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Spatial Patterns of Crime and Its Relationship with The Physical Environment: Chicago Case

Suçun Mekânsal Örüntüleri ve Fiziksel Çevreyle İlişkisi: Şikago Örneği

Elif Kırpık[1]

ABSTRACT

Although the environmental criminology, which relates crime to environmental factors and argues that the environment is not a passive determinant of the onset, continuation or termination of crime, has been on the agenda of urban studies, the relationships between elements of the physical environment and crime have not yet been sufficiently studied through exploratory spatial statistics. In the light of crime theories such as Broken Windows Theory, Crime Pattern Theory and Crime Prevention Through Environmental Design approach, this study aims to define and understand crime patterns by producing crime maps, visualizing spatial distributions, and testing the relationship between recurrent crimes in space and physical environmental elements.

With the field study carried out in Chicago, the spatial patterns and relationships between crime types and physical environment elements were analyzed using exploratory spatial statistical methods. All secondary data used in this research are open data and all analyses were carried out using Geographical Information Systems. Exploratory spatial data analyses using GIS are Average Nearest Neighbor, Optimized Hotspot Analysis, Spatial Autocorrelation (Global Moran's I) and Geographically Weighted Regression.

The analyses conducted in this study provided supporting evidence for theories of crime. The findings revealed that crimes tend to occur in close proximity to one another and cluster in specific neighborhoods and regions. This spatial concentration of crime supports the notion that criminals choose their locations intentionally or randomly. Furthermore, the study established a direct relationship between physical environmental elements and crime. Various physical factors such as inadequate street lighting, vacant and abandoned buildings, and sanitation code complaints were found to significantly contribute to the occurrence of crimes. These findings confirm the hypothesis that the deterioration of the physical environment can influence and contribute to increased criminal activity. Overall, the results of this study align with established theories of crime and provide empirical evidence for the significance of the physical environment in shaping criminal behavior.

Keywords: Crime theories, Crime studies, Environmental criminology, Exploratory spatial data analysis, Geographic information systems

Öz

Suçu çevresel faktörlerle ilişkilendiren ve çevrenin suçun başlangıcı, devamı veya sona ermesinde aktif bir etken olduğunu savunan çevresel kriminoloji, kent çalışmalarının gündeminde olmasına rağmen, fiziksel çevre unsurları ile suç arasındaki ilişkiler henüz keşfedici mekânsal istatistiki yöntemler aracılığıyla yeterince çalışılmamıştır. Bu çalışma, Kırık Camlar Teorisi, Suç Örüntüleri Teorisi ve Çevresel Tasarım Yoluyla Suç Önleme yaklaşımı gibi suç teorileri ve yaklaşımları ışığında, suçun mekânsal dağılımlarını görselleştirip suç haritaları üretmeyi ve mekânda tekrar eden suçlar ile fiziksel çevre unsurları arasındaki ilişkiyi test ederek suç örüntülerini tanımlamayı ve anlamayı amaçlamaktadır.Şikago'da gerçekleştirilen vaka çalışması ile suç türleri ve fiziksel çevre unsurları arasındaki mekânsal örüntüler ve ilişkiler, keşfedici mekânsal istatistiki yöntemler kullanılarak analiz edilmiştir. Bu araştırmada kullanılan tüm ikincil veriler açık veridir ve tüm

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analizler Coğrafi Bilgi Sistemleri kullanılarak gerçekleştirilmiştir. Çalışma kapsamında Ortalama En Yakın Komşu Analizi, Optimize Edilmiş Sıcak Nokta Analizi, Mekânsal Otokorelasyon (Global Moran's I) ve Coğrafi Ağırlıklı Regresyon analizleri kullanılmıştır.

Bu çalışmada kullanılan analizler bahsi geçen suç teorilerini ve yaklaşımlarını destekleyici kanıtlar sağlamıştır. Bulgular, suçların birbirine yakın yerlerde meydana gelme eğiliminde olduğunu ve belirli mahalle ve bölgelerde kümelendiğini ortaya koymuştur. Suçun bu mekânsal yoğunlaşması, suçluların yerlerini dağınık seçmek yerine kasıtlı veya rastgele seçtikleri fikrini desteklemektedir. Ayrıca, çalışma fiziksel çevre unsurları ile suç arasında doğrudan bir ilişki kurmuştur. Yetersiz sokak aydınlatması, boş ve terk edilmiş binalar ile temizlik şikayetleri gibi çeşitli fiziksel faktörlerin suçların oluşumuna ve devamlılığına önemli ölçüde katkıda bulunduğu kanıtlanmıştır. Bu bulgular, fiziksel çevrenin bozulmasının suç faaliyetlerinin artmasını etkileyebileceği ve buna katkıda bulunabileceği hipotezini doğrulamaktadır. Genel olarak, bu çalışmanın sonuçları mevcut suç teorileri ve yaklaşımları ile uyumludur ve suç davranışını şekillendirmede fiziksel çevrenin önemine dair ampirik kanıtlar sunmaktadır.

Anahtar Kelimeler: Coğrafi Bilgi Sistemleri, Çevresel kriminoloji, Suç çalışmaları, Suç teorileri, Keşifsel mekansal veri analizi

INTRODUCTION:

The relationship between crime and the environment has been the subject of considerable academic interest in the social sciences. The prevalence of high crime rates, particularly in urban areas characterized by physical decay, poses a significant challenge to both residents and policy makers. The interplay between crime and the built environment has attracted considerable attention because of its potential implications for understanding the underlying causes of criminal behavior and formulating effective crime prevention strategies. Understanding the complex dynamics between these factors has significant implications for crime prevention and urban planning efforts.

In this study, we aim to explore this relationship by using spatial statistical methods to analyze the spatial patterns and associations between the physical environment elements and crime, and to contribute to the growing body of knowledge on crime prevention strategies and urban planning. In addition, an essential dimension of this study is the availability of openly accessible data with spatial attributes.

Chicago was chosen as the case area due to the comprehensive and openly available crime data it offers. In a difference to the US, countries like Turkey lack detailed crime data that are openly shared with the public, typically limited to neighborhood-level information rather than a comprehensive dataset. Therefore, selecting a city where crime studies are frequently conducted was deemed suitable for this study. This aspect is of great importance as it enables the expansion of research in this area. The usage of openly available data ensures transparency, reproducibility and enables further exploration and validation of our findings by other researchers in the field.

In summary, this study aims to shed light on the intricate interplay between physical environment elements and crime, ultimately contributing to a deeper understanding of the underlying mechanisms and providing practical insights for addressing the complex challenges associated with crime in urban areas.

1. Literature Review

Criminal behavior is associated with biological and sociological reasons when discussed with traditional approaches. The environmental perspective which associates crime not just with individual but also environmental factor focuses on place, time, criminals and actions, in short the existing dynamics of crime and crime prevention instead of dwelling on the causes of crime, rehabilitating criminal or reintegrating criminals into society (Wortley & Mazerolle, 2008). One of the first sociological studies made with an environmental perspective is Social Organization Theory (Shaw, 1931; Shaw & McKay, 1942). The theory, which emerged from studies made by sociologists at the University of Chicago in the 1920s and 1930s, shows that crime depends on socioeconomic disadvantages and characteristics of the neighborhood such as inappropriate dwelling, poor sanitary conditions instead of an individual's

natural features. The prominent crime theories that theorized later and accepted as modern are; Jane Jacob's design who developed principles on the prevention of crime through urban design (1961), similarly the Crime Prevention Through Environmental Design (Jeffery, 1977), the Defensible Space Theory which examines the causes of crime in connection with environmental design (Newman, 1972), the Routine Activity Theory which explains with activities of daily living (Felson & Spaeth, 1978) and the Broken Windows Theory which associates with social disorganization (Wilson & Kelling, 1982). Considering these theories, it is obvious that the environment is seen as an important factor in the initiation, continuation or termination of the crime rather than just a passive characteristic in which an crime is committed, and crime analysis are consulted to examine crime's patterns and tendencies in the environment (Emig et al., 1980). In summary, the literature review highlights that the environmental perspective has shifted the focus from individual-level factors to the influence of the environment on crime.

At this juncture, the question of which factors influence crime assumes significant importance. Ayhan and Çubukçu (2007) have posited that crime is influenced by a range of social, political, cultural, economic, demographic, and spatial factors. These factors may manifest as the use of buildings, the demographic composition of neighborhoods, or cultural norms and values. Among the diverse array of factors shaping crime, particular intrigue surrounds the role played by physical environmental elements.

In the 1970s, especially the Crime Prevention Through Environmental Design (CPTED) approach, mentioned by C. Ray Jeffery in his book of the same name, is one of the literatures that focus intensively on the relationship between physical environmental elements and crime (Jeffery, 1977). This approach emphasizes the role of effective environmental design and improved physical surroundings in reducing both the fear and occurrence of crime, offering a range of methodologies for achieving this goal (Crowe, 2013). Within this framework, the relationship between physical deterioration and crime is frequently highlighted, asserting that the physical environment influences the occurrence of criminal activities (Taylor & Harrell, 1996). The CPTED approach claims that a large number of physical environment elements can have an impact on crime. These factors include, but are not limited to, vacant dwellings, street lighting, natural surveillance, accessibility of facility areas, adequacy and distribution of urban functional zones, littering, graffiti, abandoned vehicles and unmaintained streets.

Numerous studies have provided empirical evidence from different perspectives to support the relationship between physical environment elements and crime. For instance, Sun et al. (2022) found that factors such as the density of commercial establishments, hotels, entertainment venues, and housing prices exerted the greatest influence on property crimes such as burglary, robbery, theft, and motor vehicle theft. In a study on the impact of lighting on crime, Fotios et al. (2021) revealed that increased darkness was associated with higher rates of robbery, arson, and curfew violations, while it coincided with lower rates of public disorder, non-violent family crimes, and prostitution. Kooi (2013) claimed that bus stops clustered close to each other can facilitate an increase in crime incidents, Lavi et al. (2022) discovered a high correlation between graffiti and crimes against pedestrians, and Kondo et al. (2015) proved that improvements to abandoned buildings reduce general crimes, assaults, gun attacks and nuisance offenses around the buildings and in the whole city.

Furthermore, it is worth noting that all of the aforementioned studies are deeply rooted in the spatial dimension. The utilization of spatial representations and statistical analyses in the field of crime studies represents a rapidly expanding body of literature. These spatial approaches provide valuable insights into the spatial patterns, relationships, and dynamics of criminal behavior, contributing to a more comprehensive understanding of crime phenomena. The first spatial study about crime was carried

out in the 1830s by Quetelet (1831) and Guerry (1833) who researched the relation between social factors and rates of detention. In the 1930s, researchers of the Chicago School mapped children's criminality. In 1942, it was found out by the study made by Shaw and McKay (1942) that crime intensified in certain parts of cities and this intensity tended to remain stable in time.

Since 1980, with the development of new theories of crime models and advent of geographic information systems, it is seen that studies on understanding and analyzing the geospatial dimension of crime are increasing. Especially in the 1990s, with the development of desktop mapping programs and the increase of personal usage of Geographic Information Systems, spatial studies were enriched. The first hotspot maps, based upon the Routine Activity Theory, prepared by Sherman, Gartin and Buerger (1989) with a large data set and helping us to ask questions about criminogenic structure of places, opened a new era in the applied mapping of crime.

According to the Routine Activity Theory, criminals generally bunch crime up and as a consequence mutual committal becomes a topic for the theory. Criminals commit crimes in nearby places to one another and at proximate times with "convergence" (Felson, 2008). Hotspot maps, which enable determination of places where criminal provisions intensify and decrease, also aid in finding out spatial patterns of crime. Crime Pattern Theory also claims that crime is not randomly or monotonously dispersed in time and place, it does not occur randomly or coequally in neighborhood, social groups or during an individual's daily activities or through a person's life and indicates that understanding of this clustering is especially important for crime prevention activities (Brantingham & Brantingham, 2008). Crime Pattern Theory also looks at crime as a complicated phenomenon and says that there are hotspots and cold spots for crimes, repetitious criminals and repetitive victims are strictly linked together.

It should be pointed out that the increasing use of Geographic Information Systems, guided by theories of crime, has led to a growing body of literature that focuses on the impact of physical environmental elements on crime. However, one significant challenge in conducting these studies is the availability of appropriate data. As a result, there is a need for more detailed and fine-grained studies to better understand the influence of physical environmental factors on crime in such contexts (Cinar & Cubukcu, 2012).

The main purpose of this study is to obtain information about crime patterns and to investigate the relationship between crime incidents and physical environmental factors. To achieve this, the research employed the visualization techniques and exploratory spatial analysis methods of Geographic Information Systems (GIS). A field study was conducted in the city of Chicago as a representative case. Due to its extensive and openly available detailed dataset, Chicago has been the subject of numerous crime studies in recent years. There is an impressive literature on the factors that influence crime, and similar exploratory spatial statistical methods have been used in this research (De Nadai et al., 2020; Hou et al., 2023; Schertz et al., 2021; Singleton et al., 2023). Since 2020, one of the most significant contributions to this literature has been studies examining the relationship between Covid-19 and crime (Campedelli et al., 2020; Yang et al., 2021). Another emerging literature focuses on data analysis (Dayara et al., 2022) and crime prediction and forecasting using artificial intelligence (Safat et al., 2021).

By generating crime maps through GIS, the study seeks to visualize and analyze the spatial distribution of crime incidents in Chicago. This spatial representation will provide a comprehensive understanding of the patterns and trends of crime across different areas of the city. The analysis will further explore the relationship between crime and various physical environmental factors such as abandoned vehicles, vacant and abandoned buildings, graffiti removal, alley lights out, street lights one out, street lights all out, garbage carts, sanitation code complaints, tree trims, tree debris and potholes.

This study endeavors to contribute to the existing literature on the effects of environmental factors on crime by incorporating a comprehensive range of variables, encompassing various street crimes, and considering physical environmental elements that potentially contribute to the deterioration of urban areas. Through the utilization of an extensive dataset, this research aims to shed light on the complex relationship between crime and its surrounding environment. Furthermore, by advocating for the use of open data in crime studies, this study seeks to set an example for promoting transparency and accessibility in the field.

2. Scope and Methodology

In this study, exemplary fieldwork was conducted in the city of Chicago to examine how crime tends to occur in place with other crimes, its shift over time, its dependence on place, and its relationship to crime-related physical environmental elements.

The research questions of the study are:

- What are the spatial analysis methods of crime?
- How does crime show tendency (random, dispersed, and clustering) in the place?
- Does crime have spatial continuity or is it independent of place? Does spatial concentration differ according to the type of crime?
- Can physical environmental factors explain crime? Which elements are correlated with which types of crimes?

This research was conducted based on fieldwork utilizing secondary data. The study area chosen was Chicago, which is the third largest city in the USA in terms of population. Chicago comprises a central business district known as The Loop, as well as the surrounding North, South, and West sides. The city exhibits a diverse ethnic identity, with ethnic groups not being evenly distributed throughout. Commercial centers are dispersed across the city, extending beyond The Loop, while residential areas cater to various socio-economic groups both in the city center and suburbs. Additionally, the city experiences high crime rates in several areas.

Chicago was selected as the case area due to its comprehensive crime data available since 2011, which is accessible as open data. Opting for an urban scale analysis was motivated by the need to eliminate exceptional cases where distinctive local features cannot be identified. Furthermore, employing a large volume of data enhances the statistical method's reliability. Census Tracts, one of the different geographical units of The U.S. Census, were used as the units of analysis in the study. All independent and dependent variables are analyzed in the track in which they are located. 881 different population tracks in Chicago were subject to analyses.

The data utilized in this study was obtained from the City of Chicago's open data portal (City of Chicago, 2023a). It encompasses all street crimes that occurred between 2011 and 2017. By incorporating this broad time frame, any sudden fluctuations or anomalies in crime rates were accounted for to ensure the accuracy of the results. To examine the relationship between crimes and various physical environment factors, the study relied on the locations mentioned in the reports made to 311 City Services (City of Chicago, 2023b). The independent variables included complaints and issues reported between 2011 and 2017, such as abandoned vehicles, vacant and abandoned buildings, graffiti removal, alley lights out, street lights one out, street lights all out, garbage carts, sanitation code complaints, tree trims, tree debris and potholes.

The rationale behind selecting these variables stems from the Broken Windows Theory, which posits that the deterioration of physical spaces can contribute to a decline in social order and an increase in criminal behavior. According to this theory, when areas exhibit signs of neglect or disrepair, the

motivation to uphold societal norms and maintain order diminishes, potentially leading to an uptick in criminal activities. By examining these variables, the study aims to explore the extent to which these physical environmental factors correlate with different types of crimes.

To identify, observe and visualize spatial distribution, define atypical places or spatial deviations, confirm clustering or hot spot pattern, the following "Exploratory Spatial Data Analysis" was consulted:

- Average Nearest Neighbor
- Optimized Hotspot Analysis
- Spatial Autocorrelation (Global Moran's I)
- Geographically Weighted Regression

Among these analyses, the Average Nearest Neighbor analysis was utilized to measure the average distance between each crime, while the Optimized Hotspot Analysis was employed to visualize areas where crimes spatially concentrate, exhibit a normal distribution, or become sparser. Spatial Autocorrelation was applied to determine the compatibility of all dependent and independent variables for the establishment of the model. Geographically Weighted Regression, on the other hand, was preferred to define the level of relationship between the dependent and independent variables. These analyses were selected to gain insights into various aspects of the spatial data, examine patterns and relationships within the dataset, and contribute to the overall validity and comprehensiveness of the research findings.

Lastly, all these spatial statistical methods were applied using the ArcGIS Desktop program (ESRI, 2023).

3. Chicago Case

3.1. Exploring Crime and Physical Environmental Factors in Chicago

In the city of Chicago, 31 crime types and 471333 cases committed on the street between 2011-2017 were reached. Figure 1 illustrates the counts of crimes. The top three crimes committed most were theft, criminal damage and motor vehicle theft.

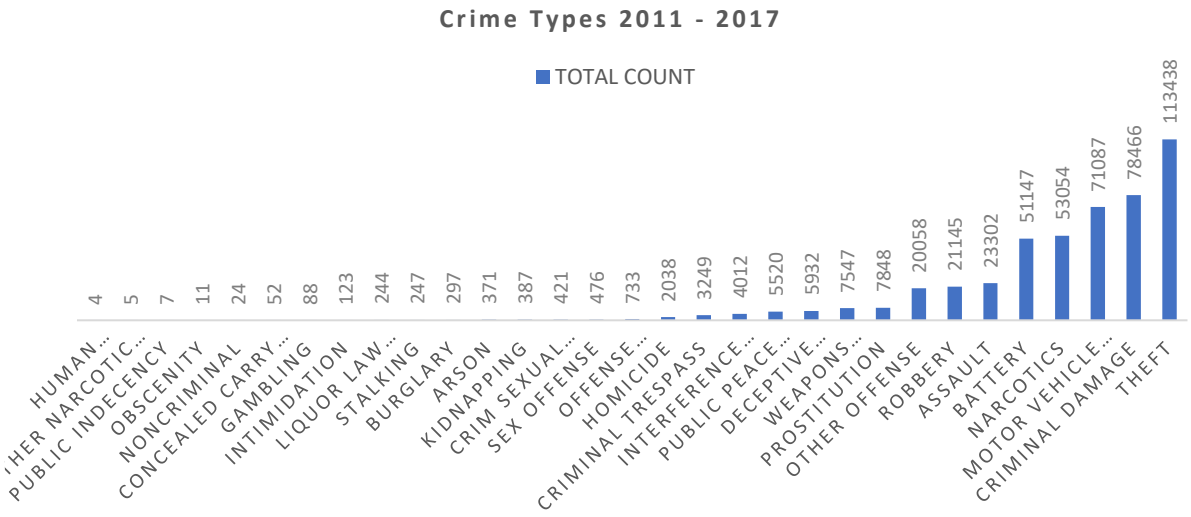


Figure 1. Total Counts of Street Crimes in Chicago Between 2011 – 2017

The study analyzed data from 311 City Services reports and complaints like crime data from 2011-2017. Firstly, all reports and complaints reported to 311 City Services were evaluated. Eleven elements of the physical environment that were located on the street and whose locations could be accessed were

selected as independent variables of the research, utilizing open data. As mentioned earlier, these were abandoned vehicles, vacant and abandoned buildings, graffiti removal, alley lights out, street lights one out, street lights all out, garbage carts, sanitation code complaints, tree trims, tree debris and potholes reported. The total number of reports and complaints between 2011-2017 can be seen in Figure 2.

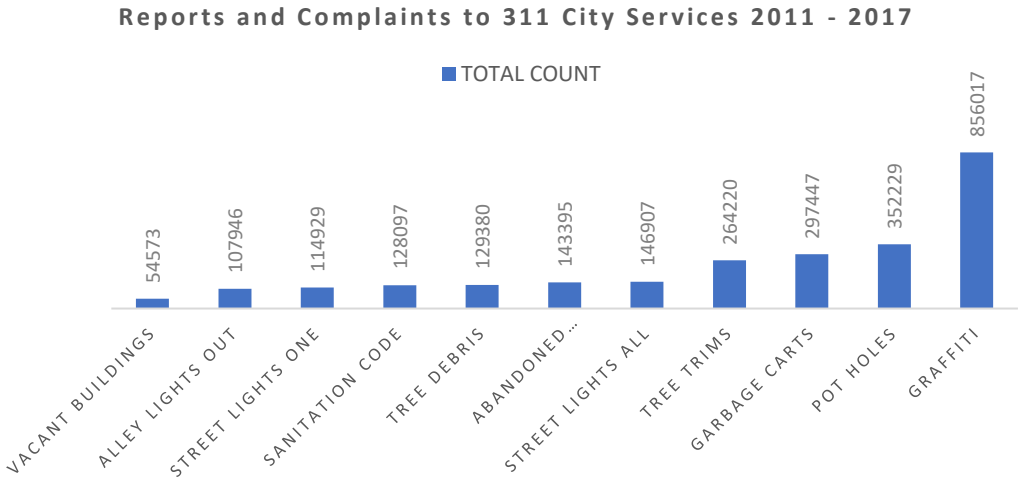


Figure 2. Total Counts of Reports and Complaints to 311 City Services in Chicago Between 2011-2015

3.1.1.Average Nearest Neighbor Analysis

Average Nearest Neighbor Analysis was carried out to test whether the crime which decreased depending upon the time, showed any clustering tendency in the place. This analysis explains whether the data tends to be dispersed, random or shows a tendency to clustering by measuring each point's distance to the nearest point. Since the distance of the crime incidents to each other was needed in this research, the Euclidean method, which linearly measures the shortest distance between two points, was chosen as the distance method. In light of the Average Nearest Neighbor Analysis, it is noteworthy that the observed average distance between crime incidents was found to be approximately 2.7 meters, deviating significantly from the expected average distance of approximately 24.7 meters (Figure 3). This indicates a highly clustered pattern of crime occurrences. Moreover, the z-score (-1167.47) obtained from the analysis suggests that the probability of this clustered pattern being the result of a coincidental chance is less than 1%.

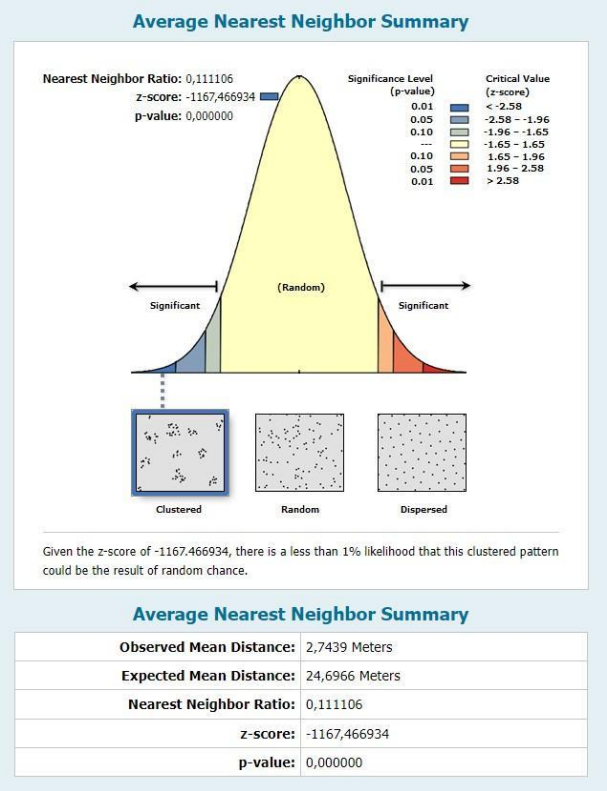


Figure 3. Average Nearest Neighbor Analysis Result Summary for All Crimes

These findings provide convincing evidence of a spatially significant relationship between crime incidents, but for the reliability of the study the same analysis was repeated for all crime types. The same area size was used for all analyses.

Table 1. Average Nearest Neighbor Analysis Results for Crimes

CRIME TYPES	Observed Mean Distance	Expected Mean Distance	Nearest Neighbor Ratio	z-score:	p-value:	Pattern Type
ALL CRIMES	2,74 m.	24,70 m.	0,111	-1167,47	0	Clustered
ARSON	505,25 m.	880,27 m.	0,574	-15,70	0	Clustered
ASSAULT	45,80 m.	111,07 m.	0,412	-171,61	0	Clustered
BATTERY	23,11 m.	74,97 m.	0,308	-299,29	0	Clustered
BURGLARY	630,50 m.	983,84 m.	0,641	-11,84	0	Clustered
CONCEALED CARRY LICENSE VIOLATION	1265,39 m.	2351,25 m.	0,538	-6,37	0	Clustered
CRIM SEXUAL ASSAULT	517,13 m.	826,34 m.	0,625	-14,69	0	Clustered
CRIMINAL DAMAGE	17,33 m.	60,53 m.	0,286	-382,44	0	Clustered
CRIMINAL TRESPASS	162,97 m.	297,46 m.	0,548	-49,30	0	Clustered
DECEPTIVE PRACTICE	104,51 m.	220,14 m.	0,475	-77,40	0	Clustered
GAMBLING	826,28 m.	1807,42 m.	0,457	-9,74	0	Clustered
HOMICIDE	160,83 m.	375,58 m.	0,428	-49,39	0	Clustered
HUMAN TRAFFICKING	6942,87 m.	8477,56 m.	0,819	-0,69	0,489	Random
INTERFERENCE WITH PUBLIC OFFICER	121,66 m.	267,68 m.	0,454	-66,10	0	Clustered
INTIMIDATION	734,65 m.	1528,79 m.	0,481	-11,02	0	Clustered
KIDNAPPING	542,96 m.	861,88 m.	0,630	-13,93	0	Clustered
LIQUOR LAW VIOLATION	599,33 m.	1085,44 m.	0,552	-13,38	0	Clustered
MOTOR VEHICLE THEFT	18,94 m.	63,59 m.	0,298	-358,17	0	Clustered
NARCOTICS	21,90 m.	73,61 m.	0,298	-309,52	0	Clustered
NONCRIMINAL	2336,81 m.	3460,95 m.	0,675	-3,04	0,002	Clustered

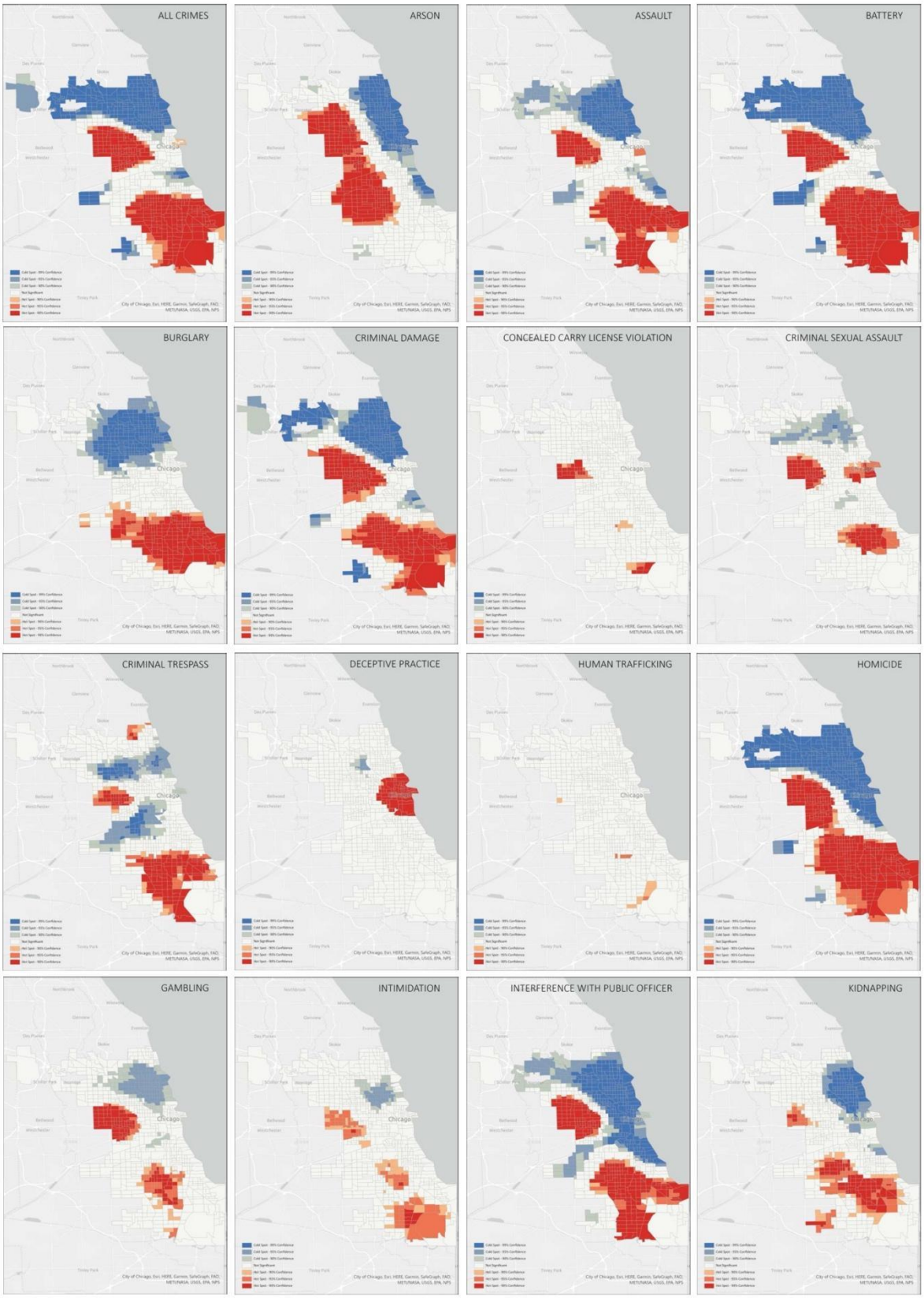
OBSCENITY	3800,74 m.	5112,16 m.	0,743	-1,63	0,104	Random
OFFENSE INVOLVING CHILDREN	351,49 m.	626,25 m.	0,561	-22,72	0	Clustered
OTHER NARCOTIC VIOLATION	6933,67 m.	7582,56 m.	0,914	-0,37	0,714	Random
OTHER OFFENSE	48,98 m.	119,71 m.	0,409	-160,09	0	Clustered
PROSTITUTION	20,74 m.	191,39 m.	0,108	-151,11	0	Clustered
PUBLIC INDECENCY	4714,95 m.	6408,43 m.	0,736	-1,34	0,181	Random
PUBLIC PEACE VIOLATION	100,49 m.	228,21 m.	0,440	-79,54	0	Clustered
ROBBERY	47,68 m.	116,60 m.	0,409	-164,42	0	Clustered
SEX OFFENSE	438,90 m.	777,14 m.	0,565	-18,17	0	Clustered
STALKING	663,33 m.	1078,83 m.	0,615	-11,58	0	Clustered
THEFT	12 m.	50,34 m.	0,238	-490,77	0	Clustered
WEAPONS VIOLATION	90,06 m.	195,17 m.	0,461	-89,50	0	Clustered

Upon examining Table 1, it became evident that 27 out of the 31 crime types analyzed exhibited a closer spatial clustering than expected. Notably, the offenses of human trafficking, obscenity, other narcotic violation, and public indecency, however, were found to be closer to a random distribution. Furthermore, upon examining the p-values associated with these four physical environment elements, it is evident that they do not yield statistically significant results. Hence, it can be inferred that applying spatial autocorrelation analysis to all variables would be appropriate and necessary.

In sum, these findings suggested that the majority of crime types displayed a clustered pattern, indicating the presence of underlying spatial factors or dynamics that contributed to their clustering patterns.

3.1.2.Optimized Hotspot Analysis

Optimized Hot Spot Analysis, which uses statistical techniques to detect spatial clusters, was applied for each crime type. The results of the Optimized Hotspot Analysis conducted for each crime type can be observed in the accompanying maps. In this analysis there are 7 categories. It includes 3 levels of hot, 3 levels of cold and the average value. While hotspots show the areas where the crime is committed more than the average, the cold spots show the areas where the crime is getting rarer.


ALL CRIMES
ARSON
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BURGLARY
CRIMINAL DAMAGE
CONCEALED CARRY LICENSE VIOLATION
CRIMINAL SEXUAL ASSAULT
CRIMINAL TRESPASS
DECEPTIVE PRACTICE
HUMAN TRAFFICKING
HOMICIDE
GAMBLING
INTIMIDATION
INTERFERENCE WITH PUBLIC OFFICER
KIDNAPPING

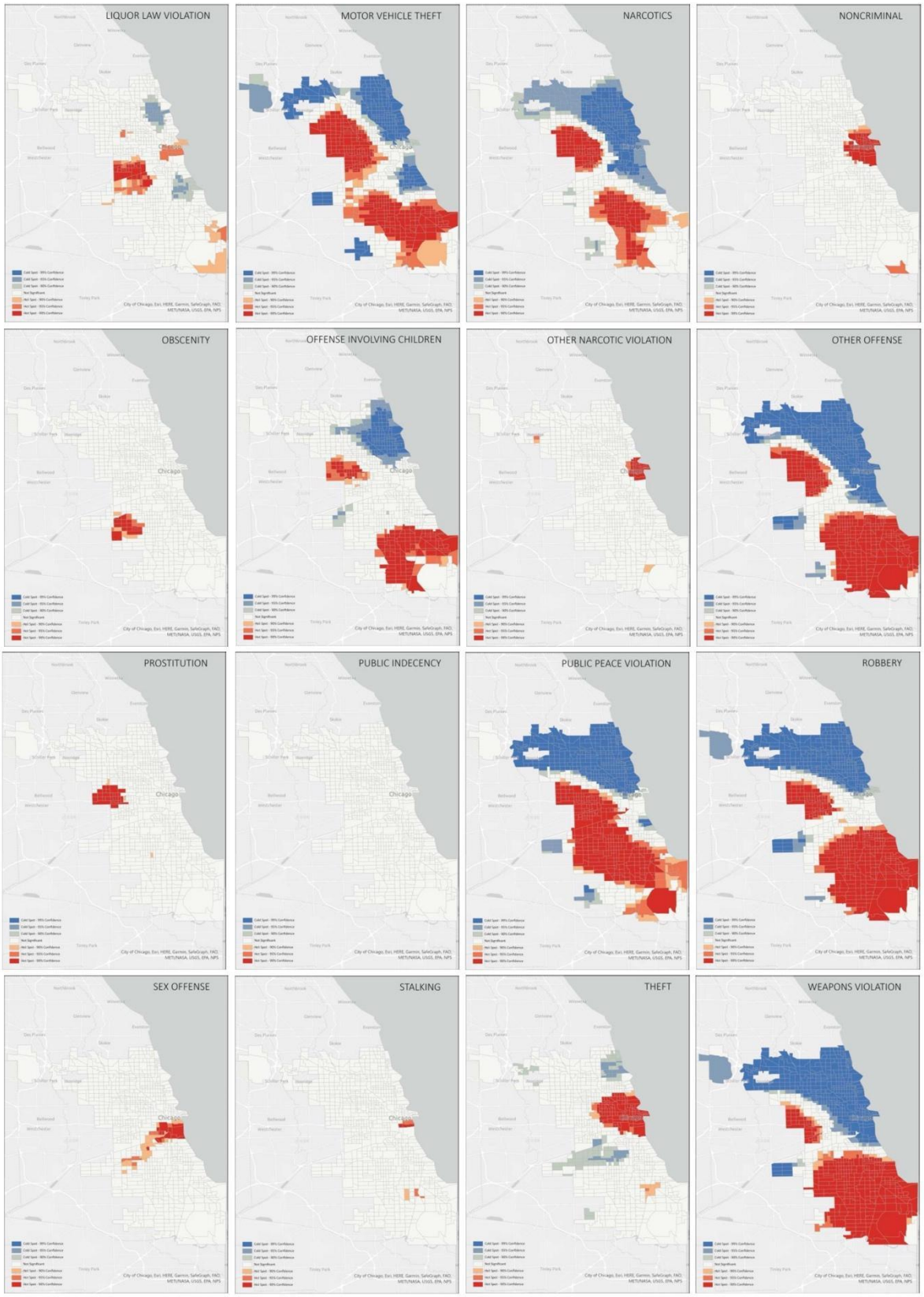

Figure 4. Optimized Hotspot Maps of Crimes

In the generated maps (Figure 4), it was evident that the spatial analysis revealed distinct patterns of hot, average and cold spots for each crime type. Focusing on the hot spots, it became apparent that specific areas within the city exhibited concentrated occurrences of different crimes. Notably, noncriminal activities, other narcotic violations, liquor law violations, sex offenses, stalking, and theft

demonstrated a concentration in the central business district. On the other hand, robbery, weapons violations, public peace violations, offenses involving children, and other offenses were concentrated in the southern region of the city. The presence of similar hotspots across various crime types, combined with the differentiation of the overall distribution pattern, yielded a robust model for assessing the explanatory value of the physical environment elements employed in this study.

An optimized hotspot map of all physical environment elements has also been added to provide spatial insights (Figure 5).

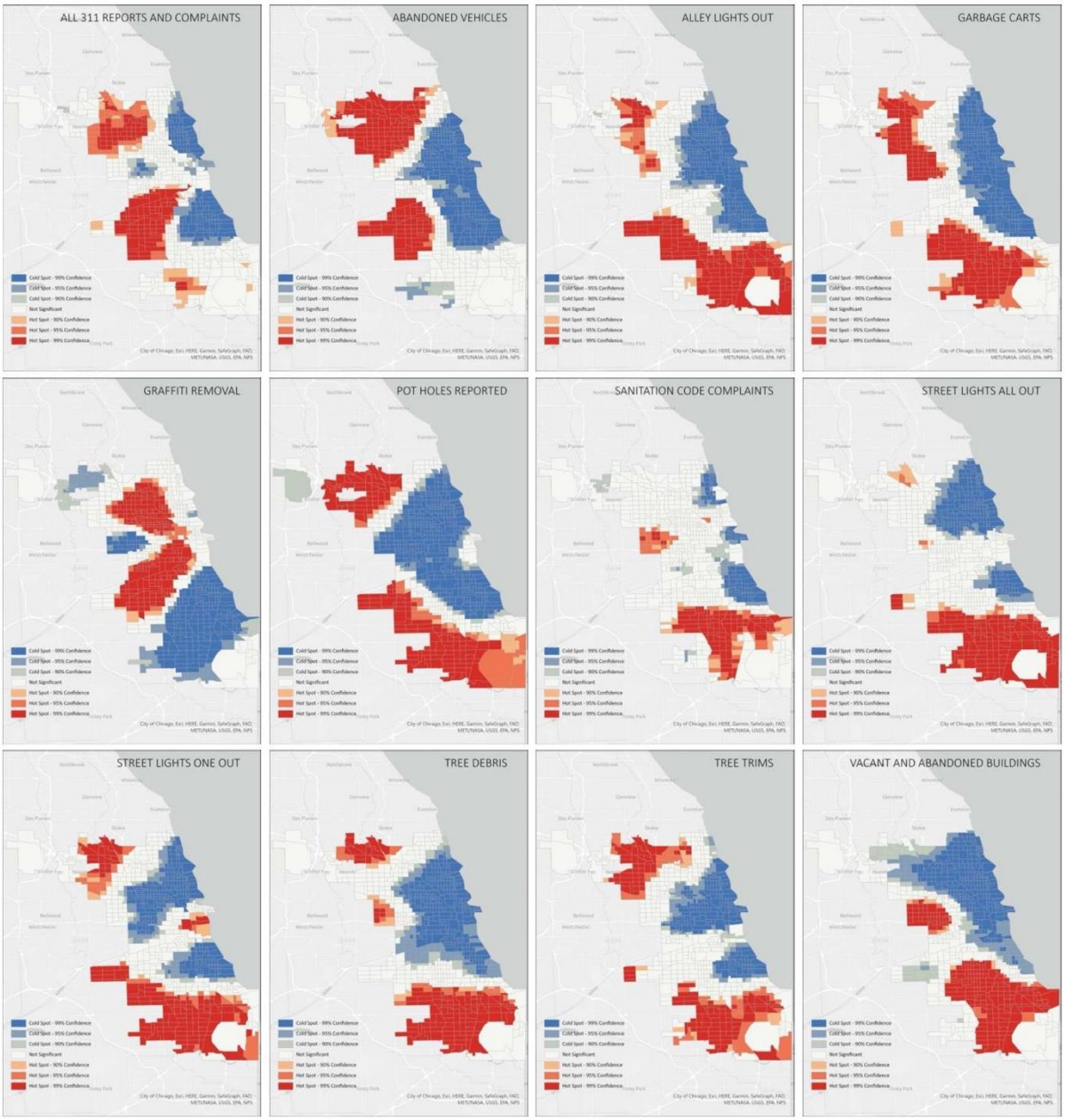

Figure 5. Optimized Hotspot Maps of Physical Environment Elements

Despite the varied spatial distribution of different crime types throughout the city, the distribution pattern of physical environmental elements exhibits a more conservative trend. Specifically, the cold spots, indicating areas with fewer occurrences of these elements, are concentrated in the central region of the city. Notably, only the presence of street lights one out was reported in the city center, indicating relatively lower levels of complaint notifications to 311 City Services in this area. Conversely,

the hotspots, representing areas with higher concentrations of these elements, are predominantly situated in the southern and northwestern peripheries of the city. This observation suggests that there may be spatial variations in the levels of reported complaints and the distribution of physical environmental elements, highlighting potential areas of concern that may require targeted interventions and resource allocation to address specific issues related to the urban environment and crime prevention.

3.1. The Relationship of Crime and Physical Environmental Factors

In this part of the field study, spatial autocorrelations and relationships between various physical environmental elements and crime types in Chicago were analyzed.

3.1.1.Spatial Autocorrelation (Global Moran's I)

Moran's I statistic was preferred to analyze the spatial autocorrelation of the physical environment elements in the data set. Using this analysis, it was evaluated whether the 11 independents were clustered, dispersed, or random. The table below shows the Moran's I index, expected index, variance, z-score and p-value values for each variable. These values are statistical measures used to analyze whether the variables show spatial clustering. In this statistical analysis, Moran's I value takes a value between -1 and 1. Positive values indicate a spatial clustering that gets stronger as it approaches 1, negative values indicate dispersed pattern, and a value close to 0 indicates randomness or spatial independence.

As a result of the analysis presented in Table 2, the spatial autocorrelation values of all independent variables were positive and all were statistically significant (p-values<0.05). Given the z-scores, all of these clustered textures were clustered in a meaningful way, randomization is not possible. In addition, according to Moran's Indices, the variable with the strongest spatial relationship was Vacant and Abandoned Buildings, while the variable with the weakest relationship was Sanitation Code.

Table 2. Physical Environmental Elements' Spatial Autocorrelation Results

311 ELEMENTS	Moran's Index	Expected Index	Variance	z - score	p-value
SANITATION CODE	0,252547	-0,00125	0,00008	28,46	0
TREE TRIMS	0,307798	-0,00125	0,000079	34,69	0
POTHOLES	0,317027	-0,00125	0,000079	35,71	0
ABANDONED VEHICLES	0,344615	-0,00125	0,000079	38,83	0
STREET LIGHTS ONE	0,349933	-0,00125	0,000079	39,43	0
STREET LIGHTS ALL	0,376614	-0,00125	0,00008	42,38	0
ALLEY LIGHTS OUT	0,421283	-0,00125	0,000079	47,43	0
GRAFFITI	0,432991	-0,00125	0,000079	48,88	0
GARBAGE CARTS	0,442508	-0,00125	0,00008	49,74	0
TREE DEBRIS	0,481304	-0,00125	0,000078	54,66	0
VACANT BUILDINGS	0,533423	-0,00125	0,000079	60,23	0

In conclusion, the results in this table show that there was a spatial regularity or similarity between certain independent variables and that these variables were potentially related to each other.

Like the physical environment elements selected as independent variables, the spatial autocorrelations of all crimes selected as dependent variables were analyzed (Table 3). The results of the analyses revealed that the p-values for public indecency, human trafficking, obscenity, and other narcotic

violation crimes exceeded 0.05, leading to their exclusion from the study. Upon examining the z-scores and p-values of the remaining crime types, it was observed that 24 crime types exhibited p-values of 0, while 3 crime types displayed p-values ranging between 0 and 0.05. Based on the analysis results, except for public indecency, human trafficking, obscenity and other narcotic violation offenses, it can be concluded that all 27 crime types exhibited spatial clustering. It is important to mention that, in addition to the crime types with p-values exceeding 0.05 in the subsequent GWR analyses, concealed carry license violation, gambling, and intimidation crimes were excluded from the study due to insufficient case counts or variations that hindered meaningful spatial analysis.

Table 3. Crime Types' Spatial Autocorrelation Results

CRIME TYPES	Moran's Index	Expected Index	Variance	z-score	p-value
PUBLIC INDECENCY	-0,004882	-0,00125	0,000069	-0,44	0,661
HUMAN TRAFFICKING	-0,004675	-0,00125	0,00006	-0,44	0,659
OBSCENITY	0,008986	-0,00125	0,000073	1,20	0,23
OTHER NARCOTIC VIOLATION	0,011	-0,00125	0,000064	1,53	0,126
STALKING	0,023302	-0,00125	0,000078	2,78	0,005
CONCEALED CARRY LV	0,025572	-0,00125	0,000077	3,06	0,002
SEX OFFENSE	0,031346	-0,00125	0,000079	3,67	0
INTIMIDATION	0,052383	-0,00125	0,000078	6,08	0
BURGLARY	0,059432	-0,00125	0,000079	6,81	0
NONCRIMINAL	0,06144	-0,00125	0,000077	7,15	0
LIQUOR LAW VIOLATION	0,068921	-0,00125	0,000079	7,92	0
KIDNAPPING	0,075678	-0,00125	0,000079	8,66	0
GAMBLING	0,094238	-0,00125	0,000077	10,87	0
CRIM SEXUAL ASSAULT	0,122513	-0,00125	0,000079	13,96	0
PROSTITUTION	0,125231	-0,00125	0,000067	15,47	0
ARSON	0,145157	-0,00125	0,000079	16,49	0
OFFENSE INVOLVING CHILDREN	0,178873	-0,00125	0,000079	20,23	0
CRIMINAL TRESPASS	0,185723	-0,00125	0,000079	21,02	0
THEFT	0,212224	-0,00125	0,000074	24,79	0
CRIMINAL DAMAGE	0,251142	-0,00125	0,00008	28,30	0
DECEPTIVE PRACTICE	0,254718	-0,00125	0,000071	30,30	0
MOTOR VEHICLE THEFT	0,314929	-0,00125	0,00008	35,44	0
PUBLIC PEACE VIOLATION	0,335293	-0,00125	0,000079	37,82	0
HOMICIDE	0,372443	-0,00125	0,000079	42,09	0
ASSAULT	0,406608	-0,00125	0,00008	45,74	0
BATTERY	0,441315	-0,00125	0,000079	49,69	0
NARCOTICS	0,467111	-0,00125	0,000078	53,09	0
INTERFERENCE WITH PO	0,476805	-0,00125	0,000079	53,89	0
ROBBERY	0,500369	-0,00125	0,00008	56,24	0
OTHER OFFENSE	0,50851	-0,00125	0,000079	57,24	0
WEAPONS VIOLATION	0,518992	-0,00125	0,000079	58,44	0

While theft, criminal damage, and motor vehicle offenses had the highest total numbers of incidents, the offenses with the strongest spatial correlation, as indicated by Moran's Indexes, were weapons violation, other offenses (including other vehicle offenses, parole violation, etc.), and robbery.

3.1.2.Geographically Weighted Regression

In the remainder of the study, Geographically Weighted Regression was performed both to see the relationships between the independent variables and to examine the impact of these independent variables on crime types in more detail. The reason why GWR analysis was preferred in this study, which claimed that crimes were related to the physical environment elements, was that it offered the opportunity to analyze the spatial variability of the phenomenon and test this relationship by considering local effects. Additionally, the Poisson regression model was used instead of the Gaussian model or the Logistic regression model due to the discrete nature of the dependent variable, crime incidents, and the presence of overdispersed data. Additionally, Distance Band and Golden Search parameters were selected for the neighborhood type and neighborhood selection method, respectively. Distance Band parameter ensures that the neighborhoods remain consistent for each feature, resulting in different feature densities in dense and sparse areas, and Golden Search method aims to minimize the AICc value to determine the optimal neighborhood size and thus increase the accuracy of the analysis (ESRI, 2023).

Table 4 presents the model diagnostics for the analyses conducted on each dependent variable (crime types) using 11 independent variables representing physical environment elements.

Table 4 Model Diagnostics for GWR Analyses with Physical Environment Elements and Crime Types

DEPENDENT VARIABLE	Distance Band	Deviance Explained by The Global Model (Non-Spatial)	Deviance Explained by The Local Model	Deviance Explained by The Local Model vs Global Model	Aicc	Sigma-Squared	Sigma-Squared MLE	Effective Degrees of Freedom
ALL CRIMES	11505	0,61	0,77	0,40	50683,82	569696,30	523956,55	737
ARSON	12309	0,20	0,30	0,12	785,17	4,30	4,07	759
ASSAULT	11506	0,58	0,74	0,37	3851,46	1317,36	1211,99	737
BATTERY	11506	0,60	0,76	0,41	9516,65	7923,44	7335,24	742
BURGLARY	19122	0,11	0,17	0,07	716,12	2,82	2,70	769
CRIM SEXUAL ASSAULT	19926	0,15	0,20	0,07	867,04	2,64	2,56	777
CRIMINAL DAMAGE	11506	0,57	0,71	0,32	8143,95	13315,04	12190,22	733
CRIMINAL TRESPASS	11512	0,32	0,44	0,18	1463,64	20,56	18,76	731
DECEPTIVE PRACTICE	11507	0,42	0,60	0,31	2683,68	164,34	151,15	737
HOMICIDE	13303	0,66	0,69	0,18	3601,18	4,97	4,58	737
INTERFERENCE WITH PUBLIC OFFICER	11507	0,52	0,67	0,30	2169,47	61,48	57,70	752
KIDNAPPING	32747	0,13	0,15	0,02	798,87	2,45	2,40	784
LIQUOR LAW VIOLATION	11623	0,12	0,27	0,17	711,11	8,38	7,93	758
MOTOR VEHICLE THEFT	11506	0,56	0,74	0,41	7908,10	11374,91	10485,60	738
NARCOTICS	11505	0,57	0,75	0,40	17571,05	13148,00	12312,90	750
NONCRIMINAL	45875	0,21	0,24	0,04	156,59	17,49	17,96	823
OFFENSE INVOLVING CHILDREN	11533	0,23	0,36	0,17	973,94	3,00	2,77	741
OTHER OFFENSE	11506	0,57	0,75	0,42	5115,74	1312,91	1219,16	744

PROSTITUTION	11506	0,27	0,48	0,28	19626,62	2054,70	2301,98	897
PUBLIC PEACE VIOLATION	11507	0,43	0,58	0,27	2615,48	88,41	81,82	741
ROBBERY	11506	0,50	0,72	0,45	5249,51	1302,99	1212,84	746
SEX OFFENSE	16213	0,11	0,17	0,07	952,81	2,41	2,30	763
STALKING	29341	0,13	0,15	0,03	678,02	3,30	3,23	786
THEFT	11505	0,45	0,66	0,38	19665,49	37908,07	34763,15	735
WEAPONS VIOLATION	11506	0,58	0,73	0,36	2778,88	199,17	187,11	752

In this analysis, Pearson's r values (shown in pink and green in the matrix) were used to understand the linear relationship between each physical environment element and each other, and R-squared values (shown in blue in the matrix) were used to express the explanatory power of the independent variables in the model.

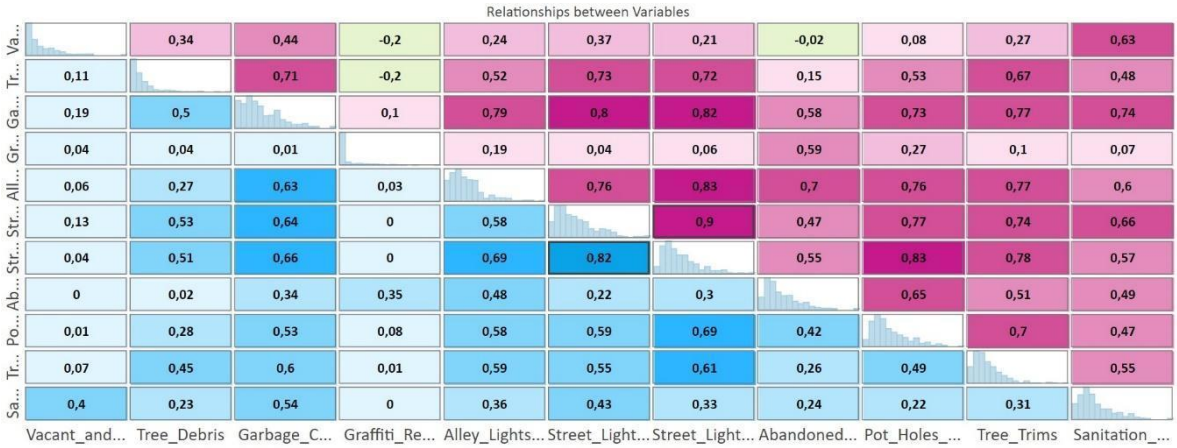

Figure 6. Physical Environmental Elements' Relationships (R-squared and Pearson's r values)

According to the results of the Geographically Weighted Regression (Figure 6), positive relationships were found in almost all of the 11 selected physical environment elements. Negative relationships were observed in only 3 cases, and these values were close to 0, suggesting a very weak or non-existent relationship. The strongest positive linear relationships were observed in variables related to street lighting, tree trims, garbage carts, and potholes. When examining the R-squared values, it becomes apparent that these same variables had high explanatory power. Therefore, it can be concluded that issues pertaining to the physical environment in Chicago coexisted in similar locations, particularly problems associated with lighting and street maintenance. It is worth noting, however, that graffiti and vacant and abandoned buildings exhibited very low or no explanatory power with regards to almost all other physical environment elements.

After analyzing the relationship between the elements of the physical environment and each other, their relationship with crimes was examined. Geographically Weighted Regressions were conducted for each crime type separately, using independent variables (physical environment elements). The R-squared values for these regressions can be seen in Table 5.

Table 5. Relationship between Crime and Physical Environment Elements (R-squared values)

VARIABLES	VACANT BUILDINGS	TREE DEBRIS	GARBAG CARTS	GRAFFITI	ALLEY LIGHTS OUT	STREET LIGHTS ONE	STREET LIGHTS ALL	ABANDONED VEHICLES	POT HOLES	TREE TRIMS	SANITATION CODE
ALL CRIMES	0,42	0,07	0,22	0,00	0,14	0,14	0,31	0,06	0,11	0,07	0,42
ARSON	0,06	0,00	0,07	0,05	0,04	0,01	0,04	0,05	0,01	0,01	0,06
ASSAULT	0,53	0,12	0,24	0,00	0,17	0,17	0,36	0,04	0,11	0,08	0,37
BATTERY	0,56	0,08	0,16	0,01	0,09	0,09	0,25	0,01	0,05	0,03	0,32
BURGLARY	0,04	0,04	0,04	0,00	0,05	0,08	0,08	0,02	0,05	0,05	0,07
CRIM SEXUAL ASSAULT	0,06	0,00	0,02	0,00	0,01	0,02	0,05	0,00	0,02	0,00	0,05
CRIMINAL DAMAGE	0,31	0,07	0,27	0,04	0,20	0,18	0,34	0,15	0,16	0,12	0,44
CRIMINAL TRESPASS	0,18	0,17	0,22	0,02	0,13	0,14	0,22	0,04	0,12	0,17	0,20
DECEPTIVE PRACTICE	0,01	0,00	0,00	0,01	0,00	0,08	0,04	0,00	0,10	0,00	0,02
HOMICIDE	0,51	0,06	0,17	0,01	0,09	0,02	0,14	0,00	0,00	0,03	0,27
INTERFERENCE WITH PUBLIC OFFICER	0,55	0,08	0,19	0,03	0,09	0,03	0,13	0,00	0,01	0,03	0,25
KIDNAPPING	0,09	0,05	0,10	0,00	0,05	0,05	0,08	0,02	0,03	0,03	0,07
LIQUOR LAW VIOLATION	0,00	0,00	0,00	0,06	0,01	0,02	0,02	0,03	0,03	0,00	0,01
MOTOR VEHICLE THEFT	0,25	0,06	0,30	0,08	0,21	0,14	0,28	0,20	0,12	0,14	0,46
NARCOTICS	0,45	0,06	0,22	0,02	0,10	0,02	0,13	0,01	0,01	0,03	0,25
NONCRIMINAL	0,00	0,00	0,00	0,01	0,00	0,03	0,01	0,00	0,03	0,00	0,00
OFFENSE INVOLVING CHILDREN	0,16	0,08	0,12	0,00	0,10	0,09	0,19	0,01	0,06	0,05	0,15
OTHER OFFENSE	0,63	0,12	0,24	0,02	0,16	0,08	0,25	0,01	0,03	0,07	0,34
PROSTITUTION	0,04	0,00	0,01	0,00	0,01	0,00	0,01	0,00	0,00	0,00	0,02
PUBLIC PEACE VIOLATION	0,39	0,02	0,11	0,01	0,06	0,04	0,13	0,01	0,02	0,02	0,19
ROBBERY	0,46	0,08	0,14	0,02	0,08	0,07	0,23	0,00	0,03	0,03	0,03
SEX OFFENSE	0,00	0,01	0,02	0,04	0,03	0,06	0,04	0,06	0,05	0,04	0,03
STALKING	0,02	0,01	0,01	0,01	0,02	0,06	0,77	0,01	0,05	0,02	0,03
THEFT	0,01	0,00	0,02	0,04	0,01	0,12	0,12	0,03	0,16	0,02	0,12
WEAPONS VIOLATION	0,67	0,13	0,22	0,04	0,13	0,05	0,21	0,00	0,01	0,06	0,33

In terms of their relationship with crimes, the analysis results indicated that the malfunctioning of a single street lamp on the street had minimal significance, whereas the absence of lighting on the entire street was found to explain 31% of all crimes. When examining the specific crimes in detail, it was observed that 77% of all stalking offenses were accounted for by this factor, representing the highest level of correlation in our study. Furthermore, offenses such as assault, criminal damage, motor vehicle theft, battery, and other offenses were found to be more likely to occur in areas with inadequate street lighting.

The variable of vacant and abandoned buildings, in general, emerged as the most significant physical environmental factor explaining crimes. It accounted for 42% of all crimes, 67% of weapons violations, 63% of other offenses, 56% of battery offenses, 55% of interference with public officer cases, 53% of assault cases, and 51% of homicide cases. Additionally, it explained more than 25% of robbery, narcotics, public peace violation, criminal damage, and motor vehicle theft cases. These findings, based on the conducted analysis, provide evidence of the high explanatory power of the vacant and abandoned building variable in relation to crimes.

Sanitation code complaints, such as garbage in the alley, unemptied dumpsters, overflowing carts, and dog feces in yards, were another variable that explained 42% of all crimes, just like vacant and abandoned buildings. Moreover, these two physical environmental factors exhibited similarities in terms of their high explanatory power (more than 25%) for certain crime types. Specifically, motor vehicle theft, criminal damage, assault, other offenses, weapons violation, battery, homicide, interference with public officers, and narcotics showed a similar pattern. Although the results indicated similarities, we had previously observed that the explanatory power between these physical environment elements was 40%.

Garbage carts, which are closely related to sanitation code complaints in terms of content, accounted for 22% of all crimes and were predominantly found in areas where motor vehicle theft and criminal damage offenses were committed.

Despite exhibiting spatial clustering, the crimes of arson, burglary, criminal sexual assault, deceptive practice, kidnapping, liquor law violation, noncriminal, prostitution, and sex offense showed correlations of less than 10% with any of the selected physical environment elements. Except for stalking, which demonstrated a significant correlation with street lighting, the other physical environment elements did not exhibit meaningful relationships with these crimes. With the exception of its 39% correlation with vacant and abandoned buildings, public peace violation crime did not demonstrate associations with other physical environment elements. It is important to note that this study exclusively relied on incidents reported to 311 City Services. Hence, it is plausible that these crimes may be linked to other physical environment elements. Moreover, they could potentially occur in spatial contexts where prompt measures are taken, thereby precluding complaints. Further investigation into the relationships of these crimes necessitates scrutiny using alternative variables and datasets.

When evaluating the other independent variables, namely graffiti, tree trims, tree debris, street lights one, and potholes, it was discovered that they had little or no explanatory power exceeding 20% for any crime. However, it was observed that alley lights accounted for 21% of motor vehicle theft and 20% of criminal damage, while abandoned vehicles explained 20% of motor vehicle theft as well. It should be noted that these physical environmental elements exhibited limited associations with crimes and possessed low explanatory capacity.

CONCLUSION:

With this case study done in the city of Chicago, based on secondary data and carried out through exploratory analyzes, crime was handled in the context of place, and its relations with physical environment factors were questioned. The findings of this study contribute to the growing body of knowledge on the relationship between crime and the physical environment. By utilizing spatial statistical methods and exploring the spatial patterns and associations between physical environment elements and crime, this study sheds light on the complex dynamics between these factors.

The first finding of this study is the significant clustering of crime incidents in the city of Chicago. Average Nearest Neighbour analysis revealed that all crime incidents tended to occur in close proximity, suggesting a clustered pattern rather than a random distribution. According to Crime Pattern Theory, crimes are concentrated in certain areas because criminals make a deliberate or random choice of location to commit the crime (Eck & Weisburd, 2015). In the study, it was also found that 27 out of 31 crime types, except human trafficking, obscenity, other narcotic violation, and public indecency, were committed much closer to each other than the expected distance. This indicates that certain crimes tend to cluster in certain areas.

The second finding of the research is that there were certain neighborhoods or regions where each type of crime was clustered. According to the results of the Optimized Hotspot Analysis to determine the areas where crime incidents are concentrated, it was found that each type of crime is concentrated in the same or different parts of the city, except for public indecency, which has very low crime incidents, and each crime has a unique pattern. For example, noncriminal activities, other narcotic violations, liquor law violations, sex offenses, stalking, and theft are concentrated in the city center, while robbery, weapons violations, public peace violations, offenses involving children, and other offenses are concentrated in the southern part of the city. Again, these findings support the Crime Pattern Theory, which claims that crimes may follow a certain order or pattern and may be repeated in these areas.

The research revealed that not only crimes but also abandoned vehicles, vacant and abandoned buildings, graffiti removal, alley lights out, street lights one out, street lights all out, garbage carts, sanitation code complaints, tree trims, tree debris and potholes are concentrated in certain areas of the city. This situation showed that certain parts of the city are much more neglected than the rest of the city and the streets have started to deteriorate. The first three findings prove that the factors affecting crime should be taken into consideration. The other findings of the research are about the elements of the physical environment that affect the types of crime.

Firstly, the research used spatial autocorrelation analysis (Global Moran's I) to assess the overall spatial pattern of crime and its correlation with elements of the physical environment. The analysis confirmed the presence of positive spatial autocorrelation, indicating that areas with high crime rates tend to be surrounded by other areas with high crime rates, and areas with low crime rates tend to be surrounded by other areas with low crime rates.

Then, the study employed Geographically Weighted Regression to examine the relationships between dependent and independent variables. Exploratory spatial statistical analyses revealed that problems related to the physical environment in Chicago are positively correlated with each other. In particular, problems related to lighting and street maintenance were found to coexist in similar locations and to have explanatory power over each other. In places where street lighting was problematic, over 60 per cent also had problems with garbage carts. This information is consistent with the Broken Windows Theory, which states that a small irregularity or violation in the environment can lead to other irregularities and violations.

According to the results of Geographically Weighted Regression to identify the spatial relationships between each crime type and 11 physical environment elements, inadequate street lighting, specifically the absence of lighting on an entire street, is significantly associated with crimes, accounting for 31% of all crimes. Notably, the lack of lighting explains a substantial proportion of stalking offenses (77%), demonstrating the strongest correlation in the study. Moreover, areas with insufficient street lighting are more prone to experiencing offenses such as assault, criminal damage, motor vehicle theft, battery, and other crimes.

The variable of vacant and abandoned buildings emerges as the foremost physical environmental factor contributing to crime, encompassing 42% of all offenses. It demonstrates a substantial explanatory capacity for various crime categories, such as weapons violations, other offenses, battery offenses, interference with public official cases, assault cases, and homicide cases. Moreover, it elucidates more than a quarter of burglary, narcotics, public order offenses, criminal damage, and motor vehicle theft cases.

Sanitation code complaints, including issues such as street litter, unattended waste bins, overflowing carts, and canine excrement in residential yards, constitute an additional variable that accounts for 42% of all offenses, akin to the significance of vacant and abandoned buildings. These two physical environmental factors exhibit notable explanatory prowess (exceeding 25%) for specific offense types, such as motor vehicle theft, criminal damage, assault, other offenses, weapons violations, battery, homicide, interference with a public official, and narcotics. In addition, garbage carts, which are closely related to complaints about cleanliness rules, account for 22% of all offenses and are predominantly associated with areas where motor vehicle theft and criminal damage offenses are committed.

In addition to all findings, crimes such as arson, burglary, theft, sexual assault, deceptive practice, kidnapping, liquor law violation, non-criminal offences, prostitution and sexual offences show less than 10% correlation with the selected physical environment elements. The offense of breach of the peace does not show a significant correlation with the other physical environment elements, except for the 39% correlation with vacant and abandoned buildings.

The study also found that other independent variables such as graffiti, tree cuts, tree debris, street lights and potholes have limited explanatory power for any crime (less than 20%). However, it is reported that street lights not being lit explains 21% of motor vehicle theft and 20% of criminal damage, while abandoned vehicles explain 20% of motor vehicle theft. These elements of the physical environment have limited associations with offenses and low explanatory capacity.

These findings are in line with the Broken Windows Theory, which suggests that the deterioration of physical spaces can contribute to increased criminal activity. Underlining these correlations, this study provides empirical evidence of the importance of protecting and improving the physical environment as a crime prevention strategy as recommended by CPTED.

This study seeks to contribute to the existing literature on the impact of environmental factors on crime by incorporating a comprehensive set of variables, covering different types of street crime, and considering physical environmental elements that may contribute to the deterioration of urban areas. By using an extensive dataset, this research aims to shed light on the complex relationship between crime and the built environment. Furthermore, by advocating the use of open data in crime research, this study aims to set an example in promoting transparency and accessibility in this area.

It is important to note that this study is based only on incidents reported to 311 City Services and therefore may exclude crimes that are linked to other physical environment elements or occur in areas where swift action was taken to prevent complaints. Future studies in the field are advised to incorporate a broader range of variables in order to comprehensively examine the relationships between crime and physical environmental elements. While solely focusing on physical environment factors such as parcels, structures, roads, parks, and bus stops can provide valuable insights, augmenting these with socio-economic indicators including census data, household information, employment statistics, as well as health and education data would further enhance the clarity and robustness of the results. By incorporating these additional dimensions, researchers can obtain a more comprehensive understanding of the complex interplay between crime and the socio-physical environment.

Compliance with the Ethical Standard

Conflict of Interest: *There is no conflict of interest between the author and any third party individuals or institutions.*

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REFERENCES:

Ayhan, İ., & Çubukcu, K. M. (2007). Suç ve kent ilişkisine ampirik bakış: Literatür taraması. *Süleyman Demirel Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *5*, Article 5.

Brantingham, P., & Brantingham, P. (2008). Crime pattern theory. In *Environmental criminology and crime analysis* (pp. 78–93). Willan.

Campedelli, G. M., Favarin, S., Aziani, A., & Piquero, A. R. (2020). Disentangling community-level changes in crime trends during the COVID-19 pandemic in Chicago. *Crime Science*, *9*(1), 21. https://doi.org/10.1186/s40163-020-00131-8

Cinar, E. A., & Cubukcu, E. (2012). The Influence of social, economical and physical environmental factors on crime rates: A case study of the Bosphorus Conservation Area, Istanbul, Turkey. *İstanbul Ticaret Üniversitesi Fen Bilimleri Dergisi*, *11*(22), Article 22.

City of Chicago. (2023a, May 30). *Crimes—2001 to present*. Chicago Data Portal. https://data.cityofchicago.org/Public-Safety/Crimes-2001-to-Present/ijzp-q8t2

City of Chicago. (2023b, May 31). *CHI 311*. 311 City Services. https://311.chicago.gov/

Crowe, T. (2013). *Crime prevention through environmental design* (L. J. Fennelly, Ed.). Elsevier.

Dayara, T., Thabtah, F., Abdel-Jaber, H., & Zeidan, S. (2022). Crime analyses using data analytics. *International Journal of Data Warehousing and Mining (IJDWM)*, *18*(1), 1–15. https://doi.org/10.4018/IJDWM.299014

De Nadai, M., Xu, Y., Letouzé, E., González, M. C., & Lepri, B. (2020). Socio-economic, built environment, and mobility conditions associated with crime: A study of multiple cities. *Scientific Reports*, *10*(1), 13871. https://doi.org/10.1038/s41598-020-70808-2

Eck, J., & Weisburd, D. L. (2015). *Crime places in crime theory* (SSRN Scholarly Paper No. 2629856).

Emig, M. N., Heck, R. O., & Kravitz, M. (1980). *Crime analysis: A selected bibliography*. US National Criminal Justice Reference Service.

ESRI. (2023, May 30). *About ArcGIS*. ESRI Mapping & Analytics Software and Services. https://www.esri.com/en-us/arcgis/about-arcgis/overview

ESRI. (2023, July 14). *How Geographically Weighted Regression (GWR) works*. ESRI Mapping & Analytics Software and Services. https://pro.arcgis.com/en/pro-app/2.9/tool-reference/spatial-statistics/how-geographicallyweightedregression-works.htm

Felson, M. (2008). Routine activity approach. In *Environmental Criminology and Crime Analysis* (pp.

70–77). Willan.

Felson, M., & Spaeth, J. L. (1978). Community structure and collaborative consumption: A routine activity approach. *American Behavioral Scientist*, *21*(4), 614–624. https://doi.org/10.1177/000276427802100411

Fotios, S. A., Robbins, C. J., & Farrall, S. (2021). The effect of lighting on crime counts. *Energies*, *14*(14), 4099. https://doi.org/10.3390/en14144099

Guerry, A. M. (1833). *Essai sur la statistique morale de la France*.

Hou, K., Zhang, L., Xu, X., Yang, F., Chen, B., Hu, W., & Shu, R. (2023). High ambient temperatures are associated with urban crime risk in Chicago. *The Science of the Total Environment*, *856*(Pt 1), 158846. https://doi.org/10.1016/j.scitotenv.2022.158846

Jacobs, J. (1961). *The death and life of great American cities* (Reissue edition). Random House.

Jeffery, C. R. (1977). *Crime prevention through environmental design*. Sage Publications.

Kondo, M. C., Keene, D., Hohl, B. C., MacDonald, J. M., & Branas, C. C. (2015). A difference-in-differences study of the effects of a new abandoned building remediation strategy on safety. *PLOS ONE*, *10*(7), e0129582. https://doi.org/10.1371/journal.pone.0129582

Kooi, B. R. (2013). Assessing the correlation between bus stop densities and residential crime typologies. *Crime Prevention and Community Safety*, *15*(2), 81–105. https://doi.org/10.1057/cpcs.2012.15

Lavi, B., Tokuda, E. K., Moreno-Vera, F., Nonato, L. G., Silva, C. T., & Poco, J. (2022). 17K-Graffiti: spatial and crime data assessments in São Paulo city. *Proceedings of the 17th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications*, *Volume 4: VISAPP*, 968–975. https://doi.org/10.5220/0010883300003124

Newman, O. (1972). *Defensible space; crime prevention through urban design.* Macmillan Publishing.

Quetelet, A. (1831). *Recherches sur le penchant au crime aux différents âges*. Hayez.

Safat, W., Asghar, S., & Gillani, S. A. (2021). Empirical analysis for crime prediction and forecasting using machine learning and deep learning techniques. *IEEE Access*, *9*, 70080–70094. https://doi.org/10.1109/ACCESS.2021.3078117

Schertz, K. E., Saxon, J., Cardenas-Iniguez, C., Bettencourt, L. M. A., Ding, Y., Hoffmann, H., & Berman, M. G. (2021). Neighborhood street activity and greenspace usage uniquely contribute to predicting crime. *Npj Urban Sustainability*, *1*(1), Article 1. https://doi.org/10.1038/s42949-020-00005-7

Shaw, C. R. (1931). A delinquency area. In *The natural history of a delinquent career* (pp. 13–25). The University of Chicago Press. https://doi.org/10.1037/13522-002

Shaw, C. R., & McKay, H. D. (1942). *Juvenile delinquency and urban areas*. University of Chicago Press.

Sherman, L. W., Gartin, P. R., & Buerger, M. E. (1989). Hot spots of predatory crime: Routine activities and the criminology of place. *Criminology*, *27*(1), 27–56. https://doi.org/10.1111/j.1745-9125.1989.tb00862.x

Singleton, C. R., Winata, F., Parab, K. V., Adeyemi, O. S., & Aguiñaga, S. (2023). Violent crime, physical inactivity, and obesity: Examining spatial relationships by racial/ethnic composition of

community residents. *Journal of Urban Health: Bulletin of the New York Academy of Medicine*, *100*(2), 279–289. https://doi.org/10.1007/s11524-023-00716-z

Sun, L., Zhang, G., Zhao, D., Ji, L., Gu, H., Sun, L., & Li, X. (2022). Explore the correlation between environmental factors and the spatial distribution of property crime. *ISPRS International Journal of Geo-Information*, *11*(8), 428. https://doi.org/10.3390/ijgi11080428

Taylor, R. B., & Harrell, A. (1996). *Physical environment and crime*. U.S. Department of Justice, Office of Justice Programs, National Institute of Justice.

Wilson, J. Q., & Kelling, G. L. (1982). Broken windows. *Atlantic Monthly*, *249*(3), 29–38.

Wortley, R., & Mazerolle, L. (Eds.). (2008). *Environmental criminology and crime analysis*. Willan.

Yang, M., Chen, Z., Zhou, M., Liang, X., & Bai, Z. (2021). The impact of COVID-19 on crime: A spatial temporal analysis in Chicago. *ISPRS International Journal of Geo-Information*, *10*(3), Article 3. https://doi.org/10.3390/ijgi10030152