic tool in this study but assists in establishing the relationship between bars and assaults.

The process in calculating how data clusters is as follows:

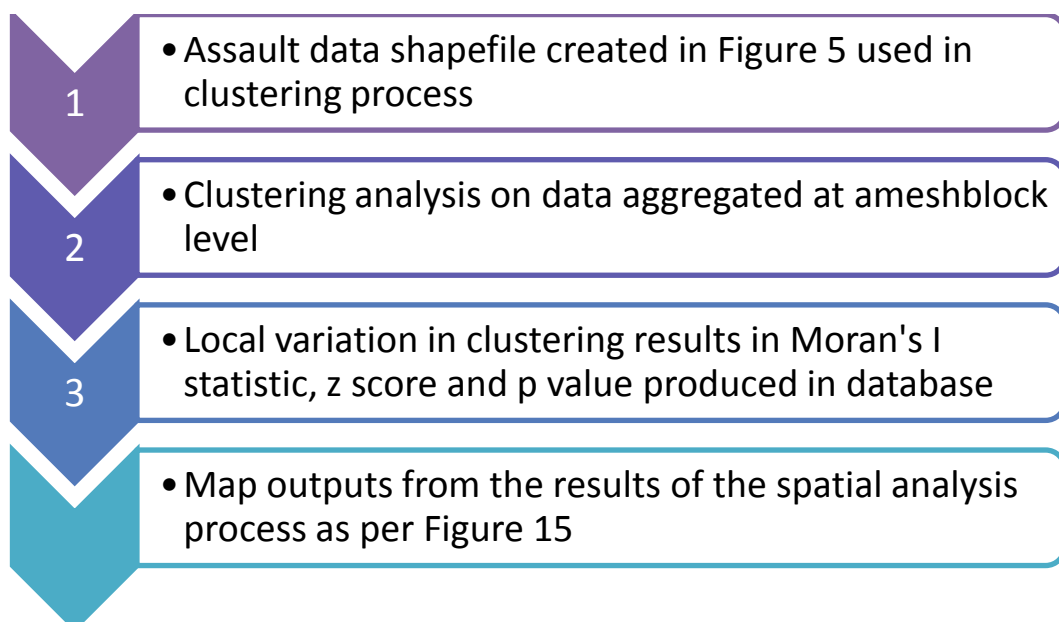


Figure 11: Process in calculating data clustering statistics

6.4.3 Density Based Analysis Process

More complex forms of density analysis by which to visualise distributions of data include the use of kernel density (Silverman 1986) and point density analysis ESRI (2008) techniques. Both point and kernel techniques use differing methodologies in visualising data, however to date, kernel density analysis techniques have been more widely used in crime research than point density analysis techniques.

6.4.4 Kernel Density Analysis Process

The cell size for kernel density in this study is 50 square metres. Sensitivity analysis was performed on the data to test the effects of different raster cell sizes on the visual results of the maps. Using a cell size that is larger than 50 square meters resulted in a “blocky” appearance. The size of 50 square metres is slightly smaller than that of 110 square metres in size used in the Fitzgerald (*et al.*, 2004) study as determined by the sensitivity analysis on the data. The search radius was similarly determined by sensitivity analysis applied at 1000 square metres. Where a search radius of smaller than 1000 square metres was used, visualisations were excessively spiky; i.e. there were too little data analysed around each analysis point. By contrast, search radii greater than 1000 square meters results in too much data under analysis around the survey point and produced excessively “smoothed” graphs. The results of the kernel density analysis were calculated according to cell size and displayed per square kilometre in ArcGIS (ESRI 2008 Help menu). The final kernel density output maps were displayed per square metre and were considered a more appropriate scale for use.

The process for conducting analysis using the kernel density analysis is as follows:

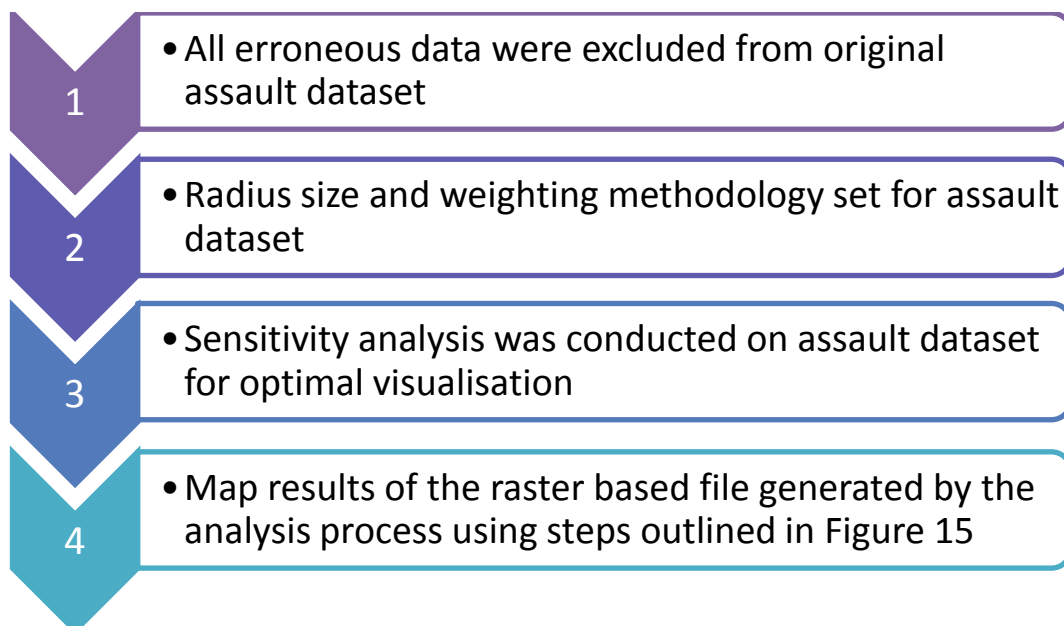


Figure 12: Process of Kernel Density analysis

6.4.5 Point Density Analysis Process

The process for conducting the point density analysis procedure on the data is as follows:

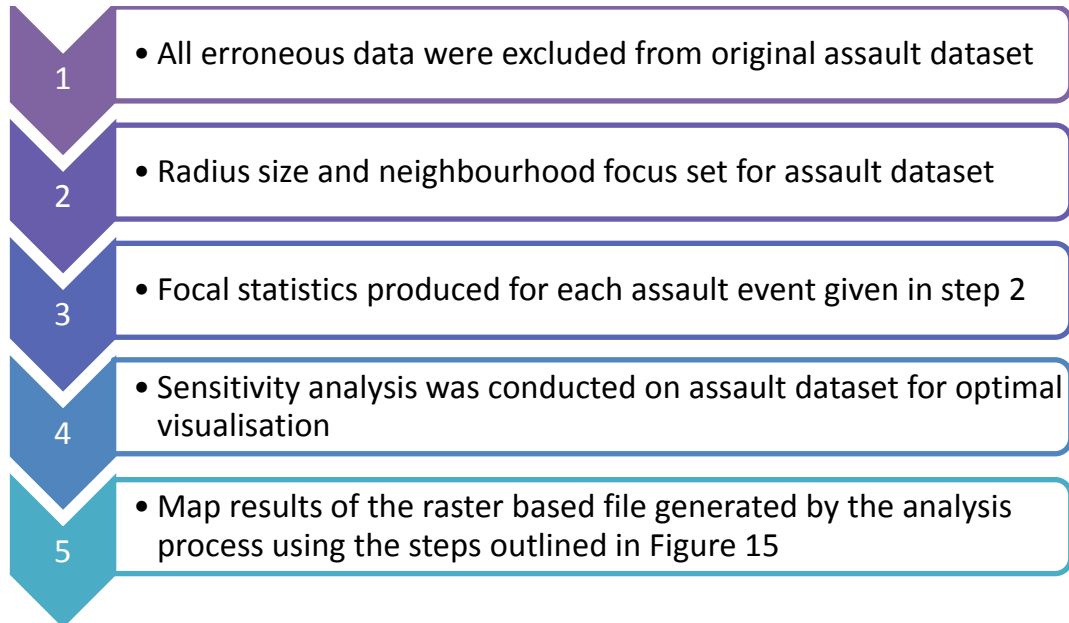


Figure 13: Process of Point Density analysis

As with the kernel density analysis, all erroneous data was excluded from analysis including where Northings equal zero on each spatially referenced data point. For assault data a circle with an area of 50 square metres is the defined area of the cell to be used in the analysis. Each cell in the data set is analysed in this way. As with kernel density analysis, sensitivity analysis is applied on the data that results in the best visual output, one that is not too “smooth” or “blocky” in character. The below graph (Figure 14) provides an illustration of different point density analyses on the same dataset.

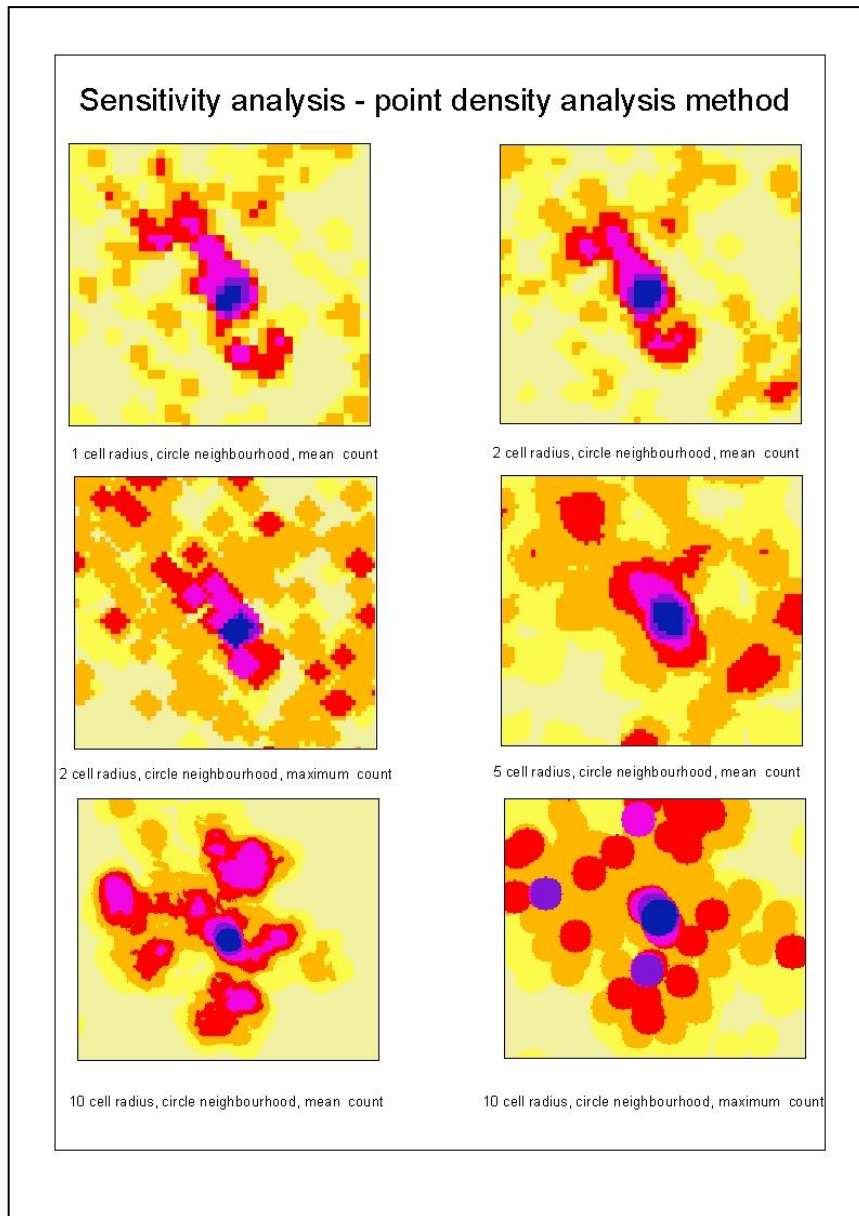


Figure 14: Sensitivity analysis on assault data

Figure 14 illustrates how analysis using a smaller neighbourhood results in a coarser analysis, whereas analysis with a larger neighbourhood results in a “smoother” picture but results in outputs that are less accurate. Initially, a five-cell “mean” neighbourhood analysis was applied on the data. This strategy resulted in an output that was too “smooth”. Therefore a more appropriate point density analysis, that of a two cell “mean” analysis was applied and resulted in a more accurate, yet manageable representation of assault patterns in Hamilton and throughout the Waikato. The results displayed include the

magnitude per square kilometre of all the point features that fall within the defined neighbourhood (ESRI 2008 Help menu).

Note: Due to the similarity of the visual outputs of point and kernel density functions, only point density maps are included in the analysis and results section. Calculation of density estimates were more straight-forward using the point density approach as opposed to using the kernel density approach.

6.5 Cartographic Aspects

An effective map should highlight the importance of characteristics of data that may vary due to scale, location, or pattern through space, according to Harries (1999). Creating such a map should consider these different characteristics and involve appropriate frame design and data classification to represent data at different scales and locations.

According to Dent (1990) maps should consider balance, focus and internal organisation, all of which contribute to a visually harmonious image. The three features of balance, focus and internal organisation are considered in map production; in which certain laws or standards assist in contributing to visual harmony and also help to deliver an understanding of what messages the map is trying to project (Belbin 1996).

6.5.1 Data Classification for Maps

For this research, data was produced as divergent, sequential or categorical data. Bar and assault statistics, geographically weighted regression r-squared values aggregated at a meshblock level and point and kernel density statistics produce data that can only either be zero or greater and therefore must be classified as sequential. Moran's I statistic is a measure that diverges around zero; hence a divergent colour scheme is applied to the data. Research has revealed that divergent map schemes give greater emphasis to data clustering (Brewer, MacEachren, Pickle and Hermann, 1997).

Following categorisation of the data, the classification scheme used and the number of classes used to display the information were applied to the data. The

classification scheme relates to the division of discrete data when represented on a map. An appropriate classification scheme may be applied according to the distribution characteristics of the data set (i.e if it is normally distributed or otherwise (Smith 1986)). On each map, it was decided that five classes should be used for the bulk of the data (excluding zero and/or missing data) due to the distribution of the data. Exceptions to this classification were six classes for Point Density diagrams and seven classes for geographically weighted regression.

Research by Smith(1986) showed that testing using the quartile, standard deviation, equal interval, “Natural Breaks” or “Jenks optimisation” method established that no one classification scheme was deemed to be entirely accurate. However, results from research conclude that first, quartile and standard deviation methods are most accurate when used on normally distributed data, however are deemed to be inaccurate on skewed data. The “Natural Breaks” method happened to be most unreliable on normally distributed data (Smith 1986). Second, quartile method is deemed most accurate on tests on epidemiological data and the “Natural Breaks” method does not appear to offer any benefits over the quartile method (Brewer and Pickle 2002). In conclusion, it appears as though the most accurate classification schemes are the quartile and “Natural Breaks” method with little to choose between the two after considering the benefits and limitations of each method. In this research, the “Jenks Optimisation” or “Natural Breaks” method of classifying data has been applied on all analysis parameters.

6.5.2 Application of Colour to Maps

The use of colour in maps also influences the visual output in the process of area differentiation (Harries 1999).As a result the way colour is applied affects the way a map is perceived visually and analysed. The use of colour is applied on maps to stand for something happening in the real world (Harrower and Brewer 2003). Recently software has been developed by researchers to enable novice map makers to produce colour ramps on maps that are attractive and appropriate given the nature of the data being analysed.

The software, available online and known as ColorBrewer⁸ allows a user to “test run” the use of a colour code on a map. (Harrower and Brewer 2003). The choice of colour on maps is now a more scientific than subjective process by using the ColorBrewer software. The software has been designed using a scale with different shades of up to three different colours; and vary in hue according to whether the data is divergent, sequential or categorical (Harrower and Brewer 2003).

In this research, the ColorBrewer colour ramps have been applied on much of the data according to the data analysis methods previously outlined. Most of the data being analysed, including density and distance data is greater or equal to zero. For these analyses, it is not possible to have data less than zero, and sequential scales are thus applied. Exceptions to the use of sequential scales relate to the analysis of data clustering, here divergent scales are used as data deviates around zero and may be a negative or positive result.

The results of these applications mean that “sequential” style maps should, accordingly be shaded lighter for lower densities or lower absolute values and darker for higher densities or higher absolute values. Likewise, for distance analysis results displayed at the choropleth or meshblock level, darker shades are applied to represent closer average distance from assault to nearest bar, and lighter shades for longer average distances from assault to nearest bar per meshblock. The use of darker shades in this context highlights the close association between assaults and bars at the meshblock level.

A range of different colour ramps may be applied on data. For all the analysis parameters, with the exception of “point density” maps, different colour maps were applied using ColorBrewer software. The point density maps were shaded using a “yellow-red-dark blue” colour ramp that was provided in ArcGIS version 10 software. The colours applied are yellow for lower densities, red for moderate densities and blue for higher densities. This ramp was considered by the researcher visually effective in highlighting assault “hot-spots” over areas of

⁸ The Colorbrewer online website (<http://colorbrewer2.org>) is created by Cynthia Brewer, Mark Harrower, Andy Woodruff and David Heyman. All Colorbrewer colour ramps used in mapping from www.ColorBrewer.org by Cynthia A. Brewer, Geography, Pennsylvania State University.

lower assault densities. Otherwise, the maps were shaded using ramps from the ColorBrewer software. Here, up to three different colours with various shades are typically applied on data.

For the choropleth density analysis, grey represents light densities of assault, green-blue for moderate densities of assault, and dark green for high densities. For distance analysis, yellow represents meshblocks that have on average, long distances, between assault and nearest bar. Teal green represents meshblocks that on average have moderate distances between assault and nearest bar and dark blue represents meshblocks that on average have short distances between assault and nearest bar. Data that is more clustered in nature is coloured red, as opposed to randomly distributed data coloured yellow and divergently distributed data that is blue in colour. This colour scheme is in accordance with crime hotspots coloured “red” and crime cold-spots coloured “blue”.

6.5.3 Frame Design of Maps

The construction of a suitable map frame using ArcGIS software was problematic, due to the irregular narrow shape of the Waikato region. Initially two sets of maps were devised; the first set of Hamilton City, and the second set of maps of different sub-regions within the district loosely corresponding to territorial authority boundaries. The initial drafts of maps were drawn at an A4 portrait frame, illustrating an urban-rural disparity of assault distribution, along with townships included as insets surrounding the rural focus. However, the township insets blocked some useful analysis information that was displayed in rural areas.

The large volume of maps produced using different sub regions could create difficulties for a reader. Subsequent drafts with fewer outputs were drawn illustrating the Waikato region in the centre, surrounded by insets containing assault and bar information on townships. Due to the high number of townships to be included for analysis, for reasons previously explained, the second drafts of maps were drawn at a landscape as opposed to a portrait frame. This ensured that more information was included in the maps. The Hamilton City maps were not re-drafted. The resulting maps were hence redrafted so that there were only

two maps for each analysis variable which made for easier visualisation and reader analysis.



Figure 15: Process for frame design and data classification

Creating maps has been shown not to be an arbitrary process. There has been much research into the application of correct cartographical methods on maps,

including the appropriate use of colour, classification of data on a map as well as what constitutes a befitting layout and design. Well designed maps are necessary for analysis of results and may indeed be misleading if poorly designed.

There has been reference in the previous chapter to a variety of different analysis procedures by which to analyse the data, using methods gained from different theoretical perspectives. The analysis of data results in a wide body of information to be considered in context with the research objectives. Attention now turns to the results of the analysis through both spatial and non-spatial methods.

Chapter 7: Results

7.1 Relationships between Bars and Assaults

This chapter summarises the results of the different analyses and presents the influence of place and population characteristics on the “bar to assault relationship” using a range of different techniques including distance decay graphs, as well as point and choropleth analysis graphs.

7.1.1 The Relationship between Assault Density and Bar Density

The relationship between assaults and bars is explored by seeking to establish whether there is any correlation between number of assaults and number of bars at a meshblock level -the smallest unit of aggregation which is least likely to suffer the effects of the “Ecological Fallacy” (Robinson 1950), where the larger the unit of representation, the less representative the unit is of local data. As already noted, a reasonable relationship between the two variables ensures that the data is considered appropriate for further analysis using geographically weighted regression.

Initial analysis examined assault density versus bar density at the meshblock level in the form of a scatterplot. A regression line was fitted to the scatterplot representing each data point at the meshblock level. There is a linear relationship (r-squared value = .8523) between bar density and assault density in each meshblock.

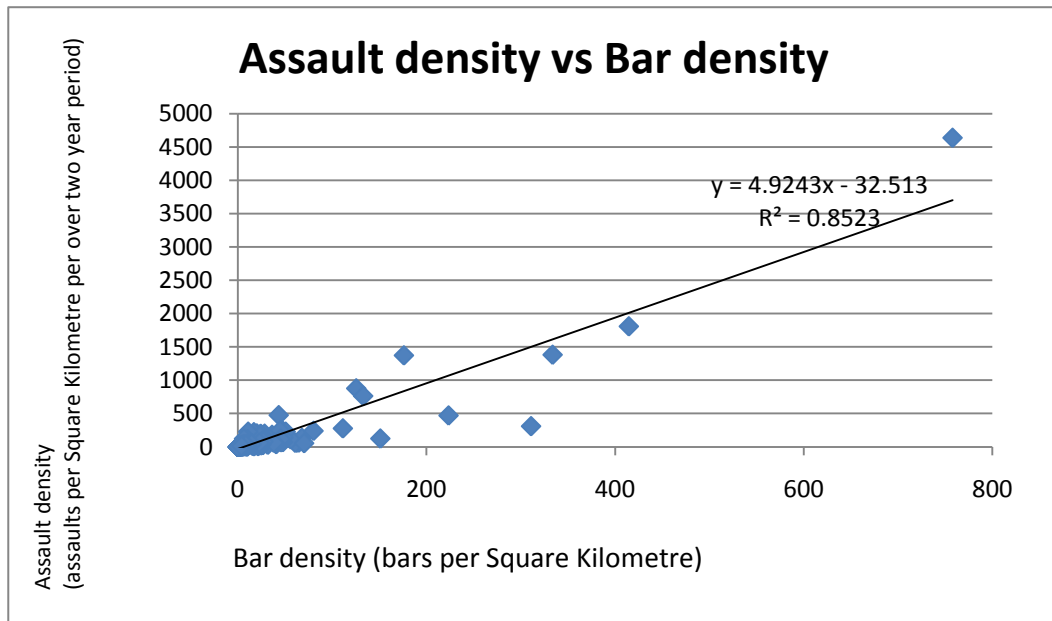


Figure 16: Bar density versus assault density (per Meshblock)

The results show that, at the meshblock level, as the density of bars per meshblock increase, so does the density of assault. This relationship can be explained as an increase of just under 2.5 assaults per square kilometre for every addition to bar density per square kilometre over the course of one year. This relationship strongly supports the findings of the 2008 study by Livingston which established that there is a positive association between violence and alcohol outlet density. It is also consistent with a marked increase in assault prediction above a certain threshold as advanced by Livingston (2008) based on earlier research by Gruenewald(2007). The spatial dimension to this straight line relationship between bar and assault densities is represented through the geographically weighted regression analysis which is discussed in a later section.

7.1.2 Distance Relationships between Bars and Assault

The distance relationships between bars and assault are shown in the accompanying graphs below:

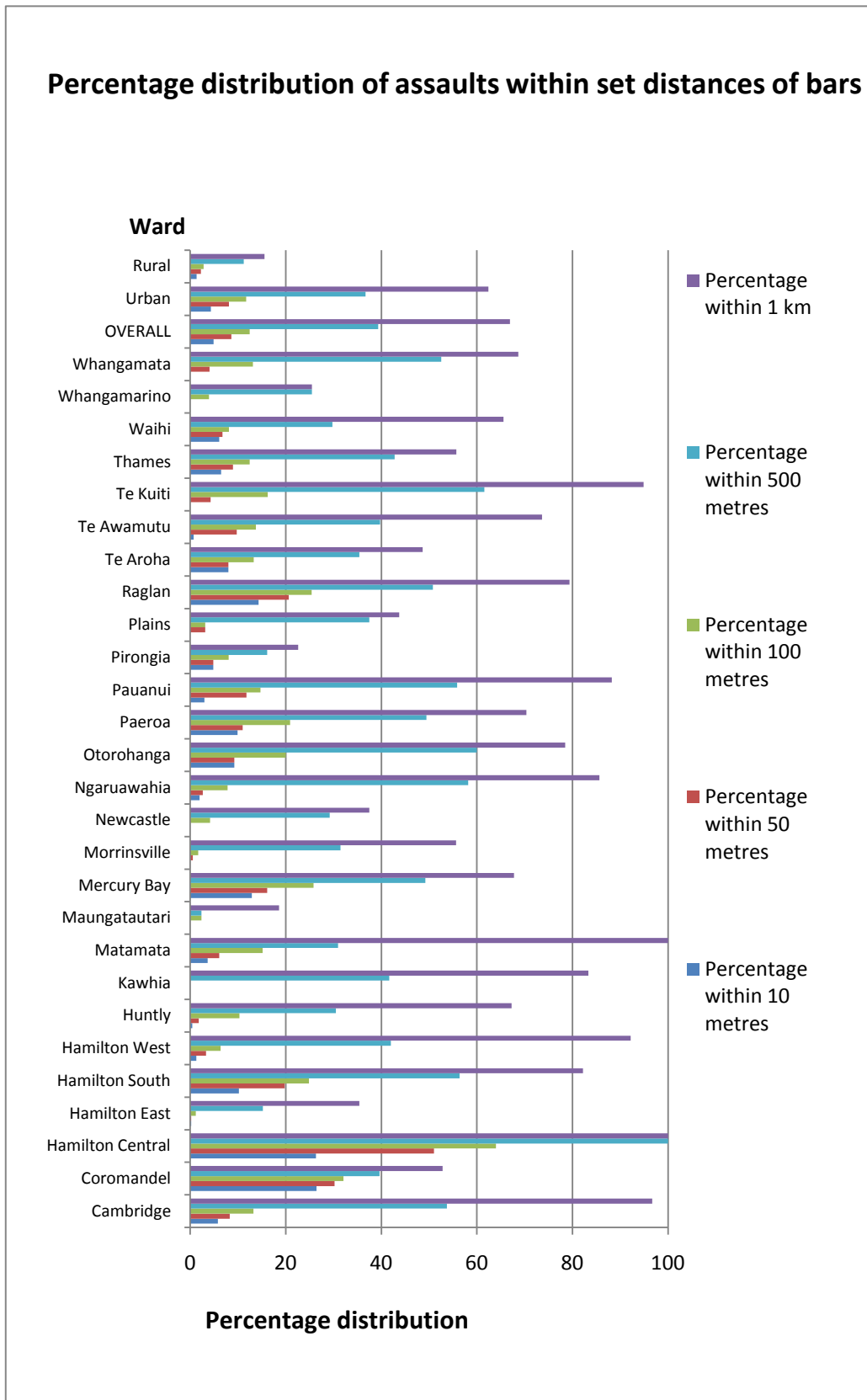


Figure 17: Percentage distribution of assaults within set distances of bars

Ward	% within 10 metres	% within 50 metres	% within 100 metres	% within 500 metres	% within 1 km	Average Distance from Assault to Nearest Bar (km)	Total number of assaults per Ward
Cambridge	5.79	8.26	13.22	53.72	96.69	0.46	122
Coromandel	26.42	30.19	32.08	39.62	52.83	2.34	54
Hamilton Central	26.32	51.03	63.97	100.00	100.00	0.10	680
Hamilton East	0.23	0.23	1.13	15.19	35.37	1.23	882
Hamilton South	10.18	19.76	24.85	56.35	82.22	0.53	1671
Hamilton West	1.27	3.29	6.35	42.00	92.15	0.54	1339
Huntly	0.45	1.79	10.31	30.49	67.26	0.79	223
Kawhia	0.00	0.00	0.00	41.67	83.33	2.32	12
Matamata	3.64	6.06	15.15	30.91	100.00	2.28	166
Maungatautari	0.00	0.00	2.33	2.33	18.60	3.24	43
Mercury Bay	12.90	16.13	25.81	49.19	67.74	2.04	125
Morrinsville	0.00	0.56	1.69	31.46	55.62	2.08	179
Newcastle	0.00	0.00	4.17	29.17	37.50	2.22	25
Ngaruawahia	1.96	2.61	7.84	58.17	85.62	0.57	154
Otorohanga	9.23	9.23	20.00	60.00	78.46	0.55	66
Paeroa	9.89	10.99	20.88	49.45	70.33	0.91	92
Pauanui	2.94	11.76	14.71	55.88	88.24	1.66	34
Pirongia	4.84	4.84	8.06	16.13	22.58	3.16	62
Plains	0.00	3.13	3.13	37.50	43.75	2.36	32
Raglan	14.29	20.63	25.40	50.79	79.37	0.72	63
Te Aroha	7.96	7.96	13.27	35.40	48.67	2.48	113
Te Awamutu	0.72	9.75	13.72	39.71	73.65	0.70	277
Te Kuiti	0.00	4.27	16.24	61.54	94.87	0.41	117
Thames	6.47	8.96	12.44	42.79	55.72	0.98	201
Waihi	6.08	6.76	8.11	29.73	65.54	1.42	148
Whangamarino	0.00	0.00	3.92	25.49	25.49	6.73	51
Whangamata	0.00	4.04	13.13	52.53	68.69	1.02	99
OVERALL	4.89	8.61	12.45	39.32	66.92	1.19	6563
Urban	4.33	8.09	11.71	36.72	62.38	0.72	5635
Rural	1.31	2.24	2.80	11.21	11.51	5.62	535

Table 2: Percentage distribution of assaults within set distances of bars (tabular format)

Note: an illustration containing all the wards in the Waikato region is found in Appendix B. Some rural wards with small numbers of assaults and bars have not been included in the analysis. Some meshblocks in Waikato were not able to be coded either urban or rural hence the discrepancy between total numbers of assault per ward against urban or rural data.

The overall distance relationship between bars and assault is illustrated in Figure 17 and Table 2 which show that 67% of all assaults took place within 1 kilometre of the nearest bar and 40% took place within 500 metres of the nearest bar.

These results also illustrate a significant variation between urban and rural areas of the Waikato in respect of the distance relationship between bars and assault. In urban areas, 4% of assaults took place within 10 metres of the nearest bar, 8% of assaults took place within 50 metres of the nearest bar, 37% of assaults took place within 500 metres of the nearest bar, and 62% of assaults took place within 1 kilometre of the nearest bar.

In rural areas, 1% of assaults took place within 10 metres of the nearest bar, 2% of assaults took place within 50 metres of the nearest bar, 11% of assaults took place within 500 metres of the nearest bar and also 1 km of the nearest bar.

The results of Figure 17 and Table 2 show that there are not only distinct patterns highlighted between urban and rural areas, but also within townships and within the main urban centre of Hamilton City. Coromandel, Raglan, Mercury Bay (Whitianga) and Hamilton City CBD all exhibit similar patterns in that these locations have a somewhat higher proportion of assaults close to bars, with 25% of assaults in Coromandel township and Hamilton Central occurring within 10 metres of a bar. In the Hamilton Central Census Area Unit just over 50% of assaults took place within 50 metres of a bar; and just over 60% of assaults took place within 100 metres of a bar. In fact, the closeness of the distance relationship between bar and assault in the CBD is evidenced by the fact that 14 of the 50 meshblocks with the closest average distance between assault and bar were from Hamilton City's CBD. It is reasonable to conclude that the distance distribution statistics in Hamilton City are due primarily to the concentration of bars and nightclubs located in the Central Area Unit of Hamilton City. Thirty percent (98 of 323) of the total successfully geocoded bars, nightclubs and lodges

in the Waikato are located in the Hamilton Central Census Area Unit.⁹

The wards of Huntly, Matamata, Cambridge, Ngaruawahia, Pauanui, Te Awamutu, Te Kuiti, Otorohanga, Hamilton West, Whangamata and Waihi all exhibit similar patterns for distance data. Around 5%- 10% of assaults in these locations occur within 10 metres of a bar, and 30-50% of assaults occur within 500 metres of a bar (refer Figure 17). 4 of 50 meshblocks recording closest distances from assault to nearest bar were from the Te Awamutu ward.

Other areas within Hamilton City illustrated very different “distance from assault to nearest bar patterns” from that of the Hamilton Central Census Area Unit. In both Hamilton East and Hamilton West, most assaults occurred some distance from the closest bar; in Hamilton West less than 10% of assaults took place less than 100 metres from the closest bar and around 40% of assaults took place less than 500 metres from the closest bar. In Hamilton East, just fewer than 40% of assaults took place within 1 km of bars. Hamilton South and West wards includes the Hamilton Central Census Area Unit therefore the results for this region are somewhat skewed by the results of Hamilton’s CAU area.

The results of the analysis indicate that within Hamilton city there is considerable variation in the assault to nearest bar analysis statistics. The results showed on average, quite a short distance from “assault to nearest bar” in the Hamilton CBD but these patterns were not replicated in other parts of the city. The results suggest that bars have a considerable influence on assault distribution in the central city but less so in other parts of the city. While Figure 17 and Table 2 show an overall clear distance decay relationship, there is some skewing of this relationship with larger distances between bars and assault in Coromandel and Whitianga. This is due to a proportion of assaults taking place some distance from the nearest bar.

⁹ A note on urban/rural classifications. The definition of urban meshblock based solely on population was deemed by Statistics New Zealand to be inadequate. It was determined by Statistics New Zealand that the classification of a meshblock as urban or rural would be determined on the degree of urban influence that an area has. Urban areas in this research contain all urban subcategories defined by Statistics New Zealand and likewise rural areas in this research contain all rural subcategories. Source of data (http://www.stats.govt.nz/browse_for_stats/people_and_communities/geographic-areas/urban-rural-profile-update.aspx) website accessed 21 February 2011

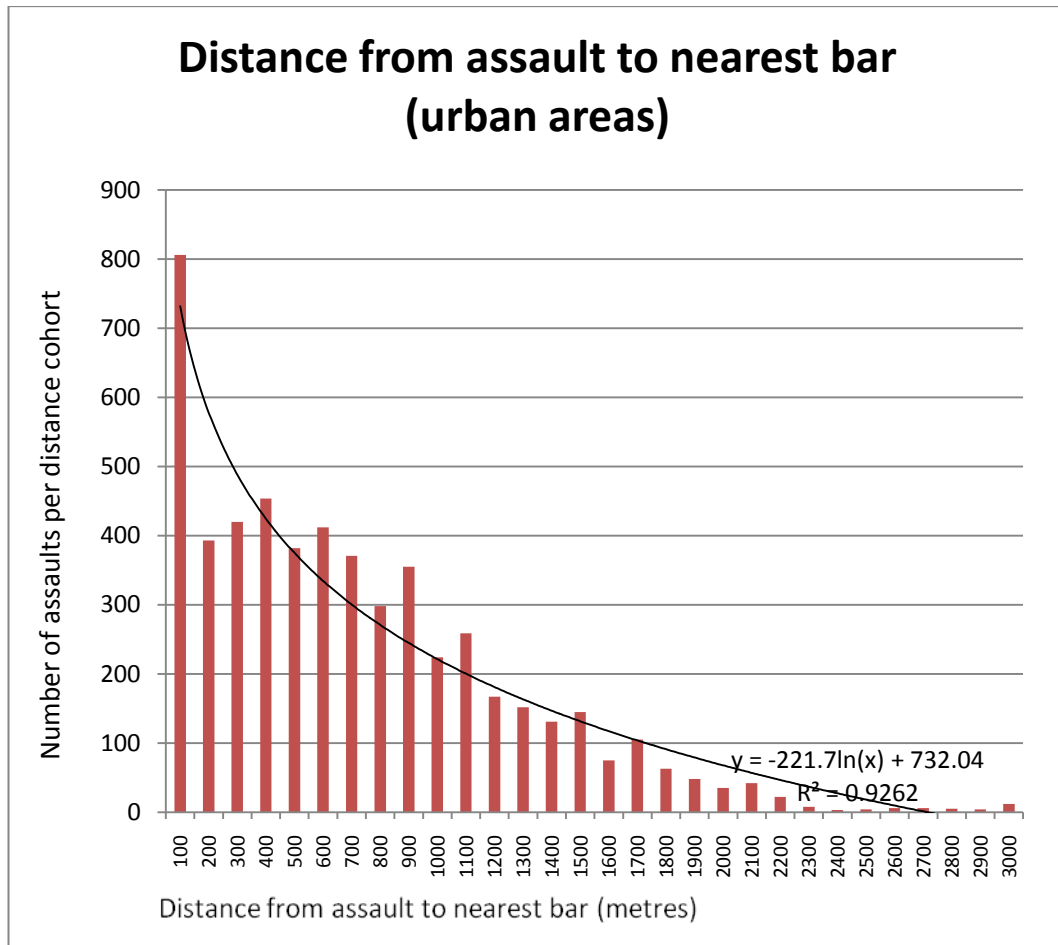


Figure 18: Distance from assault to nearest bar (urban areas)

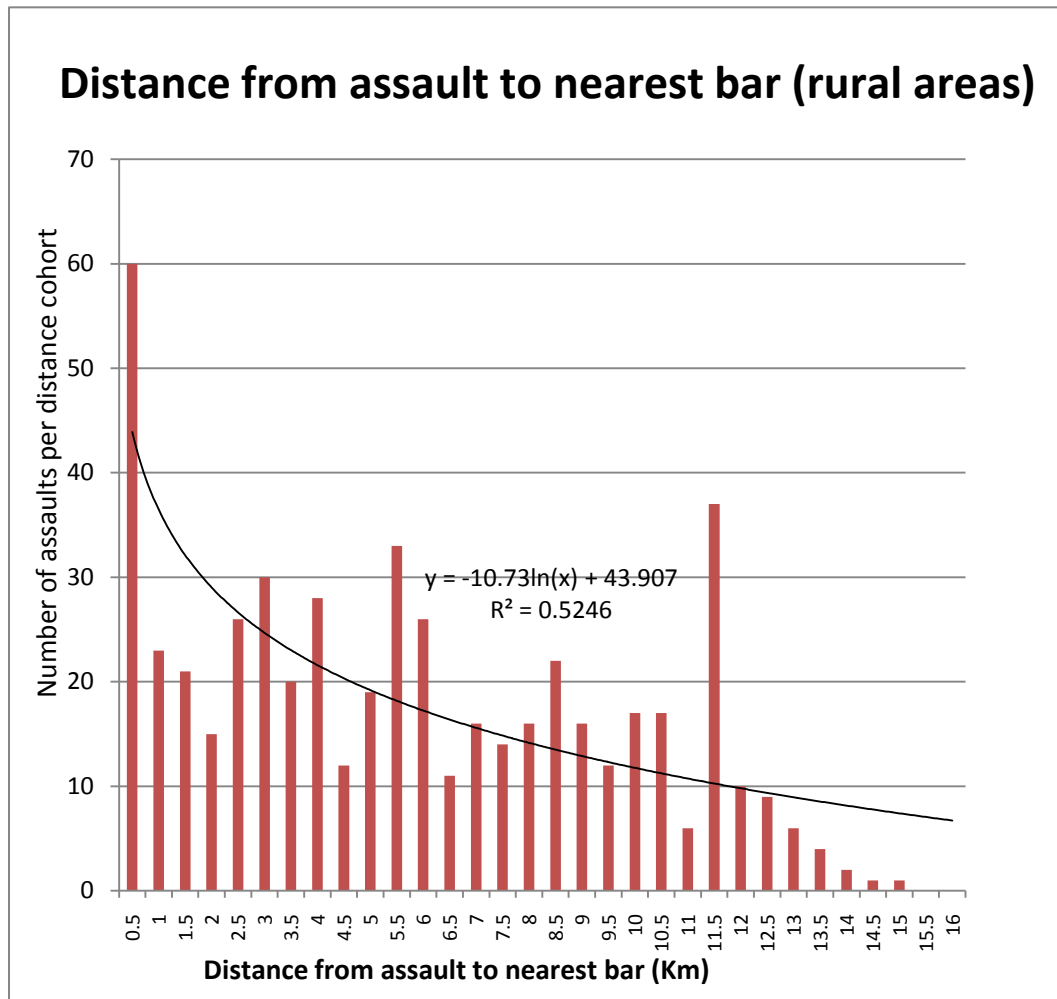


Figure 19: Distance of assault to nearest bar (rural areas)

The above figures clearly illustrate the strong “distance-decay” relationship (r -squared = .91) between assaults and nearest bar in urban areas (Figure 18) with a weaker relationship (r -squared = .53) in rural areas (Figure 19). The figures show that there is a much closer relationship between nearest bar and assaults in urban areas than in rural areas.

7.1.3 Spatial Patterns of Distance Based Relationships

The average distance from assault to the nearest bar per meshblock can be represented spatially. The total distance between each assault and bar is summed for each meshblock and divided by the sum of assaults in each meshblock to calculate the average distance. These results are shown in the following Figures 20 and 21 below:

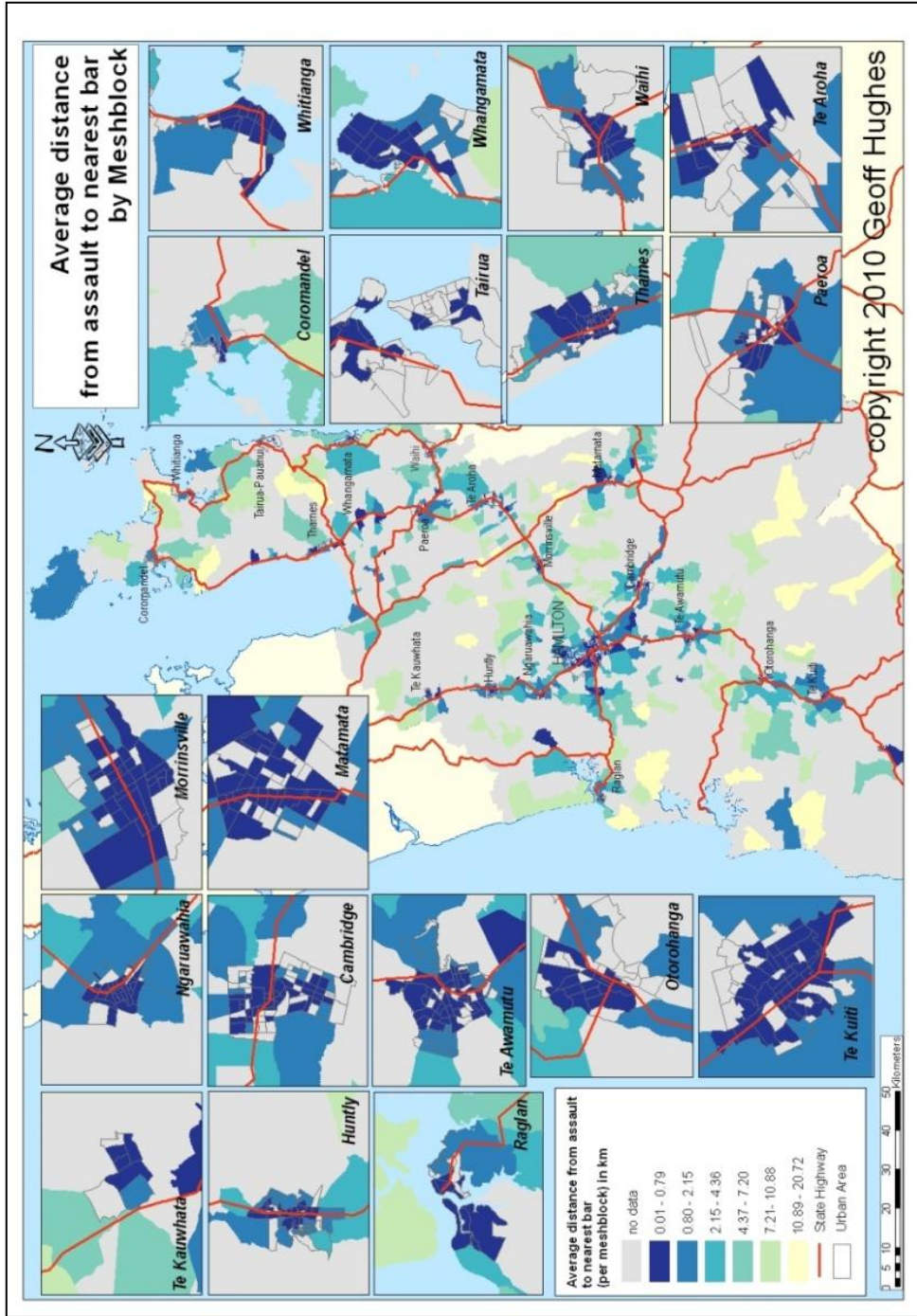


Figure 20: Average distance from assault to nearest bar by meshblock – Waikato Region

At an overall regional level, the results of the analysis confirm that assaults in rural areas tend to occur further away from bars than is the case in urban areas. Also, main roads appear from the analysis to influence the “distance from assault to nearest bar” statistics as assaults appear to take place in close proximity to roads in both urban and rural areas. There are several rural meshblocks that do not follow the general patterns of greater distances of assault to nearest bar. These are located mainly on State Highways or on main arterial routes and also two other meshblocks, one south of Kawhia and another at the extreme northern end of the Coromandel Peninsula.

At a township level, there is clear evidence that assaults tend to occur close to bars. In fact by reference to Figure 20 in all the townships, most assaults tend to take place less than 50 metres from a bar in the centre of each town.

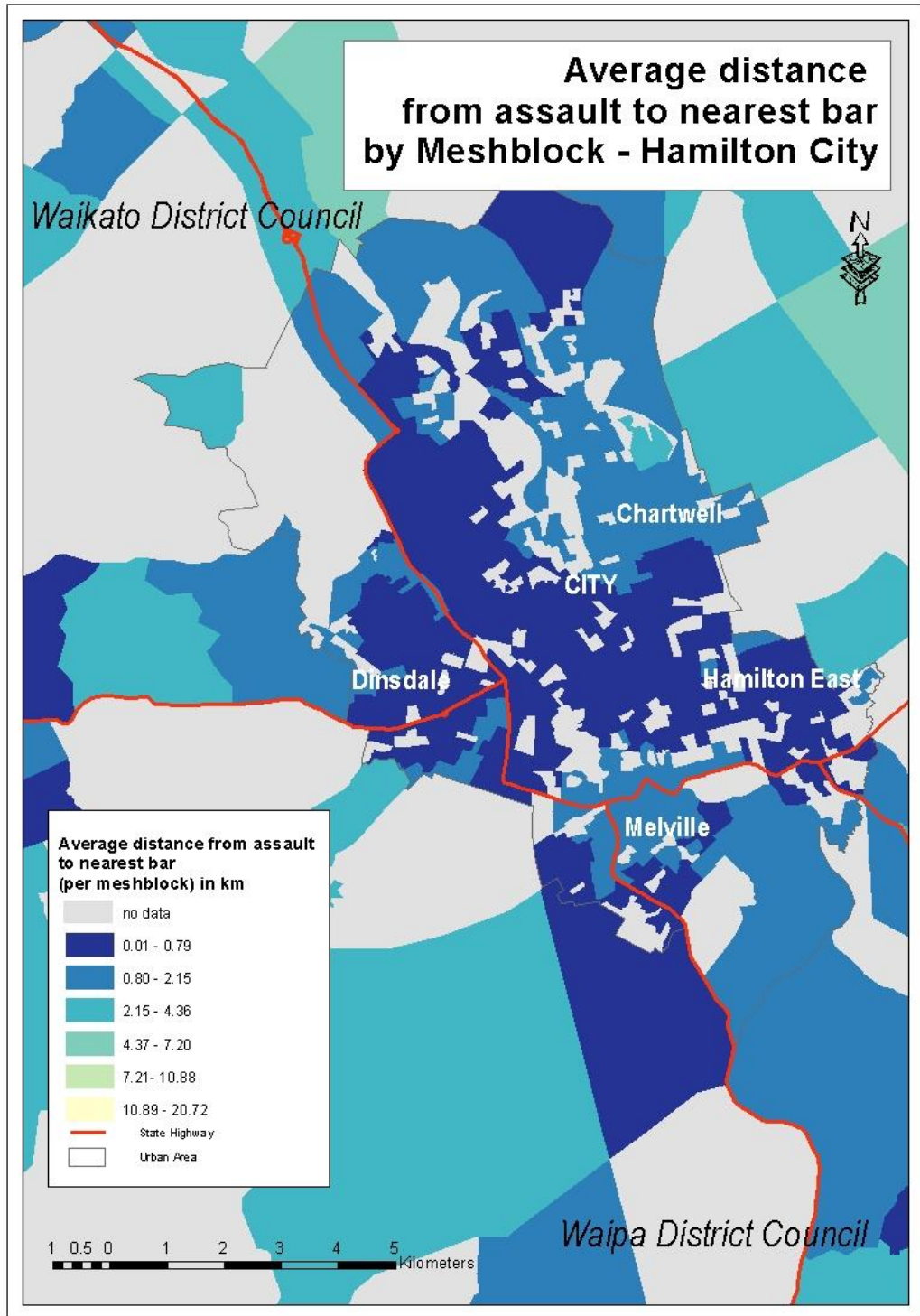


Figure 21: Average distance from assault to nearest bar by meshblock – Hamilton City

Hamilton City exhibits a greater diversity in distance relationships between assaults to nearest bar than townships throughout the Waikato region. In Hamilton City, areas where assaults occur within close proximity to bars and sports clubs include the CBD, and the suburbs of Te Rapa, Dinsdale, and Hillcrest.

There appears to be less of an influence of bars on assault patterns (by reference to the average distance from assault to nearest bar) in the suburb of Melville but also areas of northern Hamilton in Chartwell and Rototuna. Here, there is a clear distance decay relationship at work between assaults and bars; the nature of that relationship varies according to location. It is therefore appropriate that more attention is given to the spatial distribution of assaults and bars at different locations in both urban and rural areas throughout the district.

7.1.4 Geographically Weighted Regression Analysis

Geographically weighted regression can be applied first, to establish the level of variation between bars and assaults. The level of variation between these two variables is measured by the calculation of the r-squared statistic at a local level. Second, the geographically weighted regression technique is able to *predict* the number of assaults (as the dependent variable) that occurs in different areas. When analysing socio-economic data, this (geographically weighted) regression technique is commonly applied at the enumeration level (e.g meshblock level) (Mennis 2006). In this research the geographically weighted regression analysis is applied on the number of bars (as the independent variable) and assaults (as the dependent variable) present within the same meshblock. When making predictions at the meshblock level, the model calculates an intercept value, bar coefficient value and residual error value per meshblock.

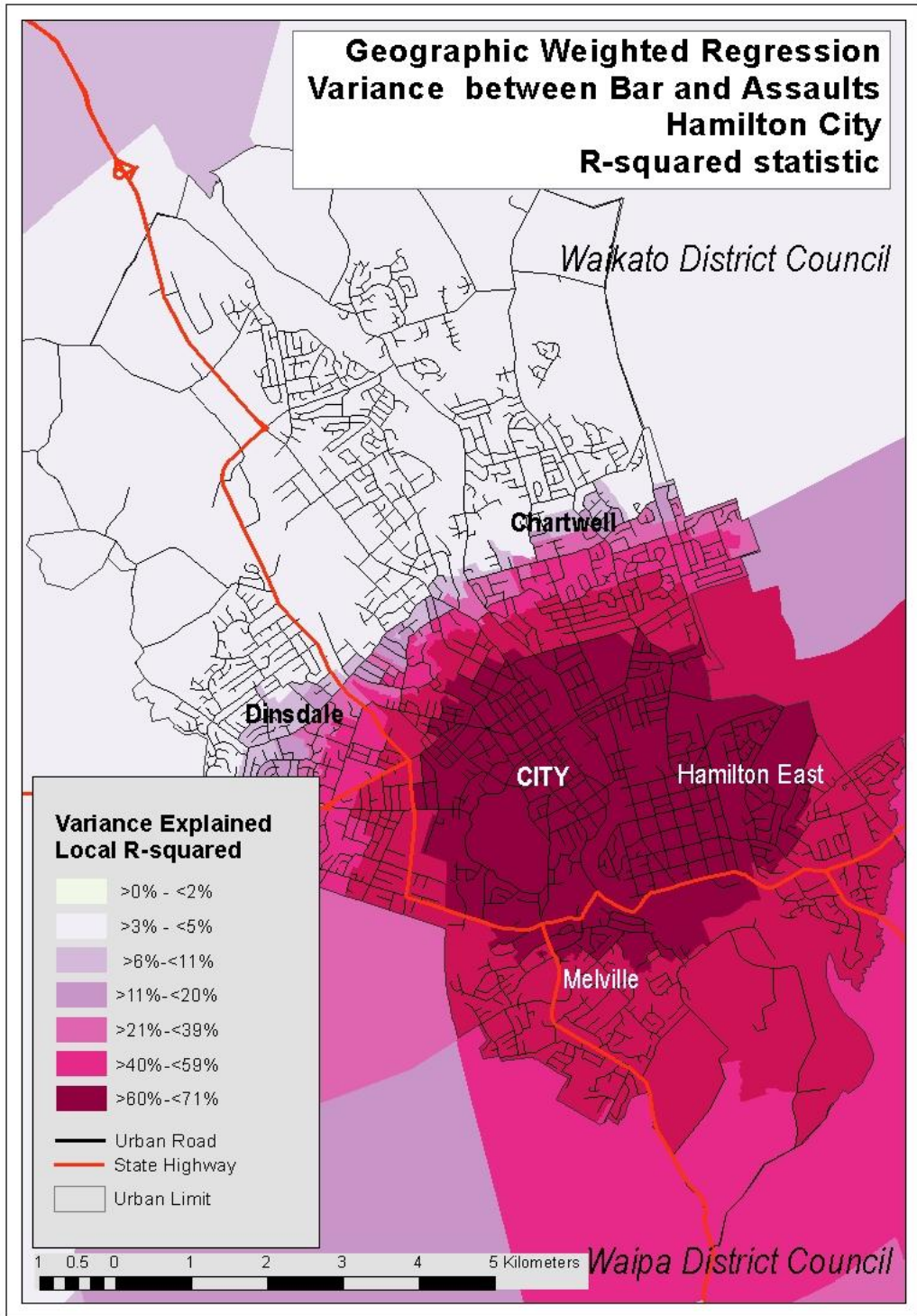


Figure 22: Geographically weighted regression Variance explained, Hamilton City

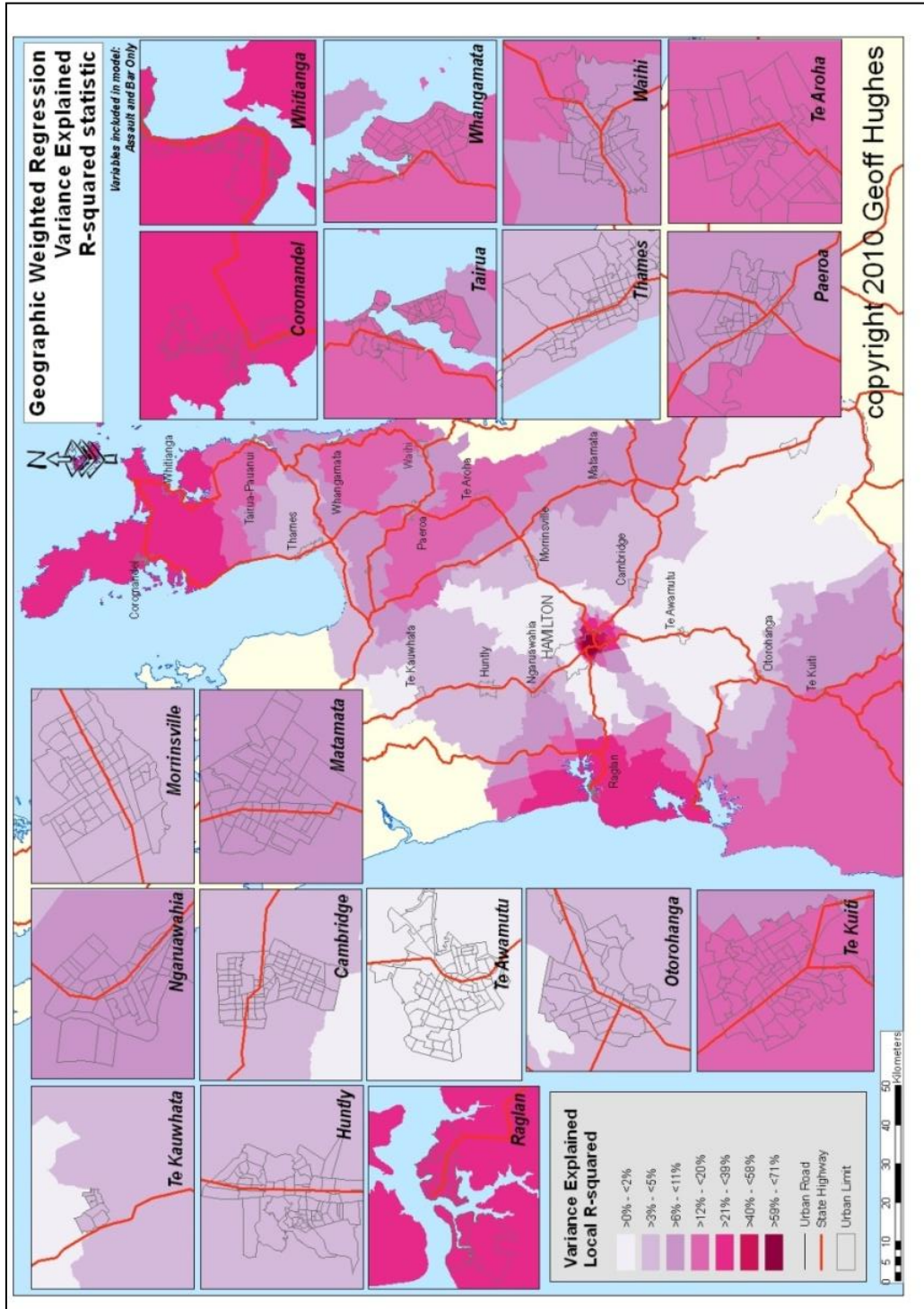


Figure 23: Geographically weighted regression Variance explained (r-squared) assaults versus bars, Waikato region

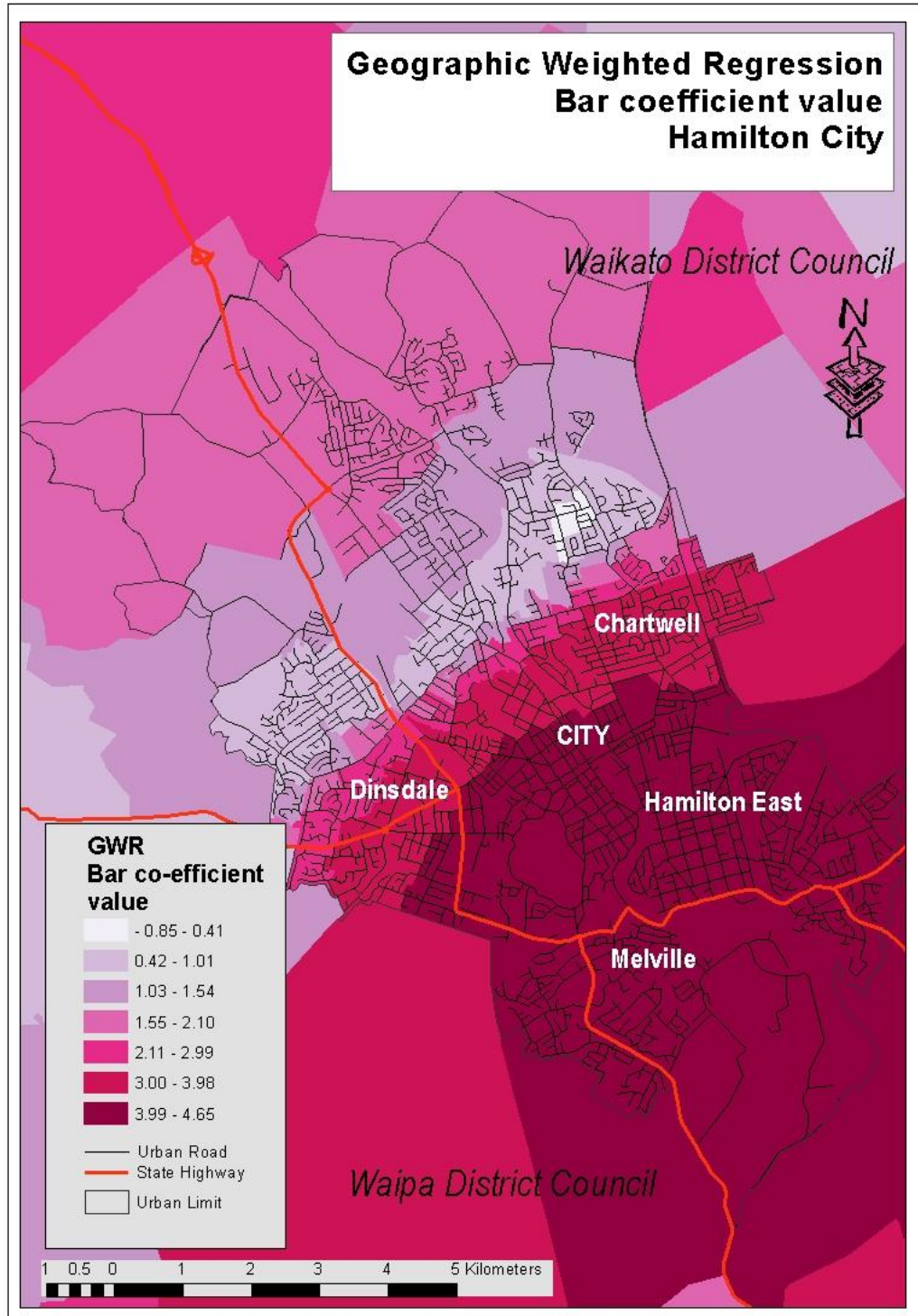


Figure 24: Geographically weighted regression – bar coefficient value Hamilton City

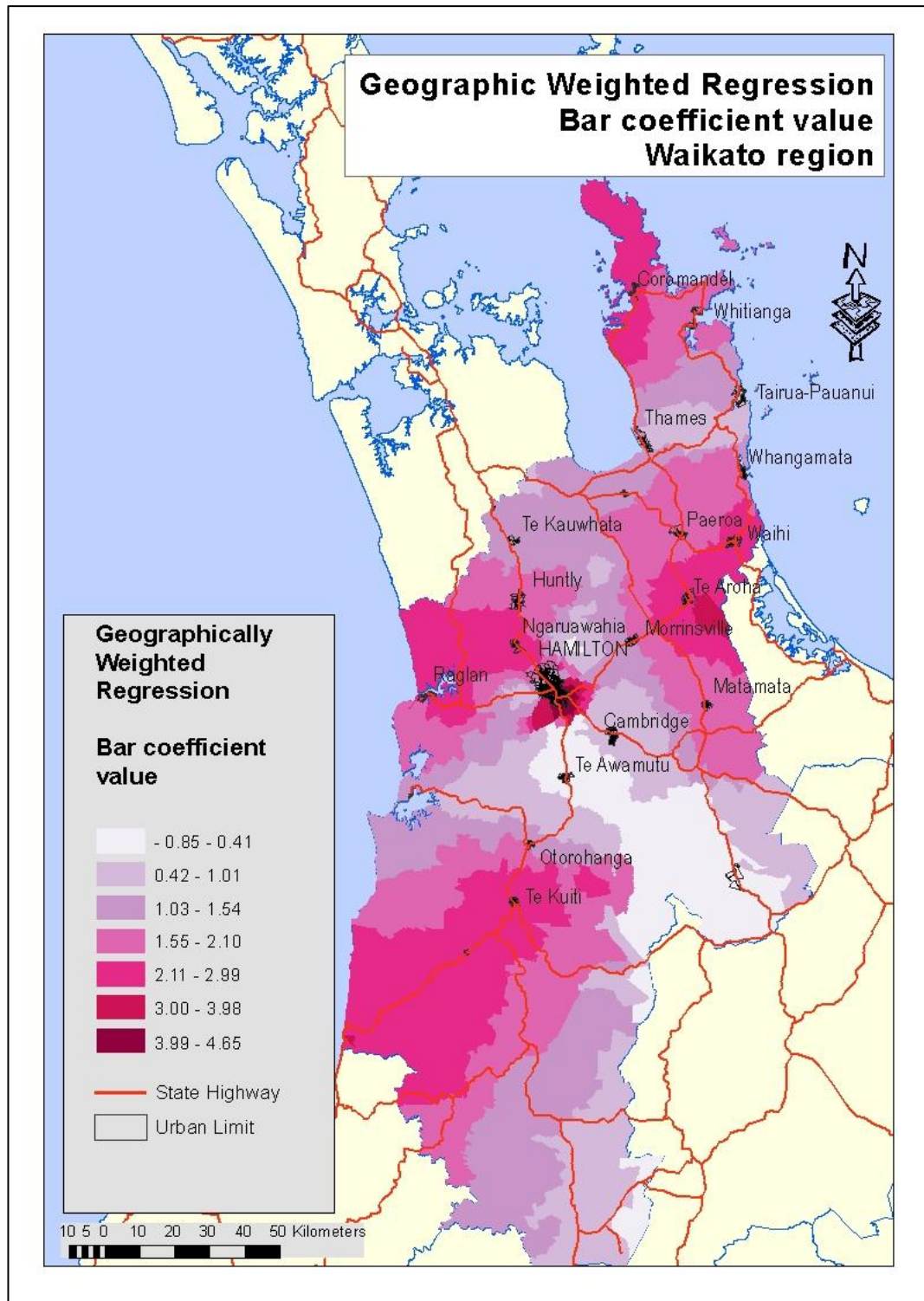


Figure 25: Geographically weighted regression – bar coefficient value, Waikato region

The application of geographically weighted regression through the outputs of the model calculated at the local level confirms first, a reasonable relationship between assaults and bars in Hamilton Central only. This provides a reasonably accurate basis for predicting assault levels at the meshblock level, with an r-

squared value of up to 71% in the CBD. This means that around 70% of the variability in assault can be explained by the distribution of bars in meshblocks throughout Hamilton's CBD.

Second, the predictive abilities of the model are evidenced through the calculation of the local intercept values, bar coefficient values and residual values at the meshblock level. In the meshblock with the highest assault numbers (153) the model predicted 112 assaults, based on an intercept value of 4.03026 and bar coefficient estimate of 4.3078 calculated by the model. In this meshblock where there are 25 bars and a predicted number of assaults of 112 the model calculates a predicted 4.47 assaults per bar for this meshblock over the two year period or 2.23 assaults per bar over the course of one year. It is evident that the model underestimates the number of assaults in this meshblock when compared to actual assault numbers within this meshblock.

In areas outside Hamilton's CBD, the geographic weighted regression model predicts a weaker relationship between assaults and bars. This is generally consistent with the results of other forms of analysis used in this study. In Hamilton City, outside Hamilton's CBD, the local r-squared value was significantly lower at less than 20%. The lower regression value found outside the CBD areas was generally matched with a lower coefficient value. Similar low values were found elsewhere throughout the Waikato except in the townships of Coromandel, Raglan and Whitianga where local r-squared estimates were as high as 49%.

In other townships there is found to be a poor relationship between assaults and bars which is perhaps not surprising given the significantly lower number of both bars and assaults that took place in these locations. In some areas, including Te Awamutu, Huntly and Otorohanga there is a much lower r-squared value of less than 10%. Not only is there a lower r-squared value between assaults and bars, but there are also lower bar coefficient values that are used in the model to predict assaults. Bar coefficient values are estimated at 0.5 throughout South Eastern Waikato, 2-3 in the townships of Te Kuiti, Raglan, Te Aroha and Waihi.

Inserting bar coefficient values into a local model for one meshblock in Whitianga (with two bars) results in a predicted number of assaults at 4.5187 over the two year period and a predicted 1.2 assaults per bar per year in this meshblock. Here it is noted that the local r-squared value is .24 or 24% therefore these results should be treated with caution and it is reasonable to conclude that other variables are more accurate predictors of assault at this location.¹⁰

These results conclude that the geographically weighted regression patterns outside Hamilton's CBD suggest a much weaker relationship between assaults and bars. The lower r-squared values at certain locations mean that the predictive abilities of these models are compromised somewhat where a poor goodness of fit exists and the results should be interpreted with caution as it is feasible that there are other variables which are more accurate in predicting assault.

For the Waikato region as a whole there appears to be some correlation between the results of the bar coefficient values and the goodness-of-fit (r-squared) models in that lower bar coefficient values appear to be located in areas where there is a poor local relationship at the meshblock level between bar and assault numbers. In reference to Figures 23 and 25, this appears to be the case with Te Awamutu. By contrast, Raglan and Coromandel with higher coefficient estimates are also matched with a higher r-squared value. On this basis, it would appear that the better the regression model is at predicting the level of spatial variation between assault and bars, the more accurate the model is at evaluating the coefficient estimates. In other words, the model cannot accurately predict coefficient estimates where the goodness of fit relationship is poor, only where the relationship is reasonable.

The results of the geographic weighted regression appear to confirm the findings of the other analyses in that there is a strong relationship between assaults and bars within the CBD, however less so outside this area. Overall, it can be concluded that geographically weighted regression is a useful analysis technique

¹⁰ Note that a full listing of geographically weighted regression model estimates is provided in the accompanying compact disc in the file GWR_ass_bar.xlsx

in areas such as Hamilton's CBD where there are high levels of bars and assaults. Outside this area with fewer bars and assaults, the value of geographically weighted regression is more limited as evidenced by significantly lower r-squared values.

7.2 Location-based Analysis of Bars and Assaults

Spatial distributions of crime patterns have traditionally been presented through density or choropleth maps. Here, assault and bar densities are presented separately using grid-based point density mapping and choropleth analysis to show assault densities. Bar densities are presented using choropleth mapping techniques only to provide anonymity for the particular bar and entertainment facilities.

7.2.1 Raster Based Density Analysis

7.2.1.1 Point Density Maps –Waikato Region

The region wide patterns of assault densities illustrate a strong rural-urban division with the assault densities being highest in urban settlements as well as on main roads outside urban areas.

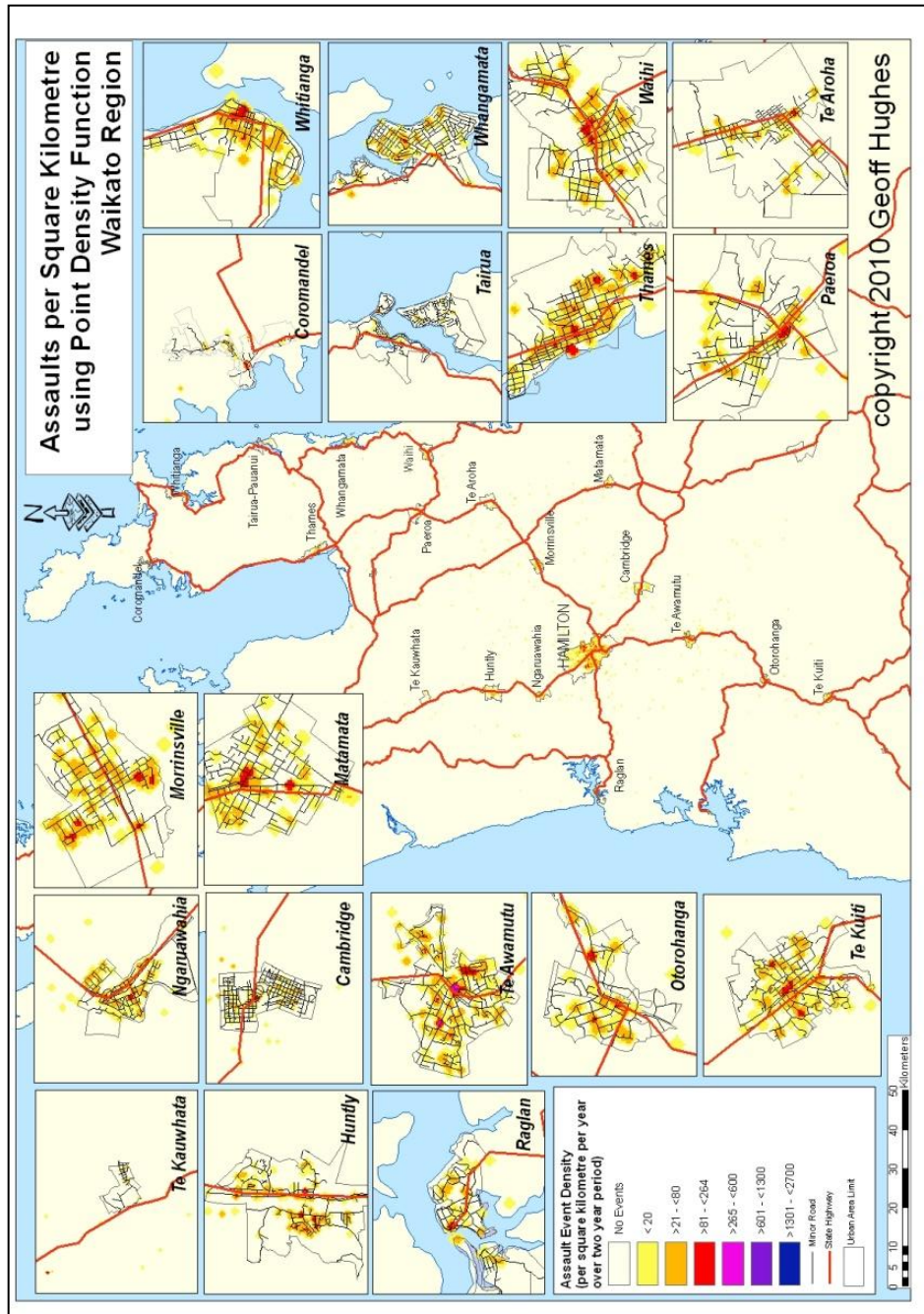


Figure 26: Assault density per square kilometre using the Point Density technique - Waikato Region

Outside urban settlements, there are very low levels of assault. This density analysis of assaults establishes that assaults in the Waikato Region are not randomly distributed but are concentrated in main urban areas.

As the spatial distribution of assault density varies at the overall regional level, so too does the distribution exhibit distinctive variations throughout the different townships and cities of the Waikato region. Referring to Figure 26, it is evident

that some townships record higher levels of assault than others, in this category are the townships of Te Awamutu, Whitianga, Te Kuiti, Matamata, Thames and Huntly with several locations within these townships recording up to 5 assaults per square kilometre per week. By contrast, the townships of Cambridge, Morrinsville and Te Aroha with similar populations have fewer locations where assaults achieve levels of 5 assaults per square kilometre per week. Clearly, population itself cannot explain these variations in assault levels and distributions.

7.2.1.2 Point Density Maps – Hamilton City

Hamilton City also shows a wide variation in assault densities which is similar to patterns exhibited in rural towns throughout the Waikato. The density map below (Figure 27) illustrates a pattern of very high assault densities (up to 50 assaults per square kilometre per week or 2700 assaults per square kilometre per year, over the two year study period) around bars located in the central business of the city. Outside the city's CBD area, there were more moderate assault densities in Dinsdale, Chartwell, Hamilton East, Nawton and Melville of up to 4-5 assaults per square kilometre per week or 200-300 assaults per square kilometre per year. These are all primarily residential suburbs. In the northern suburbs of Maeroa, Forest Lake, Te Rapa, Rototuna, Pukete and Huntingdon the assault densities are generally lower and mostly (with a few exceptions where there were recorded up to 4 assaults per square kilometre per week), these suburbs recorded a level of less than 0.5 assaults per square kilometre per week or around 25 assaults per square kilometre per year over the two year period.

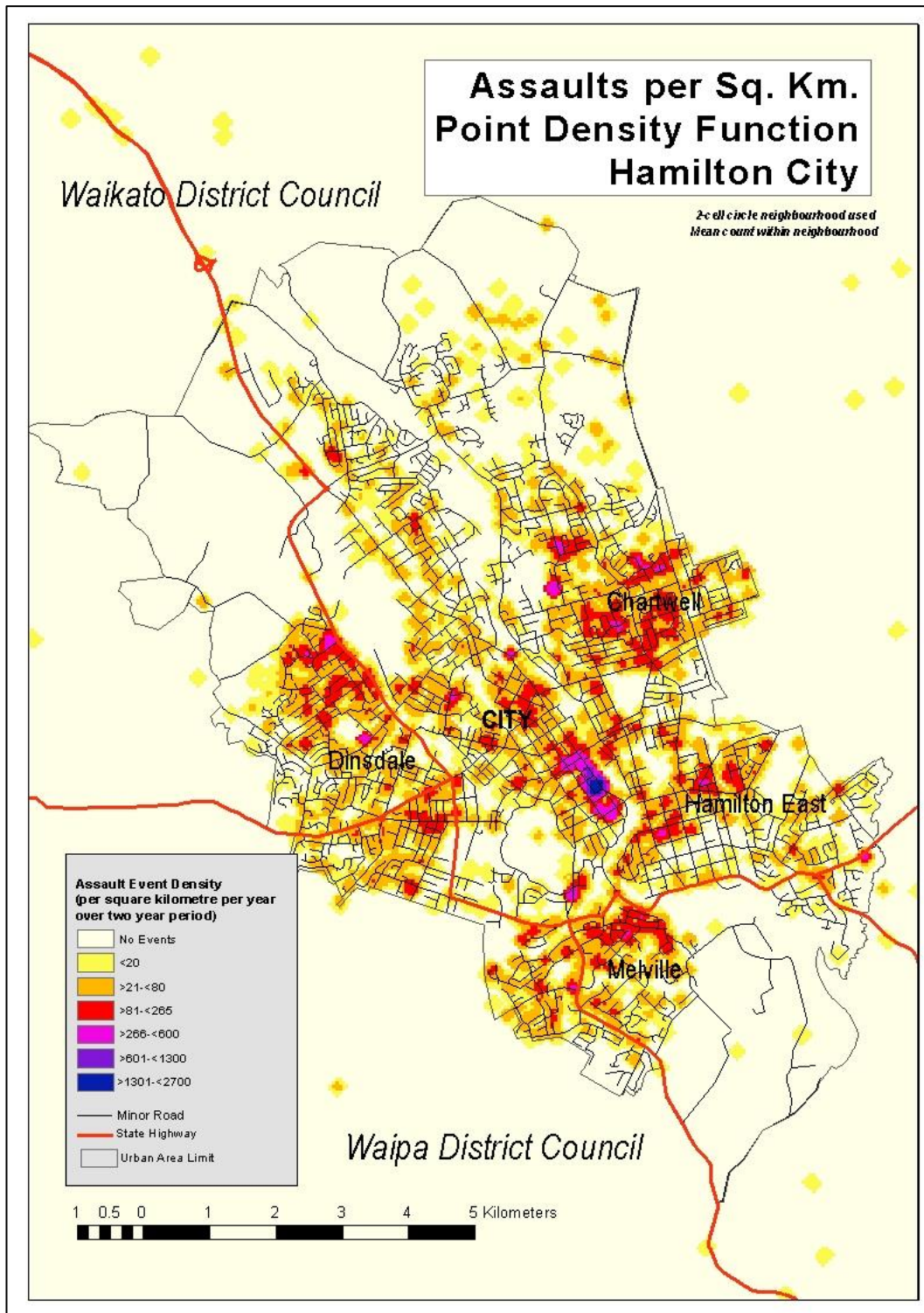


Figure 27: Assault density per square kilometre using point density technique – Hamilton City

7.2.2 Choropleth Based Density Maps

Representing the density of assaults aggregated at a meshblock level by choropleth mapping techniques results in patterns that are different from those

produced by raster based point density maps. The “point density” techniques present what is essentially a more natural distribution of data, while, by contrast, choropleth based density maps produce a “patchwork” of assault distributions that reflects the outline of enumeration units rather than exact locations. The use of areal density measures overcomes the issues associated with the varying size of the meshblock enumeration units.

7.2.2.1 Assault Density

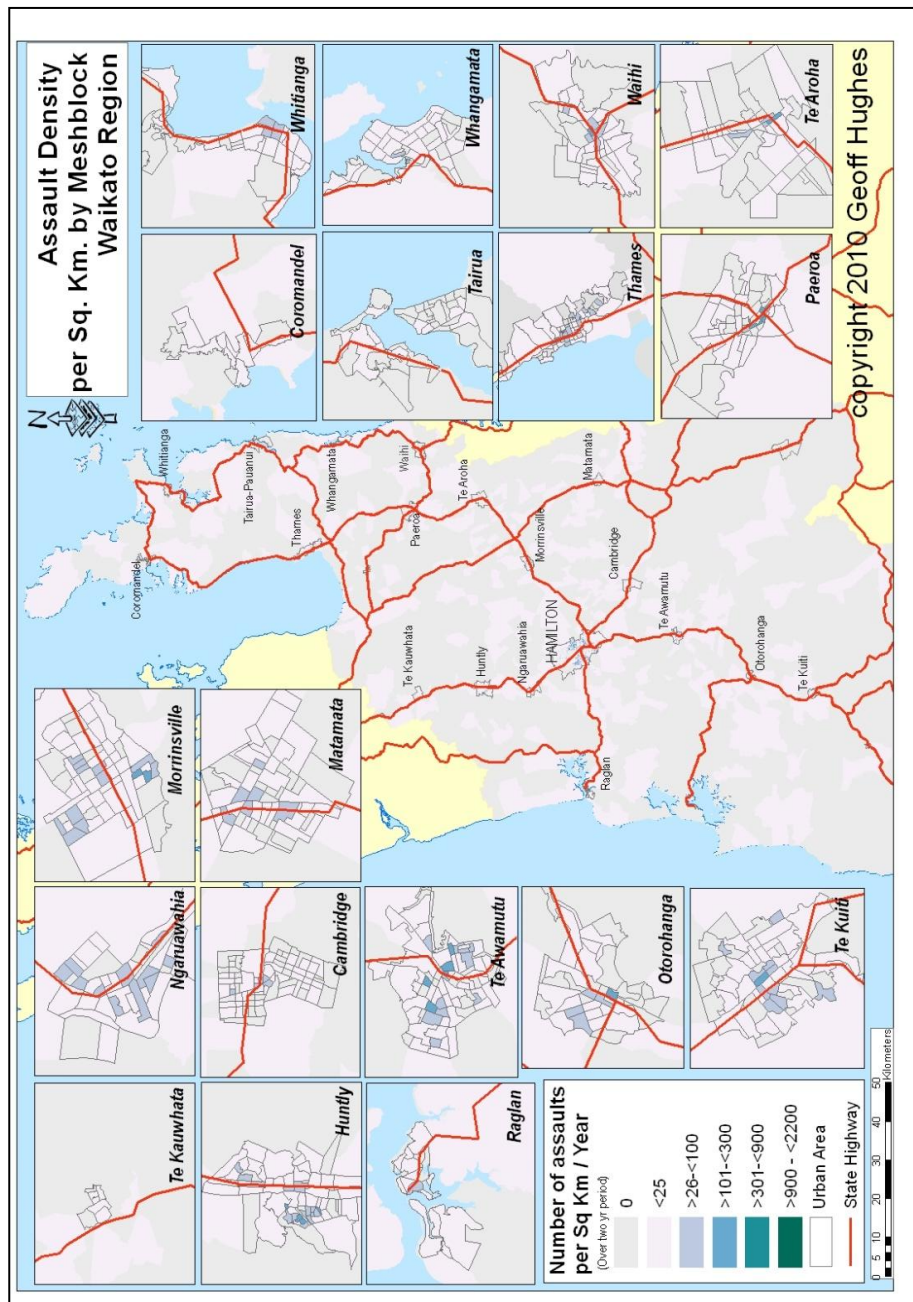


Figure 28: Assault density per square kilometre using choropleth mapping technique – Waikato region

Referring to the Figure 28, it can be seen that townships throughout the Waikato region illustrate considerable variation in assault densities per square kilometre using the choropleth mapping technique. The towns of Te Awamutu, Paeroa, Huntly, Otorohanga, Te Aroha, Morrinsville, Te Kuiti and Waihi all have some meshblocks with higher densities of assault up to 4 assaults per square kilometre per week or 100-300 assaults per square kilometre per year. Ngaruawahia, Matamata, Thames and Whitianga recorded lower assault densities at 1-2 assaults per square kilometre per week or 25-100 assaults per square kilometre per year in meshblocks scattered throughout the town. Whangamata, Tairua, Cambridge and Coromandel show lower densities of assault below 0.5 assaults per square kilometre per week or less than 25 assaults per square kilometre per year.

In the main, the choropleth analyses appear to confirm the results of the point density mapping techniques by establishing clear, if less pronounced evidence of high assault densities in central Hamilton, some suburban areas of Hamilton City and smaller towns such as Te Awamutu. Importantly however, there are differences from the point density mapping outcomes. These are most noticeable at Ngaruawahia and Whitianga where there are some relatively large meshblocks (compared to other urban meshblocks) that, through the use of the choropleth technique, have the effect of “smoothing” the data and reducing assault levels within that meshblock. The smoothing effect on choropleth mapping data is also noticeable in Hamilton’s CBD. In areas where there are recorded very high assault densities, the choropleth mapping technique again has an effect of smoothing data so that there is an effect of lower assault densities illustrated when compared with the point density technique. The effect of larger meshblock on assault density presentation is also evident in rural areas surrounding Hamilton and again leads to a “smoothing” effect with reduced assault levels compared to the point density results.

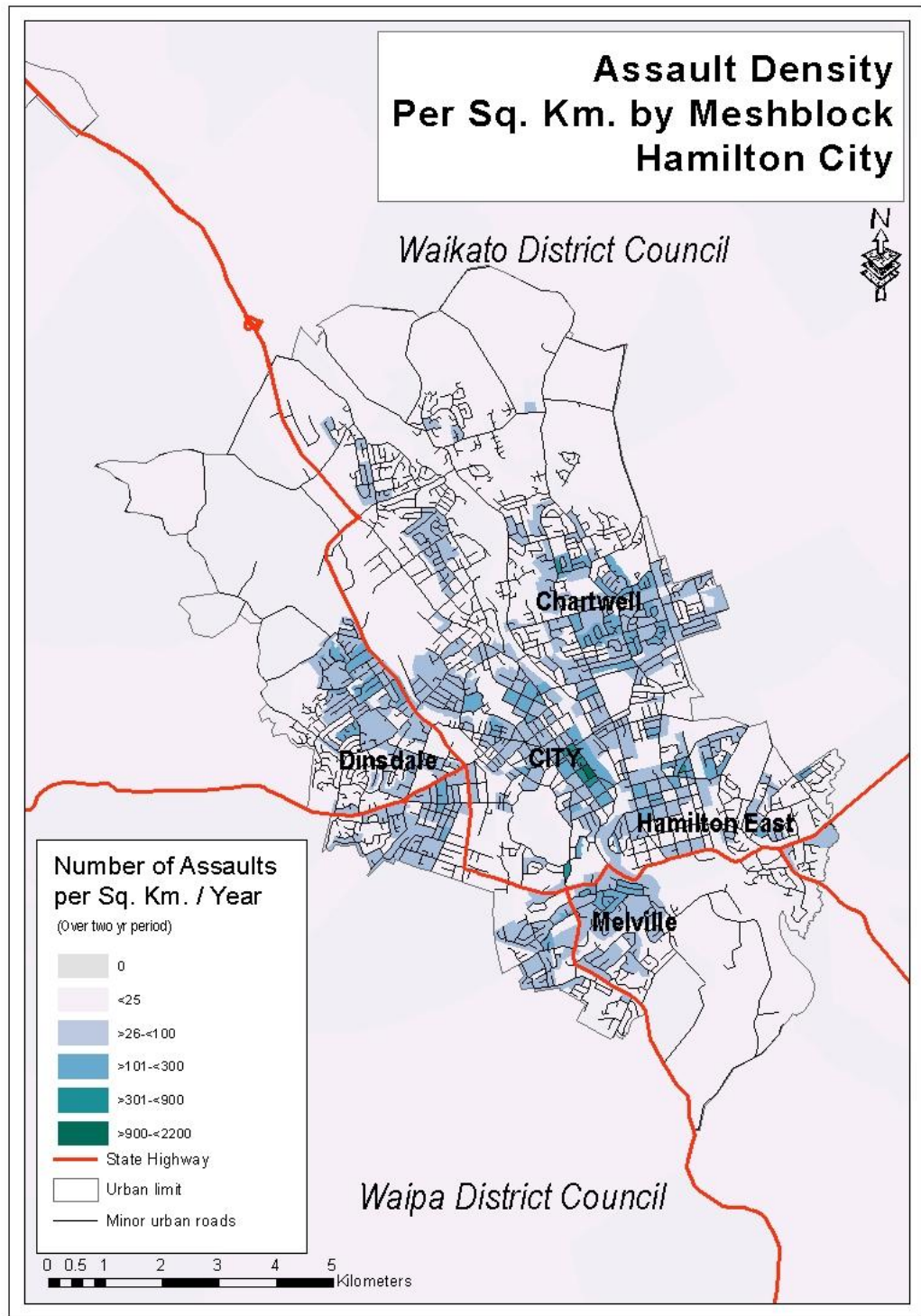


Figure 29: Assault density per square kilometre using choropleth mapping technique – Hamilton City

Figure 29 represents the assault density per square kilometre by meshblock for Hamilton City using the choropleth mapping technique. There is significant spatial variation in the distribution of assaults with the highest density of assaults in the CBD area bounded by Mill St to the north, Tristram St to the west, Bridge

St to the south and Victoria St to the east. One meshblock in the CBD bounded by Alexandra St to the West, Hood St to the south, Collingwood St to the north and Victoria St to the east has densities of around 45 assaults per square kilometre per week or 2200 assaults per square kilometre per year. Directly to the southwest of this meshblock there are reduced distributions of assault with recordings of around 10 assaults per square kilometre per week or 600 assaults per square kilometre per year. In other meshblocks surrounding the CBD, there was a more modest density of around 200 assaults per square kilometre per year or 4 assaults per square kilometre per week being recorded. This indicates that assaults are highly concentrated in a small area within the CBD.

Outside the CBD, there are three other meshblocks that record high densities of assault of around 10 assaults per square kilometre per week or 600 assaults per square kilometre per year. One is adjacent to Waikato Hospital, another in Hamilton East and a third in a residential area of northern Chartwell. Meshblocks in suburbs which recorded higher densities of assault are dispersed with meshblocks with more modest levels of assault at around 50 assaults per square kilometre per year or 1 assault per square kilometre per week. There are lower levels of assault recorded in the suburbs of Pukete, St Andrews, Rototuna, Queenwood, north Te Rapa and west of Hamilton Lake as compared to other areas in Hamilton.

The differences in assault patterns in the townships of the Waikato which emerged for the point density and choropleth analysis are not as apparent in Hamilton City where the smaller meshblocks reduce the “smoothing” effects evident with the larger meshblocks of the townships.

Generally, it would appear that using the choropleth mapping technique offers an easier approach to analysing crime densities than point or kernel density techniques, even though this technique suffers from the disadvantage of not representing high or low densities of assault as accurately as point density.

The benefits of choropleth mapping over point density are most apparent in Hamilton and townships throughout the Waikato where meshblocks are smaller. However in rural areas where there are larger meshblocks, the benefits of

choropleth mapping over point density are not as apparent. Similarly, point or kernel density mapping techniques are problematic in rural areas due to the scale at which information is represented. Due to the difficulties with both techniques, it would appear that both these techniques are better suited to representing urban as opposed to rural crime patterns where densities are much lower.

7.2.2.2 Bar Density

As with assault distributions, the distribution of bars (see Figure 30 on following page) is clearly shown as having an uneven distribution throughout the Waikato being largely concentrated in urban areas. There are low to moderate densities (less than 20 bars per square kilometre) of bars to be found in most townships throughout the Waikato, and in no one township does there appear to be any particular significant concentration of bars. In rural areas, most bars appear to be located on or close to state highways or other main arterial routes.

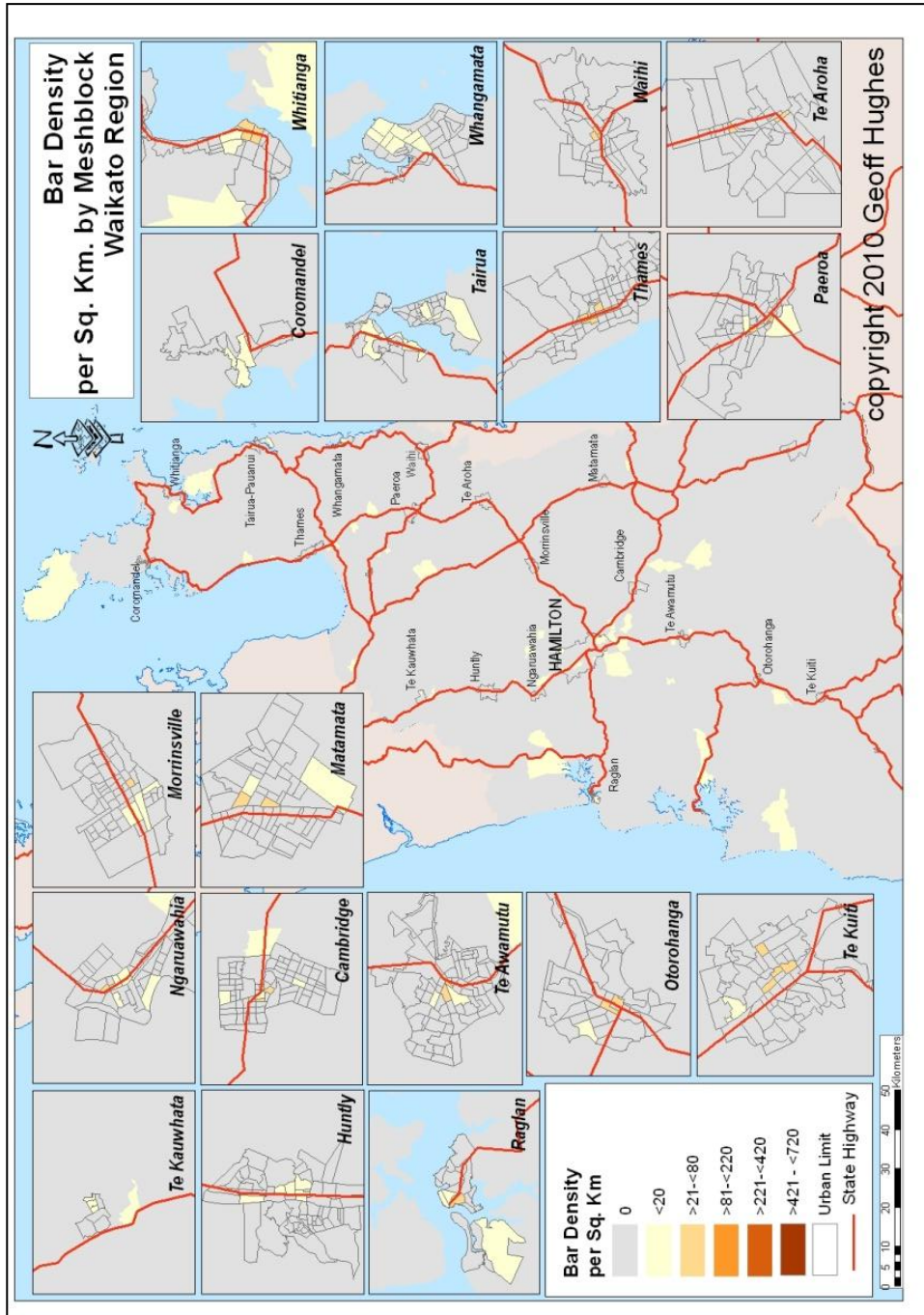


Figure 30: Bar density (per square kilometre) using choropleth mapping technique – Waikato Region

Hamilton City shows a highly concentrated distribution of bars at the eastern end of Hood St and on the eastern side of Victoria St opposite Collingwood St where bar densities are shown to be greater than 400 bars per square kilometre (refer Figure 31). There is a more moderate density of bars surrounding this focus. In other locations throughout the city there does not appear to be any significant concentration of bars or entertainment facilities.

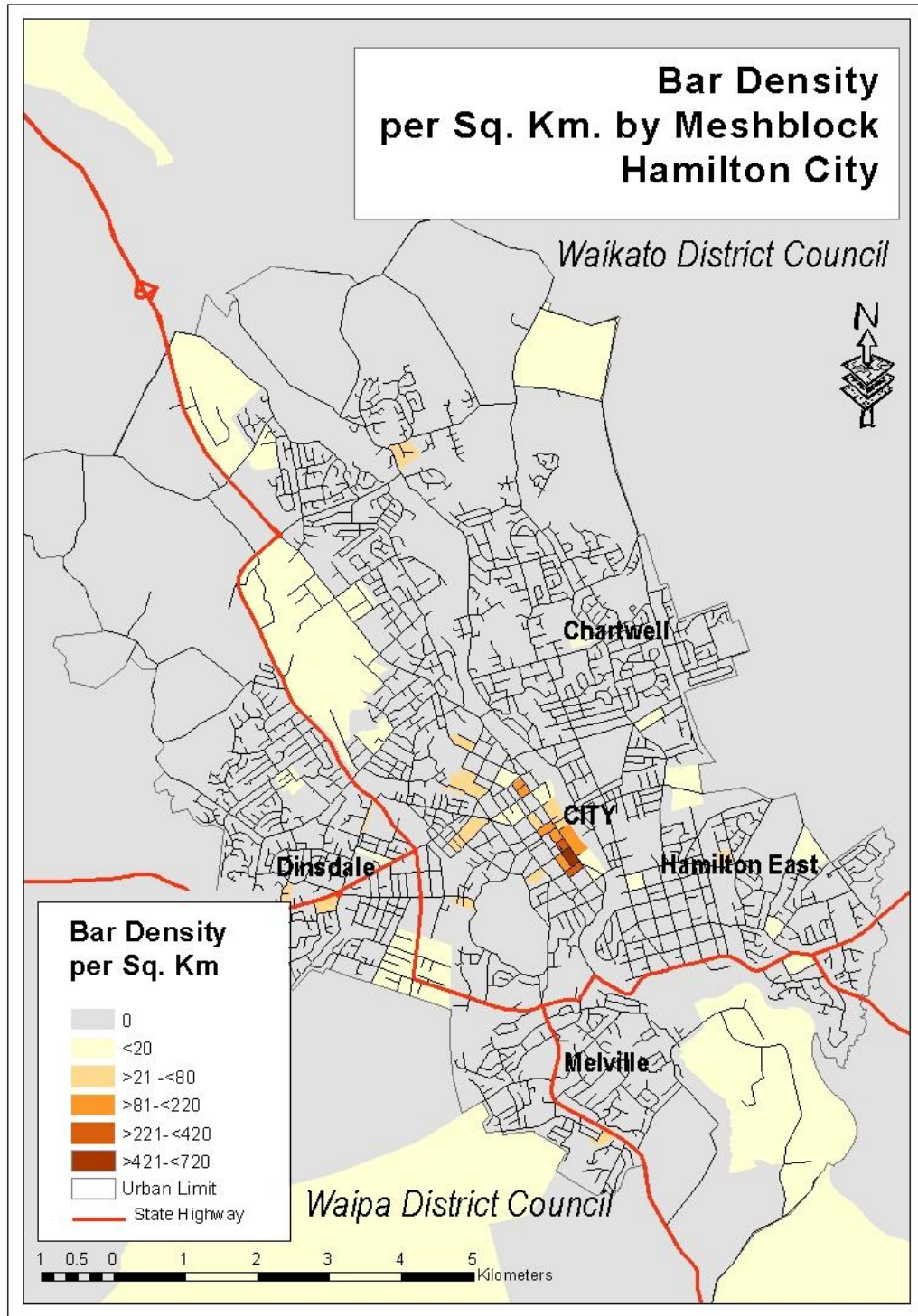


Figure 31: Bar density (per square kilometre) using choropleth mapping technique – Hamilton City

7.3 Clustering Analysis

Clustering analysis is a way of quantifying the level to which assault events relate to each other in space. These relationships range from dispersed assault patterns recording Moran's Z value of less than 0.5 standard deviations to clustered with

Moran's Z values of greater than 2.5 standard deviations. The differences in the relationship of bars to assault between urban and rural areas that have emerged from the earlier analysis are also evident in the patterns shown by this clustering analysis.

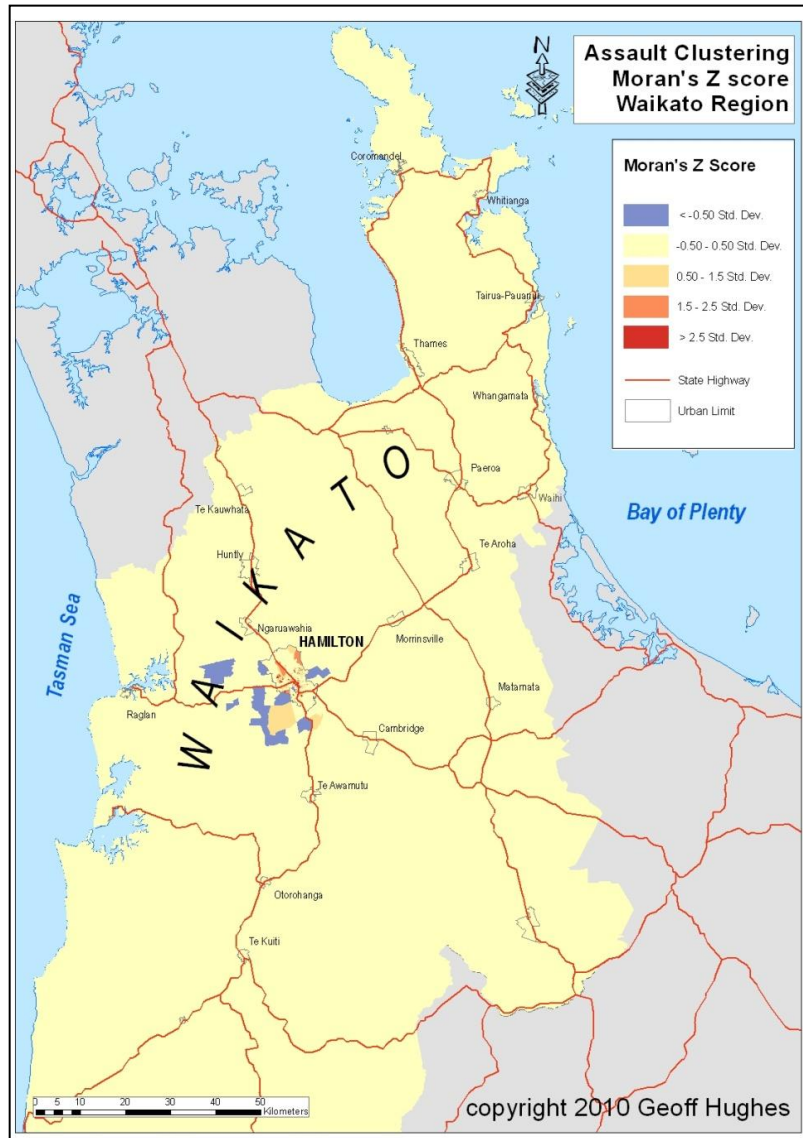


Figure 32: Assault clustering analysis in the Waikato district

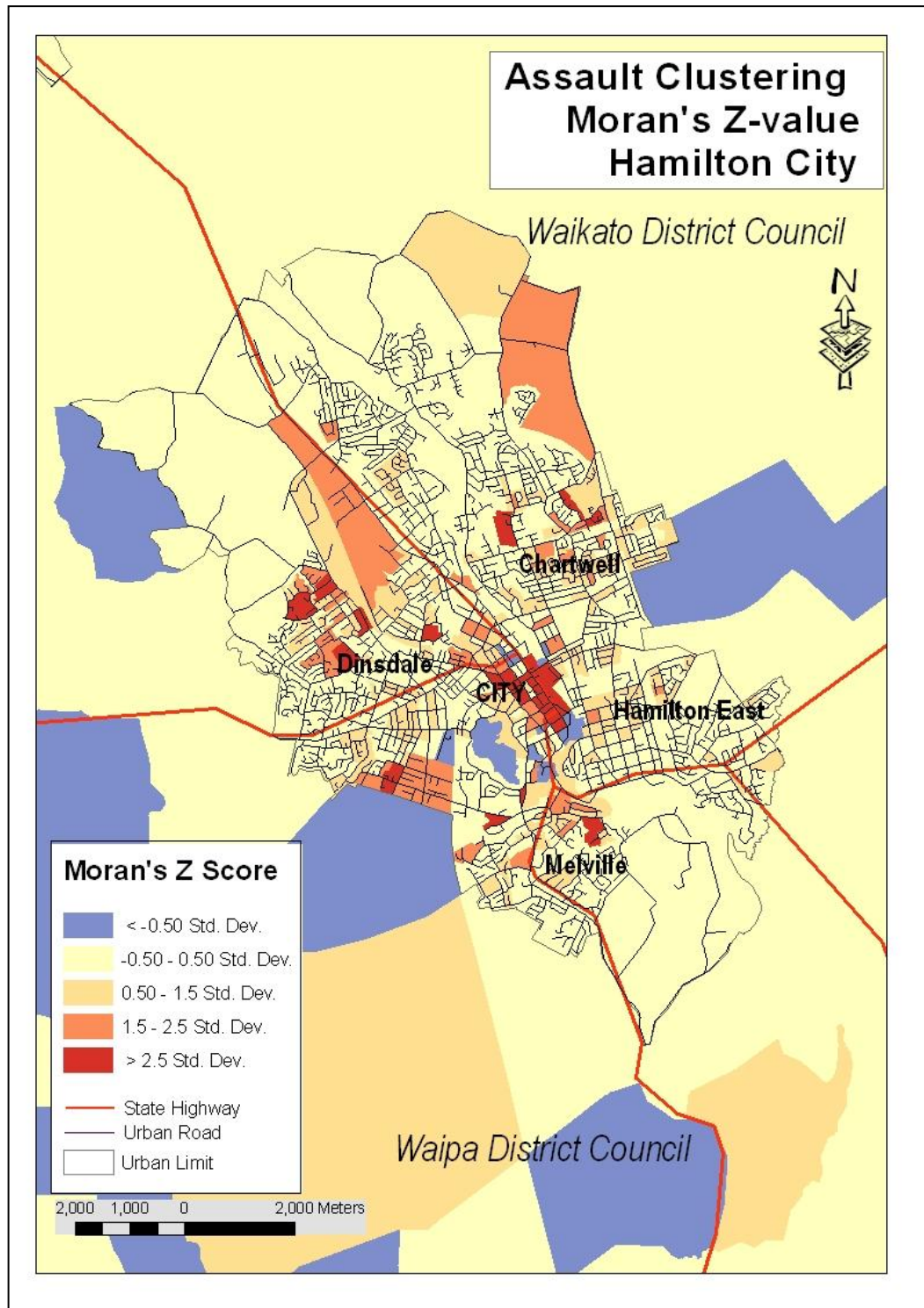


Figure 33: Assault clustering analysis in Hamilton city

Hamilton City provides evidence of assault clustering. Not surprisingly, those areas of highest assault clustering coincide with those areas which recorded high assault densities. The two measures are by no means mutually dependent however as there are some meshblocks where there are high levels of assault but due to their more dispersed distribution do not appear as assault clusters.

This pattern is more evident throughout the urban townships. High levels of assault clustering were recorded in the meshblocks with high numbers of bars in Hamilton City's CBD, and also in several locations throughout Dinsdale, Melville and Chartwell located in or close to reserves, parks, some schools and areas adjacent to hospitals. These associations with the above land uses were confirmed by field investigations by the researcher. The significant levels of clustering found in some areas of Hamilton City contrasted with a more random distribution throughout the Waikato district which probably reflects the overall low number of assaults taking place in these rural areas.

7.4 Analysis Of Population Characteristics

The previous section has considered the effects of **place** on the relationship between bars and assaults. In this section the effects of **population** characteristics on the distribution of assault is explored first through analysis of population density. Following this, the analysis explores road density as a proxy for population density and the concept of "population at risk". These two techniques – road density and population at risk have recently been applied in other studies to analyse crime patterns in terms of "population characteristics" and their applicability is explored here.

Exploratory analysis of the below graph (Figure 34) confirms that at a meshblock level throughout the Waikato, population density is a moderately useful predictor of assaults density fitting a logarithmic regression of .52.

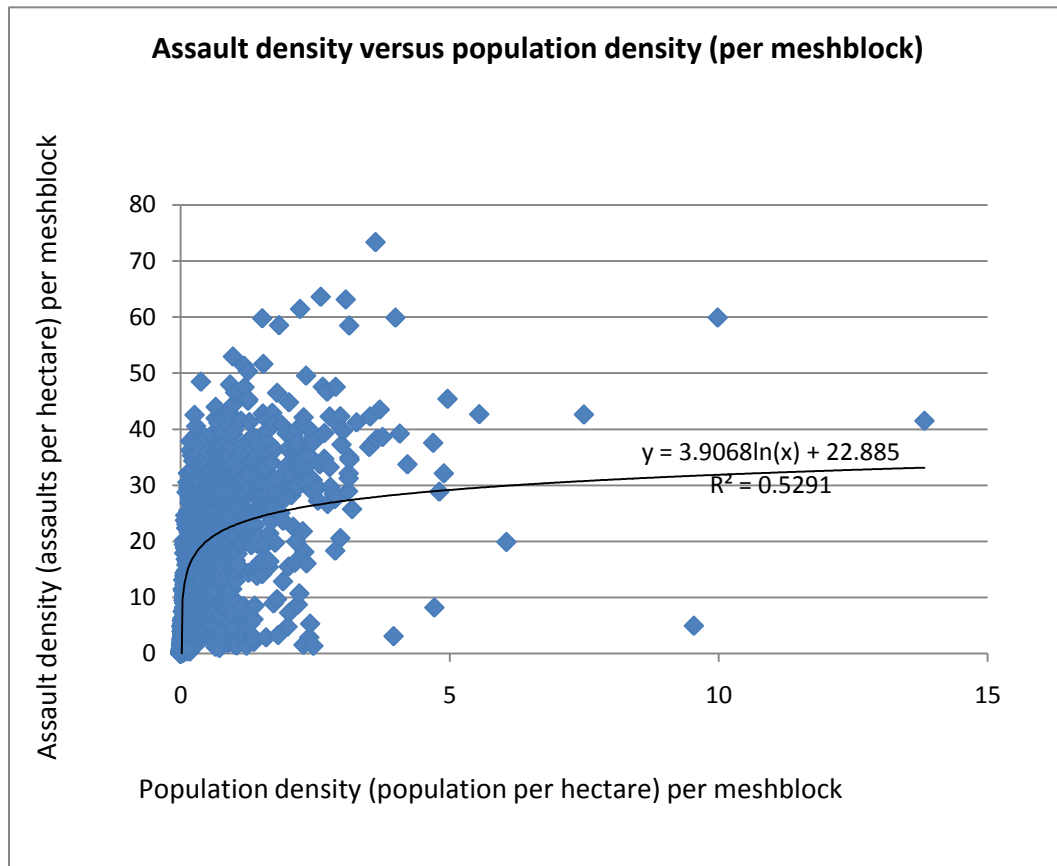
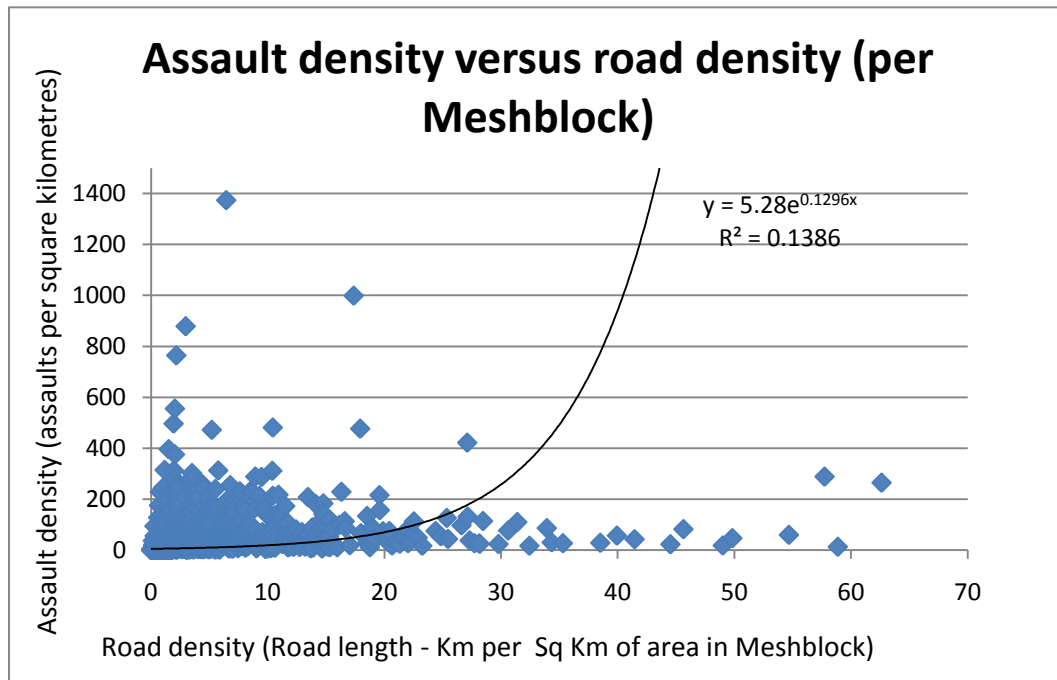


Figure 34: Population density versus assault density

Note: outliers removed from graph

Due to the moderate relationship between assault density and population density, the analysis examined the relationship between road density and assault density as an alternative and hopefully more accurate measure by which to predict assaults.

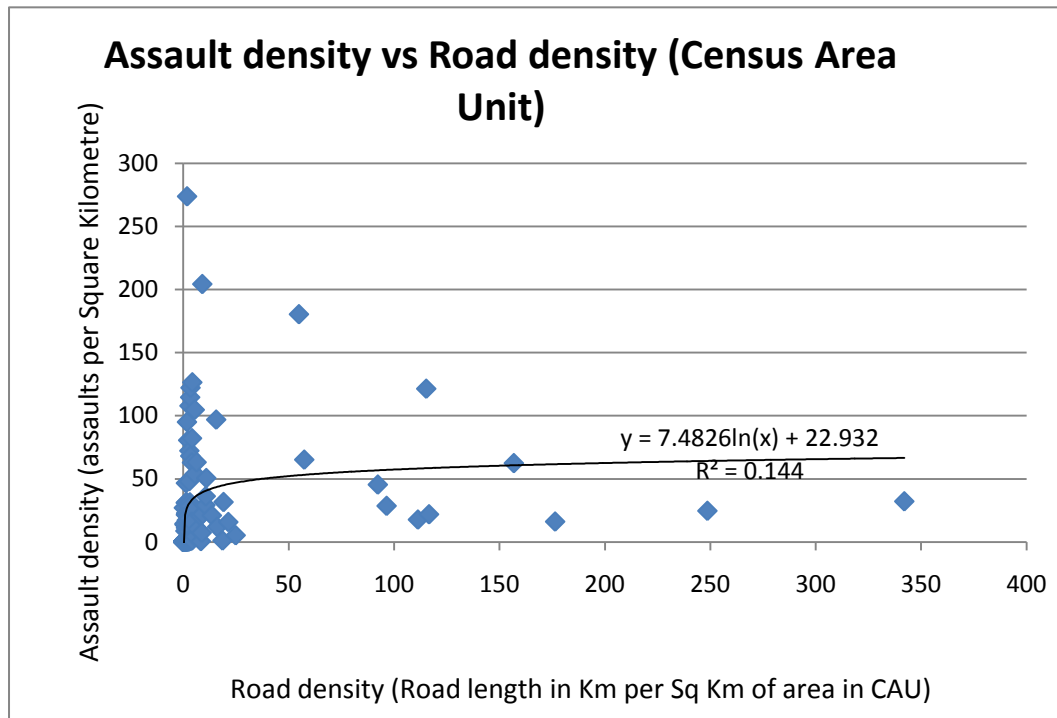
An exploratory analysis was conducted on the effects of road length on assaults using an alternative measure of road density, which standardises assault per areal unit, rather than using road length as a measure.



Note: Outliers removed from graph

Figure 35: Assault density vs Road density (per Meshblock)

The above graph clearly shows that there is not a strong relationship between assault density and road density at a meshblock level even though it could be expected that higher road densities are found within central urban areas where the highest assault densities occur. There is no evidence at this level of aggregation, that greater road lengths are associated with a higher assault density. The relationship between assault density and road density was then explored at the Census Area Unit level to investigate if there was a closer association between road density and assault density.



Note: Outliers removed from graph

Figure 36: Assault density vs Road density (per Census Area Unit)

The above graph reveals that as with the relationship between assault density and road density at the meshblock, there is no strong relationship between assault density and road density at the Census Area Unit level. A logarithmic regression fits the data the best; however there is no conclusive evidence that, at a small area level such as the Census Area Unit, increasing road densities result in higher assault densities.

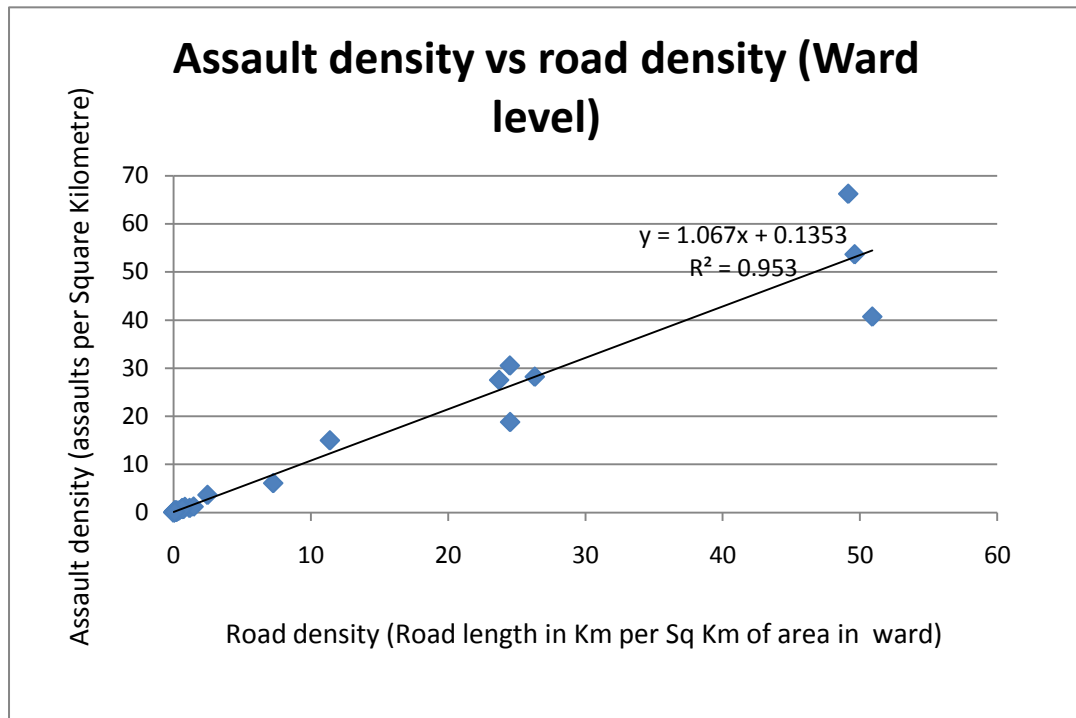


Figure 37: Assault density vs Road density (per ward)

Finally, the analysis examined assault and road densities at the ward level. Unlike the patterns shown at the meshblock and census area unit level, there is a strong relationship between assault density and road density at the ward level. There is a linear relationship with an r-squared value of .95, which is clear evidence of a strong association between assault density and road density at this level. Closer inspection reveals the wards with the highest assault and road density are the south and west wards in Hamilton City, whereas many of the rural wards have lower assault densities and road densities. At this level, the effects of the “ecological fallacy” where the larger the unit of aggregation, the greater the effect in the averaging of data within progressively larger enumerations units may be a reason for this strong association.

The results at the meshblock and Census Area Unit Levels show that the accuracy of “road density” as a means of predicting assault levels is however questionable having regard to the weak relationship at these levels of aggregation. During the analysis process, there was a problem in associating some road length data to a meshblock of interest. In some locations, roads defined the boundaries of meshblocks. This inability for road data to be associated with a particular meshblock could influence the regression results relating to assault and road

density. An attempt was also made to analyse “population at risk”, however the absence of appropriate data meant that this analysis could not continue.

This analysis clearly illustrates that the distribution of assaults throughout the Waikato is only moderately well explained by population density. Nor is there no clear evidence of a strong relationship between assault density and road density at a small enumeration unit. There is however a strong relationship between assault density and road density at the ward level which shows that developed, urban areas have greater assault densities than rural and undeveloped areas. However, the effects of the “ecological fallacy” are evident in that aggregating to the ward level effectively masks any variation that exists within these units. Here, acceptance of a strong relationship between assault density and road density at the ward level must be tempered somewhat by limitations in the analysis. Overall, the analyses of population densities and its proxies, road length and road density are not sufficiently strong to support those aspects of the Social Disorganisation, Routine Activity and the Crime Potential Theory which seek to explain assault patterns around bars in terms of variable population characteristics. Further research using other commonly acknowledged testing variables for determining population variations should be utilised to test the aforementioned theories in explaining assault distributions around bars. These however lie outside the scope of this study.

Chapter 8: Discussion – Association between Bars and Assault at Various Enumeration Unit Levels

8.1 Introduction

This section seeks to summarise the association between bars and assaults through the Waikato region by reviewing patterns of association at a variety of scales represented by different enumeration units. First, the association between bar and assault is explored by analysing results at the “census area unit” level for Hamilton City. This is followed by a discussion of patterns throughout Hamilton City through a review of the relationship between bars and assault for each of the three wards of the city, these being South ward, East ward and West ward. The discussion concludes with an analysis of the relationship between bars and assault in rural townships and rural areas.

8.2 Hamilton Central (Census Area Unit)

The results from these analyses clearly show that the relationship of bars to assault patterns is strongest in a relatively small area within the confines of Hamilton’s CBD. This is the area of the highest concentration of bars. The close association of assaults around bars is supported by the results of four other different analyses and is evidenced in the distributions illustrated in the maps.

First, there is a strong “distance decay” relationship operating in the Hamilton Central Census Area Unit so that the highest percentages of assaults are close to bars with 179 of 680 or 26% of all assaults within the study occurring in or within the immediate vicinity (10 metres) of the nearest bar within this Hamilton Central Census Area Unit. Likewise, 244 of 680 or 36% of all assaults occur within 20 metres of the nearest bar within the Hamilton Central Census Area Unit. Furthermore, 14 of 50 meshblocks recording closest distances from assault to nearest bar were from the Hamilton central Census Area Unit.

Second, there are high assault and bar densities located in Hamilton’s CBD that are in close proximity to each other. In one meshblock bounded by Alexandra St,

Collingwood St, Victoria St and Hood St, 2200 assaults per square kilometre per year or 45 assaults per square kilometre per week were recorded over the two year study period. Surrounding this meshblock, there were lower assault densities of around 600 assaults per square kilometre per year or around 10-15 assaults per square kilometre per week. Compared with overall patterns in the Waikato generally, these figures are, however comparatively high. Bar densities were also significantly higher in the centre of Hamilton's CBD. Here, one meshblock recorded a bar density of 720 bars per square kilometre. Other meshblocks within Hamilton's CBD recorded comparatively lower bar densities at between 80 and 400 bars per square kilometre. Again these are high by comparison with bar densities throughout the Waikato.

Third, the results of the geographically weighted regression support the distance related analyses in that the assault distribution can be predicted with reasonable accuracy by the local distribution of bars where there was a local r-squared statistic of up to .71, and where it was predicted that using geographic weighted regression, around 4.5 assaults are predicted per bar in meshblocks over the course of the study period throughout Hamilton's CBD (or 2.3 assaults predicted per bar for one year). Outside the CBD area the local regression models are far less accurate in estimating the number of assaults. It would be reasonable to conclude that difficulties in prediction are due to the lower number and local distributions of bars in these areas.

Fourth, the clustering analyses confirmed that assault patterns are clustered and are not randomly distributed in areas around bars, and that this pattern is consistent throughout the CBD. Outside the CBD there is also evidence by reference to the results of the clustering analysis to support assaults being associated with other land uses where an association with alcohol is less conclusive.

From the above it can be safely concluded that place is a very significant factor in explaining the association between assaults and bars. Some theories, notably the Routine Activity Theory have sought to explain such associations through variations in particular population characteristics (such as overcrowding, female

headed households, or vacant units) where bars are located or close to residential neighbourhoods. However, where as in the case of Hamilton's CBD where residential populations are low, such theories cannot be accurately tested. Nor can they be accurately tested in the resort settlements where there is again a strong place association between bars and assaults because of the significant changes in population levels throughout the year

The Social Disorganisation Theory is also considered to be not especially useful in explaining the strong associations between bars and assaults due to the typically low residential population in the main business areas of Hamilton City. It is recognised that in other large city business areas such as Sydney and Vancouver (as in the case in Andresen's research) there are often larger resident populations in the CBD so that the Social Disorganisation Theory could have greater relevance than in the Hamilton City CBD which has a low residential and negligible homeless populations.

8.3 Hamilton West

In the Hamilton West Ward, the analysis showed there is a weak association between assaults and bars. Overall, there is a low density of bars through the ward with the suburbs of Dinsdale, Frankton and Nawton all reporting somewhat higher but nonetheless moderate levels of assaults (200 assaults per square kilometre per week per year or 4 assaults per square kilometre per week per year). The results of the distance analysis also showed a weak relationship between bars and assaults with around 1% of assaults committed within 10 metres of the nearest bar, just over 3% of assaults committed within 50 metres of the nearest bar, and 6% within 100 metres. The majority of assaults (50%) were, in fact, between 500 metres and 1 kilometre of the nearest bar. The above results suggest that in the Hamilton West ward, assault patterns are related to factors other than bars.

Field investigations by the researcher have established that the presence of land uses such as parks and schools may better explain clusters and high assault density areas, in Hamilton West than proximity to bars. This is consistent with

the Routine Activity Theory which hypothesises that particular land uses provide opportunities for crime through “reduced guardianship”, “increased motivation” and “suitable targets”.

The results also suggest a more tenuous association between alcohol as a motivating factor behind assault in suburban areas as drinking is not the primary recreational activity of people in places other than bars. In these localities, assault distributions in public places such as parks may be more strongly influenced by environmental factors such as park layout and design etc, while the moderate assault distributions in some other parts of Hamilton West could be related to alcohol related domestic activity. The relationship between alcohol and assault in people’s homes is outside the parameters of this research, however this could well warrant separate research.

8.4 Hamilton South

The Hamilton South Ward includes the Hamilton CBD Census Area Unit where the relationship between bars and assault distributions has already been examined. As with Hamilton West, the suburbs of Hamilton South have few bars and entertainment areas but in common with Hamilton West, some suburbs such as Melville recorded around 4 assaults per square kilometre per week. As with Hamilton West ward, what is apparent from field investigations conducted by the researcher is that there are well defined clusters of assaults associated with particular land uses of interest including one adjacent to Waikato Hospital and other clusters close to public reserves, footpaths and parks.

8.5 Hamilton East

The Hamilton East ward exhibits an even lower association between assaults and bars. In this ward, the majority of assaults (62%) are committed greater than 1 kilometre from bars. While the research has established that there are occasional clusters of bars, commonly found in suburban shopping centres, there is no clear evidence of a link between assault and bars in these locations. These results could support the premise that bars serve different roles depending on

location, such as a focus of neighbourhood activity, as was speculated in the research by Gruenewald *et al.*, (2006).

As with other suburban areas of Hamilton, assaults may be related to factors other than bars. Field inspections of areas by the researcher where assault clusters were identified coincided with a poorly lit buffer strip adjacent to a forest in a public reserve. This suggests that environmental factors could influence the distribution of assaults and that those factors associated with the Routine Activity Theory (such as land uses) and Social Disorganisation Theory (such as neighbourhood characteristics) may help to explain assault distributions at these localities. Again, the association between alcohol and assault in explaining assault distributions in these locations is rather tenuous, however this association should not be discounted as it could be a motivating factor for assaults.

8.6 Rural Townships

The results of the analyses of the townships within the Waikato clearly show variations in assault patterns from place to place. The strength of the distance relationship between assaults and bars in Coromandel township, Whitianga (Mercury Bay Ward) and Raglan is interesting given the different population and assault densities of each township. In these townships, 15-25% of all assaults took place within 10 metres of the nearest bar. Assault densities however are relatively modest and vary from around 50 assaults per square kilometre per year in Whitianga to less than 25 assaults per square kilometre per year in Coromandel and Raglan. Even though these three townships are considered holiday “hot-spots”, this alone is not sufficient to explain the relationship between assaults and bars at these locations as other holiday “hot-spots” such as Whangamata and Tairua do not exhibit such distance relationships.

A possible explanation for the distance patterns could be related to the physical layout of the townships where there is a particularly close relationship between assaults and bars. The physical layout of Coromandel, Whitianga and Raglan is quite similar in that the location of bars and their relationship to each other

appears to be clustered compared to other townships in the region. It could be argued that the close proximity of one bar to another may promote “bar-hopping” and influence patterns of binge drinking which, in turn increases the likelihood of assault (as per the studies by Shepherd (1994) and Shepherd and Brickley (1996)). An examination of these associations offers the opportunity for further research on *how* the proximity of bars to each other contributes to assault distribution.

By contrast to the above, there is a weaker distance association between assaults and bars in the townships of Cambridge, Otorohanga, Tairua, Paeroa, Matamata, Waihi and Te Aroha where the majority of assaults took place between 500 metres and 1 kilometre from the nearest bar (Otorohanga excepted). In Otorohanga, the majority of assaults took place between 100 metres and 500 metres from the nearest bar. In all of these towns, there is slightly stronger evidence of increased assault densities (at around 2-4 assaults per square kilometre per week) in the centre of town (in and around the presence of bars). However, there is a dispersed and even assault density throughout each town. Of these towns, Paeroa shows the strongest association between assaults and bars with just under 10% of all assaults located within 10 metres of the nearest bar and higher assault densities at around 300 assaults per square kilometre per year or 6 assaults per square kilometre per week in the town’s CBD. This pattern contrasts with Cambridge which has a relatively modest 100 assaults per square kilometre per year or 2 assaults per square kilometre per week and with only 5% of assaults taking place within 10 metres of the nearest bar.

Other towns throughout the Waikato region, including Whangamata, Te Kuiti, Te Awamutu, Ngaruawahia, Huntly, and Morrinsville all exhibit very weak distance relationships between assaults and bars. In the larger towns of Te Awamutu, Te Kuiti, Huntly and Ngaruawahia there are moderate assault densities (2 -4 assaults per square kilometre per week) with higher densities in the centre of each town at around 6 assaults per square kilometre per week. In these towns, most bars are located in the centre of town; however the relationship between bars and

assaults in these townships appear to be weak due a more widespread pattern of assaults throughout each town, rather than being concentrated in one “hot-spot”. The weak distance relationship between bars and assaults at Whangamata is perhaps surprising given that the town is a prominent holiday hot-spot but may be explained by the more dispersed distribution of licenced premises in the township. Consideration of the strong relationship between bars and assault at the resort townships in terms of the Social Disorganisation Theory is limited due to changing population characteristics at different times of the year.

8.7 Rural Areas

The very weak relationships between bars and assaults in the rural wards is not surprising given the low volume of assaults and bars in these areas and their much lower population. There are however, difficulties in determining the true association between bars and assaults in rural areas as many assaults that might occur as a result of festivals, music events or special events (e.g. Rowing World Cup at Lake Karapiro) that have been granted special or one-off licences have not been included in this research. Accordingly, the results of the analysis into the association between bars and assaults in rural areas are perhaps somewhat biased and may not be truly representative of this association. The relationship between assault distribution and festivals or special events could be the subject of further research.

Chapter 9: Conclusion

This study illustrates the versatility of geographic information systems in crime research by analysing and representing spatial information at a variety of scales and locations. The particular benefits of analysis and representation are shown through the automation processes where large amounts of raw alpha-numeric data can be transformed into meaningful visual representations. Advances in technology have meant that geographic information systems may be integrated with other software such as Microsoft Excel and GeoDa in the display and representation of useful information that may exhibit both spatial and non spatial attributes.

The results of the analysis conclusively demonstrated that firstly, there is a positive relationship between assault distribution and bars in the Waikato region –the greater the density of bars, the higher the density of assaults. Where there are greater densities of bars, more assaults take place. Throughout the Waikato, the regression model of assault compared with bar densities exhibits an r-squared value of .85. For every single increase in bar density per square kilometre, there is a predicted increase of just under 2.5 assaults per square kilometre over the course of a year.

The study shows that the characteristics of **place** clearly influence assault distributions. These results are similar to patterns highlighted in the research of Gruenewald *et al.*, (2006) who, through statistical analysis, established a strong relationship between assaults and place which were modified by population characteristics. In this study, the influence of **population** was less obvious with only moderate to low associations identified between assaults and the selected predicting variables of population density and road density.

Third, the study showed that the influence of bars and entertainment precincts on assault is greater in certain urban areas, particularly in Hamilton's CBD, and to a lesser extent in the holiday townships of Coromandel, Whitianga, and Raglan. In Hamilton's CBD, around half the total number of assaults within the CBD area took place within 50 metres of bars.

These associations were confirmed through the use of distance and density mapping involving choropleth and point density techniques. Also, geographic weighted regression models support the patterns established by the above techniques and establishes a strong relationship between bars and assaults, particularly in Hamilton CBD and also to a lesser extent in other townships such as Coromandel and Raglan.

In suburban areas outside of Hamilton's CBD, social and environmental factors other than bar distribution appear likely to be the major determinants of assault patterns. Field observations of the overall patterns of assault suggest higher assault densities (approx 6-10 assaults per square kilometre per week) and clusters (Moran's Z value > 2.5) in some areas within particular suburbs, close to schools, medical facilities and parks. These patterns may be explained by these locations offering increased opportunities for assault particularly at night time. What is perhaps less clear is the role of alcohol in explaining these distributions at these locations.

Resort townships throughout the Waikato notably Coromandel, Whitianga and Raglan all show a stronger relationship between bars and assault levels than other towns in the region. In rural areas outside of towns there were very low levels of assault with these assault distributions restricted to areas around state highways and arterial roads. At these locations, however, the relationship was not as strong as was the case in urban areas. Overall, throughout the Waikato region, there was found to be a weak association between assaults and bars in rural areas, which is due primarily to low assault densities and low bar densities in these areas.

The findings of the research tend to support findings of other similar studies by Lipton *et al.*, (2003), Jochelson (1997) and Gruenewald *et al.*, (2006). What is evident from this research is that there is some merit as researched by Lipton in using road and population density to measure the influence of development on assault and bar densities. The results of the study conclude however that road density is a poor predictor of assault densities at the meshblock and Census Area Unit levels, but much stronger at a ward level. The strong relationship between

assault density and road density at the ward level clearly reveals the greater density of assaults in urban as opposed to rural areas. Notwithstanding the lack of association between assault density and road density at the meshblock or CAU level, these findings are similar to those of the Lipton *et al.*, (2003) study whose findings showed that greater assault densities are concentrated primarily in urban areas. On the basis of the research findings, it can be concluded that population density is a moderately accurate predictor of assault densities in urban areas.

The research of Jochelson in 1997 highlighted several assault clusters in well known tourist areas and business districts within Sydney's CBD. In these areas there were disproportionate numbers of assault from a few licensed premises. In Hot-Spot 1, Darlinghurst, Rd, Kings Cross 33.1% of assaults took place inside licensed premises (Jochelson 1997 21). In Hot-Spot 4, George St, Wynyard St and The Rocks, licensed premises accounted for 19.8% of all assaults (Jochelson 1997 23). These results show similar patterns to those found in this research, specifically in Hamilton's CBD but also Coromandel township, and Whitianga. In these localities, 26%, 25.9% and 19.0% of assaults respectively took place in or within 10 metres of the nearest bar.

What is noticeable about the above comparison is while the scale and character of these centres (Coromandel township, Hamilton and Sydney) are very different, the pattern of assaults in relation to bars is remarkably similar in both Hamilton and Sydney. There were 680 assaults over the two year period in Hamilton's CBD compared to an average of 319 assaults in each of the five study "hot-spots" in the 1997 study of Jochelson. These similarities suggest that similar influences relating to the "night time economy" apply irrespective of the scale and location of the centre.

The findings of the study are also moderately consistent with the central premise of the Crime Potential Theory in that population characteristics, place characteristics and their interaction are the primary determinants of violence rates across spatial areas. The research findings are also consistent to a point with the findings of Gruenewald *et al.*, (2006) that violence rates are related both

to place and population. The main findings of this study in respect of **place** relates first to the close distance association between bars and assault levels in Hamilton's CBD and certain other townships throughout the Waikato and second, to the higher densities of assault and bars in Hamilton's CBD. Where these place associations are not as strongly evident in some of Hamilton's suburban areas and other townships, population or land use characteristics are considered to be more influential on assault distributions. This is shown by increased assault densities where there are higher road densities and in some suburbs close to parks, hospitals and schools.

There is one area where the findings of this research differs from other similar studies undertaken in larger metropolitan areas such as Los Angeles, by Gruenewald *et al.*,(2006). The research by Gruenewald *et al.*, (2006) concludes that the impact of bars on violence depends on a variety of social and environmental influences present in the localities where bars are found. While there is some support to the finding that the greater the number of bars, the greater the number of assaults holds true in Hamilton as in the research area within Los Angeles, there is less evidence to link the assault patterns to varying social and environmental influences within neighbourhoods having different population characteristics. In the Gruenewald *et al.*, 2006 study it was argued that there were lower levels of assaults where there greater numbers of bars in stable wealthy and Hispanic neighbourhoods. However, in this study most bars are heavily concentrated in the centre of one urban centre whereas in Los Angeles bars are more widely dispersed through residential neighbourhoods exhibiting various socio-economic characteristics. Due to this concentration of bars in central Hamilton and certain other towns there are few opportunities to explore the bar-assault relationship in the context of population characteristics. Accordingly, the study has limited its analysis of population to an assessment of population density.

Through an analysis of distance and density relationships, the study confirmed a close association between assaults and bars. These results relate to the first objective of the study. Those aspects of the Crime Potential Theory and the

Routine Activity Theory which emphasise the importance of place in defining assault patterns around bars have been confirmed in the study through the close association between assault densities and bar densities. Population based measures were however less accurate as a predictor of assaults. The Social Disorganisation theory was not able to be comprehensively and accurately tested due, first to the concentration of bars in the central business precincts in urban centres in the Waikato where there were low residential populations. Second, the population characteristics in holiday resorts varied over the course of the year which meant that traditional measures of social disorganisation such as employment and income within a resident population could not be used as testing variables. These results relate to the second study objective.

A close comparison has been found to exist with similar studies undertaken in other parts in the world. The findings of this study showed similar findings to the 1997 study by Jochelson in that assault numbers in Hamilton were comparable in crime hot-spot locations in Sydney. Second, there were comparisons with the Gruenewald study in that there was found to be strong associations between assault density and bar density. Third, comparisons with the Lipton *et. al* (2003) study were less conclusive in that road density was only found to be associated with assault density at the ward level. These outcomes are related to the third research objective.

The outcomes of the analysis by the various spatial analysis techniques applied in the study were broadly similar in that they all confirmed the close association between assaults and bars in urban areas and the lesser association in rural areas. A comparison of the choropleth analysis technique and point density technique confirms that the choropleth methods were easier to analyse but failed by comparison with point density to highlight local variations due to the effect of arbitrarily drawn boundaries. This limitation is associated with the Modifiable Areal Unit Problem (Openshaw 1984). Both methodologies are more effective in urban as opposed to rural areas as it is difficult to identify "hot-spot" activity at a large scale using point density techniques. The choropleth density technique also fails to accurately identify local variation in rural areas due to the

larger sizes of the enumeration unit. Other spatial analysis techniques used in this study, namely geographically weighted regression and clustering analysis also demonstrated the same issues identified above due to the aggregation of data to the meshblock level. These outcomes are related to the fourth research objective.

9.1 Limitations

Perhaps the most obvious limitation having regard to the high level of community interest in alcohol related social issues is the lack of other available place and distance related research to date in New Zealand on the relationships between assaults and bars.

This research applies recently developed techniques such as distance, density analysis and geographically weighted regression to further explore the relationship between assaults and bars. Applications of these techniques are considered to have successfully established the relationship between bars and assaults but the lack of other available research in this country on the subject has limited comparative analysis. Comparisons have been made with overseas studies such as the research by Jochelson in Sydney. It is hoped that these techniques will continue to be applied elsewhere in New Zealand to better explain spatial relationships between bars and assaults. The lack of other similar research in this country does not however detract from the findings of this research.

It should also be recognised that the relationship established in this research between bars and assaults may not be an exclusive one and that similar relationships could exist with other related land uses such as burger bars, hotels, off-licences, *etc.* Such relationships, known as “co-linearity” between variables could exist however; their potential effects were not considered in this study.

Another limitation involves the possibility that hospital discharge statistics could provide a more accurate picture of the nature and numbers of assaults. This has been recognised in some previous studies such as the one by Gruenewald *et al.*, 2006 but to date no evidence exists to suggest that this approach offers any

advantage over the use of official police statistics (Holmes pers. comm. 2011). The limitations imposed by the use of official statistics are an ongoing problem inherent to any research of this nature.

Techniques used in this research have emphasized the location and the nature of the relationship between assaults and bars throughout the Waikato. Explaining the *cause of* the variations in assault patterns around bars is however more problematic and is associated in the main with incomplete or unavailable sources of data. These limitations are compounded by the significant variations in population characteristics which occur throughout parts of the Waikato during the year. These are most apparent at the holiday centres on the Coromandel Peninsula where populations can increase significantly from 26,000 to 135,000 in summer.

There were some difficulties involving the technical aspects of the research.

There were some procedures in ArcGIS and Microsoft Excel which required automation to classify data in producing maps and chart production. These processes could not be automated and were reapplied using time consuming manual “point and click” techniques as opposed to being automated. Linking data in Microsoft Excel to ArcGIS in the data classification process was especially time consuming. Removing and reapplying the join between the spreadsheets in Microsoft Excel meant that data had to be reclassified on several occasions. The geocoding process was problematic in that there were some bars, mainly in rural areas but also some locations in urban areas that could not be accurately matched to the records in the address locator and as a result affected the map outputs and the analyses. Difficulties in geocoding addresses have been recognised in previous research so it must be acknowledged this is an inherent problem associated with GIS and the spatial analysis process.

9.2 Opportunities for Future Research

The research has highlighted that there even though there is a wide range of literature on assaults around bars; there are very few comparable available studies that analyse this relationship using contemporary mapping techniques. It

is noted that published, reputable studies on the relationship between assaults and bars have to date, been limited mainly to Australia and the United States, such as urban centres of Sydney, Melbourne, Los Angeles, Cincinnati and Chicago. The failure to replicate such studies in different geographic environments is a particular concern as it is difficult to gain an impression as to whether the influence of bars on assaults is a peculiarly Anglo-American, metropolitan or large urban phenomenon as distinct from smaller centres and rural areas.

The lack of spatial analysis to date is surprising given the generally high level of community and academic interest in both alcohol and violent crime and the wider significance of these two interrelated aspects of a critical social and geography related issue. Studies of this type could be replicated effectively throughout New Zealand, and the availability of source data means that there is no impediment to such studies being carried out in this country, to see if the same patterns between bars and assaults in Australia and the United States are reproduced at the urban and at the rural level here in New Zealand. Different or unusual relationships between bars and assaults from that found in the United States could point to other local influences on assaults.

The findings of Jochelson's (1997) study were important to the planning of the Sydney Olympic games held in the city in 2000, by identifying the association between high levels of assaults around bars in tourist hot-spots. It is considered that the methodologies used in this research to highlight the location, distribution of and relationship between assaults and bars could be employed to gain further insights into the distribution of assaults around similar tourist hot-spots. This could be of particular interest given the level of debate over anti-social behaviour in the recent Rugby League test (November 2010) at Eden Park between Australia and New Zealand.

There is still opportunity for research into the development of a better integrated geographic information system that allows for the automation not only of spatial analysis processes but also of data aggregation processes taking place in Microsoft Excel. Although there has been recent development of

automated procedures in ArcGIS in the form of scripting tools and ArcInfo - a completely integrated Geographic Information System combining the functionality of Excel with ArcGIS software allowing the complete automation of spatial analysis, data aggregation, cartographic design and map presentation within one module has not yet been developed. With recent technological advancements, it is feasible to suggest that the possibility for an integrated system is not too far away.

Finally, this research has illustrated that geographic information systems enable the effective analysis and description of crime data using maps. The old adage of "A picture is worth a thousand words" (Anon) is particularly relevant when analysing data as maps are able to provide detail on the location and relationship between assaults and bars. Many earlier studies investigating the relationship between assaults and bars including those by Roncek and Maier(1991) did not provide such illustrations. It is also significant to this research study that maps also provide an aesthetically appealing way of presenting information in ways that is easily understood through the application of correct cartographic principles such as balance, the use of colour, data classification, *etc.* With further developments in Geographic Information Systems and spatial analysis it can safely be expected that there will continue to be widespread and effective use of mapping in crime research.

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Appendix A: Decision Matrix

Appendix A1: Centrographic Statistics

DECISION MATRIX			
		STRENGTHS	LIMITATIONS
ANALYSIS	Evaluation		
FUNCTION	Criteria		
Centrographic statistics	AIM: Analyse mean and standard deviation statistics of bar and assault data in areal unit		
	Storage		
	Acquisition		
	Data Manipulation	Spatial statistics tools in Arc Software make analysis of centrographic data with relative ease	
	Data aggregation	Aggregates data to a geographic mean and standard deviation	Problem with statistics function as aggregation of statistics to find geographic mean of data means all other information on data is discarded.
	Research objectives	Limited in functionality, other spatial analysis functions more useful in showing relationships between assault and bar data	
	Weighting given	Low given limitations in functionality	

Appendix A2: Choropleth Density Function

DECISION MATRIX		STRENGTHS	LIMITATIONS
ANALYSIS FUNCTION	Evaluation Criteria		
Choropleth density function	AIM: Map assault and bar densities in Hamilton/Waikato district		
	Storage		More space required for vector data than raster data
	Acquisition	Able to get data from different sources, data stored on a secure drive.	
	Data manipulation	Ability to manipulate data using spatial join techniques joining point to polygon data. Integrating data of different standards relatively straight forward	Computationally time consuming compared to other spatial analysis techniques
	Data aggregation	Data aggregated at a census or meshblock level using spatial join tool	Modifiable Area Unit Problem and Ecological fallacy with aggregated data means that information within aggregate units have same characteristics.
	Research objectives	Used extensively in previous research. Meets research objectives in highlighting densities of assaults and bars	
	Weighting given	High given functionality of choropleth mapping technique in displaying assault and bar densities. Important to crime mapping as technique emphasizes locational aspects of bar and assault.	

Appendix A3: Clustering Analysis

DECISION MATRIX			
		STRENGTHS	LIMITATIONS
ANALYSIS FUNCTION	Evaluation Criteria		
Clustering Analysis	AIM: Quantify the level of clustering of assaults around bars		
	Storage		
	Acquisition		
	Data manipulation/analysis	Reasonably straight forward to analyse assault clusters using clustering analysis techniques	
	Data aggregation		Data must be aggregated to meshblock area units
	Research objectives		Clustering analysis not used in previous research involving assaults around bars. Difficult to draw on any previous methodologies for application in this research.
	Weighting given	Low to moderate given lack of previous research on subject.	

Appendix A4: Distance Function

DECISION MATRIX			
		STRENGTHS	LIMITATIONS
ANALYSIS FUNCTION	Evaluation Criteria		
Distance function	AIM: To measure association between assault and bar by measuring Euclidian (straight-line) distance between assault and nearest bar		
	Storage	GIS analysis conducted with vector data means that analysis is more precise and accurate than is the case with raster data.	More space required for vector data than raster data
	Acquisition	Data from different sources stored on secure drive	
	Data manipulation/analysis	Able to analyse distance from assault to nearest bar. Computationally less time consuming than other spatial analysis techniques.	Inability to associate an assault with a given bar a limitation.
	Data aggregation		
	Research objectives	Meets research objectives in providing measure of association between assault and nearest bar.	
	Weighting given	High given functionality of distance analysis technique in measuring association between assault and nearest bar.	Not well previously utilized technique in analyzing the relationship between assaults and bars.

Appendix A5: Geocoding Function

DECISION MATRIX		
	STRENGTHS	LIMITATIONS
ANALYSIS FUNCTION	Evaluation Criteria	
Geocoding	AIM: Spatially reference bar data by matching existing data with records in address locator Storage	
	Acquisition	Some problems receiving data from different sources, received data on bar details in hard copy from some council. Had to manually type in data from files from other councils. Prefer to have a centralized source of data available in soft copy.
	Data manipulation	Geocoding process of coding bar address with geocoded information in database problematic for all geocoded data. Incorrect geocoding for around 15-20% of data. Rematching required for all data.
	Data aggregation	
	Research objectives	Geocoding a necessary process in matching bar location to value in address locator.
	Weighting given	High given essential role in analysis process

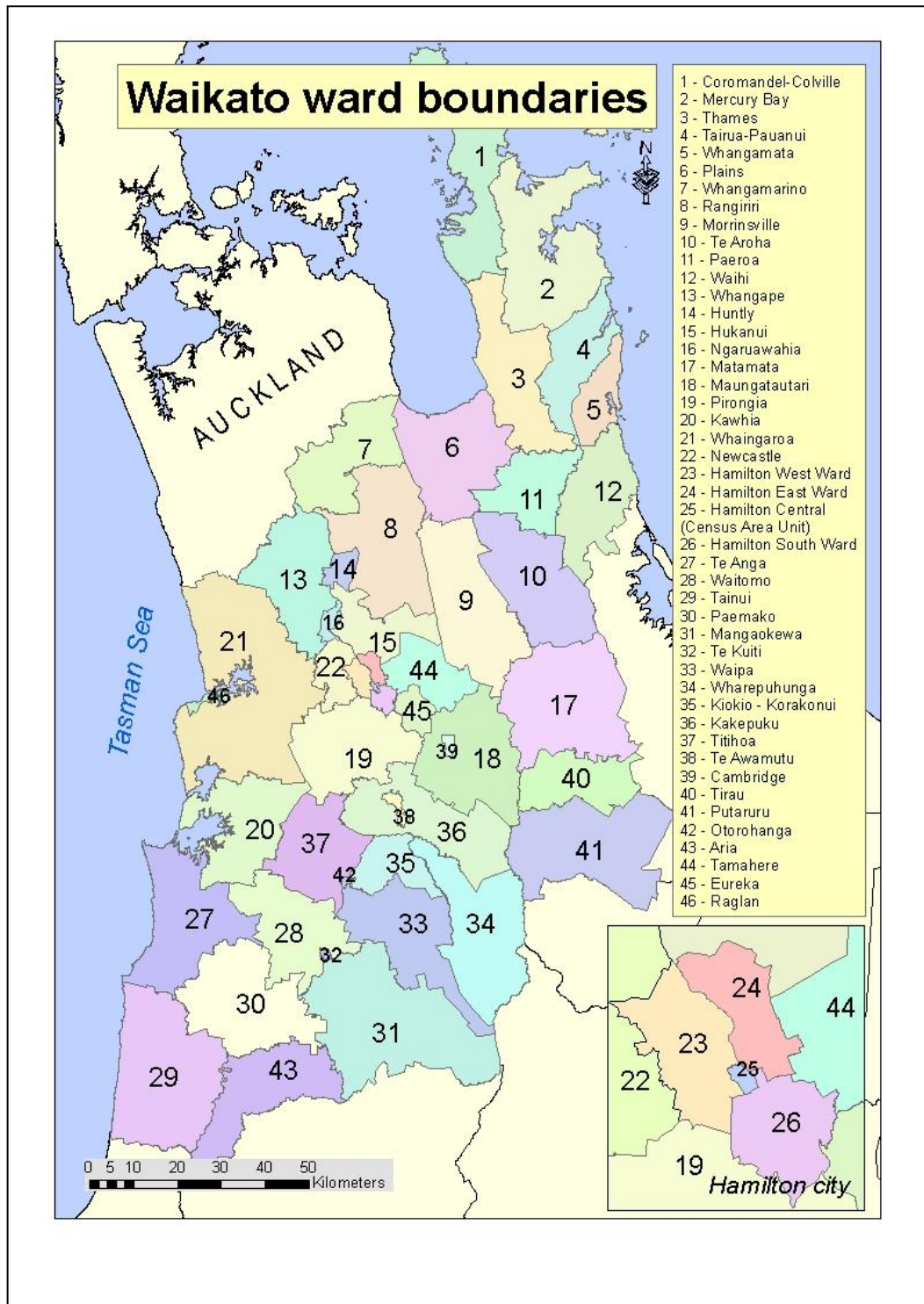
Appendix A6: Geographically Weighted Regression

DECISION MATRIX			
		STRENGTHS	LIMITATIONS
ANALYSIS FUNCTION	Evaluation Criteria		
Geographically Weighted Regression	<p>AIM: To predict number of assaults given number of bars. Geographically weighted regression explores the level spatial variation between these two events.</p> <p>Storage</p> <p>Acquisition</p>		
	Data manipulation/analysis	GWR process reasonably fast compared to other processes.	Difficulties in assessing accuracy of model. Local models difficult to manually calculate
	Data aggregation	Options of aggregating data at meshblock level. However GWR may also be conducted at the individual level	
	Research objectives	Useful in measuring the strength of relationship between bars and assault levels. GWR used to predict number of assaults given spatial location of bars.	
	Weighting given	Moderate, complements other research in providing evidence of a relationship between assaults and bars	

Appendix A7: Point and Kernel Density Functions

DECISION MATRIX			
		STRENGTHS	LIMITATIONS
ANALYSIS FUNCTION	Evaluation Criteria		
	Density based functions (point and kernel)	AIM: Highlight distribution of assault "hot-spots"	
	Storage	Raster based techniques use up less space than vector based techniques	
	Acquisition		
	Data Manipulation/Analysis		
	Data Aggregation		Aggregation not possible using point and density functions
	Research Objectives	Meets research objectives in providing alternative form of visualizing assault patterns to choropleth mapping technique	
	Weighting given	High given acceptance in crime research of technique and widespread use in prior research	

Appendix B: Waikato District Ward Boundaries



1) MAIN MODEL

i) Geocoding sub-model

Input Shapefiles

Coromandel_DC_Geocode.shp – Shapefile with successfully geocoded bar data for Coromandel (1)

Hamilton_CC_Geocode.shp – Shapefile with successfully geocoded bar data for Hamilton city (2)

Otorohanga_DC_Geocode.shp – Shapefile with successfully geocoded bar data for Otorohanga District Council (3)

Waikato_DC_Geocode.shp – Shapefile with successfully geocoded bar data for Waikato District Council (4)

Waipa_DC_Geocode.shp – Shapefile with successfully geocoded bar data for Waipa District Council (5)

Waitomo_DC_Geocode.shp – Shapefile with successfully geocoded bar data for Waitomo District Council (6)

Variables included in shapefiles 1-6: ("Shape", "Status", "Score", "Match Type", "Arc_Address", "ID", "Type", "Property Address", "Issue_Until", "Street_Num", "Zone")

Shape: type of data in shapefile (Point/line/polygon)

Status: matched/unmatched address

Score: accuracy of geocoding process

Match type: Manual/automatic match type

Arc_address: Unmatched address column in geocoding module

ID: Record ID

Type: Type of license

Property_address: Raw Data address field

Issue_Until: License expiry date

Street_Num: Number and street address column to be matched to records in address locator

Zone: Suburb/town in geocoding process

Processes

“MERGE” tool – Merges all input shapefiles into one file (7)

Outputs

Waikato_Geocode_merge_bar_new.shp (8)

ii) Distance analysis sub-model

Input shapefiles

Waikato_Geocode_merge_bar_new.shp (8)

Assault_data.shp – Shapefile of assault events (point data) spatially referenced from x y co-ordinates (9)

Variables included in assault_data.shp (shapefile (9))

Shape: type of data in shapefile (Point/line/polygon)

FID: automatic ID created

Offence Date: Date when offence took place

Day of week: Day when offence took place

Offence Hour: Hour bracket when offence took place

Offence Code

Offence Description: Nature of offence

Scene description: Environmental setting of offence

Northing: Northward measured distance (Y co-ordinate) from datum

Easting: Eastward measured distance (X-Coordinate) from datum

Recorded Offence: Number of offences recorded at point in time

Resolved offence: Offence resolved through warnings, prosecution, *et cetera* in justice system

Processes

“NEAR” tool (10) – Calculates Euclidian “straight-line” distance from assault to nearest bar

Outputs

Assault_data.shp (11) – Euclidian “straight-line” distance calculated from assault to nearest bar added to assault_data shapefile (9)

iii) Spatially join assault data to meshblock sub-model

Input shapefiles

Assault_data.shp (11)

Meshblock_data.shp (12) - Spatially referenced enumeration data in areal (polygon) format at the meshblock level. Contains information on meshblock, census area unit, ward, territorial authority, etc.

Variables included in meshblock_data_shapefile include:

Shape: type of data in shapefile (Point/line/polygon)

Ward Name and ID: Territorial unit of government with a region

Territorial Authority (TA) Name and ID: Name of local or regional authority

Const Name and ID: Council name and ID

Elect_Name and ID: Electoral district (Central Government) and Electoral ID

Centroid Y: Y co-ordinate for polygon centroid

Centroid X: X co-ordinate for polygon centroid

Area: Size of meshblock

Meshblock name and ID

Census Area Unit and CAU ID

DHB_Name and ID: District Health Board name and ID

Population Variables including: ALL (Total population), UNDER 5, OVER 65, MAORI, PI, REST

Process

“SPATIAL JOIN” tool (13) – Transfers attributes of assault data shapefile (11) to meshblock polygon

Outputs

Assault_data_SJ (14) – File of assault event data (11) “spatially referenced” to meshblock shape file(12)

iv) Assault data summary statistics shapefile sub-model

Input file

Assault_data_SJ (14)

Process

“SUMMARY STATISTICS” tool (15) – Calculates number of assaults recorded in each meshblock

Outputs

Assault_sum_statistics.dbf (16) – Database file with summary statistics for number of assaults recorded in each meshblock

Variables included in Assault_sum_statistics (16) include:

ObjectID: Unique Identifier of Input field (meshblock)

MB_ID: The input field. Meshblock values are not repeating. Null statistics recorded for a meshblock are included in a separate row.

Frequency: Number of meshblocks recording “null” statistics, otherwise assault numbers per meshblocks recorded

Sum_Join_Count: Same as “frequency” row, however where meshblocks contain no assaults, no data is recorded

All other data is same as assault_data_SJ(14) shapefile

v) Project all geocoded bar data sub-model

Input shapefiles

Waikato_Geocode_merge_bar_new.shp (8)

Process

“PROJECT” tool – Reprojects geocoded bar data from NZGD 2000 to TM 1984 coordinate system

Outputs

Waikato_Geocode_merge_bar_project.shp (15)

vi) Spatially joined geocoded bar data to meshblock data sub-model**Input shapefiles**

Waikato_Geocode_merge_bar_project.shp (15)

Process

“SPATIAL JOIN” tool (16) – Transfers attributes of (11)

Waikato_Geocode_merge_bar_project shapefile to meshblock data shapefile (12)

Outputs

waikato_geocode_merge_mb.shp (17)

vii) Bar data summary statistics database sub-model**Input shapefiles**

waikato_geocode_merge_mb.shp (17)

Process

“SUMMARY STATISTICS” tool (18) – Calculates number of bars and entertainment facilities recorded in each meshblock

Outputs

Waikato_Geocode_merge_bar_summary_statistics.dbf (19)

Variables included in Waikato_Geocode_merge_bar_summary_statistics.dbf (19)

include:

ObjectID: Unique Identifier of Input field (meshblock)

MB_ID: The input field. Meshblock values are not repeating. Null statistics recorded for a meshblock are included in a separate row.

Frequency: Number of meshblocks recording “null” statistics, otherwise number of bars per meshblocks recorded

Sum_Join_Count: Same as “frequency” row, however where meshblocks contain no bars, no data is recorded

All other data is same as Waikato_Geocode_merge_mb.dbf (17)

ix) Spatially join road data to meshblock data sub-model

Input shapefiles

Road.shp (20) – Shapefile containing data on secondary roads throughout the Waikato region

Meshblock_data.shp (12)

Variables included in road_shp include:

Shape: type of data in shapefile (Point/line/polygon)

Roads_ID: Unique ID accorded to each road

Name: Road name

Length: Road Length (m)

Process

“SPATIAL JOIN” tool (21) – Transfers attributes of Road shapefile (20) to meshblock data shapefile (12)

Outputs

Meshblock_road_join.shp (22) – Road lengths (20) “spatially referenced” to meshblock shape file(12)

ix) Road data summary statistics shapefile sub-model

Input shapefiles

Meshblock_road_join.shp(22)

Process

“SUMMARY STATISTICS” tool (23) – Calculates total road length in each meshblock

Outputs

Meshblock_road_join_sum_stat.dbf (24)

Variables included in meshblock_road_join_sum_stat.dbf (24)

include:

ObjectID: Unique Identifier of Input field (meshblock)

MB_ID: The input field. Meshblock values are not repeating. Null statistics recorded for a meshblock are included in a separate row.

Frequency: Total number of roads in meshblock

Road length: Total sum of road length in each meshblock (metres)

x) Join road length data with assault event data sub-model**Input variables**

Assault_sum_statistics.dbf (16)

Meshblock_road_join_sum_stat.dbf (24)

Process

“JOIN DATA” (25) tool joins like attributes (meshblock) from two tables.

Output

Assault_sum_statistics.dbf (25) – all columns in Assault_sum_statistics.dbf (16)

and Meshblock_road_join_sum_stat.dbf (24) files

xi) Join assault/road summary statistics database with bar summary statistics database sub-model

Input variables

Assault_summary_statistics.dbf (25)

Waikato_Geocode_merge_bar_summary_statistics.dbf (19)

Process

“JOIN DATA” (26) tool joins like attributes (meshblock) from two tables.

Output

Assault_summary_statistics.dbf (26) – all columns in assault_sum_statistics.dbf (16) and meshblock_road_join_sum_stat.dbf (24) files

xii) Join assault/road/bar summary statistics database to meshblock table sub-model

Input variables

Assault_summary_statistics.dbf (26)

Meshblock_data.shp (19)

Process

“JOIN DATA” (27) tool joins like attributes (meshblock) from two tables.

Output

Meshblock_w_pop_copy_x.dbf (28) – all columns in assault_sum_statistics.dbf (16) and meshblock_data.shp (19) files joined at the meshblock level. This is the data set with road, assault and bar data aggregated at the meshblock level.

xiii) Point density selection sub-model

Input variables

Assault_data.shp – Shapefile of assault events (point data) spatially referenced from x y co-ordinates (9)

Process

“SELECT” tool (29) selects all assault event data where northings <> “0” (any data that may have been incorrectly geographically referenced)

Output

Assault_data_select.shp (30)

xiv) Point density sub-model 1 – Neighbourhood focus

Input variables

Assault_data_select.shp (30)

Process

“POINT DENSITY” tool (31) creates type and size of neighbourhood focus around sample point.

Cell size created: 50 metres

Type: circle

Output

Point_assault_data (32) (raster file)

xv) Point density sub model 2 – Focal statistics

Input variables

Point_assault_data (32)

Process

“FOCAL STATISTICS” tool (33) creates for each input sample point a statistic of the values within a specified neighbourhood around the cell.

Statistics used: Minimum and mean count within raster unit

Output

Radius: 1,2,5 and 10 cell radius (sensitivity analysis)

Note: Maps produced using 2 cell radius (100 metre radius) only included in thesis

10 cell maps produced resulted in a “blocky” output

Output (for sensitivity analysis)

Pd_ass_mean1 (34)

Pd_ass_min2(35)

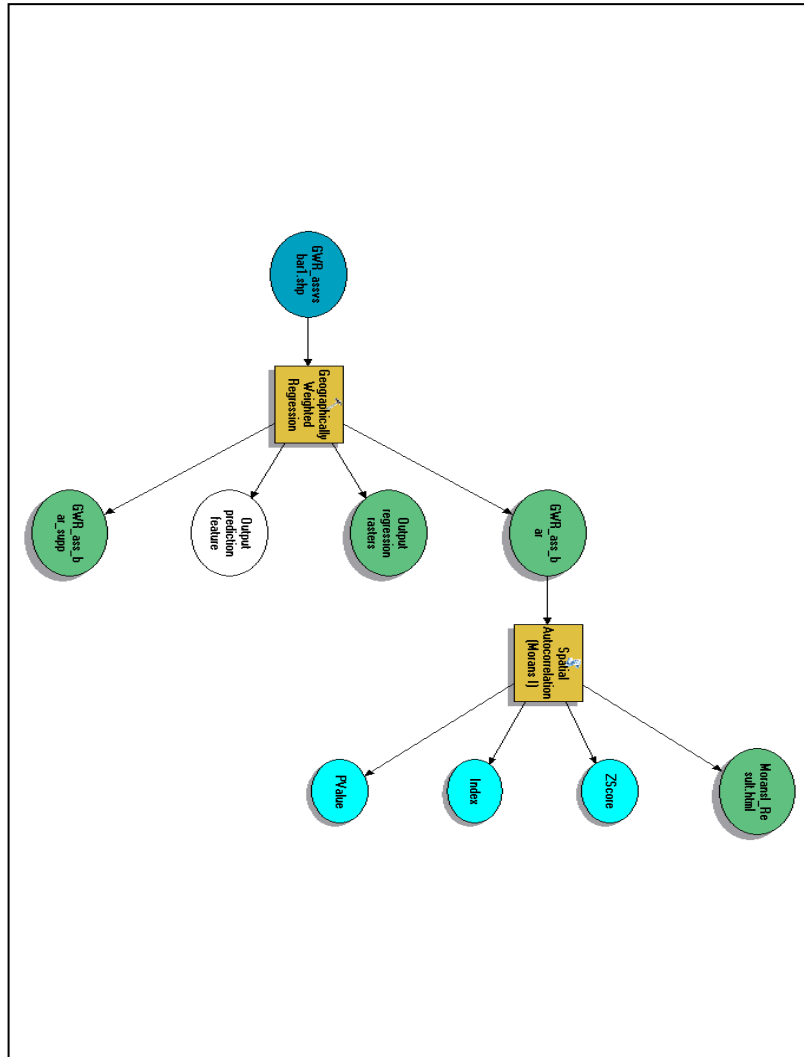
Pd_as_mean2(36)

Pd_ass_mean5(37)

Pd_ass_mean10(38)

Pd_ass_max10(39)

2) GEOGRAPHICALLY WEIGHTED REGRESSION



Note: Model script for the above model in the accompanying compact disc in the Microsoft Word document model_report.doc

i) Geographically weighted regression sub-model

Input shapefile

GWR_input.shp (1) –Shapefile dataset of data aggregated at the meshblock level from the output in main model. Only variables required in geographically weighted regression process to be included in file:

Variables included in shapefile:

FID: Unique identifier of input field

MB_ID: Meshblock;

Sum_Ass: Number of assaults per meshblock,

Sum_Bar: Number of bars per meshblock

Process

“GEOGRAPHICALLY WEIGHTED REGRESSION” (2) – Performs regression on bar and assault data at the local (meshblock) level.

Output

GWR_output.shp (3) Output dataset of geographically weighted regression at the regression level

FID: Unique identifier of input field

Shape: type of data in shapefile (Point/line/polygon)

Observed: Number of assault events per meshblock

Condition number: Collinearity test (values >30 suggest collinearity in model)

R-squared: “Goodness of fit”, how well the local regression model fits the predicted y values

Predicted value: Estimated y values computed by GWR regression model

Intercept: The intercept represents the expected value for the dependent variable (assaults) where the independent (explanatory) variables (bar) is zero

Regression coefficient (β_1): slope of the regression line; the relationship between numbers of assaults (dependent variable) given number of bars (independent variable)

Residuals: observable *estimate* of the unobservable statistical error

Standard error: amount by which an observation differs from its expected value

Input shapefile

GWR_output.shp (3) Output dataset of geographically weighted regression at the regression level

Process

“SPATIAL AUTOCORRELATION” (4) –Calculates measure to which residuals cluster

Output

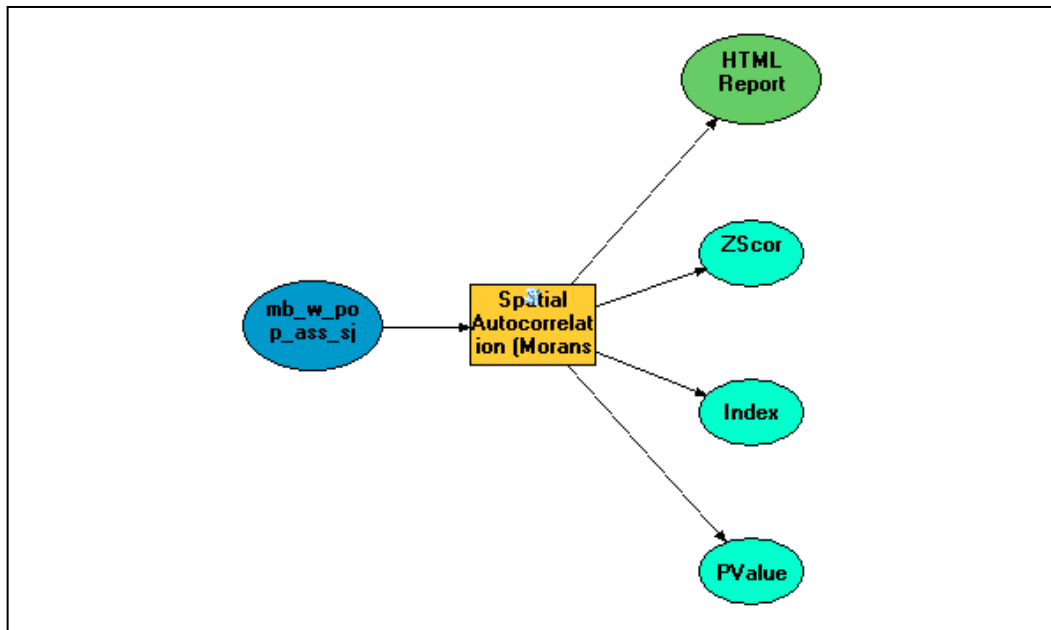
Residual_output(5)

HTML Report – graphical output of clustering results (including Moran's Index, ZScore and P-value)

Z Score – Statistical significance of clustering results (whether null hypothesis of complete random patterning can be accepted or rejected)

P-value – probability that the observed spatial pattern was created by some random process. When the p-value is very small, it means it is very unlikely that the observed spatial pattern results from random processes.

3) CLUSTERING ANALYSIS



Note: Model script for the above model in the accompanying compact disc in the Microsoft Word document model_report.doc

Input shapefile

Meshblock_data_file (1)

Process

“SPATIAL AUTOCORRELATION” (2) –Calculates clustering indices (Moran’s coefficient)

Output

HTML Report – graphical output of clustering results (including Moran’s Index, Z Score and P-value)

Z Score – Statistical significance of clustering results (whether null hypothesis of complete random patterning can be accepted or rejected)

P-value – probability that the observed spatial pattern was created by some random process. When the p-value is very small, it means it is very unlikely that the observed spatial pattern results from random processes.