Examining Accessibility in the Occurrence of Campus Crime

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Abstract: This paper examines the relationship between crime and accessibility in a university campus. It was found that accessibility is related to the occurrence of campus crime because crime concentrations are directly connected to public transport routes and in close proximity to major intersections. The paper introduces the novel application of Multiple Centrality Assessment (MCA), an urban design tool, in crime analysis. MCA, particularly closeness centrality, showed that high accessibility makes up for the poor centrality of street segments near or in crime-prone areas, thus opening up opportunities for escape as well.

Key words: campus crime, accessibility, kernel density estimation, Multiple Centrality Assessment, street centrality

1. INTRODUCTION

This study examines accessibility as a factor for crime at the University of the Philippines in Diliman (UP Diliman). The focus is on property crimes (i.e., cases of theft and robbery) that happened on campus from 2006 to July 2008. This paper is based on some of the results of a broad study that looked at how different aspects of the built environment contribute to criminal activity on campus.

Designing for crime prevention is important in even in small areas like a university campus. The success of development initiatives increases when communities are safer. However, to be able to implement appropriate safety and security measures, key actors in planning must first be aware of the value of research-based analysis of crime. This study addresses such a need by showing how crime is linked to accessibility through the use of modern tools such as Geographic Information Systems and Multiple Centrality Assessment.

The research is the first systematic analysis of crime done in the University and so it is hoped that this can serve as a meaningful guide to administrators in drawing up plans to improve safety and security on campus.

2. BACKGROUND LITERATURE

Many researchers have examined how and why crime occurs, especially as it relates to the built environment. The link between the two is not new. Medieval and classical cities found refuge in defensible space, long before the term was even coined, which can be observed in the way they walled their communities and placed few entry gates. Modification of the physical environment was also one of the major crime control efforts in the 18th and 19th century (Dhiman, 2006). In London and Paris, street lighting was introduced to reduce crime on the streets (Brantingham and Brantingham, 1993).

In 1942, prior to the age of computer-aided crime mapping, Shaw and Mckay reported that criminal behavior can be traced to the physical structure of the environment. They, along with other contemporaries, showed that there are "strong and lasting correlations among crime locations, offenders' residences, inner-city areas, non-white populations and urban poverty" (Schneider, 1988). More recent studies further reinforce the connection between crime and environmental features. In South Africa's major cities, robberies and hijackings often take place at isolated intersections and in hidden driveways, while many housebreakings occur as a result of the layout and land use of the affected residential areas (Landman and Lieberman, 2005).

Accessibility, too, was strongly linked to crime. According to Poyner (1983), the easy access to and escape from places has an impact on criminal activity. The presence of intersections appears to facilitate such movement. In residential neighborhoods, corner houses are more prone to burglary than those in the middle of the block (Hakim *et al*, 2000). Similarly, Loukaitou-Sideris (1999) noted that high-crime bus stops are located in intersections. Rubenstein *et al*. (1980) likewise posited that the kind of intersection has an impact on crime rate, with T sections being the most accessible; L sections, less accessible; and cul-de-sacs, the least accessible.

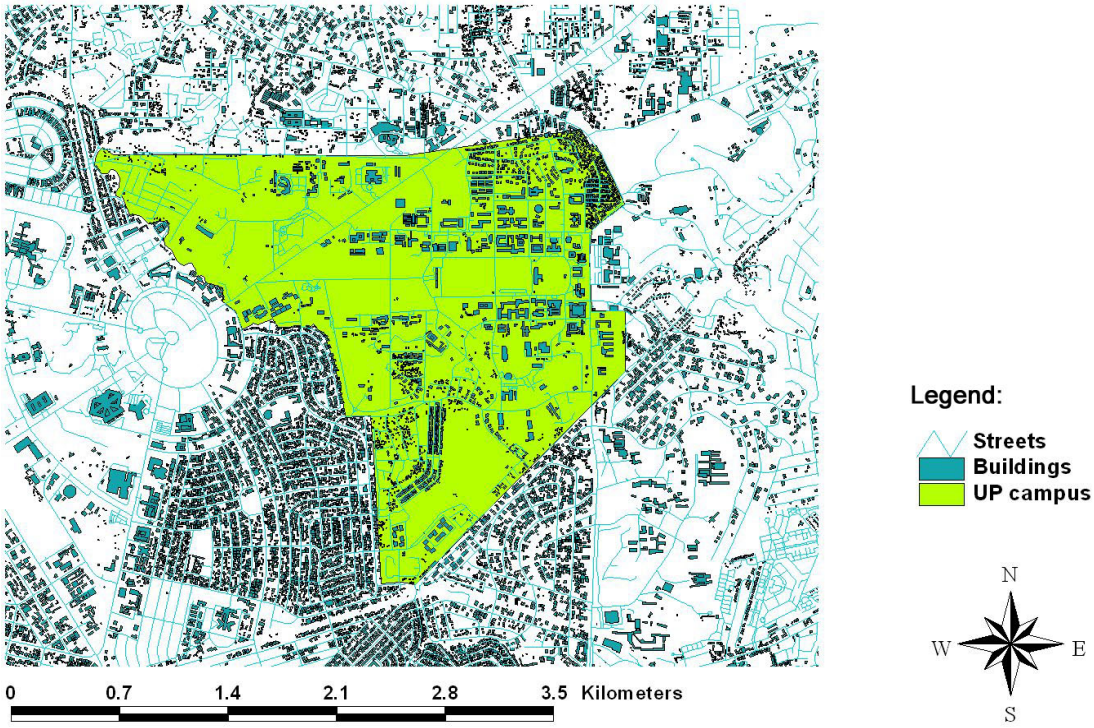
The importance of accessibility to criminal activity was further emphasized by Felson (1987) when he developed the "principle of least effort." According to this, criminals look for areas where they have the best possibility of escape when confronted by a potential threat. Hence, transport accessibility can be a big factor for offenders when considering a criminal act. Rubenstein *et al*. (1980) argued that higher victimization rates in residential areas are associated with heavy foot and automobile traffic. Clontz *et al*. (2003), using crime data from 1977 to 2000, also reported that counties in the United States with interstate highways or are close to an interstate system had the highest levels of crime.

Accessibility may also be viewed in terms of convenience to offenders – the proximity of targets to the offenders. According to behavioral geography theory, places that are closer to where offenders work or reside are at higher risk of being burglarized than places that are not within the offenders' regular route. Again, this suggests that crime rate is linked to easy accessibility (Taylor, 2002).

A few studies have been done to probe into the role of the built environment on crime - even fear of crime – on campus (Fisher and Nasar, 1992; Day, 1999; Fernandez, 2005). However, it was Long and Baran's work in 2006 that noted the presence of highly connected streets as a factor in the occurrence of campus crime. The method used to perform the analysis was Space Syntax. Additionally, the researchers observed that outdoor crimes on campus were committed closely to buildings and roads where there was greater movement and more potential victims.

3. DATA AND STUDY AREA

The site under study is the campus of the University of the Philippines Diliman in Quezon City (Map 1). UP Diliman is the flagship campus and largest constituent university of the University of the Philippines System. Lying on 493 hectares on land, it offers the most number of graduate and undergraduate courses among all universities in the Philippines. A total of 23,327 students were recorded to have enrolled in the university by December 2008.



Map 1: UP Diliman campus and its boundaries

According to the UP Diliman Police, from 2006 to July 2008, there were 268 property crimes that were committed on campus (Table 1). Property crimes in UP Diliman are committed every year. Forty-eight property crimes have occurred by the beginning of the third quarter of 2008, which translates to around half of the annual crime volume documented for 2006. Of the 268 property crimes, 205 are theft cases and the remaining 63 are incidences of robbery.

Table 1. Number of Property Crimes, UP Diliman, 2006 to mid-2008

Type of crime	2006	2007	2008	Total
Theft	61	104	40	205
Robbery	26	29	8	63
Total	87	133	48	268

4. METHODOLOGY

Geographical Information Systems was mainly used for analysis, specifically to identify the most crime-prone parts of the campus (also known as hot spots), and examine how accessibility could have contributed to their formation.

4.1 Kernel density estimation

Hot spots were located by means of kernel density estimation (KDE), where each crime was given a Gaussian probability function with a waist, σ. This means that a crime at a map position *x* and *y* would have 67 percent probability of occurring within a radius of σ/2 from *x* and *y*. The addition of the probability distribution of all crimes results in the equation,

$$KDE = \sum_{n=1}^{N} \exp\left[-\frac{(x-u)^2 + (y-v)^2}{2\sigma^2} \right] \tag{1}$$

where N: total number of crimes
u: location of the crime event at the x coordinate in the map
v: location of the crime event at the y coordinate in the map

This method is similar to a Gaussian probability function being convolved with crime events distributed at different positions (Figure 1). In the convolution theorem, the inverse Fourier transform of the product of the Fourier transforms of the factors is the convolution of the factors. In mathematical terms,

$$h(x,y) \otimes g(x,y) = \Im^{-1}\{H(\xi,\eta) * G(\xi,\eta)\} \tag{2}$$

$$= \Im^{-1}\{\Im\{h(x,y)\} * \Im\{g(x,y)\}\}$$

where $h(x,y)$ and $g(x,y)$: factors in the Cartesian plane
$H(\xi,\eta)$ and $G(\xi,\eta)$: factors in the Fourier plane (k-space)
$\Im$ and $\Im^{-1}$: inverse operators that transform the factors from the Cartesian plane to the Fourier plane and vice versa.

The power spectrum of the convolution displays the KDE:

$$KDE = \left| h(x, y) \otimes g(x, y) \right|^2 \tag{3}$$

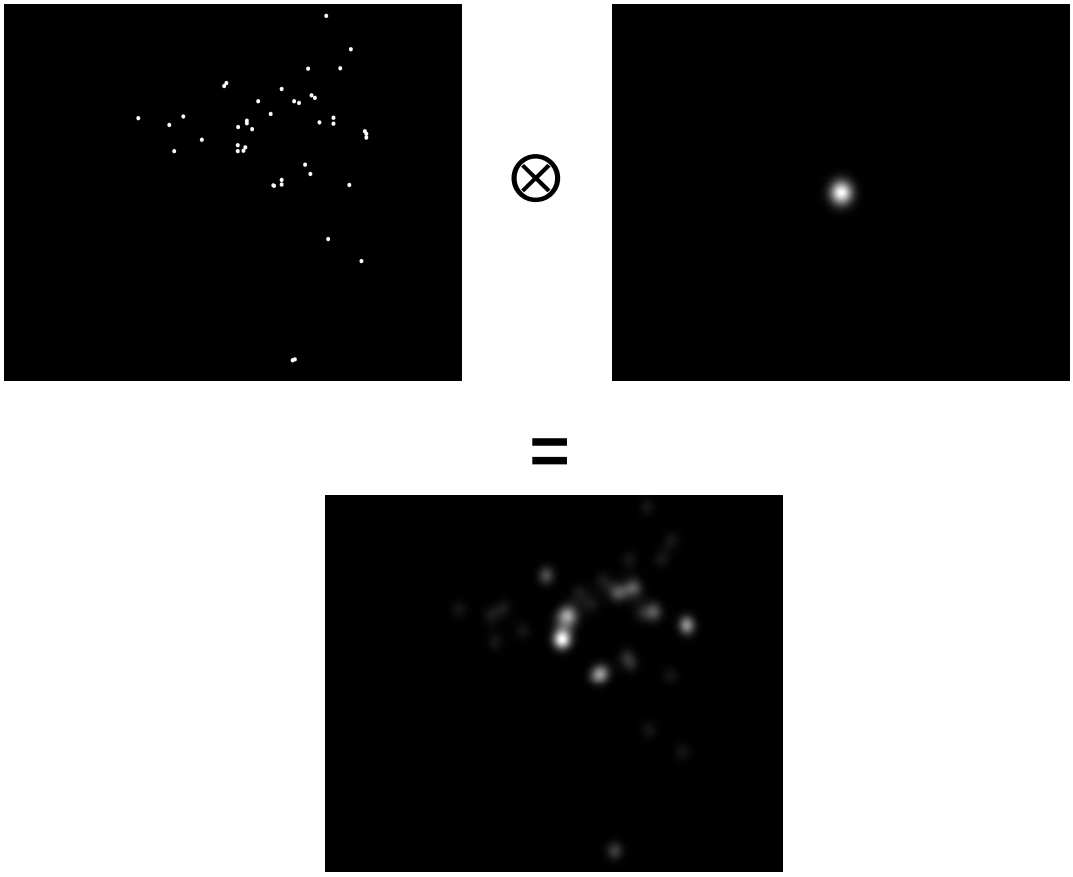


Figure 1: GIS Crime Map Convolved with a Gaussian Function and its Result

KDE generated images in which the darkest areas represent those places with the highest concentration of crime, and conversely, those with the lightest shading stand for areas with least or no crime. Crime hot spots are areas with the highest concentration of crime.

4.2 Multiple Centrality Assessment

Multiple Centrality Assessment (MCA) was performed to investigate if crime is influenced by the network of streets. MCA is based on urban design principles and the physics of complex systems. Its first professional application was in a university campus in Parma, Northern Italy at a time when plans for renovation were being prepared to improve vehicular accessibility in the university and the quality of its open spaces. MCA is based on graph theory in which mathematical structures are used to model relationships between vertices (nodes) and edges (connections between nodes). In a nutshell, the tool measures how important a node is relative to other nodes in the same graph. This measure is called centrality, which in different disciplines, is also referred to as accessibility, proximity, integration, and connectivity.

There are two measures of centrality employed in this study: closeness centrality (how close one node is to all other nodes) and degree centrality (how many connections a node has). Hence, a street segment with high closeness and degree centrality values is said to be well-connected to other segments. As of the time of writing, no known publication here and abroad has delved into the use of Multiple Centrality Assessment in crime analysis.

In calculating centrality values, map intersections were translated into nodes while streets were translated into edges. The map becomes a set *G* where all the nodes are elements with a total number *N*.

The degree centrality was calculated based on the following expression:

$$C_i^D = \frac{\sum_{j=1,N} a_{ij}}{N-1} = \frac{k_i}{N-1}, \tag{4}$$

where *D*: Degree Centrality
i: node whose centrality is being measured
k_i: number of nodes adjacent to *i*.

On the other hand, closeness centrality was calculated based on the following expression:

$$C_i^C = \frac{N-1}{\sum_{j \in G, j \neq i} d_{ij}}, \tag{5}$$

where *C*: Closeness Centrality
i: node whose centrality is being measured
d_{ij}: distance from node *i* to node *j*.

Node *i* is not similar to *j* and is an element of *G*. The study uses only local C^c (in which the value is calculated for a certain distance from node *i*) and not global C^c (where the value is calculated for all the nodes *j*). The local closeness centrality was measured using a distance of not more than 500 meters from node *i*.

5. RESULTS AND ANALYSIS

Five hot spots were identified for the period 2006 to mid-2008. They are: (1) the Chapel and its vicinity, (2) the Faculty Center (FC), College of Arts and Letters (CAL) and vicinity, (3) the College of Engineering and its vicinity, (4) Palma Hall, and (5) Vinzon's Hall and the outdoor tambayan[1] (Figure 2).

Put together, these hot spots constitute 28.4 percent of the plotted cases of theft and robbery from 2006 to mid-2008. Thirty cases happened at the Chapel and/or its vicinity while 12 transpired at FC/CAL and their vicinities. Vinzon's Hall and its outer tambayan had 9 cases, the College of Engineering and its vicinity had 6, and Palma Hall had 5 cases.

[1] A tambayan is a hangout or gathering area for a student organization. Outside the Vinzon's Hall is a large area where several tambayan spaces are situated.

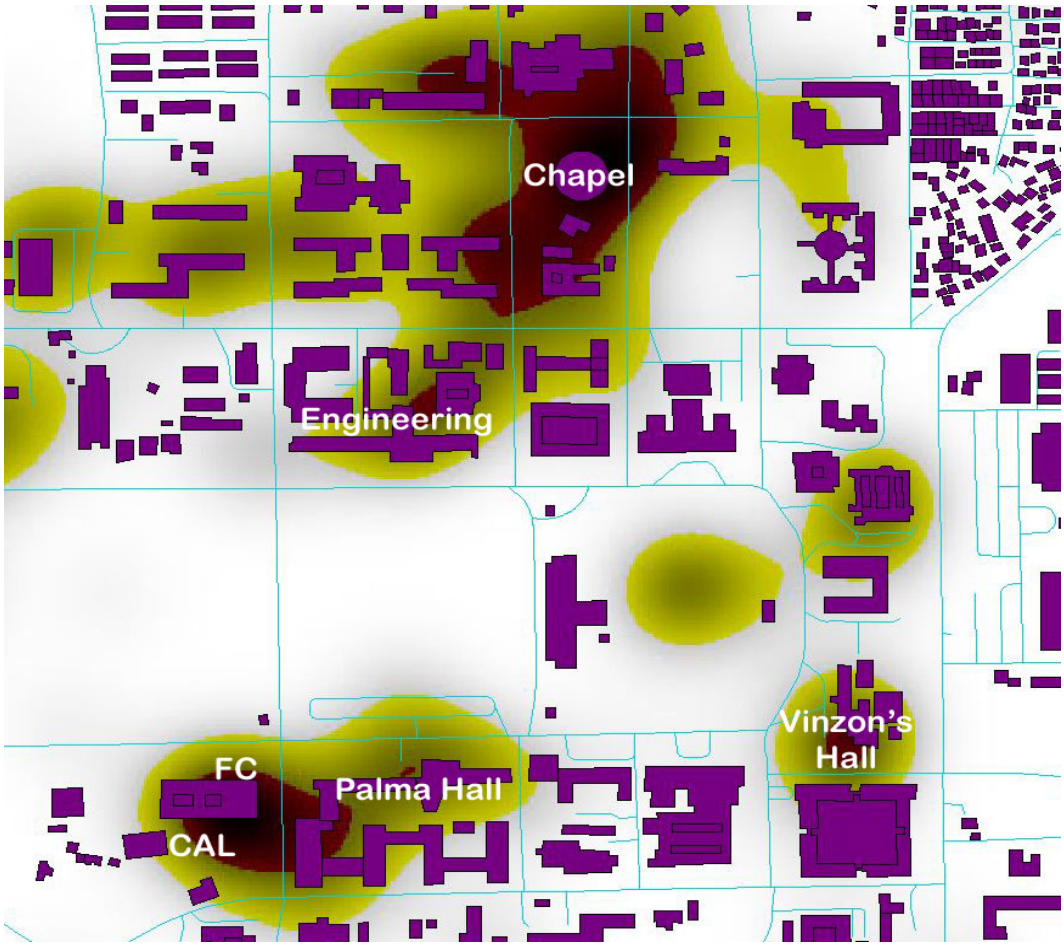
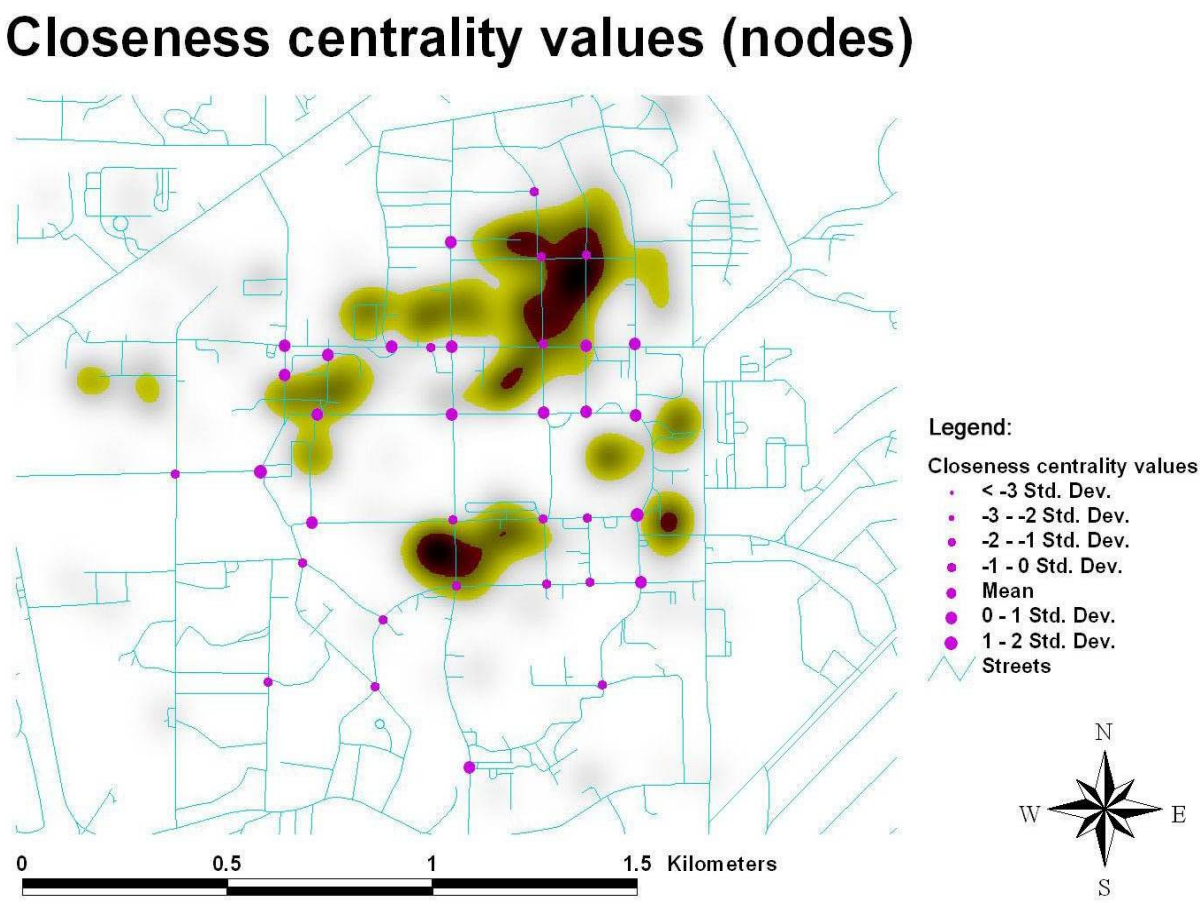


Figure 2: Location of Overall Hot Spots, UP Diliman, 2006 to mid-2008

Because it is logical for an offender to choose street segments that are most central, we would expect nodes characterized by high centrality values to be more crime-prone; high street centrality does denote more likelihood for the offenders to reach and escape from target places. Using Space Syntax Long and Baran (2006), the presence of highly connected streets was a factor in the incidence of property crimes in the campus under study. They found that "offenders in a campus setting look for opportunities, i.e. large number of potential victims, such as areas close to buildings and streets with high integration values… however, offenders also look for areas that provide opportunities for escape, i.e. high control and connectivity values."

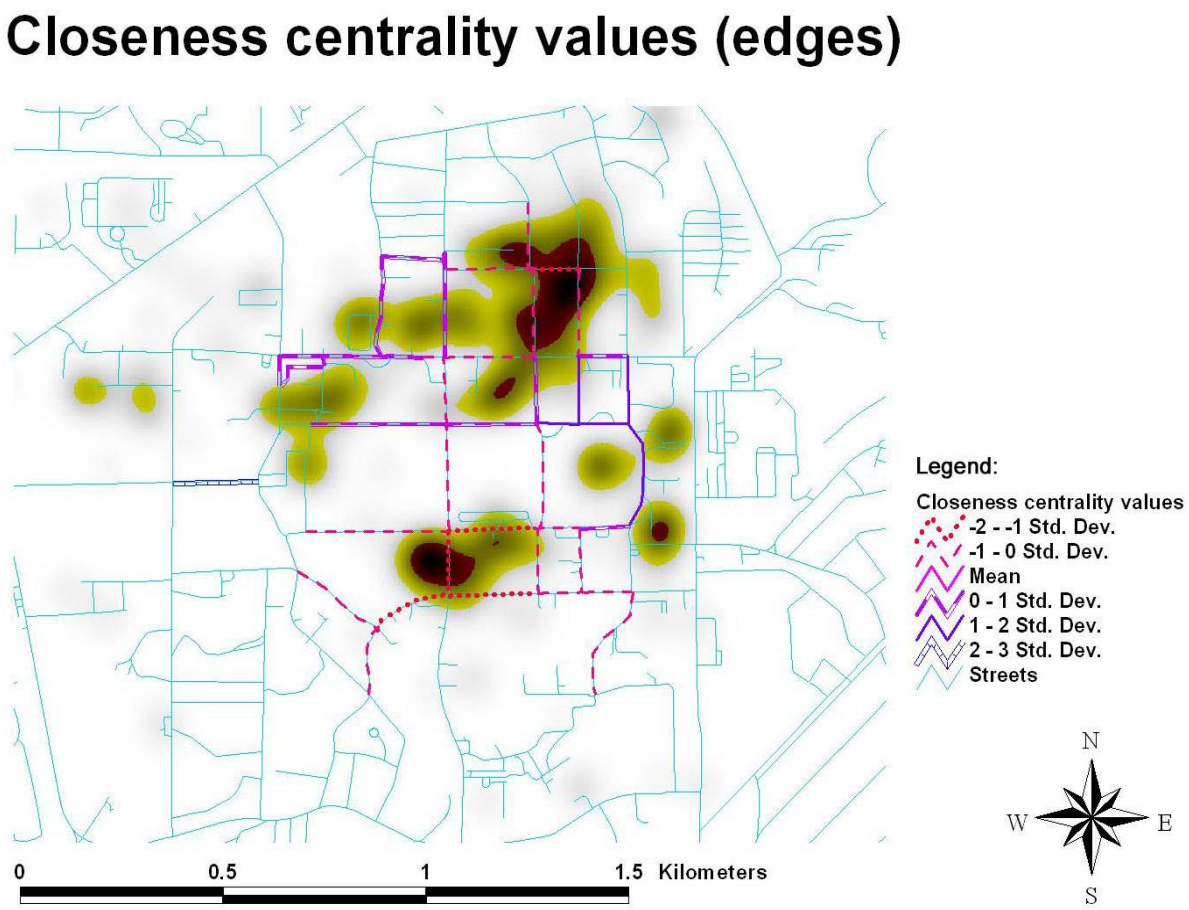
Overlaying on the hotspot map the closeness centrality map for both nodes (Map 2) and edges (Map 3) would show however that crime in UP Diliman is negatively associated to closeness centrality: four of the five hot spots are characterized by streets with low closeness centrality values. (For degree centrality, only two values appeared and so it is not particularly useful in analyzing the relationship between crime and street network in UP Diliman. This however will not affect the analysis since Closeness Centrality can stand alone as a measure of connectivity.) The hot spots at FC/CAL and the Chapel in which crime counts are higher are located on streets that exhibit low centrality. The streets at Palma Hall and the College of Engineering hot spots have low to medium centrality values. The assumption of high centrality being related to high crime incidence is evident only in the Vinzon's Hall hot spot.



Map 2: Closeness Centrality Values for Nodes, UP Diliman

What then of this observation?

Looking at the user density of the identified hot spots, it appears that criminals on campus are more concerned over the number of potential targets than over opportunities for escape. Had they put the latter first in their considerations, the University Avenue area particularly Quezon Hall would have been a hot spot since the node near the Oblation showed the highest centrality value. But that was not the case. The few crimes reported at the Quezon Hall and Amphitheater were not enough in creating a hot spot. This could be attributed to the fact that there are no sufficient targets in this area. Meanwhile, the identified hot spots exhibit high intensity of use. The College of Engineering is the largest college in UP Diliman. Palma Hall houses the College of Social Sciences and Philosophy, the second largest college, and the College of Science, the third largest college. It is also where many of the General Education classes are held. The FC/CAL hot spot sits in close proximity to the Palma Hall. The Chapel area is also characterized by high user density, as this is where the Shopping Center and other commercial establishments can be found. In short, all five areas have exceptionally large numbers of potential victims.



Map 3: Closeness Centrality Values for Edges, UP Diliman

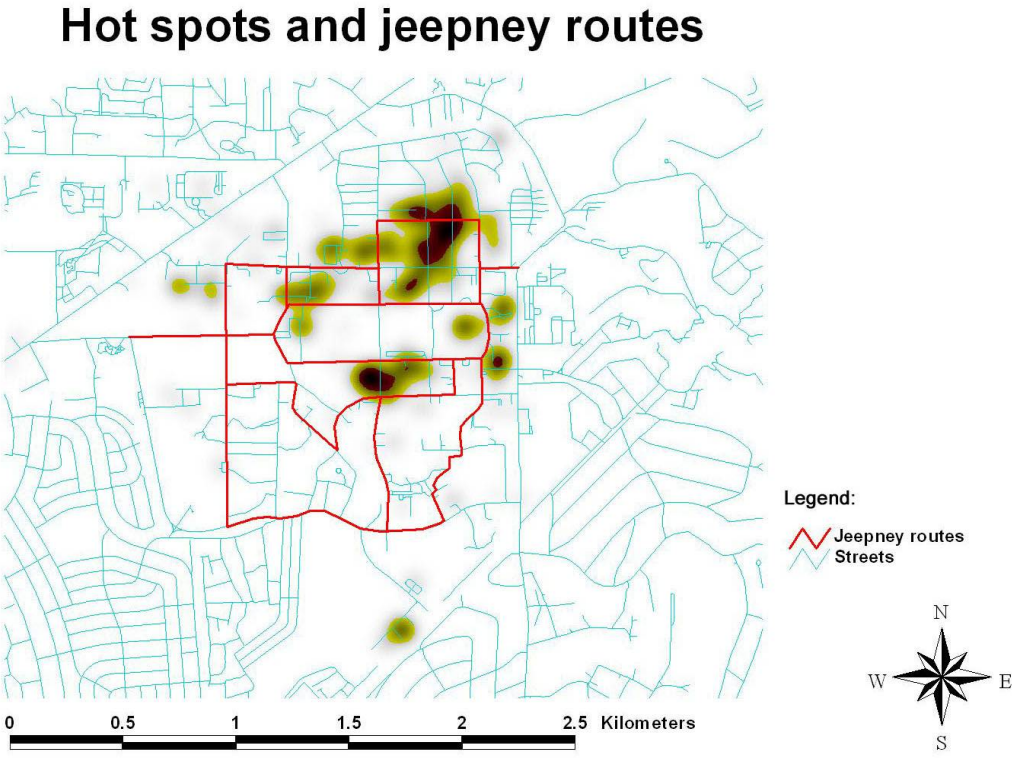
The findings only reinforce the premise of routine activity in explaining crime. According to the theory, crime occurs because of the presence of three elements: an available and suitable target; a motivated offender; and no authority figure to prevent the crime from happening (Cohen and Felson, 1979). In UP Diliman, formal and informal surveillance in most buildings and on streets is not as effective as one would have hoped. Formal surveillance on campus is provided at different levels by the UP Diliman Police, the Social Security Brigade (SSB), and security guards. Unfortunately, the police force is severely understaffed; the SSB is not strategically located; and security guards largely serve as "gate keepers" only. Informal surveillance tends to be weak too. What could have been a clear view of streets and parking areas from inside the buildings is impeded, for instance, by vegetation, poorly designed landscape, or closed or dirty windows.

With weak surveillance already established, the only element missing for a motivated offender to commit a crime is the presence of available or suitable targets. For property criminals, these include objects that are valuable, can easily be taken or are exposed to criminals (like mobile phones being used while a person is walking), objects that more likely are to be found in places where there are a lot of people engaged in their own activities. Thus, in a way, places with high user density (such as the busiest colleges) and low natural surveillance become "shopping centers" for criminals who are able to choose their targets for the highest rewards and with the lowest risks.

There is however a fourth element in the target's risk of criminal attack: access or how easy it will be for the offender to reach the target. But how can target vulnerability be completely present if hot spots on campus in general are not located on the central parts of the street network?

This is where transport accessibility enters the picture. The presence of jeepney routes makes up for what would have otherwise been poorly connected target areas for crime. Campus hot spots are directly connected to jeepney routes and this breaks down limits to criminal escape even more (Map 4). The jeepney is the chief mode of public transportation in UP Diliman, and the biggest hot spot on campus is cut by a jeepney route. That hot spot, which is the Chapel area, is by design characterized by low centrality values but transportation allows not only access to but also egress from this site.

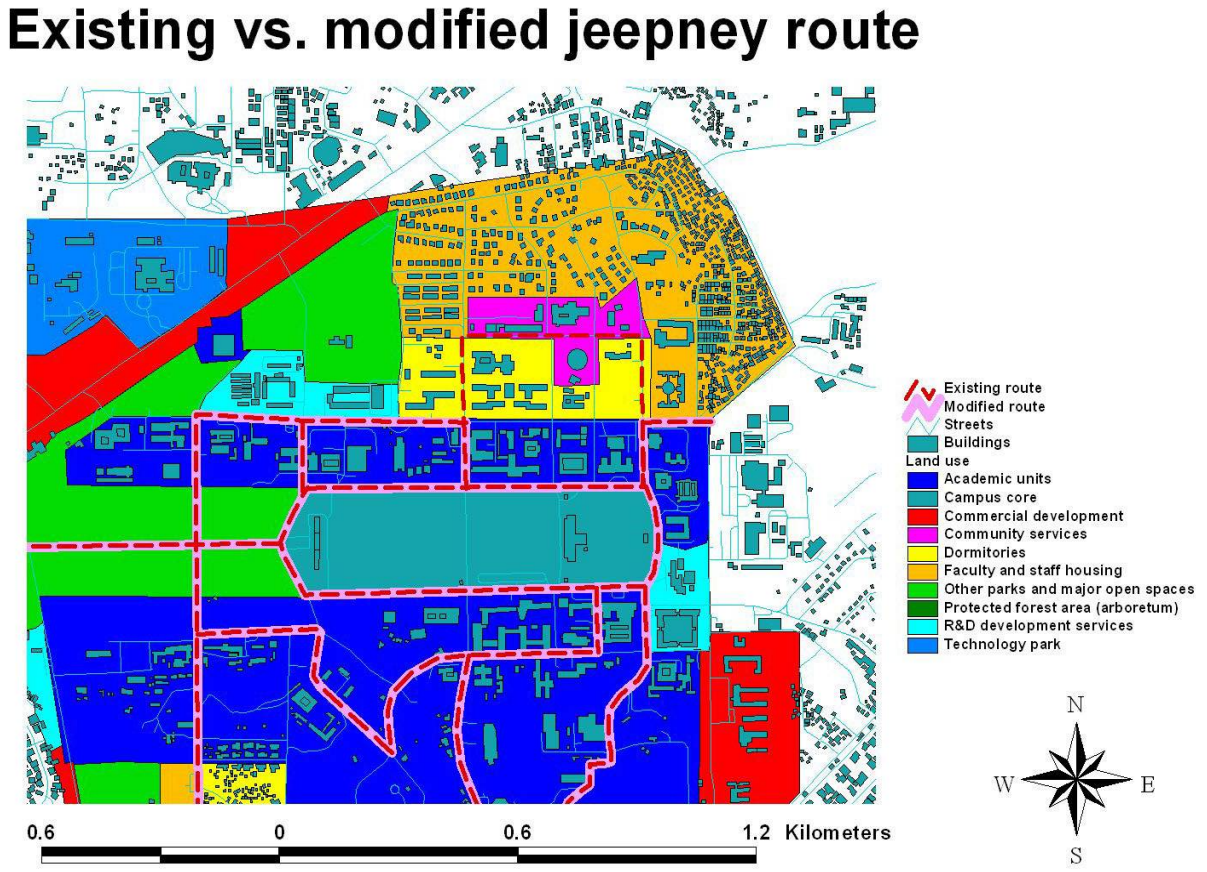
In addition, the hot spots on campus are located from 0 to about 100 meters away from intersections of streets, thus opening up escape routes. This observation is coherent with the results of previous studies in which the incidence of crime was found highest in intersections. Some would probably argue that the UP Diliman campus is naturally designed with a number of intersecting streets such that any point in the campus could in fact be prone to criminal activity. Being so, the proximity of these hot spots to intersections as a generator of crime does not merit sufficient proof. However, based on the distance of the centroid or center of the hot spot to the nearest intersection, it appears that the size of the hot spot is inversely proportional to its proximity to an intersection. The biggest hot spot the has the shortest distance to the nearest intersection and the smallest hot spot has the longest. The Chapel hot spot, the biggest of all five hot spots, is directly traversed by two main intersections on campus. Morevoer, these hot spots are all characterized by their closeness to T sections, which according to Rubenstein *et al* (1980) is the most accessible.



Map 4: Hot spots and jeepney routes, UP Diliman

Nonetheless, it would be unreasonable to say that the panacea to campus crime calls for a limit on transport accessibility or a re-routing such that jeepneys pass through low density areas only. First, doing either of the two would cause much inconvenience for students who are the most important users of the campus, and especially not at a time when the university is expanding and developing more of its lands.

As a matter of fact, Map 5 shows that a revised jeepney route that is off the high-density, high-crime land uses (i.e., community service area and a majority of dormitories) would significantly affect the accessibility of these areas to primary and legitimate users. The accessibility of faculty and staff housing would be tremendously disturbed as well since this residential land use is accessible via public transport passing mainly through dormitories and community services. Limiting accessibility might discourage potential offenders in these crime-generating land uses but there is a thin line between security and practicality. With the situation at hand, such action will lead to inconvenience for many users of the campus. Crime prevention measures might sometimes go against the legitimate objectives of land use planning; in this case, providing goods and services to users and providing housing for students. As these are important functions, reduced accessibility will impact not only on the achievement of these objectives but also on the overall goals of the university. Furthermore, passing vehicular traffic may even be used to increase natural surveillance. Passengers generally have their eyes on the street and, though not always attentive to what is happening, are quick to sense signs of crime like a snatcher running away from the scene of robbery. The presence of public transportation also means the presence of waiting sheds or areas which adds natural surveillance on street corners.



Map 5: Existing and (hypothetical) modified jeepney routes

Second, re-routing or limiting accessibility is unreasonable because it has not been established that offenders are indeed mobile, that they are "professional full-time" offenders who move around the campus in search of new targets. In three of the five hot spots, indoor crime exceeded outdoor crime in volume. This suggests that offenders could actually be regular and legitimate users of a place who just happen to find the perfect opportunities to commit crime.

But is there reason to suspect offenders to be mobile? It is likely. According to behavioral geography theory, offenders tend to commit crime in places near their residence or place of work. However, this does not necessarily mean that offenders come from within the campus grounds as some of UP Diliman's streets also serve as public thoroughfares to reach adjacent areas. Furthermore, the campus is cut by three major roads - Katipunan Avenue, C.P. Garcia Avenue, and Commonwealth Avenue – all of which are used by private and public vehicles.

Our results support the findings of Long and Baran that offenders do look for a good supply of victims and opportunities for escape, though these opportunities may not always be provided by design. In UP Diliman, it appears that the availability of transportation suffices as an option for escape, if indeed offenders are mobile. It is recommended therefore to intensify measures that address the "vulnerability" of campus users to decrease the number of potential targets or victims. Some examples are periodic building patrols during identified peak hours of crime, and implementing policies that regulate use of crime-prone places.

It is impossible to identify who among commuters are offenders, whether potential or real. Hence, the best measure against crime is giving people clues on – or at least the impression of - how tight security is on campus. This may include posting on jeepneys some signs that persuade students and other users to immediately report crime to the police, or placing posters that show pictures of recently caught offenders. Similar posters could be put up in waiting sheds or buildings to increase the chances of identifying potential offenders.

6. CONCLUSION

Street centrality appears to be negatively related to crime; the lower the value, the higher the crime volume. This contradicts the findings of other researchers that property crimes in a campus setting are positively related to high connectivity. In UP Diliman, only one of the five hot spots fits that conclusion. The others lie on street sections with either low or average centrality. Transport accessibility compensates for the poor centrality of segments in crime hot spots. Thus, though advantageous to major users of the campus, transport accessibility can unfortunately be exploited by some to serve their selfish interests. When criminals have high chances of escape and even options in their mode of escape, this encourages them to commit illegal acts. Changes in traffic patterns, however, are inappropriate and impractical. An alternative route that is separated from high-density or high-crime areas will affect land use objectives and hamper movements of even legitimate users. Thus, it is recommended to strengthen the visibility of security personnel by increasing the number of policemen and strategically locating SSB patrols in areas prone to outdoor crime.

In the Philippines, researchers are yet to fill in a void in research-based crime analysis. Understanding crime is essential to key decision-makers because it can enhance the way by which they allocate resources, whatever the scale of analysis. When all small communities work for their own safety and security, the bigger community is positively affected. Building sustainable communities is not just about managing natural resources, providing basic

education and health services, or constructing roads. It is also about creating safer places where economic investments can prosper, where people can make full use of infrastructure, and where people can be inspired to constantly improve the communities of which they are part.

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