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Integrated Analysis of Crime Incidents within a Loose-Coupled GIS-Based System: Case of Etlik Police Station Zone in 2000

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Abstract

The empirical testing of theories of the *new ecology of crime* (*place-based* theories) requires systems that permit the use of multiple analytical tools at a time. For this purpose, in this paper a loose-coupled GIS-based system is developed to facilitate an integrated quantitative analysis of *place*-related (in terms of both *space* and *time*) incident data through data input-output. The system comprises five components: a relational database management system; document and spreadsheet software; a standard desktop GIS; statistical software; and a spatial statistics/spatial data analysis tool. To test the *place-based* theoretical approach, the *spatial* and *temporal* distribution of incidents in the year 2000 against people, property, and people and property within the Etlik Police Station Zone, which is characterized by different development patterns (i.e., *planned*, *early stage gecekondu (squatter)* and *in-transition* settlements), are analyzed using the developed system. The findings of the paper supported the *new ecology* theories at a mezo-micro (intra-urban) ecological level, in that the incidents displayed differences in their *global* and *local* scale *spatial* and *temporal* distribution in different development patterns. The developed system proved to be an effective means of carrying out complicated quantitative analyses, while also providing a flexible and comparative environment for such analyses.

Keywords: *Loose-coupled GIS-based system, crime pattern analysis, new ecology (place-based) theories of crime, global-scale properties, local-scale properties*

1. INTRODUCTION

Recent decades have witnessed a gradual replacement of the pin mapping of criminal events and related interpretive bases with crime mapping studies. Today, widely accessible computerized mapping and spatial analysis techniques have lead not only to an explosion of interest [1] in crime mapping studies, but also many recent analyses of the ecological features of crime [2]. A considerable portion of crime ecology theories (Figure 1) cover *new* theories of the "fourth dimension of crime" [3], being *place*, rather than the traditional three dimensions of "the law, the offender, the target" cited by the Brantinghams [3]. Criticisms of the *traditional ecology* theories caused the emergence of theories of the *new ecology of crime* in the 1970s [4] (Figure 1), shifting emphasis from the study of criminals, offenders or delinquents to the study of criminal events, the crime environment or opportunities for crime occurrences [5].

These *new ecological* approaches to crime are also referred to as "crime *place* theories", or "*place-based* crime theories". The main argument and the common point in all these approaches is that the criminal events do not occur randomly in *place* (in terms of *space* and *time*) [3], but show distinct patterns [6]. This indicates that there are spatio-temporal factors determining the occurrence and distribution of criminal events. The unequal distribution of crime, in the *new ecology* theories very much resembles the *traditional* (*offender*) theories, but with a change of emphasis from

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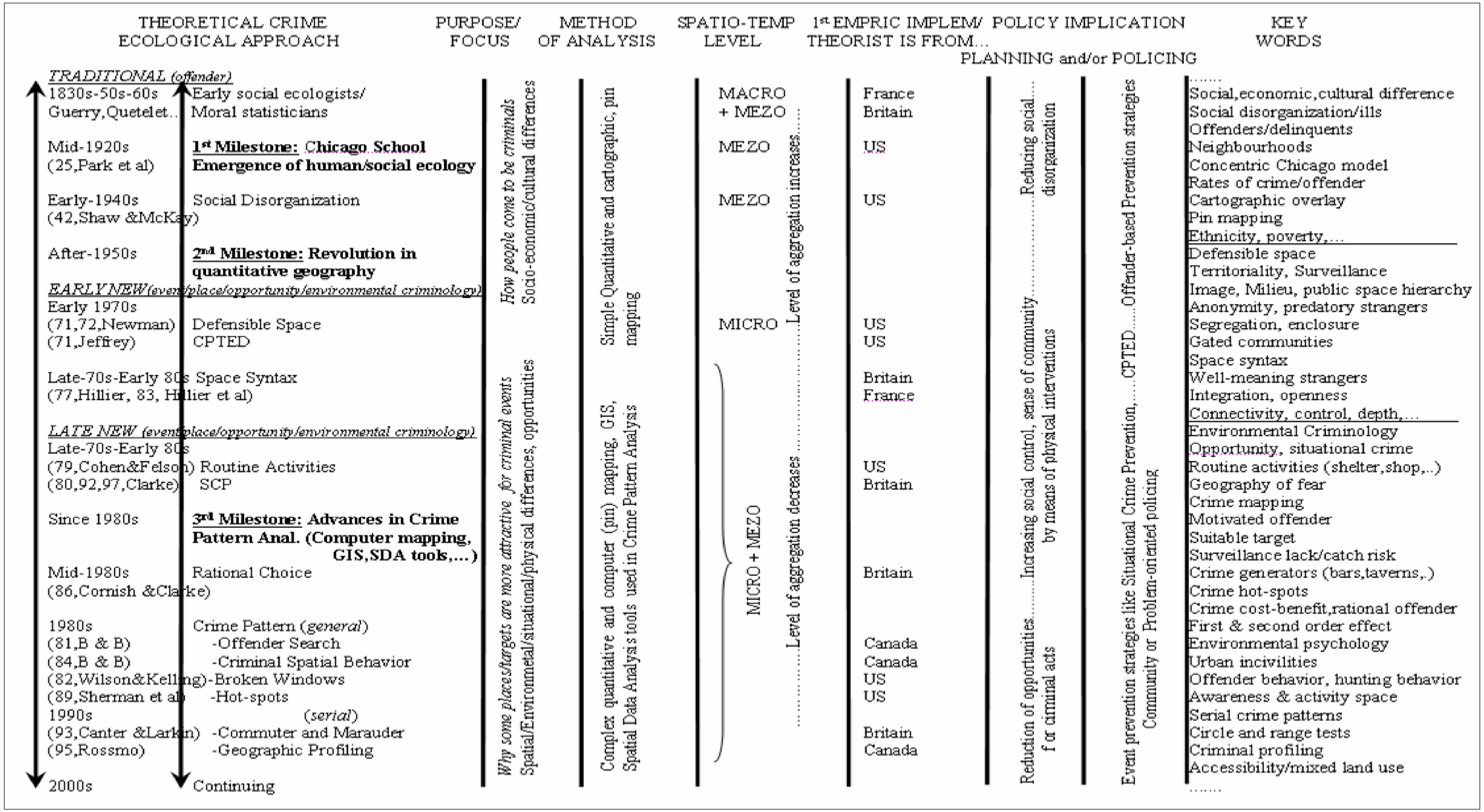

Figure 1. Crime ecological theories and their basics from a chronological perspective
Source: [7], based on the literature referred to in the figure

"offenders" towards "criminal events" and "crime environments". These theories, for this reason, are also known as "*event*" theories and "*environmental criminology*" theories, respectively. Consequently, all *new* approaches aim at a verification of this main assumption, which places particular emphasis on why some targets (in *spatio-temporal* terms) are more attractive or provide more opportunities for criminal behavior than others. Consequently, these theories have also been referred to as "*opportunity*" theories.

In Figure 1, crime ecology theories and their basic attributes, such as their focus, methodology, spatio-temporal level of resolution, and planning and policing implications, are presented in chronological order. It can be seen that the research area concerning *new crime ecology* theories today continues to develop, particularly within the field of Crime Pattern Theories.

Crime Pattern Analyses have been widely used as an extension of these theories into practice, following advances in crime mapping and spatial data analysis (SDA) tools that utilize computer technology [2]. The recent empirical studies that cover the crime pattern theories and the relevant GIS-based crime mapping and spatial data analysis tools, in fact, emerged as "an outgrowth of historical interest in the spatial identification of crime that harkens back to nineteenth century France … and England … and is allied to the development of modern environmental criminology theory" [5] (Figure 1).

According to Schneider and Kitchen [5] further empirical research is still required based on the need for an "increased emphasis on empirical study along with carefully documented case studies … toward a general theory of place-based crime prevention planning and, … a better understanding of the linkage between crime and place at all levels of analysis."

To address this need, this paper tests the *place-based* theoretical approach through the development and use of a loose-coupled GIS-based system. It follows a similar path as previous studies in terms of its use of a quantitative methodology and computer technologies (e.g., [8]; [4]; [9]; [10]; [11]); but differs in its high-level integrated use of analytical means (e.g., database construction and utilization, spatial analyses, spatial statistical analyses and statistical analyses) and appropriate software. In finding supportive results for *place-based* theories of crime, it concentrates on an integrated analysis of *place*-related crime incidents (against people, property, and people and property) by means of data input and output. As stated above, the distinct patterns that crimes display are related to the differences in the context of *place* (*space* and *time*). In order to support this premise, and different from the previous study that utilized one or two analytical tools or software, this paper puts forward the potentials and advantages of an integrated analysis of crime incidents within a "loose-coupled" [12] GIS-based system. The study exemplifies the effectiveness of the high level of integrated use of analytical tools at the mezo-micro (intra-urban) ecological level in terms of *space* and *time*.

2. EARLIER STUDIES

2.1 Classical Studies of Traditional Ecology of Crime

With reference to the chronological perspective presented in Figure 1, the *traditional* studies on spatial analysis of crime cover researches of *Moral Statisticians; Chicago School; and Social Disorganization* theorists. As implied in the earlier sections, the main argument and the common point in the *traditional ecological approaches* to crime can be stated such that human behavior is determined by mainly social factors ([13] in [14]; [5]) and the differences in the *spatio-temporal* distribution of crime can be explained by the differences in basically social conditions of the residential population [15] and they ask questions like "*why do people commit crime?*" ([16] in [17]).

In verifying their main goal, *traditional theories* utilize similar simple analytical methodologies. These methods include visual inspections and simple statistical tests made after performing cartographic techniques such as simple overlying of spatial distribution of crimes/delinquencies or offenders/delinquents with maps of spatially defined areas, which are supposed to have different social and environmental conditions of the residential population [15]. These spatial definitions can be grouped with reference to their formation types such that they can be either *administrative* ([18] and [19] in [15]), *statistical* ([20] in [21]), *conceptual* [13] in [22]), or *regular* grids ([20] in [21]).

The main findings of *moral statisticians* in France in the 1830s, Quetelet and Guerry, who carried out "macro" level studies suggested that rates of crime are unevenly distributed among the urban and rural areas of the country (i.e., violent crimes were high in the southern rural area contrary to high property crimes and "suicide" in the more industrialized and wealthier northern areas) and also that crime rates for each type of crime in each jurisdiction were stable over decades ([15]; [23] in [4]). Similarly, early English geographers of the mid-1800s (like Glyde [24] in [4]), found that different levels and mixtures of crime rates vary substantially both in different locations and in different aggregation levels (cities, counties, etc.).

On the other hand, the findings at "mezo" level consisted of results of studies carried out by *Chicago School* in the mid 1920s ([13] in [22]; [15]). They founded the first "theoretical" basis for social geography or human ecology of cities [25] and the corresponding *Chicago School Theory of Crime.* The model for the Chicago City was composed of five concentric zones [22] each of which had distinctive characteristics.

According to *Chicago School* cities evolve with ecological processes of invasion, dominance and succession such that "growth of any city is tied to the pressure from the center of the city to expand outward. For example, Zone II, or the zone of transition, will eventually be subject to the invasion by business and industrial expansion from the central business district, or Zone I" [22]. After the movement of central business district activities into this zone, previously which retained some of the most desirable housing, becomes an undesirable place to live. Already old houses deteriorate and their rents decrease. Poor who are basically unskilled workers start to live in the area characterized by warehouses, pawn shops and slums, which develop due to competing market forces of high land and low building values ([13] in [4] and in [26]). Accordingly, they found that crime and vice emerge ([13] in [4]) and are endemic in Zone II ([27] in [28]), and in the groups that live in this zone.

By making use of Chicago City Model, Shaw and McKay ([20] in [29]), the founders of *Social Disorganization Theory* concluded that delinquent rates widely vary among the different neighbourhoods of the city and they decrease with increasing distances from the CBD. Moreover, they found that delinquent rates are the highest in the areas of high social disorganization around the CBD (Zone II) characterized by low rents, physical deterioration and declining population area, which suffer from high poverty, residential mobility and ethnic heterogeneity together with other social ills such as high infant mortality rate. Another major finding is that the high rates of delinquents are persistent or stable over time in neighbourhoods where high delinquent rates are observed ([20] in [4]; [20] in [21]).

2.2 Classical Studies of New Ecology of Crime

Similar to the *traditional* studies, the social and spatial restructuring of these western cities distinguished by being modern(ist) after the 2nd World War in the mid 1940s until early 1970s is accompanied by start of a new trend of *crime ecological* thinking by *Defensible Space* [30], *Crime Prevention Through Environmental Design-CPTED-* [31] and *Space Syntax Theorists* [32]; [33]. This trend has been -is still being- improved further within the context of spatial and social restructuring of today's global(izing) cities since late 1970s and of the further new ecological approaches founded by *Routine Activities* [34], *Situational Crime Prevention-SCP-* [35]; [36]; [37], *Rational Choice* [38], and *Crime Pattern Theorists* [3]; [39]; [40]; [41]; [42]; [43]; [44] (Figure 1). Simply they focus on *events* and the *environmental* (*spatio-temporal*) conditions that some targets provide more *opportunities* and become more attractive for crime occurrences, by asking questions "*why do crimes occur in specific settings?*".

Accordingly, whereas the *traditional* theories suggest *offender-based programs* and inform policy makers on what could be done to reduce crimes in socially disorganized communities, the *new* theories provide *event-prevention strategies* and inform responsible authorities on the *ecological means* in cities for *event* occurrences and neighbourhoods that require *place-based prevention strategies* to be adopted and require greater patrolling and monitoring in addition to adoption of new security methods like community or problem oriented policing ([22]; [45]; [36] in [4]; in [46]; and in [17]; [47] in [4]; [16] in [17]; [26]; [48] in [17]; [8]; [49]).

2.3 Empirical Studies and the Case in Türkiye

Based on the theory founding studies, the majority of *new crime ecology* empirical studies utilize *traditional* or *new* theories, either in an integrated way, simultaneously or independently from each other in exploring the *spatial* distribution of criminal activities. In the section below a summary for 27 such studies is presented. The grouping of studies with respect to the ecology of crime approaches is found as in the list below:

1. *Routine Activities, SCP, Rational Choice* and/or *Crime Pattern:9*
2. *Routine Activities, SCP, Rational Choice* and/or *Crime Pattern and traditional ecology:7*
3. *Traditional ecology:5*
4. *Defensible Space*, *CPTED* and/or *Space Syntax and traditional ecology:4; and*
5. *Defensible Space*, *CPTED* and/or *Space Syntax:2*

In the first group, while researches pursue the main line of argument of the *Routine Activities, SCP, Rational Choice* and *Crime Pattern Theories* in general, particularly they focus on one of the following:

- Relationship between *spatio-temporal* patterns of incidents and their physical environments [6]; [8]; [4]);
- Impacts of selected urban land-uses on the distribution of incidents [9]; [10];
- Patterns of various crime types [50]; [51]);
- Spatial patterns of *serial crimes* committed in cities [52]; [53].

Similarly, in the second group, while researches is guided by the main argument of both *Routine Activities, SCP, Rational Choice* and *Crime Pattern Theories* and *traditional ecology* in general, they have particular concern for one of the following:

- Relationship between spatial patterns of incidents and their physical and socio-economic environments [54]; [55]; [56];
- Impacts of urban renewal/redevelopment/ revitalization on patterns of various incidents (displacement) [57]; [58];
- Effects of spatial inequality of various socio-economic variables in the spatio-temporal patterns of various crimes [59]; [60].

Thirdly, all the studies in the third group [61]; [62]; [63]; [64]; [65] have a common aim to investigate the relationship between distribution of crime and socio-spatial, economic, and/or demographic structures in the urban and/or rural areas.

The fourth group of studies [66]; [67]; [68]; [69]. commonly focus on the relationship between distribution of crime and both the social and spatial structure in which they take place. Majority of these studies make particular emphasis on peculiar effects of organization or configuration of social and spatial entities especially in residential urban areas on the distribution of crimes.

Finally, the studies in the fifth group [70]; [71] aim at investigating and testing the assumptions and/or achievements of the *CPTED* strategy in reduction of various property crimes in particularly residential urban areas.

Majority of these studies utilize a wide variety of quantitative methods, and make extensive use of computer technologies such as GIS, and a variety of statistical and/or spatial data analysis software to explore the distribution of incidents. As for the *spatial* and *temporal* levels of the analysis, all these studies utilize one or more ecological levels, which can be either “micro”, “mezo” or “macro”.

Most of the reviewed studies in Türkiye deal with crime distribution problem by means of *traditional approaches*. Consequently, they provide policies on urbanization, social welfare, migration, legal and regulative framework [72]; [73]; [74]; [75]; [64]; [65]. Among these one study utilizes GIS technology for analytical purposes [76]. There are also fewer number of existing studies that either adopt *new ecological approaches* to inspect distribution of the incidents [11]; [77]; [78] or integrate them with *traditional* theories to inspect patterns of incident, offenders, and victims [69]. The former group of studies of *new crime ecology* [11]; [77]; [78] and one of the studies stated above, which is based on *traditional ecology* (i.e., [76]) have a common premise: The idea of usefulness and effectiveness of GIS and spatial data analysis tools in exploration of crime patterns.

These studies primarily aim at proving the advantages of utilizing such geographical data analysis techniques and methods. They differentiate patterns (clustered, etc.) of incidents or incident types in urban areas [11]; [77]; [78]. In this way, they confirm the main assumption of *new ecological theories* stating that certain types of criminal events do not occur or distributed randomly in *space* and *time*, but they show distinct patterns ([79] and [80] in [6]). That is, there are *spatio-temporal* factors, which determine the occurrence and distribution of such criminal events.To achieve their aim, some researchers take into account either one type of incidents (thefts) in a police station zone in Bursa [11] or two incidents (auto thefts and thefts from auto) in metropolitan districts of Konya in 2000 [77]. On the contrary, in one study [78] more than two incidents between two police station zones (five property or violent incidents), which are Bahçelieveler and Çankaya in Ankara in 2003 are analysed and compared.

The study which integrates *new ecology* to *traditional* one [69], accordingly integrated spatial structure to social structure in the areas where almost all types of incidents took place and explored for incident patterns in four residential neighbourhoods in a central district of İstanbul for the years 1983, 1988, 1993 and 1998. The main emphasis of this study was the effects of configuration or organization of spatial and social entities on distribution of criminal activities in residential neighbourhoods.

Similar to previously mentioned *traditional ecology* studies, these studies, which either adopt *new ecology* or integrate it with the *traditional ecology*, were carried out at ‘mezo’ *spatial* and *temporal* levels, and some of them used statistical testing and detailed spatial data analysis methods (e.g., [69]; [77]). As an additional finding, some of the existing studies mentioned about the importance of public participation and interdisciplinary approach and *environmental* design in prevention of crime like *target hardening* and *lightening* or offenders’ *environmental* preferences, etc. [75]; [78].

A relatively recent study [81], which aimed at exploration of the relationship between the built environment and crime and fear of crime, explored the effects of principles of the *CPTED* approach within the context of recently redesigned İzmir Konak Square. The results of analyses, which utilized methods including quantitative techniques, systematic observations and questionnaires, supported causal relationship between the occurrence of crime or feelings of insecurity and characteristics of the spatial built environments. Finally, in this study the importance of careful consideration of planning and design issues in creating safer and livable public spaces is emphasised [81].

3. THE SCOPE AND SELECTION OF THE STUDY AREA

The selected study area and the period corresponded to mezo-micro *spatial* and *temporal* levels, whereby the *spatial* levels range from neighborhoods within the study area, i.e., the developed parts of Etlik Police Station Zone, to smaller sub-regions in these neighborhoods; and the *temporal* levels range from months, weeks, days to three daily time intervals within the study period (the year 2000). While bringing a loose-coupled methodological perspective into the analysis of crime incidents over a one-year period, the study is implemented in a case area selected within a part of a metropolitan area in a developing country, Türkiye. This raises concerns, as Schneider and Kitchen [5] point out, of the applicability of such theories and practices, which have been mainly developed and practiced in Western societies. Every country certainly has its own peculiar urbanization and urban development processes and corresponding crime/incident patterns, and accordingly there are great differences and even contrasts between the spatial and socio-cultural structures of the cities in western countries and those of developing countries. In this respect, this study may be seen as an example for urban areas with similar characteristics to the study area within Türkiye, as well as in some other developing countries, such as those in the Middle East.

The selection of the study area was based on its suitability for the testing of the *new* theories on their basic premise of whether *differentiating urban spaces* have an effect on the distribution of incidents within the urban area. *Differentiation* in this paper denotes urban sections in which a group of spatially adjacent neighborhoods have experienced, and, at the time of writing, were continuing to experience three different development patterns, i.e., *planned*, *early stage gecekondu* (*squatter*) and *in-transition.* “*Gecekondu*” literally means “built overnight” and the type of *gecekondu* housing that is referred to in this paper is *early stage gecekondu,* i.e., pre-1980, is different from *late stage gecekondu* development dominated in the larger metropolises since then. The neighborhoods that comprise the basis for the *mezo* level spatial resolution concerning the study area (*R*) are Yükseltepe, Şehit Kubilay, Sancaktepe, Ayvalı, Etlik, Aşağı Eğlence, İncirli, Esertepe and 19 Mayıs. The sub-regions, on the other hand, are the streets, squares or vicinities of specific land uses within these neighborhoods, and comprise the *micro* level spatial resolution for *R*. Area-specific data for these neighborhoods is presented in Table 1.

Table 1. Neighborhoods of the study area

		Etlik Police Station Zone (EPSZ)		Study Area (*R*)
Neighborhoods	**Area (ha)**	**Characteristics of the neighborhood part covered in the EPSZ (3)**	**Area (ha)**	**Area (ha) of the neighborhood part covered in *R* (3)**
Yükseltepe (1)	512,61	Urban settlement+Vacant land	512,61	164,51
Şehit Kubilay (2)	283,14	“	148,55	119,94
Sancaktepe (1)	93,68	“	93,68	91,54
Ayvalı	213,10	Urban settlement	210,08	210,08
Etlik	130,36	“	130,36	130,36
Aşağı Eğlence	85,58	“	85,58	85,58
İncirli	138,45	“	123,40	123,40
Esertepe	183,65	“	14,67	14,67
19 Mayıs	75,61	“	9,63	9,63
TOTAL	**1716,18**	**-**	**1328,56**	**949,71**

Notes: (1) The vacant land consists of agricultural fields. (2) The vacant land belongs to the Police Intelligence Department. (3) The characteristics of these neighborhood parts is all ‘urban settlements’, which consists of either a combination of *planned* and *in-transition* settlements or a combination of *squatter* and *in-transition* settlements.
Source: Adapted from [7]

The first settlement type is composed of areas that have developed as *planned* settlements, either since their establishment or having been transformed into *planned* settlements in their early stages of development. The second development pattern is found in peripheral areas, comprising *early stage gecekondu* housing, characterized by their means of land acquisition in the form of squatting on the publicly owned lands in non-market conditions, and distinguished by similar non-market conditions in their construction and use [82]. The third development pattern is found where the second type areas are being transformed into the first type settlements through Improvement Plans, i.e., *in-transition* settlements during the study period.

Therefore, in this paper, the testing of theories developed in Western countries (mainly North America and Europe) in an urban area selected from within a developing country city is based on the application of the *new ecology theories* in *differentiating* urban spaces. The key term “*differentiation”* here is not intended to imply the *nature of differentiation*, which corresponds to differences in the urban structure due to rapid urbanization in developing countries with no accompanying industrial development, and which refers to the Western urban structure, that is a result of much slower urbanization with the associated industrialization. However, as Erdoğan [7] states “it is also an accepted reality that the impacts of globalization and changing social, economic, and political systems have begun to produce similar segregated and fragmented urban spaces and societies throughout the world without distinguishing between developed and developing countries starting from their innermost central business districts (CBD) extending towards the gated communities in their suburbs.”

4. DATA AND METHODOLOGY

The loose-coupled GIS-based system is used to explore the *spatial* and *temporal* distribution of crime incidents in terms of both *general* (*global-scale*) and *localized* (*local-scale*) *properties.* In literature, *general* properties have different labels such as *global-scale, large scale* or *first order* properties of *space*. These properties measure the variation in the mean value of the point pattern [83]. They provide ideas about the general distribution and “are global because they represent the dominant pattern of distribution-where it is centered, how far it spreads out, and whether there is any orientation or direction to its dispersion.” [84]. These properties may also be explored for incident distribution in *time*. Similar to *general* properties, *localized* properties have different labels like *local-scale, small scale,* or *second order* properties of *space*. These properties measure the correlation or the *spatial interaction* (*dependence*) in the point pattern [83]; [85]. They “refer to sub-regional patterns or ‘neighborhood’ patterns within the overall distribution.” [84]. When *localized* properties of point distribution are explored for *space*, they refer to *spatial interaction;* and when they are explored for both *space* and *time* simultaneously, they refer to *space-time interaction* of the point distribution.

In this paper, the integrated analysis of crime incidents is exemplified, first through the exploration of the *spatial* distribution of incidents from a general or *global* perspective. In line with the *new ecological* view, this scale of *spatial* analysis is based on the expectation of differences in the *spatial* distribution of incidents in the study area, which is distinguished by *planned, squatter* and *in-transition* development patterns. The *spatial* distribution of incidents is explored in terms of both *quantity* and the *nature of the spatial pattern* (i.e., whether it is *random, clustered* or *regular (dispersed)*), and also in *time*. Subsequently, the basic example for the integrated analysis of incidents is on a localized or *local-scale*. Accordingly, this *local-scale* analysis provides a more detailed understanding of the point distribution under *global-scale* effects, as implied in the *place-based* theories. This scale of analysis is based on the expectation of incidents to display different *local-scale* patterns or *spatial interaction* (that is, whether the incidents are *clustered* [attract each other], or *dispersed* [repel each other] at the *local-scale*).

The loose-coupled system proposed in this study allows a demonstration of the high level of integration of analytical means when exploring the distribution of a subset of incidents against people, property, and people and property. These incidents were selected from the whole data set of 1,139 incidents known to the police in Etlik Police Station Zone in 2000. As will be explained in the next section, the number of incidents in this selected subset, i.e., the incidents that are analyzed within the system, is totally 529 and they have -500 and 29 points- different geocoding accuracies. In Table 2, descriptive measures concerning the neighbourhood and incident data are presented.

5. DESCRIPTION OF THE SYSTEM

The loose-coupled GIS-based system (Figure 2) is composed of a framework of five components, utilized by means of data exchange without a common interface among them [12]. The names of the software elements used in this study are given in parentheses below:

1. A relational database management system (RDBMS) (i.e., MS Access®);
2. Several additional document and spreadsheet software (i.e., MS Office® Applications);
3. A standard desktop GIS software (i.e., MapInfo®);
4. A statistical package that performs almost all kinds of non-spatial statistical analysis for the spatial data (i.e., SPSS®); and
5. Spatial statistics or spatial data analysis (SDA) software (i.e., CrimeStat®).

For each component of this system, alternative software may be substituted, depending on availability and this allows flexibility in the system. For example, in the first component Oracle® or IBM DB2®, in the third component ArcGIS®; in the fourth component R®, S-PLUS®, or SAS®; and in the fifth component point pattern analysis software, such as R® or GeoDa®, could be used.

The first component of the loose-coupled system (Figure 2) includes a Relational Database Model developed within an RDBMS (MS Access®) after developing the conceptual Entity-Relationship Model. This Relational Database Model has user-friendly interfaces to ensure easy, correct and complete data entry/updates. The database design enabled referential integrity for incidents involving more than one offender and/or victim, and serves for the computerized mapping (geocoding in GIS) of incidents, offenders and victims. The purpose of geocoding process is to assign tabular data to a location on the earth's surface to allow a visualization of their spatial characteristics [86]. The collection of designed interfaces out of the finalized database model, entitled the "Event Notebook Program" contains a total of 22 forms. Afterwards, the data sets prepared through the model were processed in the third and fourth components of the loose-coupled system.

The second component (Figure 2) covers a number of different document and spreadsheet software (MS Office® Applications), not only for data collection (including Records of Ankara Water and Sewage Works, Population and Building Censuses, and Data for Census Geography in tabular form), but also for such analyses and tests as the visualization of graphs, chi-square tests and *F*-tests. A data input/output exchange exists between this component and all the other components of the loose-coupled system.

The third component of the loose-coupled system (Figure 2) is a standard desktop GIS (MapInfo®) that serves not only for the geocoding and geographical visualization of background data with the crime incidents and their associated attributes, but also provides the opportunity for spatial and non-spatial analyses. In general, the background data include such GIS layers as street, district, parcel maps, thematic maps of socio-economic indicators, land-use maps, etc., which can be obtained from various sources (e.g. city information systems, census statistics). Here, while the former set of data has been obtained from the Greater Municipality of Ankara, the latter is produced through the geocoding of crime incidents with the required field observations and surveys. In this study, after revision following field surveys, the final geocoding resulted in the placing of 500 incidents within a 100 m accuracy out of 529 (94,52%) selected incidents. The remaining 29 incidents (5,48%) are placed according to their street/road/linear park addresses, the mid-points of which are assumed to be the incident places. Aside from geocoding and simple visualization, GIS also enables a visualization of the results of the attribute analysis.

The fourth component (Figure 2) covers statistical software (SPSS®) for analytical purposes. Whenever required, all the data sets either produced or processed by the other components are converted in this software to enable the drawing of further analytical results for explorative or explanatory analysis and testing.

The fifth component (Figure 2) of the loose-coupled system comprises a spatial statistical analysis tool (CrimeStat®) for the detection of crime patterns. In this tool, spatial statistical analyses can be performed at two levels: Explorative (level I) and modeling (level II), in which level I is usually a prerequisite for level II. Explorative analyses (level I) involve the determining of hotspots using clustering algorithms, computing the spatial densities such as *kernel density estimates* and analyzing interactions between the incidents by using distance analyses, namely the *K function,* or *nearest neighbor distances*. Modeling (level II) is more sophisticated and can include journey-to-crime or space-time analysis, depending on the purpose [84]. If required, the results obtained from this component can be further converted into the third component, i.e., into the GIS medium, to allow visualization and interpretation.

6. INTEGRATED SPATIAL AND/OR TEMPORAL ANALYSIS OF THE INCIDENTS

The test of the main argument behind the theories of the *new ecology of crime* involves an analysis of whether the incidents display differences in their *spatial* and *temporal* distribution among *planned*, *squatter* and *in-transition* settlements.

6.1 Global-Scale Spatial Properties of Incidents Together

One of the most illustrative integrated analyses of incidents involves the *global-scale* spatial distribution of incident points, in which the three incident types (against people, property, and people and property) are taken together.

In this analysis, a detailed assessment of the spatial pattern or density of the incident distribution is carried out to ascertain whether the incidents are evenly (or

Table 2. Comparison descriptive measures concerning the neighbourhood and incident data

Development pattern	**Neighbourhoods**	**Development Pattern Area (%)**			**Frequency (Z Scores)**			**Rate: Freq.per 10000 pop. (Z Scores)**			**Location Quotient**		
		Squatter	Planned	In Tran.	Peop.	Prop.	Pe.&Pr.	Peop.	Prop.	Pe.&Pr.	Peop.	Prop.	Pe.&Pr.
Mostly *squatter* (~3/4) and partially *in transition* (~1/4)	Yükseltepe	98,52	0,00	1,48	16 (-0,71)	0 (-1,02)	2 (-0,71)	13,10 (-0,98)	0,00 (-1,78)	1,64 (-0,54)	1,60	0,00	1,43
	Şehit Kubilay	64,69	0,00	35,31	30 (-0,11)	5 (-0,78)	2 (-0,71)	21,67 (1,30)	3,61 (-1,20)	1,44 (-0,67)	1,46	0,37	0,70
	Sancaktepe	63,31	0,00	36,69	16 (-0,71)	10 (-0,55)	3 (-0,43)	18,58 (0,48)	11,61 (0,09)	3,48 (0,76)	1,00	0,94	1,33
Sub Mean		**75,51**	**0,00**	**24,49**	**20,67 (-0,51)**	**5 (-0,78)**	**2,33 (-0,62)**	**17,78 (0,27)**	**5,07 (-0,96)**	**2,19 (-0,15)**	**1,35**	**0,44**	**1,15**
Percentage Total: (100%)					**73,81**	**17,86**	**8,33**						
Mostly *planned* (~3/4) and partially *in-transition* (~1/4)	Ayvalı	0,00	70,81	29,19	39 (0,27)	55 (1,57)	8 (0,95)	12,11 (-1,25)	17,08 (0,98)	2,48 (0,06)	0,69	1,46	1,01
	Etlik	0,00	80,29	19,71	64 (1,34)	27 (0,25)	6 (0,40)	17,28 (0,13)	7,29 (-0,61)	1,62 (-0,55)	1,19	0,76	0,80
	Aşağı Eğlence	0,00	100,00	0,00	56 (1,00)	53 (1,47)	11 (1,78)	18,54 (0,47)	17,55 (1,05)	3,64 (0,87)	0,84	1,20	1,18
	İncirli	0,00	49,76	50,24	61 (1,21)	33 (0,53)	7 (0,68)	22,10 (1,42)	11,96 (0,15)	2,54 (0,10)	1,09	0,89	0,89
	Esertepe	0,00	62,03	37,97	6 (-1,13)	6 (-0,74)	2 (-0,71)	14,29 (-0,67)	14,29 (0,52)	4,76 (1,66)	0,77	1,16	1,84
	19 Mayıs	0,00	100,00	0,00	5 (-1,17)	6 (-0,74)	0 (1,26)	13,33 (-0,92)	16,00 (0,80)	0,00 (-1,69)	0,82	1,48	0,00
Sub Mean		**0,00**	**77,15**	**22,85**	**38,5 (0,25) 55***	**30 (0,39) 42***	**5,67 (0,73) 8***	**16,28 (-0,14)**	**14,03 (0,48)**	**2,51 (0,08)**	**0,9**	**1,16**	**0,95**
Percentage Total: (100%)					**51,91**	**40,45**	**7,64**						
Total					293	195	41						
Mean					32,56 40,28*	21,67 26,14*	4,56 5,57*	16,78	11,04	2,40			
Standard deviation					23,47	21,28	3,61	3,75	6,19	1,42			
Standard error					7,82	7,09	1,20	1,25	2,06	0,47			
95%Confidence Interval based on *t* distribution					14,51-50,60	5,31-38,03	1,78-7,33	13,90-19,66	6,29-15,80	1,31-3,49			
Overall Total						529							
Overall Mean									30,22				

Notes: (*) Mean excludes the two extreme neighbourhoods of Esertepe and 19 Mayıs because of their relatively much smaller areal proportions in R. Source: [7]

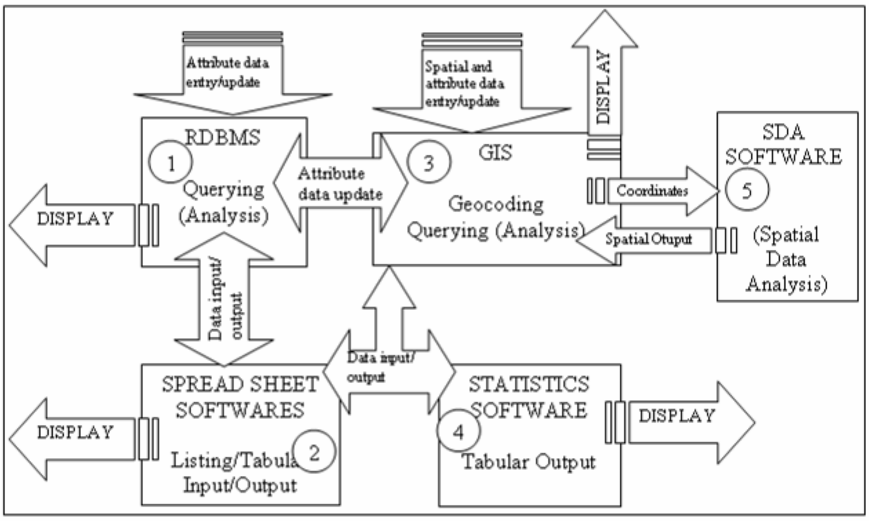

Figure 2. Developed loose-coupled GIS-based system showing the main relationships between the components *Source:* [7]

randomly) distributed in *space*. To this end, three types of analyses are carried out: a quadrat method tested by chi-square to reveal whether the incident point pattern displays clustering; a kernel estimation, and a one-way ANOVA on its results to reveal whether the incident densities are different in the three development patterns; and pairwise multiple comparison tests to assess which development pattern differs from another in terms of incident densities.

As explained previously, *global-scale* properties display the extent to which the point pattern of the overall incidents deviate from spatial randomness [2]. The exploration techniques for the point pattern at this scale cover mainly the analysis of the measure of variation in the expected value (mean) of the spatial process [83], denoted by λ.

The quadrat method, which is a *global-scale* point pattern analysis, is simply based on finding an intensity measure by summarizing the spatial pattern through a partitioning of the study area (*R*) into equal grids or quadrats. This is one of the most basic methods of converting discrete point data into a continuous density surface representation found by means of a frequency count in each quadrat, divided by its area [83].

In the study area, the quadrat method was carried out to determine whether the general trend in the mean value of the incidents distribution followed a homogeneous Poisson distribution or complete spatial randomness (CSR). The CSR or Poisson process assumes an equal λ (mean) all over the *R*; furthermore, it also assumes that the s^2 (variance) is equal to λ [87]. Therefore, the test of whether the point process is random and $\lambda = s^2$ and λ is the same all over the *R,* is the same as stating the null hypothesis as $\lambda_{squatter} = \lambda_{in-transition} = \lambda_{planned}$ meaning there is no significant difference in the spatial distribution of incidents with respect to different urban development patterns. This assessment is made by utilizing the quadrat method to find whether the observed point distribution is regular, clustered or random [83]. In the analysis, a chi-square test statistic computed from a variance-mean ratio (VMR) is utilized.

An issue that needs an elaboration in using the quadrat method is the size of the quadrat [88]. There are different methods to obtain the optimal quadrat size to be overlaid on the study area concerned. On the basis of previous studies of Greig-Smith [89], Taylor [90] and Griffith and Amrhein [91], Wong and Lee [88] gives a standard formula for the quadrat size as "*2A/r* where *A* is the area of the study area, and *r* is the number of points in the distribution.". This computation results in a quadrat width of approximately 200 m for 500 incidents in the study area of 949,71 ha (Table 1).

In addition to this method, it is also worth to mention here the further suggestions made by researchers, among whom Greig-Smith [92] is the same. This time they consider both the mean count per quadrat and the percentage of zero count quadrats [93]. Some of these proposals are summarized in Table 3.

In line with this approach, which at the same time include the result of the standard formula, different size quadrats were tested in the GIS (third) component (Figure 2) of the loose-coupled system in order to achieve the suggested mean and percentage of zero count quadrats as much as possible in *R*. Accordingly, by performing spatial queries with the incident data, which were previously prepared in the RDBMS (first) component of the system and then transferred to and geocoded in the GIS (third) component (Figure 2), the distribution of the 500 incidents in quadrats of 100 m, 200 m, 300 m and 400 m width yielded different results, in which the mean density value increased as the size of grid increased (Table 4 and Figure 3).

Among these results, with the standard formula [88] given above the sought mean count per quadrat but not the percentage of zero count quadrats is found according to Barlett's ([94] in [93]) proposal (Tables 3 and 4). Therefore, in a bid to improve the reliability of the test results, testing was applied to all of the different sized quadrats designed for *R*.

The clustering is found by the use of index of dispersion (VMR) and the index of cluster size (1 subtracted from the index of dispersion) and they were assessed by the use of chi-square test in the spreadsheet (second) component of the loose-coupled system. The significant clustering in all different scales of grid units (p<0.0005), where the mean intensity in *R* was not constant, suggested that the *spatial* distribution of the incidents have significantly differentiating intensities within the study area, which is characterized by different

Table 3. Proposals on finding optimum quadrat size

Mean count per quadrat	**Percentage of quadrats with zero counts**	**Researchers**
1.6	20%	Barlett, 1948
1.0	40%	Greig-Smith, 1964
4.0	2%	Curtis and McIntosh, 1950

Source: [7], based on explanations of Upton and Fingleton [93]

Table 4. Different size spatial quadrats designed for the study area and their descriptive figures

Size of one side of the quadrats	**Number of quadrats (N)**	**Number of empty quadrats**	**Mean count per quadrat**	**Percentage of quadrats with zero counts**
100 m	1101	793	0.45	72%
200 m	312	144	1.60	46%
300 m	144	45	3.47	31%
400 m	90	25	5.56	28%

Source: [7]

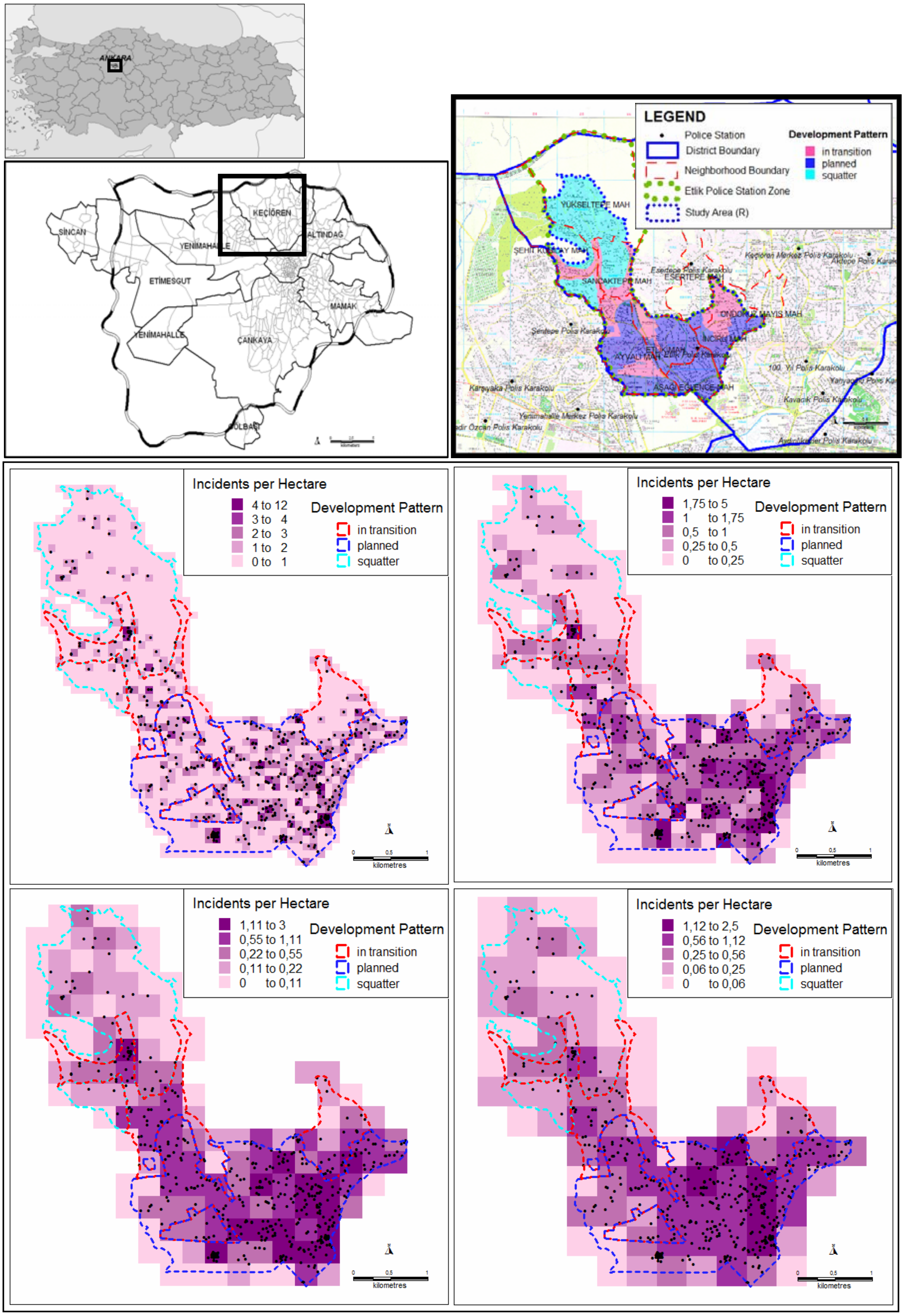

Figure 3. Study area (*R*) and the results of the Quadrat Method with units of incidents per hectare
Source: Adapted from [7] and based on Ankara City Plan, 2001-2002; Ankara Water and Sewage Works Land Information System, 2004.

development patterns. The results of the quadrat method were mapped in the GIS component of the system with density classes obtained through natural break algorithms (Figure 3). As hypothesized, these results displayed a higher number of clusters and higher densities in the southern neighborhoods, where all the *planned* development took place (3/4 *planned* and 1/4 *in-transition*); as opposed to fewer clusters and relatively regular and lower densities in the northern neighborhoods where all the *early stage gecekondu* (*squatter*) development took place (3/4 *squatter* and 1/4 *in-transition*).

At this point, it is essential to mention about the resolutions for *edge* or *boundary* effect ([91] in [88]), which is the result of irregular form of the study area. This bias is the outcome of the assumption that the study area is a continuous and regular rectangular or circular surface. Certainly there are incidents that take place in the other administrative boundaries around *R*, the spatial analysis method used in the quadrat method is based on the regular grids, which is independent of the those boundaries and thus is still robust [95] despite the form of the study area.

Kernel estimation and a one-way ANOVA on the results of this estimation provide another example for the integrated analysis of incidents, in testing whether the incident densities are different in the three development patterns.

The kernel estimation, which is another *global-scale* point pattern analysis, improves upon the quadrat method to take into account the relative locations of events, and is also known as kernel smoothing, in that it provides a smoother continuous density map [96]. This explorative analysis still has shortcomings in the appropriate bandwidth size (τ) selection; that is, the radius of the circular 3D floating function in which the smoothing is done [83]. To overcome this fixed bandwidth problem and to improve the kernel estimation, where λ is assumed to be constant all over the study area [87], an *adaptive* kernel estimation obtained from different values of τ at each observed event in study area has been devised [83] using the variable density λ.

In performing the *adaptive* kernel estimation in the study area, the *spatial* statistics/SDA (fifth) component (Figure 2) allowed different trials with different bandwidths and on two different functions (normal and quartic) for the incidents belonging to the set of 500 points. The results were mapped in the GIS (third) component, whereby the densities were classified through the natural break algorithm of the software. This visualization enabled an increased ability to differentiate among the resultant outputs. The intensity estimate result, which was found to be the most suitable for the purpose of capturing the *global* trend in the spatial process, was chosen for further interpretation and analyses.

The edge effects (biases) of the kernel estimation that occur in the form of spikes at the edge of the study area, which is defined as the rectangular area drawn by the lower left and upper right coordinates of the *R,* and thus outside of *R,* were eliminated within the GIS component (Figure 2) by trimming the reference grid outside of *R* [84].

In order to compare the selected kernel estimation results with respect to the three development patterns in *R*, the kernel results found within the spatial statistics/SDA component of the system and mapped in the GIS component were transferred into the statistical software (fourth) component. This transfer was performed such that each kernel pixel (reference grid) value displaying the density in space became a row (case) in the statistical software. Prior to the transfer process, a variable was added into the kernel density estimation pixels GIS layer, i.e., into the reference grids displaying the incident densities. This variable was populated with the “Development Pattern” variable in the relevant region GIS layer by means of a “within” spatial analysis, such that the centroids of the pixels (reference girds) lie within the entities of the reference region layer.

After the addition of this variable into the kernel estimation data it became possible to perform a one-way ANOVA on the data within the fourth component, as stated above. This analysis was based on an equality of variances. For this purpose, a concurrent Levene test was also applied, which gave a result of $p<0.0005$. As a result, instead of an *F* test, robust tests of equality of means (Welch and Brown-Forsythe) were preferred, and it was found that they were both significant ($p<0.0005$). That is, the analysis between the dependent variable of densities computed for each kernel grid were computed for three incident types together, and the independent variable of different development patterns was significant. In line with this, differences among the mean densities in the different development patterns were assessed through a pairwise multiple comparison test, which suggested significantly ($p\leq0.05$) different mean densities among all three development patterns.

6.2 Global-Scale Spatial Properties of Incident Types and Global-Scale Spatial Properties of Incidents Together in Time

Examples that include further complications within the integrated analyses in the loose-coupled system involve an increased number of these analyses, applying them for each of the three incident types or for all types of incidents together in different periods, such as with respect to months.

In the example, where the kernel estimation and a one-way ANOVA are carried out on the results, assessing the differences between the three development patterns for each of the three incident types, the parameters of the kernel were required to be the same with respect to the different incident types. Therefore, a quartic function with a *fixed* bandwidth kernel estimation was carried out for each of the three point distributions. The bandwidth choice was made following a trial-error process that resulted in a 500 m bandwidth, which allowed a common detail or variation in visualizing the *global* trends for each data set. These trials were obtained by the spatial statistics/SDA (fifth) component, and were mapped in the GIS (third) component. Afterwards, the data were transferred into the statistical software (fourth) component of the system (Figure 2) in such a way that each kernel pixel (reference grid) value displaying the density in space became a row (case) in a similar way to the previous analysis explained earlier. Once more, one-way ANOVA analysis, at this stage, for each of the incident types this analysis became possible. Therefore, "robust tests of equality of means" (Welch and Brown-Forsythe), and pairwise multiple comparison tests (Tamhane, Dunnett T3, Games-Howell, Dunnett C through the fourth component) (Figure 2) were also performed among the spatial density units of each incident type, with respect to different development patterns (obtained through the third and fifth components). The former set of tests indicated for each of the incident types revealed mean densities that are significantly ($p<0.0005$) less in the northern (mostly *squatter*) settlements, and are complementarily high in the southern (mostly *planned*) settlements. Moreover, the latter set of tests, which were performed for point pattern densities to find differences in the distribution of each incident type between each pair of development patterns, suggested statistically significant differences between all pairs of the three development patterns for each of the three incident types ($p<0.05$).

Similarly, in the example, in which the *time* dimension is added into the comparison of *spatial* distribution of incident types together, again the same 500 m *fixed* bandwidth kernel estimation was utilized (Figure 4). However, this time, instead of applying a one-way ANOVA (in the fourth component) on the kernel results for each of the three incident types (obtained by the fifth and third components), one-way repeated measures ANOVA multivariate tests were applied to each of the monthly distributions of incident types together (obtained by the same respective components). Moreover, since the number of pairwise comparisons increased from 6 to 66, instead of the previous pairwise multiple comparison tests, this time, paired t tests with a Bonferroni adjustment were preferred for the differences between monthly distributions (Figure 4) in the fourth (statistical software) component (Figure 2). The results of these analyses suggested the rejection of the null hypothesis stating that there is no significant difference in the spatial distribution of the incidents with respect to months of the year and different development patterns. In other words, the *global-scale* spatial distribution of incidents in *time* (monthly periods) suggested that the *planned* areas provide more opportunities for the repetition of incidents.

The edge effects in these monthly kernel estimations were resolved in the same manner as in the previous kernel analysis, i.e., by trimming the reference grid outside of R [84]. Therefore, these estimations of kernel are robust as in the previous one.

6.3 Local-Scale Properties of Incidents Together, Incident Types and Commitment Types

The final example within the loose-coupled system is based on an exploration and comparison of *local-scale* properties of incidents together, and when they are differentiated with respect to their types and with respect to their most frequent commitment types under conditions of *global* effects. That is, the assessment of these properties reveals whether these sets of incident points *interact* in urban *space,* or if there are any *spatial dependences* [85] among them. The most frequent commitment types against people are aggravated battery (AB), simple battery (SB) and domestic violence (DV); and against property, residential burglary (RB), commercial burglary/theft (CB/T), and theft from auto (TFA).

In order to assess these *local-scale* differences, a K-order nearest neighbor index analysis (15-order NNI), which was tested for its first order through a z test (Clark-Evans) was utilized (Figure 5). If the NNI, which is found by dividing the observed mean of the nearest neighbor distance (NND) of the incident points by their expected (mean) NND under complete spatial randomness (CSR), has a value of 1, then it represents the equality of the observed mean NND to the expected NND under spatial randomness (mean random NND). The observed mean NND is found by adding the distances between each point and its nearest neighbor, and dividing it by the number of points [84].

For the incidents in general, with direct measurement the respective observed and expected nearest neighbor distances were found to be 56.71 m and 68.91 m, resulting in an NNI of 0.8229 and thus suggested *local-scale* clustering, i.e., *spatial interaction*. In the significance testing of the first order NNIs, the standard error and the z test statistic were 1.61 m and -7.5763, respectively; and the test statistic z was significant at $p=0.0001$, both for the one and two tail tests. The order of significant *local-scale* clustering (in terms of NNI) for the two incident types, which displayed the highest clustering for incidents against property, and moderate clustering for incidents against people, was also reflected in their respective commitment types.

Similar to kernel estimations, these analyses were carried out within the spatial statistics/SDA (fifth) component based on the coordinate information of the incidents together, their types and commitment types that were extracted from the GIS (third) component; and the results were visualized (Figure 5) in the spreadsheet (second) component for further interpretation (Figure 2).

With further analyses, significant *local-scale* differences were found to exist among each pair of incident types. Similarly, as for commitment types, *local-scale* differences were found to be among all the pairs of such types, except for pairings of theft from auto-residential burglary (TFA-RB), theft from auto-domestic violence (TFA-DV), and residential burglary-domestic violence (RB-DV). To analyze these; i.e., to test whether the differences in the means of the nearest neighbor indexes up to the 15^{th} order are significant, a one-way repeated measures ANOVA was carried out. Subsequently, for controlling from where the real difference(s) come(s) from among the pairs of incidents within each grouping, a paired t test based on a Bonferroni adjustment was carried out within the statistical software (fourth) component (Figure 2).

As for the edge effect bias in the K-order NNI analysis, its order was limited 15 ([97] in [84]). Moreover, the edge corrections made for both assuming the study area as rectangular and circular [84] were carried out for 500 points. The comparison of relative clustering of the incidents in general, or their types and commitment types in terms of the results of the K-order NNIs with no edge corrections with the ones that edge correction was made suggested almost no differences in between, implying the robustness of the spatial analysis through K-order NNI.

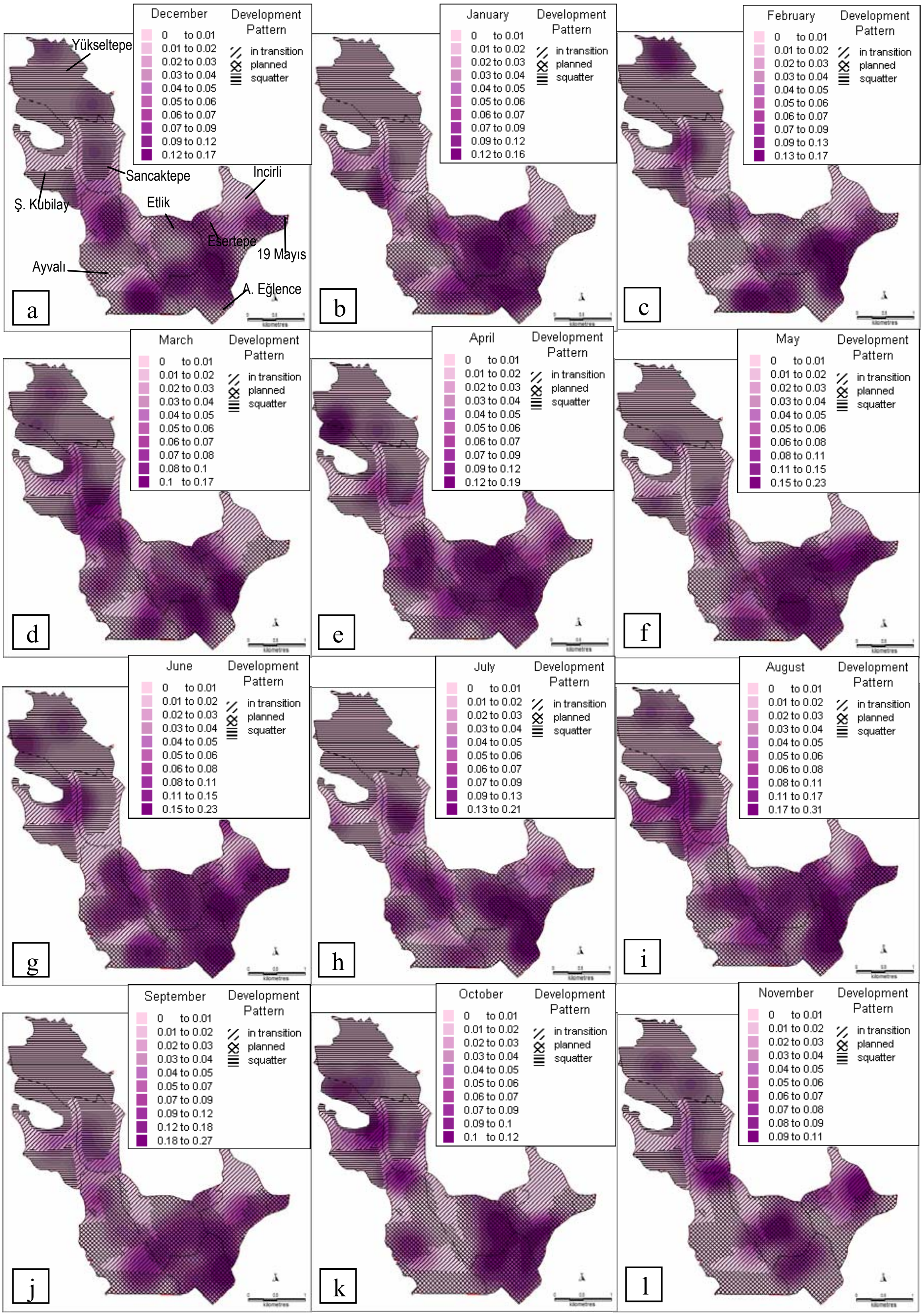

Figure 4. Results of the *fixed bandwidth (500 m) Kernel Estimation*

Notes: The incidents belonging to the set of geocoding for 500 points with units of incidents per hectare with respect to months of the year (year 2000)

Source: Adapted from [7]

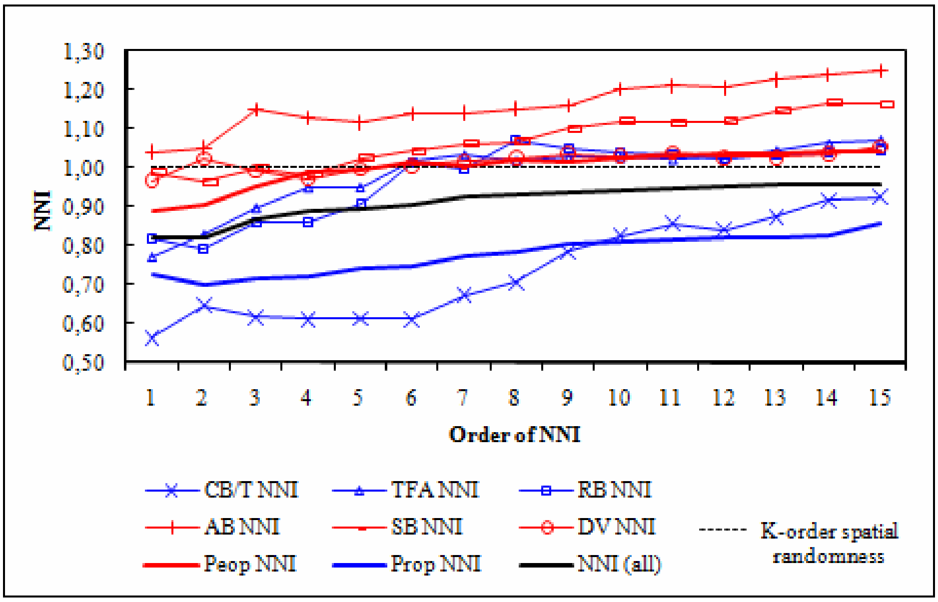

Figure 5. Plots of NNI values up to 15th order versus their orders for the three types of incidents together, for each types, and for their most frequent commitment components with no edge correction
Notes: The incidents belonging to the set of geocoding for 500 points is used in this analysis.
Source: Adapted from [7]

7. CONCLUSIONS

The purpose of this study was to develop a loose-coupled GIS-based system that could serve for the integrated analyses and tests of incidents and related data in an empirical testing of the main premise of *new ecology theories*. The system, due to its different components, allowed them to be performed according to nature and requirements of the data and thus, it enabled a flexible and comparative environment for different visualizations and testing of the data.

In testing the *place-based* theories, the differences in the distribution of *place* (in terms of both *space* and *time*) related incidents (i.e., against people, property, and people and property) are compared in a case area at a mezo-micro (intra-urban) ecological level. Since these theories argue that some places are more attractive or provide more opportunities for criminal activity, the distributions of incidents were analyzed in a selected area that covers three different development patterns, being *planned*, (*early stage gecekondu*) *squatter* and *in-transition* settlements.

This paper supports the *new* theories, as the incidents displayed clustering at both *global* and *local scales.* The clustering at the *local-scale* implied *spatial interaction* or *dependence* among incident points. In line with this, incidents in aggregate concentrated mostly in the *planned*; less in *in-transition* areas, and least in the *squatter* areas.

The high level of concentration and the characteristics of the clustering areas in the *planned* settlements, which are stated below, provide validation of the *new ecological theories.* In line with these theories, (*Routine Activities, Rational Choice, Crime Pattern*) crime incidents displayed a clustered distribution. Unlike in the *squatter* areas, it is in *planned* developments, and then *in-transition* areas that there are more *opportunities* for incident occurrences. These *opportunities* in the sub-regions of the neighborhoods are effective in the clustering of a higher number of incidents in smaller areas, i.e., in creating hotspots, both having similar and/or dissimilar environmental features for incident concentration. However, a general statement about the structure of hotspots can be that they contain one or more of the following characteristics, as suggested by the *new ecology* studies:

- High accessibility;
- Point/on route of public transportation;
- Mostly mixed land use, occasionally commercial/service;
- Relatively crowded, displaying a level of CBD properties; and
- Mostly having open areas, such as parks, in the vicinity.

On the one hand, the *planned* areas, with more heterogeneous and mixed land uses and higher densities of population and places for different *Routine Activities* of targets, have an increased likelihood of occurrence of the three conditions for incidents (motivated offender, suitable target and lack of crime suppressor) [34] in these places. The low level of neighborhood relations, the high concentration of people of mixed origin and the low sense of community also contribute to this likelihood. Therefore, according to this theory, *planned* settlements are vulnerable for incident occurrences, mainly in *routine activity spaces* and *times,* such as residences, diverse commercial and service workplaces, and places containing different kinds of transportation facilities.

On the other hand, the *planned* settlements have more suitable *environmental* conditions for a rational offender. In other words, as suggested by the *Rational Choice Theory*, when an offender would commit an incident (s)he thinks that the *opportunities* offered by the *planned* settlements have more benefits (more rewards) and less costs and risks when compared to other types of settlements. For example, the *planned* neighborhoods attract offenders, due to the higher number of *opportunistic* targets of commercial and business workplaces, and of residential and market areas where more affluent people live/use, and more automobiles. Furthermore, *planned* settlements offer more supportive *environmental* conditions for the easy escape of offenders from the incident scene, given their highly accessible, predictable roads, crowded places/streets and the indifference to strangers.

In addition to the physical (spatial) means or *opportunities* offered by the *planned* settlements, their social contexts also make them more vulnerable for the occurrence of incidents. For instance, the heterogeneous social composition, and the high likelihood of people who are foreign to each other at one place at any time increases the likelihood of an occurrence of an incidence. As an example, an incident against people or against people and property can take place due to some minor traffic or car parking quarrel among two drivers, even though they have no planned intention to commit a crime.

In general, it can be suggested that the rapid urbanization process characterized by migration from the rural areas did not cause directly an increase in crime incidents, at least in its *early stages*. Interestingly, this is still the case as far as the study area and period (2000) is concerned. What happened, in fact, is that with the urbanization process the people of rural origin regenerated their rural life styles and neighborhood relations in the urban peripheries, creating peaceful and socially supportive communities similar to those of their rural origins. In the study area in 2000, these settlements were found to be relatively more secure places in terms of crime incidents due to their social and physical characteristics.

Therefore, in the *early stage gecekondu* settlements, with their mostly residential characteristics and homogenous physical and social environment, the number and rate of crime incidents is not high, and certainly less than in *planned* and *in-transition* neighborhoods. Even though people living in these *squatter* areas are economically worse off −at least for the study period as the majority did not benefit from the rent of *gecekondu* transformation−, the sense of community they experience and their feeling of belonging to a place and being a part of the community likely prevents them from exposure to high incident rates, despite some fragmentations between the different ethnic/religious groups. The second reason for the low incident rates may be because such areas do not provide *opportunities* for incidents. Since there are higher frequencies and rates of incidents in *planned* settlements than in *squatter* areas, the hypothesis that the urban functions and urban life style, which generate *environmental* conditions for crime incidents, is confirmed.

Also, in line with the *new ecology*, incidents against people and against property are predominant respectively in the *squatter* and *planned* areas. It may be stated that in the areas such as *early stage gecekondu* (*squatter*) settlements, where physical and socio-economical *opportunities* do not encourage incidents against property, incidents against people are more likely to take place; while the reverse can be said to be true for *planned* settlements.

Moreover, incidents against property displayed the highest level of *spatial clustering* at a *global-scale*; and particularly *spatial interaction* (mainly for commercial burglaries/thefts) at a *local-scale.* Complementarily, the relatively homogenous *global-scale* spatial distribution of incidents against people is accompanied by their *non-local scale spatial interaction*.

The lower level of clustering of incidents against people in the study area reflects the relatively homogenous distributional characteristic of this form of incident. In addition to the effect of the homogeneous urban structure on the relatively random (e.g., the relatively clustered distribution of commercial burglaries/thefts compared to relatively random distribution of residential burglaries) distribution of incidents, other contributing factors should also be considered. It is likely that while some incidents are distributed more evenly in *space* due to their lower relevance to *environmental* settings (such as domestic violence); for others, such a pattern is due to the relatively even distribution of targets in *space* (such as residential burglaries and auto thefts).

The finding on the *spatial* distribution in *time* (monthly periods) suggested that the *planned* areas provide more opportunities for the repetition of incidents.

All these results supporting the *new ecology* theories were obtained through integrated analyses within the developed loose-coupled GIS-based system; and as such, this paper has demonstrated that the system is an effective tool in the integrated analysis of crime incidents, particularly at a mezo-micro (intra-urban) ecological level. It has enabled complicated quantitative analyses of incidents and related data from a variety of sources and in different formats through the input-output of data among its different components.

In this respect, the possibility of the maximum utilization of the analytical capabilities in each of the different components in the designed system is indicated. The effectiveness of such an integrated approach in the spatial and/or temporal analysis of incident data is exemplified, unlike an analysis of incident data within each of the components separately. In such a case, the loosely coupled components comprise a relational database management system, document and spreadsheet software, a standard desktop GIS, statistical software and a spatial statistics/spatial data analysis tool in turn.

With this paper, it has also become possible to indicate that the loose-coupling promotes creativity and a dynamic medium for its users. As a final remark, it could be stated that in achieving concrete *place-based* strategies and policy implications for the prevention/reduction of criminal activities in urban areas, such a system enables coordinated and cooperative interdisciplinary teamwork for criminologists, crime analysts, geographers, urban planners, sociologists and policemen.

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