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Criminal geographical profile

as a methodology of spatial analysis applied to psychology and criminology. A case study of Quito, Ecuador

Perfil geográfico criminal como metodología de análisis espacial aplicado a la psicología y criminología. Quito (Ecuador) como caso de estudio

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Resumen

Combatir la actividad criminal representa un desafió para el sistema de seguridad. El perfil geográfico permite ubicar, con un grado de pertenencia, la zona más probable donde se pueda encontrar un agresor. Sin embargo, actualmente se carece de una metodología definida o estandarizada. El sistema de información geográfica (SIG) es una poderosa herramienta para el análisis y la toma de decisiones, ya que más del 80% de la información puede ser espacializada. Por ello, el presente estudio definió una metodología que permite la construcción de un Perfil Geográfico Criminal (PGC) mediante el uso de un SIG. Se simuló espacialmente la construcción del PGC, tomando como caso de estudio el denominado 'Mata Viejitas'. Los resultados obtenidos indicaron una disminución del 79,83% en el área de influencia del delito, con un ahorro mensual de USD $ 43.406,10. Adicionalmente, una reducción promedio de casi el 90% del área de influencia criminal en otros casos simulados.

PALABRAS CLAVE: perfil geográfico criminal; SIG; metodología; psicología; criminología.

Abstract

Fighting criminal activity represents a challenge for the security system. The Geographic Profile allows locating with a degree of belonging the most probable area where an aggressor can be found. However, a defined or standardized methodology is currently lacking. The geographic information system (GIS) is a powerful tool for analysis and decision-making since more than 80% of the information can be spatialized. For this reason, the present study defined a methodology that allows the construction of a Criminal Geographical Profile (CGP) through the use of a GIS. The construction of the PGC was spatially simulated, as a case study called "Mata Viejitas". The results obtained indicated a decrease of 79.83% in the area of influence of the crime, with a monthly saving of USD $ 43,406.10. Additionally, an average reduction of almost 90% of the area of criminal influence in other simulated cases.

KEYWORDS: criminal geographic profile; GIS; methodology; psychology; criminology.

1. Introduction

In the United Nations Development Program (UNDP) it is referred in the objective 16, where peace, justice and solid institutions appear, it states that 'without peace, stability, human rights and effective governance based on the rule of law, it is not possible to achieve sustainable development', because the higher the levels of armed violence, insecurity and corruption, economic growth will be decimated (UNDP, 2019). The United Nations Office on Drugs and Crime (UNODC) reaffirms it with the objective of 'contributing with the States to face the threats that put governance, social stability at risk and threaten the basic conditions necessary to advance in the human development of our peoples' (UNODC, 2019).

Within the National Secretariat for Planning and Development (SENPLADES), Ecuador's government policy proposes below point 8.4 to "*Fight against impunity, strengthening inter-institutional coordination and the effectiveness of the processes for the detection, investigation, prosecution, sanction and execution of sentences*" (SENPLADES, 2017: 103). In addition to this, it is the objective of the Ministry of the Interior or now Government to 'Increase the effectiveness of citizen security services through decentralized quality services in anticipation, prevention and comprehensive response to violence and committing offenses, fighting organized crime and delinquency' (Ministerio del Interior, 2018).

Consequently, to the aforementioned, creating and implementing new investigative tools that facilitate the capture, detention and location of the aggressor(s) will help to enhance citizen security and intelligence services. One of these investigations is the so-called Geographic Profiling, which is a criminal investigation method that analyzes the location of a series of crimes related to the same perpetrator, where it seeks to determine the most probable area of residence of the offender or anchorage area (Snook *et al.*, 2005; Salafranca, 2016; Jiménez Serrano, 2012; Reyes Yunga & Estrella, 2019). Similarly Matthews (2013) and Pozuelo Fúnes (2008), propose that the Geographic Profile is the product of the interaction of three sciences, being psychology, criminology and geography, where the latter adds and reinvents the concept of criminal profiling to the criminal geographic profiling in order to locate the most likely area where the criminal's anchor point may be found, be it this place of work, residence or another, based on the geospatial location of the crime.

Geography in psychology and criminology, allows to understand the spatial behavior of the aggressor at the crime scene or in the surrounding environment, therefore, geography in psychology allows defining the parameters or ranges of displacement and models of search. On the other hand, the geographic one in criminology allows proposing the search strategy through the analysis of the spatial configuration of the environment with respect to the geolocation of the crime scene (Reyes Yunga & Estrella, 2019; Willson & Kelling, 1982).

One of the bases underlying the Geographic Profile is Environmental Criminology (EC), which is part of the sciences of criminology with the clear objective of providing possible solutions in analysis, intervention and crime prevention. Therefore, its objective is to study the different criminal events as a product of the relationship between potential targets and aggressors who are in specific points of space and time with a low or no level of security. Hereby, it is based on theories of criminal opportunity, which starts from the routine activities, it continues with rational choice and is described in a criminal pattern (Fernández *et al.*, 2014; Brantingham & Brantingham, 1981). Criminal Profiling (CP) is based on two methods, being inductive and deductive, where various authors such as Douglas *et al.* (1986), Rossmo (1995), Turvey (2008), Jiménez Serrano (2012; 2018) and

among others have used these methods as a basis for posing their CP processes as detailed below.

The Criminal Investigation Analysis (CIA) methodology of the Federal Bureau of Investigation (FBI), developed by Douglas *et al.* (1986), divides the CP into five phases. First, it begins with the collection of the necessary information such as time of the event, weather, social and environmental conditions at the time the crime happened, which can be taken from the crime scene report, victimology, crime scene, victimology and other official records. Second, it carries out an evaluation of the crime to make decisions, a phase that involves the reconstruction of the facts and analyzes the sequence of behavior conducted by the criminal and the victim. Third, CP phase that tries to give information about the unknown author of a crime. Fourth, the investigation phase that evaluates the criminal profile of the suspect and identifies him with a certain degree of belonging to the perpetrator of the events. In this phase, feedback is able to be applied to the previous processes. Lastly, fifth, the criminal's arrest phase.

Rossmo (1995) raises the CP from a spatial approach, where the study of the aggressor's spatial behavior with the environment determines the possible routes that the aggressor has followed to commit a crime and with this, identifies the peculiarities in the aggressor's mobility. Hereby, it raises a series of questions that need to be answered in order to build a CP such as: Why does that victim choose in that particular place? Why does he choose that area? How did he get there? The route followed has characteristics, such as is it easy, well-known, peculiar? What has been able to attract them from that place, what relationship can it have with it? In the case of serial crimes, what would be the geographic patterns that are repeated (places, routes, hours...)? How do you get out of that place and what characteristics does this escape route have? Is it an appropriate place for this type of behavior? Are there any signs that the victim has been taken to there from another place or that it was approached there? A completed questions based on the quality and availability of the information integrates the result and raises a geographical profile of the aggressor, thus surrounding the area of greatest probability where the aggressor can be found and can be located.

Turvey (2008) proposes a deductive CP model that extracts the aggressor's individual traits, characteristics and tendencies from the evidence found at the crime scene, where the conclusions are not based on predictions, but on critical and logical thinking. This model assesses the nature of evidence of behavior in a particular crime or series of crimes committed by the same perpetrator, reducing the number of possible suspects and with the possibility of linking related crimes.

The methodology includes the study of the analysis of the forensic report, which is an examination and interpretation of each and every one of the evidence found at the crime scene with the aim of reconstructing the facts. This is followed by an analysis of the victimology, where it evaluates the level of risk of the victim, through the reconstruction of the last 24 hours, in which it is intended to relate to a type of aggressor. In both cases, the collection of crime scene characteristics analyzes the type of location, the links, the approach methods, the attack method, the control method and the precautionary actions. This occurs in order to finally integrate it into a deductive analysis process to define the characteristics of the profile of the criminal and thus find the aggressor.

The integrative methodology proposed by Jiménez Serrano (2012) unites the inductive and deductive methods, with the aim of reinforcing the deductive conclusions, filling in the gaps that the deduction does not cover due to lack of evidence from the inductive methodology. This model begins with the collection and preliminary analysis

of the information of the case from the official documentation, forensic documents, evidences, indications, statements and among others. Then, he performs a chronological and geographical analysis of the case, emphasizing the reports of the forensic experts to reconstruct the facts, where nothing is assumed. Later, the Modus Operandi (MO) and the aggressor's signature are analyzed, where the behaviors performed by the aggressor at the crime scene are inferred. Subsequently, the victimology study is conducted, which seeks to relate the aggressor and raise some psychological characteristic. With the information ready, we proceed to the geographic analysis in time and space of the criminal's movements in order to identify a possible anchor point. Finally, it raises a criminal activity zone and describes some characteristics of the aggressor in a criminal profile.

Although there is no structured and consensual methodology for the elaboration of a CGP (Jiménez Serrano, 2018), still one raises a series of indications to build it. This begins with the collection and spatialization of the data from official reports, then performs an analysis in retrospect of similar cases that occurred in the area, in order to relate them to other cases that may be part of a series, followed by developing the cognitive maps of the offender and victim taking into account the space and time factor. For this, it considers the characteristics of a MO and the review of databases, in order to be able to propose a possible statistical analysis between the similarity of the criminal act with other similar ones. Then, it makes use of location algorithms with GIS tools to build a map that allows to identify the possible anchor point and the areas of action with a degree of probability, which will allow to propose an investigation strategy that prioritizes the suspects, reduces the areas of attention and vigilance to find the aggressor. In any of the processes it is always receptive to new information.

A Geographic Information System (GIS) is a powerful tool that helps to create strategies and build new analyzes on the behavior and dynamics of the spatial distribution of the crime pattern through the spatialization of data. Since more than 80% of public or private information can be spatialized, modeled, interpreted and analyzed on a map (Dueñas Ornay, 2012).

2. Methodology

In the first place, the psychological one was characterized spatially, which allows defining the ranges of criminal displacement according to the type of crime committed, which subsequently will allow the investigated to identify with a degree of probability the place occupied by the routine activities of the aggressor, as well as to delimit and reduce search fences as seen in FIGURE 1 (Reyes Yunga, 2019).

Additionally, the spatialization of psychology that allows building the spatial cycle of the aggressor's violence, depending on the volume of information collected, the cycle begins with the fantasy phase from the anchor point, then moves to the loitering phase in the routine activities until reaching the courtship phase where the cognitive map of the aggressor and the victim intersects. Later it will find themselves in the capture phase where the aggressor intersects or leaves the cognitive map in order to locate themselves in the murder or crime scene phase. Upon leaving the scene of the events, it passes to the totem phase where the aggressor returns to his routine activities so that he finally passes into the depressive phase at his anchor point, where the cycle of violence begins again (Reyes Yunga, 2019).

The spatial characterization of criminology starts from the conception of storing criteria, clues and evidence found at the crime scene and associating them with a coordinate in space and

time, as well as describing the characteristics to be formed in the environment of the crime scene (Reyes Yunga & Estrella, 2019). Consequently, in order to store this information, two geodatabases were created. The first one allows to store thematic information of the configuration of the territorial or administrative political unit associated with the crime scenes. In this case the canton of Quito, for which we used the guide of the SENPLADES (2015) as a method of classification and structure of the cartographic elements that are associated with the components of the territorial ordering (TO). The cartographic elements present in TABLE 1 are minimum elements to start with a spatial analysis of the environment of crime scene.

It should be clarified that the elements present in the table are not restricted, since depending on the volume of information it can be continuously increased and refined, otherwise the available information can be used in order to carry out a first iteration. However, if information is not available, it could be collected from different official entities or open data systems on the web such as OSM, Google Earth and Morales (2016)

FIGURE 1. Displacement ranges according to crime.
ADOPTED BY REYES-YUNGA, 2019 [SALAFRANCA, 2016; JIMÉNEZ SERRANO, 2012]

Phenology	Description	0 km	1 km	1.5 km	2 km	2.5 km	3 km	3.5 km	4 km
Violet crime	Occurs close to residence, average of 2 km (Salafranca, 2016)								
Rape 1	79% of minor 26 of age, up to 3 km (Anne Davies & Andrew Dale, 1995)								
Rape 2	68% of those over 26 years old, more than 3 km (Anne Davies & Andrew Dale, 1995)								
Rape 3	For the first time they move of about 1.875 km, and in average 2.44 km (Santtila *et al.*, 2007)								
Homicide	Movement of 0.85 km in average (Santtila *et al.*, 2007)								
Theft	Movement of 3.36 km in average (Canter & Youngs, 2008)								
Burglary	Movement less than 2.5 km (Canter & Youngs, 2008								

TABLE 1. Minimum cartographic elements that configure the territory for a CGP.
REYES YUNGA & ESTRELLA, 2019

Territorial Planning Component	Cartographic Element
Human settlements	Buildings
Biophysicist	Current land use 2016
Connectivity and mobility	Viability
Institutional Politician	Cantonal and neighborhood boundary
Sociocultural	Community Police Units (CPU) and theft of cars, auto parts, domicile, business premises, people and properties

among others. With this geodatabase one is able to build maps of threat and vulnerability of the crime, accessibility of the CPU´s to the population and travel costs of the CPU´s, among others. The main map that integrates the previous maps is the crime-deterrent (crimepetal) and crime-escape (crimefugal) map, where the crime-escape area is the place where the configuration of the territory does not facilitate criminal action, unlike a crime-deterrent area (Reyes Yunga & Estrella, 2019).

The second geodatabase is oriented to the CGP, which was created based on the proposal of Reyes Yunga & Estrella (2019) called 'Geospatial Crime Investigation', which allows to manage the information collected from the investigation under the approach of a data infrastructure space with the aim of organizing, structuring, capturing, debugging, specializing, analyzing and disseminating information on the crime. This database is not completely rigid, since it can be modified and fed according to the volume and quality of the information that is acquired or required. For the exemplification and simulation of the case study, the coverage of the Aggressor or CGP_AGR01 was used, since this allows to store and identify the location of the aggressor at the crime scene and of the victims, since any of the three aforementioned coverages tends to share the same point spatial geometry and its spatial location. Following this, a comparison was performed between the processes that run the different PC options (TABLE 2).

Based on the comparison of the criminal profiling processes (TABLE 2) and the criteria for spatialization of the psychology and criminology variables, a scheme was constructed (FIGURE 2), which collects the fundamental and general characteristics of any CP method. This allows to build a standard model of spatial analysis of crime, which can be replicated, scaled and adapted according to the quality and availability of the information.

As a retrospective case study for spatial simulation, the Barraza or 'Mata Viejitas' case, which occurred in Mexico, was adapted on the Metropolitan District of Quito (MDQ), belonging to the Quito canton. The cartographic information of the Barraza case that occurred in Mexico, which allowed the spatial location of the place where the victims were found. The case report indicated that the aggressor was posing as a nurse, gaining the trust of her victims, who were elderly women who lived mostly alone and from the middle to upper class. The place of murder was the victim's house, which are located in a residential area, however the anchor point of the aggressor was in an area of mixed land use. The aggressor worked as a saleswoman near the sand of Mexico, a place that when analyzing the case in retrospect through the CGP technique would have been able to find the anchor point of the aggressor (Suárez Meaney, 2015).

In order to start with the simulation, first the criminal pattern was transferred to the MDQ, taking three reference points. The first being the counterpart of the Mexican arena with the Atahualpa Olympic stadium, the others were placed in residential areas. In such a way it allowed to match the georeferencing criterion, a transfer, a rotation and a scald factor (Pérez Quesada & Amores Carredano, 1998). Later, with the CGP geodatabase, the attacker's coverage was built with a total of 33 points, allowing to simulate and transfer the serial activity. It should be noted that the territorial configuration of the MDQ versus Mexico City are different, so there may be crime scenes that fall within green areas.

Continuing with the analysis of the crime scene, an area of criminal influence was identified that encloses the criminal acts. For this a 10-minute service area was calculated, at a speed of 4 km/h for a person walking (Newfeel, 2007). Then a buffer area was built to the zone of influence with the

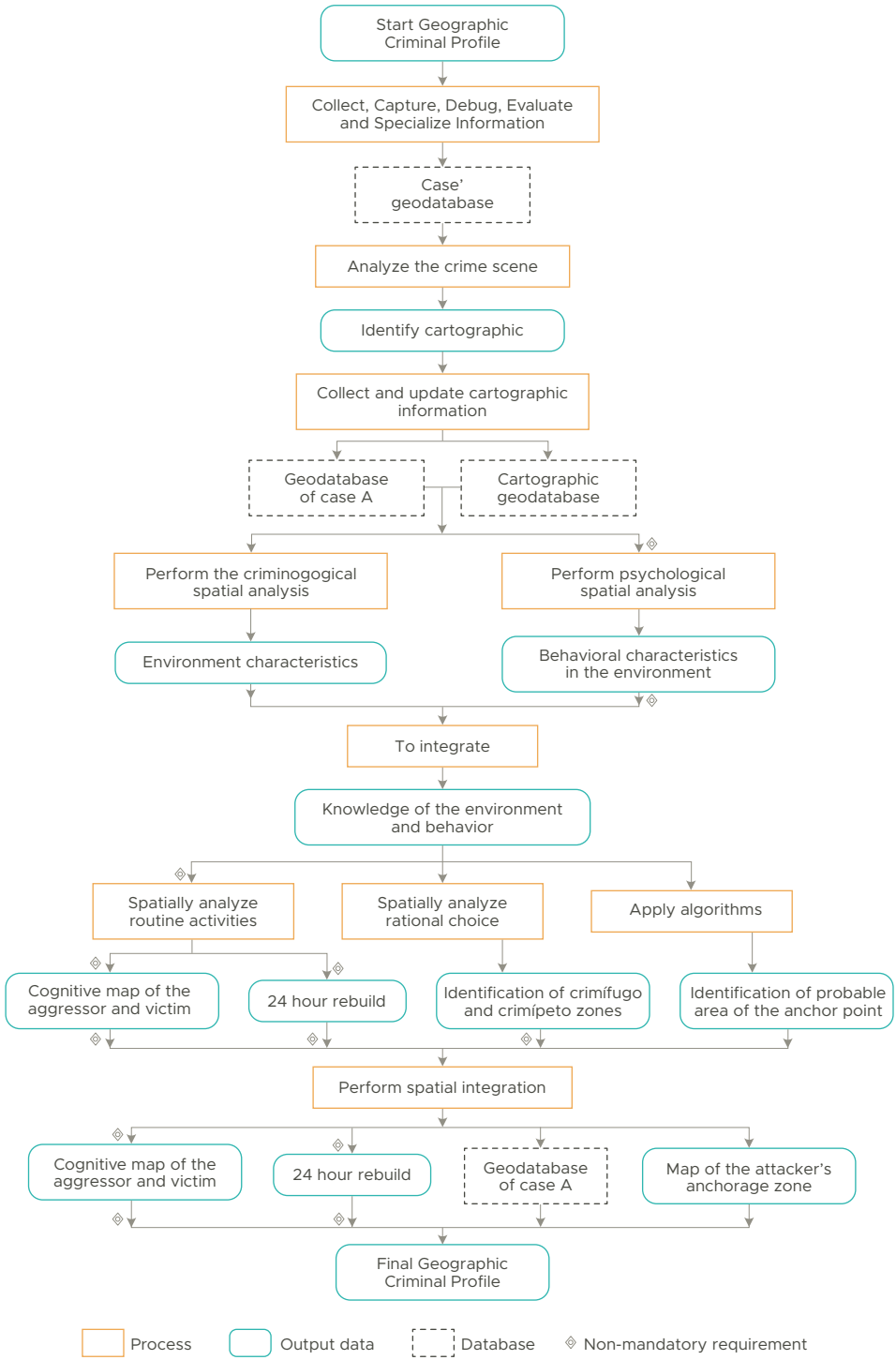
TABLE 2. Methodological comparison of criminal profiling processes.
REYES YUNGA & ESTRELLA, 2019

General processes of criminal profiling	CIA	BEA	Integrative of Jiménez	PG Rossmo	Clues CGP
Gathering information from the crime scene	1	1	1	1	1
Preliminary analysis of existing information	1	0	1	0	1
Retrospective analysis of other cases in the area	0	0	0	0	1
Forensic analysis and review of preliminary police reports	1	1	1	0	0
Evidence analysis	1	1	1	1	0
Interpretation of evidence	0	1	0	1	1
Statistic analysis	0	0	1	0	0
Characterization of the environment or setting	1	1	1	1	1
Victimology analysis	1	1	1	1	0
Reconstruction of the last 24 hours	0	1	1	1	1
Reconstruction of the facts	1	1	1	1	1
Direction of travel or chronology	0	1	1	1	1
Identify the approximation methods	0	1	0	1	1
Risk analysis of the victim and aggressor	1	1	0	1	1
Geographic analysis	1	0	1	1	1
Behavioral analysis of the planning or disorganized aggressor	1	0	0	0	1
Motivation analysis	1	1	1	1	1
Modus operandi analysis	1	1	1	1	1
Signature analysis	1	1	1	0	0
Analysis of precautionary acts	1	1	1	1	1
Aggressor Escalation Analysis	1	0	1	0	0
Analysis of victim knowledge	0	1	0	0	0
Scenario knowledge analysis	0	1	0	1	1
Criminal career analysis	1	1	1	1	1
Forensic knowledge analysis	0	1	1	0	0
Analysis of the criminal career	0	1	0	1	0
Behaviors before and after the crime	1	0	1	0	0
Profile integrativos and formulation	1	1	1	1	1
Feedback	1	1	1	1	1

criterion of spatial interception with the coverage of neighborhoods involved in a criminal act. This occurred to obtain a macro area in the spatial analysis and at the same time reduced from the MDQ, in order to optimize the processes.

Furthermore, the thematic cartographic information of the first geodatabase was used to analyze some characteristics of the environment, where various circumstances were encountered. These settings have been that the area of criminal

FIGURE 2. Standard Methodology of Criminal Geographical Profiling



acts is located more than 50% in a residential area and that the connection routes between all the criminal acts add up to a distance of approximately 51.7 km. These concepts have been formulated in previous works (San Juan, 2000) in which the 'crime-deterrent' is a space that has been understood as the urban setting that, due to its special physical and architectural characteristics, could favor the commission of certain crimes, while on the contrary, a space called 'crime-escape' would inhibit the commission of crimes.

Then, the map of crime-deterrent and crime-escape was constructed through Saaty's hierarchical analysis (Bosque Sendra, 2005). The maps used were Crime vulnerability (X_1), Criminal threat (X_2), CPU travel cost (X_3), CPU accessibility to population (X_4) and Vulnerability of crimes due to land use (X_5), (Reyes Yunga, 2019). The following equation is the one that describes the map of crime-deterrent and crime-escape in a map algebra, where the coverage of criminal threats has the greatest weight with a value of 0.3125 and the least weight is 0.0938 corresponding to accessibility from the CPU to the population.

$$0.1875X_1 + 0.3125X_2 + 0.25X_3 + 0.092998X_4 + 0.1563X_5 \quad \text{(eq. 1)}$$

Afterwards, the radius centers of the aggressor's location were identified based on the equations of the anchor point, which may be calculated by techniques of centroid, harmonic mean, geometric mean, median, center of the circle and center of the minimum distance (TABLE 3), being those that are associated with the Salafranca Circle Theory (Salafranca, 2016).

The input data for each method are the coordinates of the 33 points of the crime scenes, the results of these calculations are listed in TABLE 3. The standard deviation for X and Y respectively are 71.61 m and 223.01 m. In order to build the radius or security fence for the aggressor, the buffer areas of 850 m to the centers of the radios were built. This value is defined by the type of crime, in this case homicide. Then, all the buffer areas of the radii were dissolved in a single polygon, thus obtaining the radio safety polygon (FIGURE 3).

Then we continued with the application of algorithms, starting with the Rossmo algorithm, for which the gvSIG software and the 'Rossmo's formula' script were used, where the input layer was the places where the victims were found, the distance between points is 200 m. This corresponds to the mesh drawing, while the distance of the buffer radio zone is 500 m, which was taken from the analysis result for the resolution of the Mata Viejitas case, where the value of 800 m corresponds to a homicide. The values of k, g and f are 1 (Suárez Meaney *et al.*, 2017). The result of this process are demonstrated in FIGURE 4. The anchoring zone of the high probability aggressor is green, while the red to yellow color are those with a low probability of finding the criminal.

TABLE 3. Centers for locating the aggressor

Method	X	Y
Centroid	780410.761	9979761
Harmonic mean	780410.129	9979760.86
Geometric mean	780410.445	9979760.93
Median	780368.966	9979790.25
Circle center	780555.096	9979270.4
Center of minimum distance	780031.046	9979684.93

FIGURE 3. Safety radios for the case study area

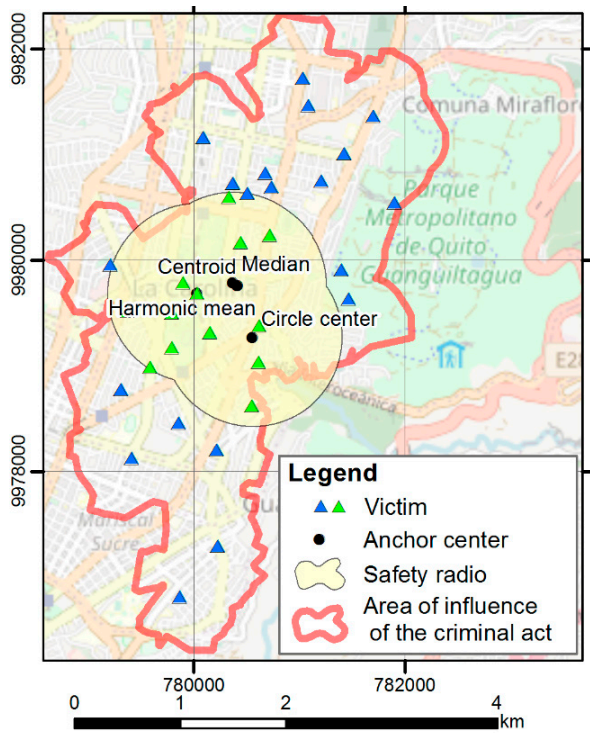
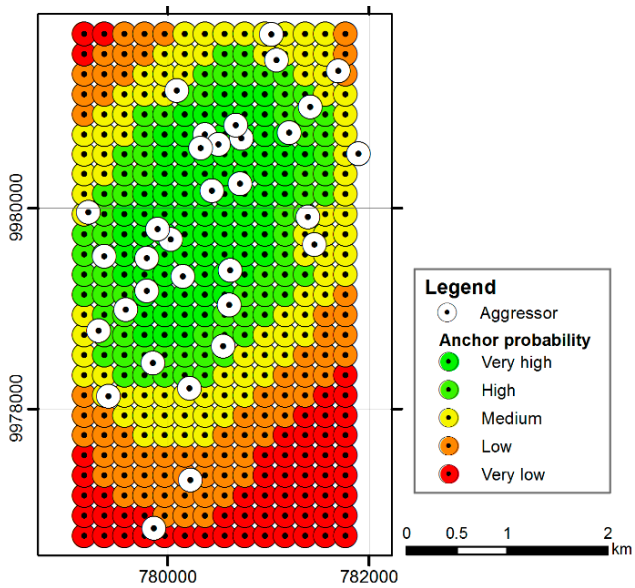


FIGURE 4. Anchorage area for the 'Mata Viejitas' case adapted to the Quito canton



The value yielded by the Rossmo algorithm is dimensionless, where the highest values indicate a high probability of finding the aggressor Suárez Meaney *et al.* (2017), therefore, the classification method used was the natural breaks, the one that groups into classes, where its variance is minimal within the class and high variation between classes (ESRI, 2019). However, regardless of the method, the last class is the one that best defines the anchor area since it has the highest values.

As a second spatial analysis algorithm, the travel cost analysis was applied, which is a function of the theory of distance decay and the cost/benefit ratio, for which the cost map was first built. This map has as inputs the road axes, the built areas and as a limit the buffer area of criminal acts. These, when joined to constitute a raster, where the digital value 10 represents buildings, 5 for intermediate values that are considered green areas and others that do not they are neither roads nor constructions. Finally, we used the value of 1 for the road axes (Reyes Yunga, 2019).

Consequently, the cost distance map was built, taking as origin each point of the crime scene towards the cost map, thus generating a total of 33 maps. Then a sum was applied between all of them in order to have a map that defines the attacker's anchorage area where the green color represents the highest probability of finding it as opposed to red (FIGURE 5). The classification method was the standard deviation in intervals of one deviation, which allows showing the difference between the mean value of the values with respect to the calculated one, therefore, the value of interest is the one that is closest to the mean (ESRI, 2019).

Regarding the spatial analysis of routine activities, only the area that encloses the points of high anchoring probability and that is covered by the safety radii of the study case was analyzed. This is called the anchoring zone and for this case study is the intersection of the results of the application of the Rossmo algorithm and the application of the Circle Theory (FIGURE 6). It should be clarified that by itself, this area already represents the area of greatest probability where the aggressor can be found.

FIGURE 5. Anchorage area by distance cost, case 'Mata Viejitas', Quito canton

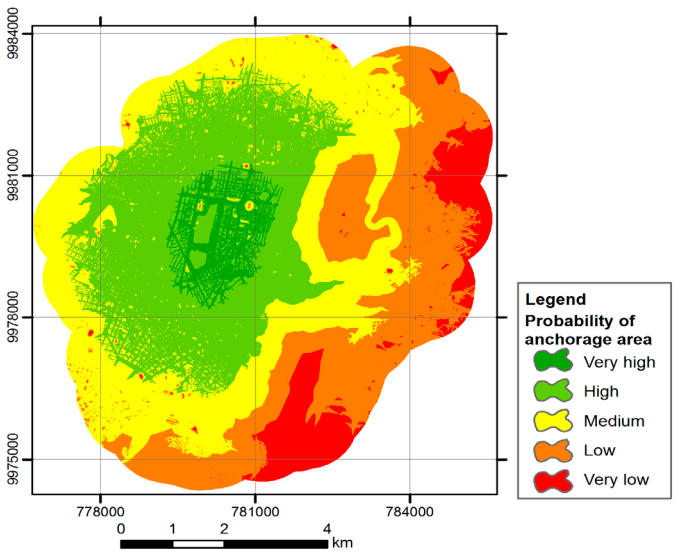
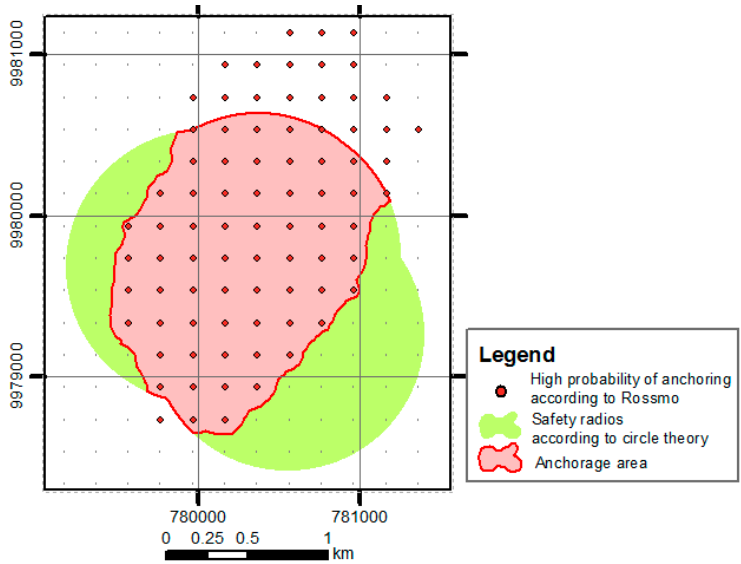


FIGURE 6. Anchorage area in the case of 'Mata Viejitas' adapted to the Quito canton



With the anchorage zone ready, the information was extracted from the crime-deterrent and crime-escape Space map and from the Distance Cost map, where both were normalized in order to build the anchorage map in the assailant's routine activities using map algebra. Hereby, a weight of 0.2 was assigned to the first map and to the second of 0.8, as a result of this sum the map was obtained (FIGURE 7) where the green color shows the most probable place where the aggressor is circulating in his activities routine.

3. Discussion

FIGURE 8 demonstrates the CGP of 'Mata Viejitas' that compares in extent the area of influence of the criminal acts with respect to the anchorage area, a place where the aggressor can be located in a smaller area and consequently more easily. Additionally this map documents the probability of finding the aggressor based on routine activities, where the green color indicates the highest probability of finding him or her. The surroundings of the Atahualpa Olympic Stadium are demarcated in light green, a place that is the anchor point of the aggressor in its routine activities, therefore, the functionality of the CGP methodology is verified. Additionally, the design of the methodology has a characteristic of being resilient since it is able to be adapted and scaled based on the case study, available information and the scene of the events.

The area of criminal influence is reduced by 79.83% (TABLE 4), and the number of CPUs linked to the case are referred to only two instead of eleven. Finally, the patrol area is reduced by 80.34%, which means that the patrol has a distance of 43.79 km corresponding to the road network that is part of the anchorage area. Thus, it was possible to demonstrate the potential of this methodology, as well as the ease of replication.

Theoretically, the monthly economic values that could be awarded to the investigation of the case in a month are several considering to involve the eleven CPUs, with a staff of 4 police officers in

FIGURE 7. Probability map of routine activities in the 'Mata Viejitas' case

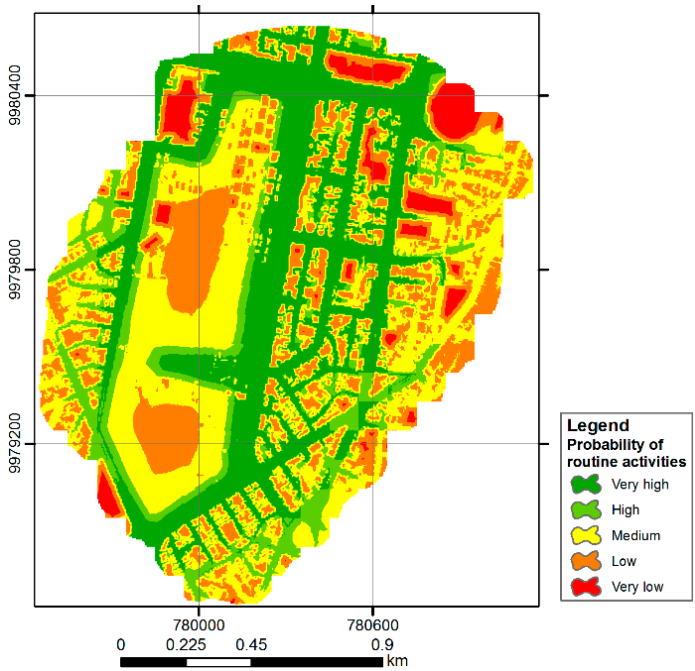


FIGURE 8. Map of probability of finding the aggressor within the anchorage area

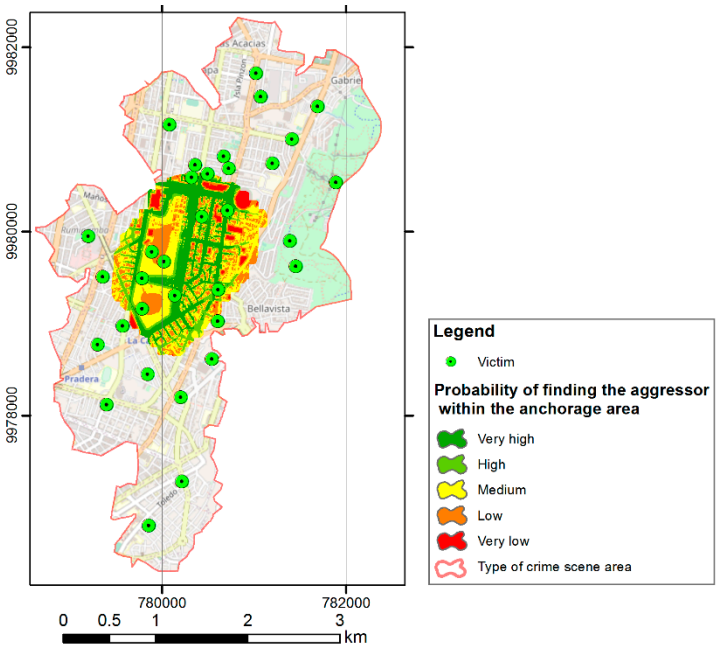


TABLE 4. Resources invested in the search for the aggressor by type of area

Area type	Investigation area		Human resource		Mobility on the tracks		Victims	
	[ha]	%	#CPU	%	Distance km	%	#	%
Area of influence of criminal acts	1149.17	100	11	100	222.76	100	33	100
Anchorage area or safe zone of the aggressor	231.81	20.17	2	18.18	43.79	19.66	9	27.27

each of them, receiving an average monthly salary of USD $ 1.200 [Ley Orgánica de Transparencia y Acceso a la Información Pública (LOTAIP, 2019)], having additionally that each CPU has a car to move around and that requires an average of 48.18 km/gallon (Autodaewoospark, 2019) at a gallon cost of gasoline of USD$ 1.85 (Orozco, 2019). Consequently, the cost involved in analyzing the entire area of influence of the criminal acts would have a value of USD$ 53,056.50 as opposed to only using the resources that are within the anchorage area with a value of USD$ 9,650.40, which would mean savings of 81.81% of the investment, This demonstrated the advantages of the methodology which allows optimizing resources and simultaneously providing a strategic tool against organized crime.

On the other hand, in order to analyze the theoretical applicability of the methodology, a hypothetical simulation of serial crimes was performed on four people. All the subjects live or work in the Quito canton and have some perspective of the possible vulnerable places in the city. The age range of those involved reaches from 21 to 51 years, while the respondents are men and women with different professions such as administrative personnel, military personnel and students.

The result of the CGP's of the hypothetical cases is listed in TABLE 5, where on average there was a reduction of the search area by 88.89%, that is, the work involved should focus on 11.12% on average. However, it should be noted that each case by itself is independent of the spatial behavior of each aggressor. That is why the maximum percentage in the search area is 18.8%, which corresponds to the hypothetical case called 'Artista' and the minimum is 3.62%, which responds to the hypothetical case called 'Viuda Negra' (Reyes Yunga & Estrella, 2019).

TABLE 5. Performance of the search for the aggressors

#	Hypothetical case	Influence area [ha]	Anchor area [ha]	Reduction in search area in %
1	Viuda negra	740.96	26.86	96.38
2	Mercenario	7841.48	673.33	91.41
3	Niñera	7707.64	1036.78	86.55
4	Artista	706.86	132.90	81.20

4. Conclusions

The use of the criteria for the spatialization of the psychology and criminology variables allowed it to provide a solid technical basis when preparing a CGP. The methodology presented theoretically turns out to be a powerful tool in serial crime analysis, reducing the area of influence of the criminal act by an average of almost 90%.

In the same way, it demonstrates the potential that GIS has when studying criminal activity as one more element of the space that is able to be modeled and captured on a map, allowing it to provide a new functionality in citizen security and intelligence services.

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