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Crime Mapping for the Purpose of Policing in Slovenia - Recent Developments

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The development and use of Geographic Information Systems (GIS) as a method of crime analysis is a relatively new analytical method, where geographical maps present an integral part of the crime analysis. A review of previous studies on crime mapping in Slovenia confirmed that GIS enables fast, efficient and with the analytical methods used, supported decision making about the problem of crime in the studied environment. The aim of this study is to present the use of GIS as a tool for crime mapping in Slovenia for the purpose of policing and criminal investigation. In the present paper, the use of GIS for crime analysis in two studies are presented: 1) property crime analysis for year 2010 in the two largest Slovenian cities, Ljubljana and Maribor, using crime hot spot analysis; and, 2) the project Krimistat.si, where police statistics database and Google maps application are combined in order to prepare a web-application that would be user friendly and possibly accessible to everyone that uses the internet. The results of the property crime analysis in Ljubljana and Maribor in 2010 using crime mapping show similar situations as in surveys conducted in 2003 and 2004. The highest density of property crime is in the city centre of both cities and expands alongside the main roads to the outskirts of the city, thus the increase of the property crime is detected also in the shopping and entertainment areas. Finally, the encountered advantages and obstacles are discussed. The Krimistat.si is a new project that enables that public is informed about the distribution of reported crime occurrences. However, there is a legal obstacle related to the protection of personal data that prevents the public use of this web-application. Despite that, the web-application and other crime mapping analysis represent a progress in this field, because they follow the contemporary police trends in crime analysis. This is the beginning of research in this field with the use of contemporary analytical tools and techniques in Slovenia.

Keywords: crime mapping, crime analysis, criminal investigations, project Krimistat.si, Slovenia

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1 Introduction

In our contemporary society of numerous chances and hazards, known since the eighties as the 'risk society' (Beck, 1992), security has become an increasingly appreciated as well as a much sought-after good. In parallel with social development and progress, new forms of 'threats' to individuals' security are developing, such as cyber-crime, environmental crime, increasingly sophisticated bank cards thefts, etc. Due to this, new forms and methods of providing security are developing. The police in western societies are trying to get closer to people (Weber & Bowling, 2012) with the provision of pieces of information they possess about crime and public disorder. They try to inform people – enable the access to information about any non-secure sites in and around cities – so that residents of the city as well as visitors, have an opportunity to check and be informed about possible occurrences at places they want to visit or where they actually live. When people are better informed about dangerous areas, they can better take responsibility for their own security. Some examples are the projects SpotCrime.com in Baltimore and Trulia.com in San Francisco, which later spread to New York and Denver. A similar application was developed in Slovenia in the framework of the project Krimistat.si in collaboration between the Faculty of Electrical Engineering and Computer Science, University of Maribor, and the Faculty of Criminal Justice and Security, University of Maribor, which is presented in detail in the present paper.

Crime and criminal behaviour analyses (data collection, search of links and connections, sample analyses, etc.)

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have been a subject of human interest for quite some time. At the present, crime analysis as a discipline includes the detailed development of the committed crime, and Boba Santos (2013: 6) defines crime analysis as a systematic process in which the data on crime and other crime-related factors are collected and stored for longer time periods. Contemporary crime analysis, having once relied on one's own observations and memories of crime incidents, uses a complex computer system, which performs various analytical techniques. These range from simple ranking of sample analysis to complex statistical data analysis and crime mapping with the aim of identifying crime hotspots or crime areas.

Criminology and criminal investigation present important areas of research in criminal justice education, thus the study of forms of crime, trends and criminal behaviour patterns also includes the elements of crime analyses. At the Faculty of Criminal Justice and Security, University of Maribor, crime analysis is an integral part of undergraduate and postgraduate study programs. Since 2011, special emphasis has been given to the analysis and presentation of data on crime and public disorder by using Geographic Information Systems (hereafter GIS) (crime mapping) as a component of crime analysis. Within the framework of the basic research project Environmental crime - criminological, victimological, crime-prevention, psychological and legal aspects (Meško, Sotlar, & Eman, 2012) at the Faculty of Criminal Justice and Security GIS laboratory, was established and computer laboratory was equipped with the ArcGIS software. In cooperation with the Slovenian police, access was granted to their geospatial data on crime, and the first analysis of geographical distribution of reported environmental crime in Slovenia was conducted and possible solutions together with crime maps were presented to police chiefs (Eman, Meško, & Ivančič, 2012). In this way the foundation for developing and teaching of GIS use in studies of security issues, particularly crime mapping and crime analysis methods, was assured. For criminal justice students, the mapping of crime and public disorder presents a new and far from by now known aspects and methods of the security issues studies and analyses. The use of GIS and a spatial analysis of crime and disorder are closely related to the previously mentioned criminal analysis and also to situational crime-prevention.

The aim of this paper is to present the use of GIS as a tool for the mapping of crime in Slovenia for use in policing and especially problem oriented policing, including criminal investigation. The development and use of the GIS as a method of crime analysis is quite interesting, and is a relatively new and increasingly utilized analytical method. The geographical maps, showing the distribution of crime in a given environment, are an integral part of crime analysis, which plays an extremely important role in the crime management. Its use and applicability is presented as an example of property crime analysis for year 2010 in the two largest Slovenian cities, Ljubljana and Maribor, using crime hot spot analysis. In the second part of the paper, the other possibility for the use of GIS for crime analysis is presented using the example of the project Krimistat.si. In this project, the police statistics database and Google maps application were combined in order to prepare a web-application that would be user friendly and possibly accessible to anyone that uses the internet. According to the development of crime mapping in the past decades, the afore mentioned projects underscore the development of crime mapping analysis of the police in western countries. In combination with a web-application Google maps we managed to create a user-friendly web-application Krimistat.si, which enables very detailed graphical presentation of crime data. We could describe it as a very attractive matter, that is possible to use for the purpose of police analysis, but on the other hand in case of public use things become little more complicated. Finally, advantages and obstacles that were encountered are discussed. In conclusion, the authors present possible solutions for the use of project results that would fulfil the necessary requirement to be in the national and European Union legal frameworks and, at the same time, remain accessible and usable for all citizens of and visitors to Slovenia.

2 The use of Geographic Information Systems in crime analytics

2.1 The development and use of the crime mapping as a method of crime analysis

Although crime mapping has an extremely important role to play in contemporary crime analysis, it was actually brought into practice and became an integral part of analysis a mere two decades ago (Boba Santos, 2013: 9). The first study of the spatial distribution of deviance reaches back to the beginning of the 19th Century, and until today crime mapping has developed slowly and gradually. The majority of researchers have dealt with the interpretation of the spatial distribution of crime occurrences and with the spatial distribution of offenders' residence (Boba Santos, 2013; Pečar, 1964). The first studies of spatial and temporal distribution of events and its scientifically oriented attempts at statistical presentations are traced back to the first half of the 19th Century (Pease & Laycock, 1996). At the time, researchers, who belonged to the so-called 'cartographic school of criminology', examined the crime rates in certain areas (regions) and the existence of possible links to social factors such as socio-economic status (Groff & La Vigme, 2002). In 1829, folklorist and geographer Adriano Balbi, and lawyer André Michael Guerry created

the first crime map. They used crime statistics for the period from 1825 to 1827 and demographic data from the population census, and analyzed property crime and all forms of crimes against human health and life in France; the analysis also included level of education. They discovered that areas with high property crime rates have low numbers of attacks on humans and that larger numbers of educated people lived in areas with more property crime (Weisburd & McEven, 1997). During the same period, astronomer and statistician Adolpho Quetelet, using a map analyzed the correlations between crime and transport trade routes, educational level, and ethnic and cultural variations (Boba Santos, 2013: 10).

In France, Guerry and Quetelet studied the concentration of crime in different parts of the city. They were interested in crime rates and social living conditions that could have an impact on the occurrence of crime (Meško, 2010; Pease & Laycock, 1996; Urh, 2007). In a study in Sheffield, United Kingdom, Bottoms (1994) discovered that the environments where the crime rates are the highest, differ significantly from the environments where the perpetrators actually live. Based on these findings, he assumed that the perpetrators migrate daily, but again, not so very far away from their home. The majority of property crime was committed within a radius of several kilometres from the offender's home (Clarke & Eck, 2008). These findings had an important impact on the development of environmental criminology and prevention, on the methods of the residential buildings construction, and the development of security services and other crime prevention techniques (mostly situational crime-prevention). Likewise, Roncek and Maier (1991) studied crime in the city and discovered links between crime and public order violations and the number of restaurants in Cleveland, Ohio. In Sweden, Wikström (1991) found a link between the rate of burglaries and the locations of wealthy households, thus confirming the thesis that the perpetrators of crime offenses generally plan their acts. Skogan (1990) found out that disorder in certain environments is relatively strongly connected with poverty, security and national diversity of the population of that area.

After Philips (1972) stressed the existence of numerous studies that at first had used only crime mapping, but later they added GIS and both methods combined into a tool with a wide range of usability, Harries (1999) collected studies conducted since 1830 and divided them into three main schools: 1) the cartographic or geographic school; 2) the typological school; and 3) the social ecological school (Klinkon & Meško, 2005: 134). Harries (1999) assumed that the first computerized crime mapping using crime analysis was carried out in the mid-1960s of the last Century. For approximately 20 years the use of GIS developed and was widely used in police organisations. Klinkon and Meško (2005: 135) state that the rapid development of information technology allowed the use of increasingly complex and intensive computing techniques, which presented the basis for a quantitative spatial analysis of crime.

In the United States of America, the use of crime mapping began somewhat later than in Europe. In the early 20th Century, the Chicago school began to combine qualitative and quantitative analyses of events in the study of problematic areas, which meant great progress in the study of spatial events. The first actual spatial crime analysis was carried out in the 1920s and 30s of the 20th Century in Chicago by the so-called urban sociologists (Shaw & McKay, 1942). In this study, crime maps were designed and researchers attempted to find links between crime and delinquency, and social factors such as social disorganisation and poverty. Especially interesting is the fact that all crime maps were made by hand. In the following decades, the interest of sociologists and other researchers for crime mapping continued.

Park, Burgess, and McKenzie (1925) took into account the gender, age, and home address of the offender, and the type of crime. Thereupon Trasher (1927) studied the behaviour and activities of street gangs, and while analyzing the scope of their formation, found out that gangs occur where the residential areas begin to move away from commercial and industrial areas. Shaw and McKay (1942), analyzing the constant repetition of individual criminal events in neighbourhoods, discovered a negative correlation between the incidence of crime and the distance of the business district in the city centre. Curry and Spergel (1992), representatives of the New Chicago School, analysed the relationship between poverty, lack of social control, and crime. Tita, Enberg, and Cohen (1999) as well, discovered that street gangs appear first in poorer areas, where a lack of social control is most often found. Industrialization had a significant impact on the design of urban settlements, whose number was increasing, especially in the sleeping areas of the city. Because a large concentration of people occurred at one place, the possibility and risk of certain events increased as well. In order to easier study events in the selected areas, Burgess and Park (McKenzie, Park, & Burgess, 1967) developed a model of concentric circles, typical for urbanization and the settlements growth.

In the beginning, interpretation and analysis of geographic methods employed remained simple and unpretentious, because the researchers focused more on sociological factors. It was not until the end of the 1960s, when in spatial analyses larger computer systems and unsophisticated visualization methods have been used (Weisburd & McEwen, 1997). Between 1960 and 1980, a group of researchers from Europe, Canada and the United States withdrew from traditional

criminology and studying the criminal offender, and focused on the analysis of crime events and their context, including the physical and social environment that contribute to the emergence of opportunities for crime. In addition, environmental criminology, whose proponents include Branthingam and Brantingham (1981), Clarke (1980, 1983) and Cornish (Cornish & Clarke, 1986), developed further. This had a major impact on crime mapping, as researchers from the entire crime analyses and sociological factors focused on the analyses of separate criminal events and their locations. The use of mapping slowly expanded to include all forms of crime, and was used for the allocation of police officers in city areas and the planning and design of police work. With the development of information systems and computer technology, (crime) mapping within the police forces in the U.S. and elsewhere started to develop more rapidly. Due to the wide applicability and efficiency, crime mapping in the U.S. received governmental support and funding to further its development. An important role in the history of mapping in the U. S. has been played by the Community Oriented Policing Service department (COPS), which is very similar to the Center for Problem-Oriented Policing (POP Center). In the U.S. different programs, whose purpose is to develop as much simple and police officers' friendly and useful crime mapping as possible (e.g., MORE, MPAS, CompStat, etc.), are carried out.

Crime analytics deals with objects (crimes), subjects (perpetrators and victims) and procedures (criminal investigation and judicial procedures), their identification and providing an insight into the relationship between crime data and other potentially relevant data in terms of criminal justice procedures and legislation (Rupnik, 2004: 182). Marilyn Peterson (1998) defined it as the use of specific analytical methods on data collected for the purposes of a criminal investigation. In addition, Gottlieb, Arenberg, and Singh (1994) write about a series of systematic analytical processes directed to provide timely and relevant information on crime patterns. Their primary purpose is to support the operational and administrative staff. Crime analytics uses unified methods and techniques, and is focused on achieving the objectives of crime investigation, such as: detection of crime and its perpetrators, prosecution of perpetrators and implementation of criminal sanctions, and more and more often mentioned crime-prevention (Rupnik, 2004: 176). In other words, crime analytics is focused on the development and testing of hypotheses (versions), reconstruction of individual crimes, identification of serial crimes, understanding of criminal networks, and analyses of the dimension and patterns of criminal activity.

Crime analytics, by definition enables the identification of relevant data and their interaction on a higher cognitive level. In this process are as a 'raw material' used all available police and judicial data, which are combined with data from other areas. For this reason, we talk about a systemic approach in which we primary want to clearly define and determine all the elements and attributes of the data. At the same time, we search for any links with the environment. Typical examples of such approach are crime studies in time series, in specific geographically limited space and their linkage with demographic, economic, social, and similar data. In this way researcher wish find deeper causes of crime; it is therefore a gnoseological process leading to a detailed understanding of the problem and therefor offering a suitable basis for the response of the crime control system on the one hand and the wider community on the other, if these criminogenic factors appear in their environment.« (Rupnik, 2004: 182–183) Veršnik (2002) believes that the development and implementation of crime analytics in policing is a difficult and time-consuming process. He emphasizes that the problems that occur with increased criminality can the most effectively be solved with analytics. Crime analytics is functionally divided into strategic and operative analytics.

Table 1: Division of crime analytics methods (source: Maver et al., 2004: 192).

Subject of analysis	Strategic analyses	Operative analyses
Criminal offence	Criminal patterns analysis	Case analysis Comparative case analysis
Perpetrator	Analysis of general profile	Analysis of specific profile Crime groups analysis
Crime control methods	Analysis of control methods	Analysis of investigations

GIS are most often used by crime analysts in crime pattern analysis. Rupnik (2004: 192) describes this method of crime analytics as a »study of the nature, expansion and development of a certain crime form in a selected geographical area within a definite period of time«. Its aim is the identification of crime patterns and trends, which eventually develops in the certain area. In the analysing of crime patterns, processing of the statistical data is the most important, resulting in the so-called basic picture of the extent and quality of the research. The results are presented in the form of statistical tables or graphs together with GIS's tools of presentation (Rupnik, 2004: 193). At this point it should be noted that the analyses of crime patterns often form the foundation for decision making by criminal policy makers.

The presentation of data using geographic maps for investigators and analysts makes it possible to graphically present the data (e.g., thefts as a studied crime form) for the selected time period (e.g., one or more years, divided to months or weeks, etc.) on a geographical basis (e.g., city map, local community map, map of the municipality). Rupnik (2004: 197) argues that GIS represent the most progress in this field because it combines data in formatted forms of relational databases (known as DBMS), unformatted data in free text format, and geographic data in raster and vector format. A geographical distribution of crime (the so-called layer of points) in the chosen map of the study area is plotted in the form of one or more sites with high crime density or crime hotspots, which are usually expressed with a stronger shade, different colour or with contour lines, as shown below in the Figure 1.

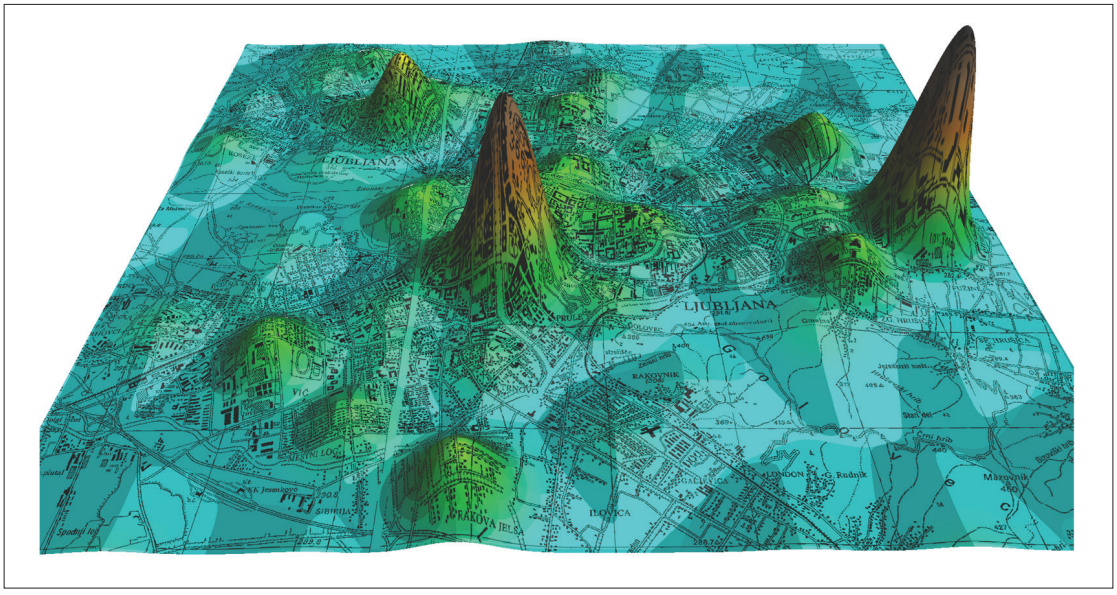

Figure 1: *Example of crime mapping of property crimes in Ljubljana using Isopleth mapping technique (source: Klinkon & Meško, 2005).*

Klinkon and Meško (2005: 147) pointed out that in the geographical study and analyses of crime, the impact of the physical and social environment, which affects its formation and development, should always be taken into consideration. Only in this way is the problem of crime tackled holistically. If the analysed data are not reliable and valid, we cannot get the real picture of crime density and situations in a given area. In this case, we are faced with the so-called GIGO phenomenon – 'Garbage In Garbage Out' (maps remain attractive, but useless) (Meško, Maver, & Klinkon, 2010: 315).

2.2 Geographic Information Systems - GIS

GIS are a tool that allows the classification of selected events in space and time. In other words, assists in the collection, storage, retrieval, transformation and presentation of spatial and time data of selected (criminal) events (Klinkon & Meško, 2005: 133). Režek (1993) and Korte (1994) described GIS as computer-based spatial information systems for the collection, storage, retrieval, analysis, maintenance, use, display and distribution of spatial data and information. GIS present a decision-based support system involving the integration of spatial information in the best possible environment to solve specific problems. In this process, data visualization for the analysis and demonstration, which often highlights the studied problem, is particularly important.[5] From a review of the definitions it is evident that GIS have initially been used merely for the spatial data analysis, and only later was the temporal

[5] Environmental System Research Institute [ESRI] (2012) is one of the leading institutions in the development and use of GIS (more about ESRI on http://www.esri.com). Their definition of GIS is as follows: »A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analysing, and displaying all forms of geographically referenced information. GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.«

component introduced. For Longley, Goodchild, Macguire and Rhind (2005: 24) GIS present tools that allow describing, explaining and forecasting of the models in geographical and temporal relation. They see GIS as a technology and a 'science' that combines useful methods, tested technology and tools to solve specific problems by measuring, mapping, and analysing the real world.

As mentioned above, GIS allows the combining of data (geological, geodesic, satellite, time, data, crime statistics data, etc.) and their presentation in the form of maps. The strength and specificity of GIS is in data integration, where all captured data are actually a simplified representation of reality. We are talking about *the model of the studied area* (e.g., street, industrial building, district, municipality, country). These models enable us to understand easier and faster the processes of the real world. Moreover, it is possible to display them in a simplified, more comprehensive way. The latter is particularly important in the analysis of crime issues, including criminality,[6] as described in the next section.

2.3 GIS analysis of the crime and public disorder

A primary goal of crime mapping using GIS is the synthesis and presentation of the majority of the research findings on transparent maps (Kraak & Ormeling, 2003). The maps and mapping as tools actually appeared after the joining of cartography and GIS (Klinkon & Meško, 2005: 136). This unique new tool allows quick presentations and overlaying (joining) multiple layers from different data sets. Furthermore, it enables fast, efficient and, with the analytical methods, supported decision making in the studied environment (Kraak & Ormeling, 2003). All of these characteristics are actively used by police when solving different crime and disorder problems. As a matter of fact, GIS replaced the traditional location tagging of crime hotspots on the map with pins or magnets to help police while performing crime analysis. Filbert (2008) distinguishes three objectives of the use of GIS in the context of police work: 1) GIS enables the analysis and understanding of crime occurrences and with it related social problems in a given community, and the links between crime and the factors that affect it; 2) GIS allows more efficient planning of policing and allocating resources on the basis of crime analysis; and 3) GIS provide information to the community about crime hotspots, crime trends, crime statistics and other topics.

In terms of crime analysis, GIS can be described as »a tool that connects programs for database management, graphic designs, creates visual images with different data and various cartographic formats. Displaying data on maps makes it easier to understand WHERE, WHEN, and WHO has committed a crime. The real power of GIS is to enable users to analyse multiple layers of information at the same time ...« (Klinkon & Meško, 2005: 133–134). The use of GIS technology can be linked together with seven golden questions of criminal investigation: what, when, where, how, with what, who and why (Maver et al., 2004), although use of crime maps in crime analysis can provide answers only to the following three of seven questions: what, when, where. If we want to answer to remaining four golden questions, additional studies and analysis, in addition to crime mapping, are necessary. The greatest advantage of the systems described here is the possibility to see and recognize a new relationship between the data that we analyse. In this analysis of databases, GIS are capable of creating new information to help us in our decision-making (Klinkon & Meško, 2005; Longley et al., 2005; Urh, 2007). Maps, in which events are presented as points or other geometrical forms, are most commonly used in police crime analysis. The presentation of analysed events allows very precise placement of their location on the map and thereby allows more efficient planning of operational activities of the police (Harries, 1999). In the process of geo-location of police records, the following three reference databases, which are usually already included in GIS, are used (Urh, 2007: 58): 1) the database of house numbers; 2) the database of road network; and 3) the database of the national border, divided into sectors and sections.

Everything occurs in space and time, and criminality is thereby no exception (Klinkon & Meško, 2005: 136). GIS are a software tool that allows presentation of data on maps in the form of points, lines and polygons. In the labelling of crime incidents on the map, Clarke and Eck (2008: 60) distinguish between 'acute' and 'chronic' crime hotspots. They see three types of 'chronic crime hotspots', in detail explained by Ratcliffe (2004): 1) *hot dots* – locations with high crime rate, where the dots label locations (building, address) where more crime occurs; 2) *hot lines* – streets where crime is concentrated; and 3) *hot areas* – neighbourhoods or areas outside the cities where crime is concentrated.

In these analyses, the locations with increased concentration of events where hot dots and hot spots are identified and labelled, are particularly interesting and useful for crime ana-

[6] The use of GIS in the analysis of security issues can be divided into: 1) the modelling and presentation of the distribution of security occurrences and processes (mostly crime mapping, data presentation in the space, 3-D data display and/or time data display); 2) the identification of the links between parameters (e.g., frequency and timing of the studied occurrences and with it related problems certain areas); and 3) the detailed analysis of individual security issues in selected areas (crime hot spots, crime areas, potential targets) and the planning of solutions (situational crime-prevention methods).

lysts. Klinkon and Meško (2005: 137) pointed out that crime is not an infinite continuum, as the offenses occur at a certain time and at a certain point in a geographic space. The values between the known points can be estimated by (crime) analysts and then a continuous surface presentation in a form of map is created. In this way crime mapping makes it possible to present analysed data in the form of thematic maps, which are used to display the spatial patterns of one or more variables and geographical attributes. Additionally, these thematic maps are very useful for sample comparison (Slocum, McMaster, Kessler, & Howard, 2005). Harries (1999), Slocum et al. (2005) divide thematic maps into statistical, point, choropleth, isopleth, aerial, and linear. Klinkon and Meško (2005) divide maps into quantitative and qualitative. The most important tool or feature of GIS is their analytical value and the ability to quickly create maps with large and often complex contents of data. The process of selecting and displaying systematic information can be divided into four types: 1) mapping of time; 2) mapping of space; 3) mapping of incidents; and 4) mapping of the attributes of victims and/or suspects.

When studying crime and its distribution, it is necessary to consider several demographic and other factors, which also affect its appearance and distribution; e.g., population density, specific characteristics or forms of crime (e.g. drugs, environmental crime, etc.), life styles and patterns in a selected area (e.g. towns, villages, etc.), lack of informal social control, daily migration, tourist presence and migration, organisation and work of the police, forms and techniques of crime detection, investigation and sanctioning (Meško, Maver, & Klinkon, 2007), and the presence of city wardens in addition to the police (Jere, Sotlar, & Meško, 2012; Lobnikar, Sotlar, & Meško, 2013). When talking about plural policing, in some cities crime analysis together with GIS and crime mapping are used to predict and prevent as much crime as possible (Meško & Sotlar, 2012). Likewise, Tilley (2002), emphasizes that the priority of contemporary policing is reduction of crime and disorder. This includes problem-oriented policing, when the police move from reactive – responding to events – to more proactive activities, which includes analyses of events and planning of responses, as well as crime-prevention methods.

2.4 The history of crime mapping in Slovenia

Until recently in Slovenia, five extensive studies, which included crime analysis together with the mapping and use of GIS tools, have been conducted; all five surveys covered the area of the capital Ljubljana. In 1975, Pečar (1975) conducted research on the extent of deviance in Ljubljana, where he tried to figure out why in certain areas a concentration of specific crime and public disorder issues occurs. He examined the interconnectedness of these with physical and demographic factors by using cartograms. The results showed that: 1) the major security problem present alcoholics, housed in areas with old buildings in the city centre; 2) predominantly urbanized areas outside the city (i.e., dormitories) are more problematic and burdened in respect of concentrations of deviants; and 3) deviance of young offenders and violations of public order is increasing, especially in residential areas, and in slightly more remote locations, such as the Ljubljana Marshes (orig. Ljubljansko barje). In the city centre, the density of deviants around residential areas was not detected. Pečar (1975) discovered that crime and offenders are very unevenly distributed around the urban area of Ljubljana. Almost all deviance, except sexual offenses and suicide, tended to show larger density in the city centre, and therefore Pečar (1975) stressed the positive impact of the presence of formal social control on the extent and nature of crime.

A large number of serious car accidents, resulting in death and serious injuries (which after 1973 began to rise sharply), and the desire to improve road safety were the reason for conducting the second survey 'Determination of 'black spots' on the main roads of the Socialist Republic of Slovenia'. In terms of the general problem of the traffic safety, Zemljič et al. (1979) identified four influencing factors – human, vehicle, road and environment – under which sites or sections of the road network that are typical for the recognition of the possible car accident, are recognized. We are talking about 'dangerous places', better known as 'black spots' where an excessive number of car accidents occurs. Based on studies conducted in the United States of America and Sweden, researchers used the method of critical accident rates by calculating the number of traffic accidents in a certain place and their distribution according to Poisson to determine dangerous places on the main roads of the Socialist Republic of Slovenia. They analyzed 5,796 official traffic accidents records for a period of three years; 1976–1978. With the use of a specific computer program 323 dangerous places, or so called black spots, were defined, where the probability that a traffic accident will happen is much higher. For all identified dangerous spots or sections that were shown on map of SR Slovenia (Figure 2 below), authors prepared a proposal of necessary improvements, most of which are physical or technical nature. A comparative study from the year of 1979, which included sites that were at least partially reconstructed and improved, confirmed the positive effects of the proposed measures and the consequent reduction of traffic accidents on the identified dangerous sites (Zemljič et al., 1979).

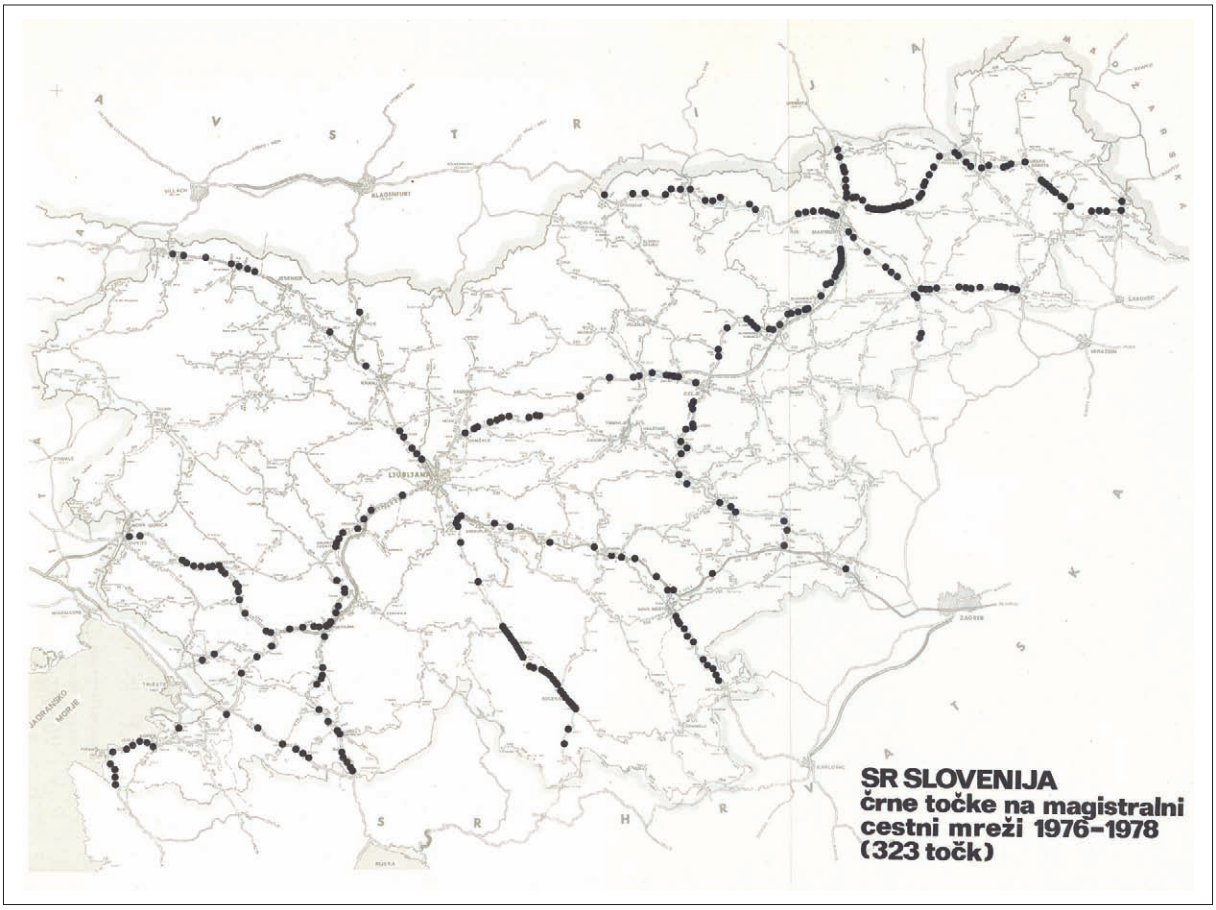

Figure 2: *Map of 323 identified dangerous places - black spots – in Socialist Republic of Slovenia from 1976 to 1978.*

The third study was conducted in 2001 by Meško, Dobovšek, and Bohinc (2003), in which they analyzed the distribution of deviance in Ljubljana and thereby for the first time used GIS for crime mapping. The research results showed the distribution of reported crimes in different parts of Ljubljana. Three areas really stood out in terms of located hotspots, where researchers discovered a large number of pubs, discotheques, and nightclubs; on the contrary, the detected areas close to schools and companies were very rare (Meško, Dvoršek, Dobovšek, Umek, & Bohinc, 2003).

In the fourth study, Klinkon, Meško, and Rebernik (2004) tried to find out what sort of impact socio-demographic factors had on the development of crime in Ljubljana. Using GIS, they prepared maps of spatial distribution of crime in Ljubljana, and compared the interaction between crime rates and socio-demographic factors. In the second part of the study, they compared these results with opinions of citizens, collected using a public opinion poll. With the help of residential perceptions of the studied issues, the authors tried to identify crime with more burdened areas – hot areas. The cartographic presentation and respondents' perception indicated that the high crime density areas are differently distributed in particular parts of the Municipality of Ljubljana. The results indicate that the socio-demographic structure of Ljubljana has an impact on different levels and types of crime, and vice versa (Klinkon, 2004).

The final study by Meško, Maver, and Klinkon (2010), used crime mapping for the purpose of criminal investigation and analysed crime density areas of thefts, burglaries and robberies in Ljubljana in 2003 and 2004. They used the Kernel density method, which showed hot areas for the studied crime forms to be in the centre of the Slovenian capital, and their expansion alongside the main roads to the outskirts of the city, as evident in Figures 3, 4, and 5 below.

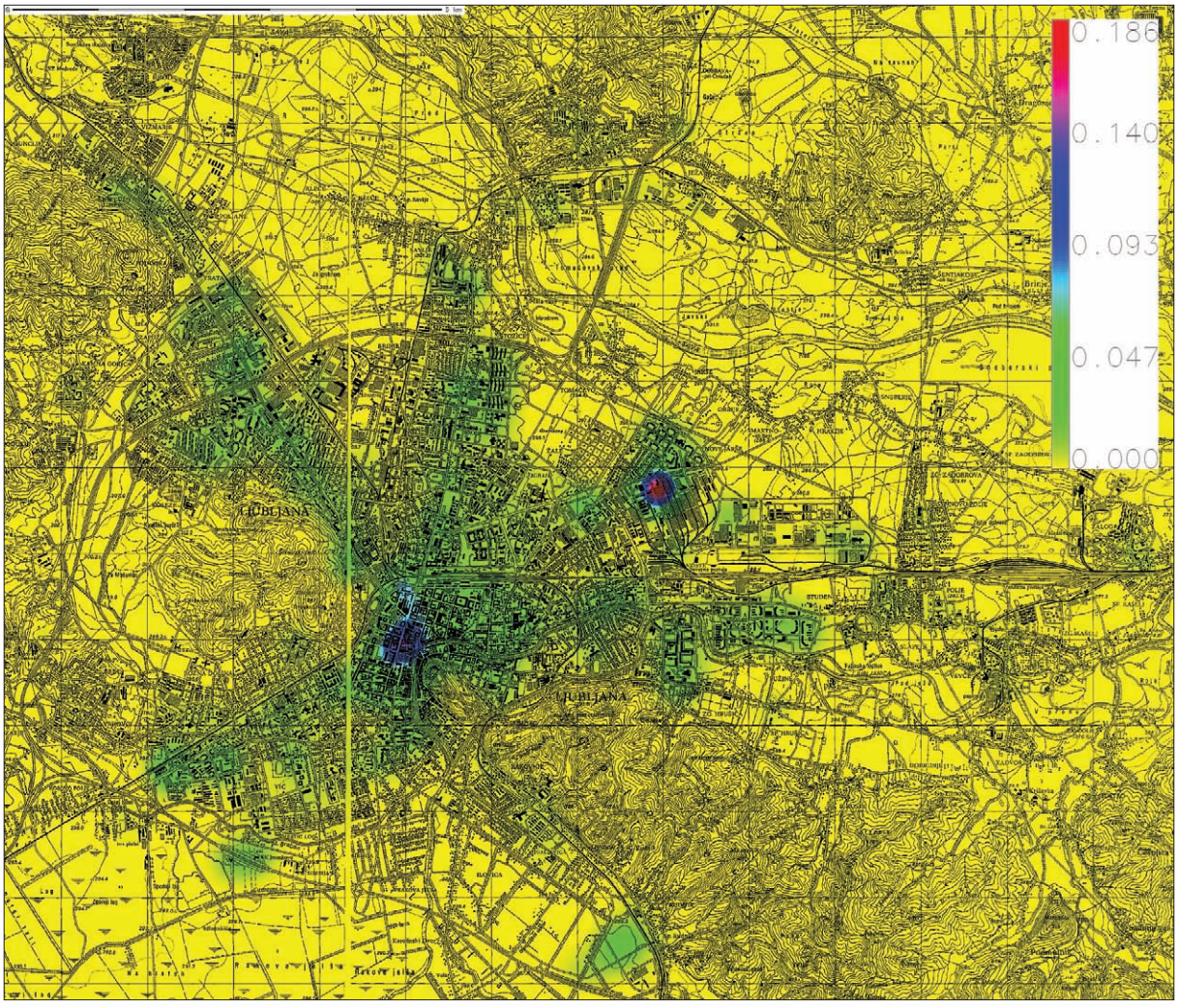

Figure 3: *Kernel density interpolation of larceny events in Ljubljana (source: Meško, Maver, & Klinkon, 2010: 312).*

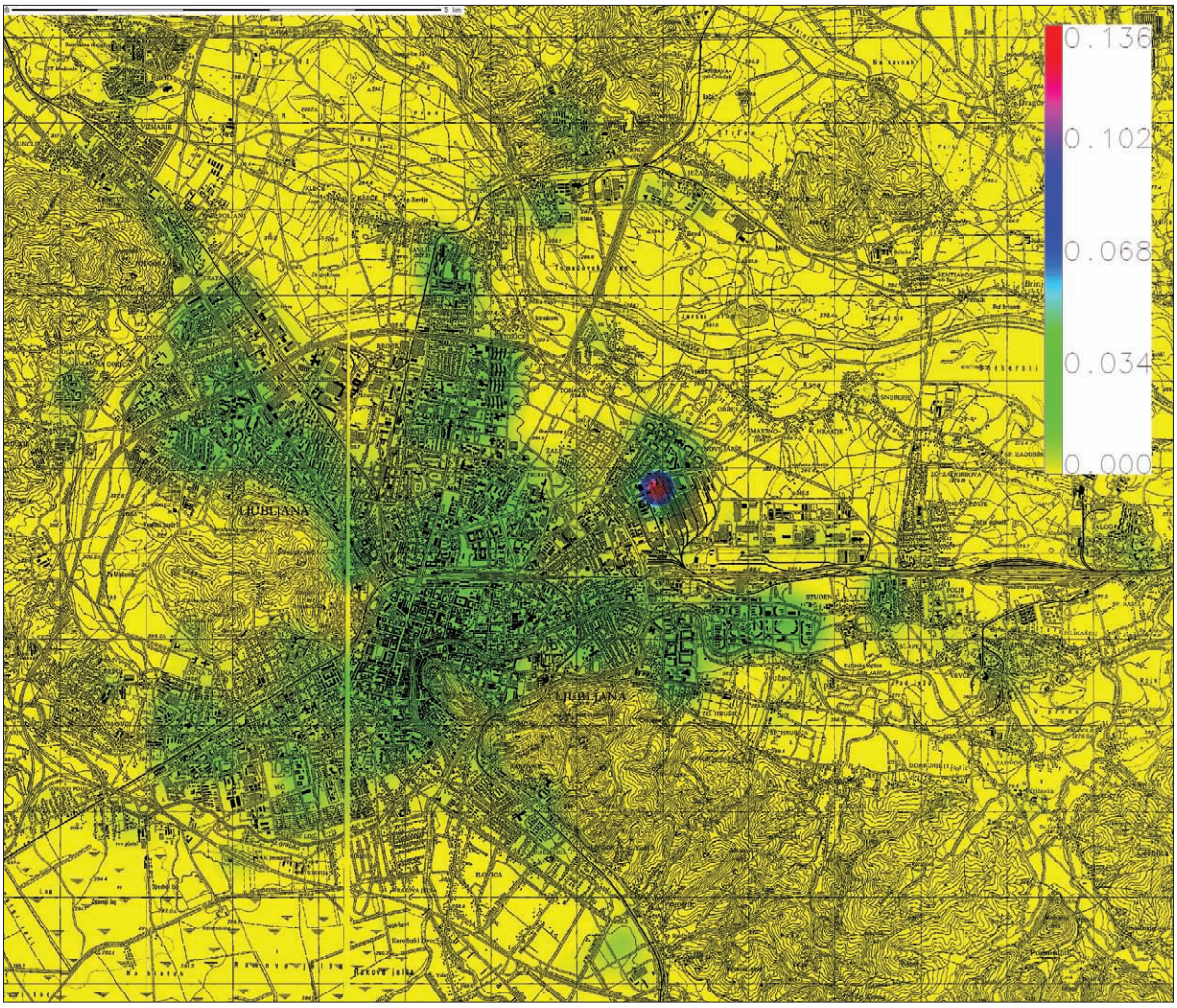

Figure 4: *Kernel density interpolation of burglary events in Ljubljana (source: Meško, Maver, & Klinkon, 2010: 312).*

Hot spots were detected in the following areas: 1) the shopping and entertainment area called BTC, which is characterized by large car parking lots and a high fluctuation of people; 2) the city centre, where the main railway and bus station is located; Tivoli park (park and sports facilities); 3) the city quarter Tabor (a neighbourhood in the centre, very close to the methadone centre and a known meeting place for young people, a centre of alternative culture, called Metelkova mesto); and 4) other neighbourhoods on the outskirts of the city, such as Remiza, Trnovski pristan and Nove Fužine (Meško, Maver, & Klinkon, 2010).

Slovene Police began to use GIS in 1992 with the goal to provide quality information necessary for the efficient and rational implementation of operative police duties. It has been introduced as one of the information sub-systems, which allow the connection of existing alpha-numerical databases with spatial maps of Slovenia (Urh, 2007: 55). In 1993, police carried out the composition of a second set of applications, enabling processing of spatial data about traffic accidents. Since 1994, the use of GIS enabled various spatial analyses of different events in the territory of the Republic of Slovenia (Drevenšek, 2005). Statistically-spatial processes

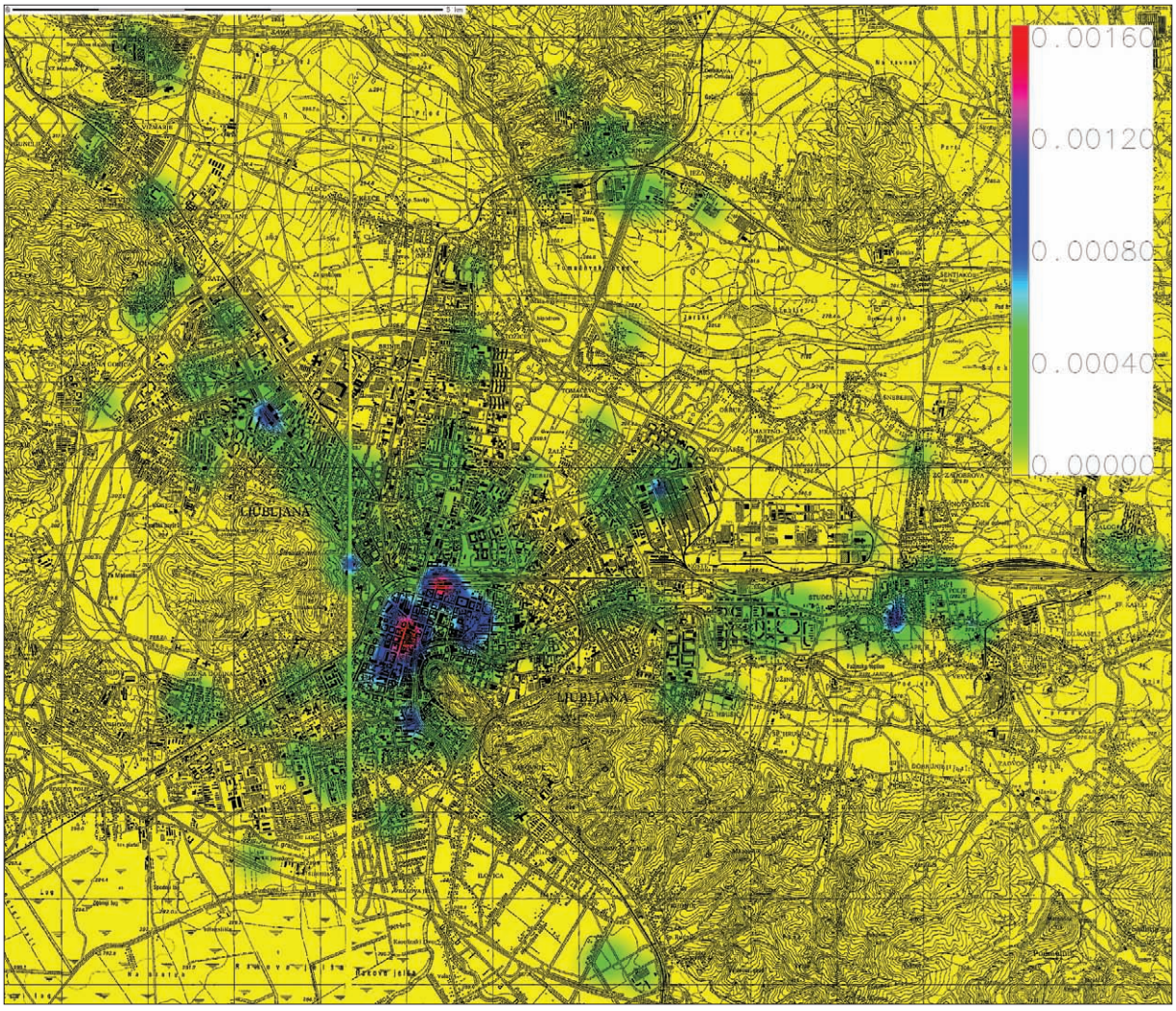

Figure 5: *Kernel density interpolation of robbery events in Ljubljana (source: Meško, Maver, & Klinkon, 2010: 312).*

of geo-spatial data on crime and other security events are the most useful for the police. Urh (2007: 56) states that spatially-statistical analyses can be used in analysing traffic accidents, violations of the public order, different groups of offenses (e.g., thefts, robberies, burglaries, drug dealing, etc.) and elsewhere, where security problems arise and the spatial dimension. This together with the use of multi-layer analysis of data about incidents, allows us a better overview and understanding of security. LeBeau (2002) pointed out that by combining events and emergency calls into a logical whole, it makes it much easier to understand them as if they appear only in the form of points at a given location. As noted by Hughes (2004), with the use of GIS police officers can be more efficient and engage in user-friendly analysis of events in the selected area, as presented in the second part of this paper.

2.5 Crime hot spot analysis in Ljubljana and Maribor

In this section, we present the analysis of property crime in Ljubljana and Maribor where the hot spot methodology[7] for the hot areas identification was used. In years 2003 and 2004 Meško, Maver, and Klinkon (2010) used kernel density interpolation method on the case of Ljubljana. In the present study, an ordinary distribution with the ArcGIS tool of the police was used to detect property crime (larceny and burglary) incidents in 2010.

The spatial distribution of crime in Ljubljana and Maribor are presented in Figures 5 and 6 below.

Figures 6, 7 and 8 show maps of spatial distribution of property crime events in Ljubljana and Maribor in 2010. Results are similar to those in a study by Meško, Maver, and Klinkon (2010) covering the years 2003 and 2004. The widest distribution of theft and larceny events are in the city centre (community district Center), and their expansion along the main roads to the outskirts of the city (community districts Šiška, Bežigrad, Posavje, Črnuče, Vič, Trnovo). The increase of property crime is also detected in the shopping and entertainment areas; high theft and larceny events density in the BTC shopping area is similar to those found in the study of Meško, Maver and Klinkon, thus in the crime map two new areas with two new shopping centres that developed and expanded after 2003 were identified – these two areas are shopping centre Rudnik in community district Rudnik and shopping centre Merkator in community district Šiška.

Spatial distribution of robbery events in Ljubljana is concentrated in the city centre (community district Center and southern part of the community districts Bežigrad). Crimi-nal offences usually occurred around the railway and bus station, and along the main street (Slovenska Cesta) that runs along the main shopping area in the city centre. Furthermore, the identified locations of robberies in the city centre were two main squares and their surroundings where large

[7] Crime hot spot methodology is based on identification of the locations (i.e., hot spots or hot areas) with the concentration of reported criminal incidents. Meško, Maver, and Klinkon (2010: 312) describe them as »chronic crime places, where crime is concentrated at high rates over extended periods of time«.

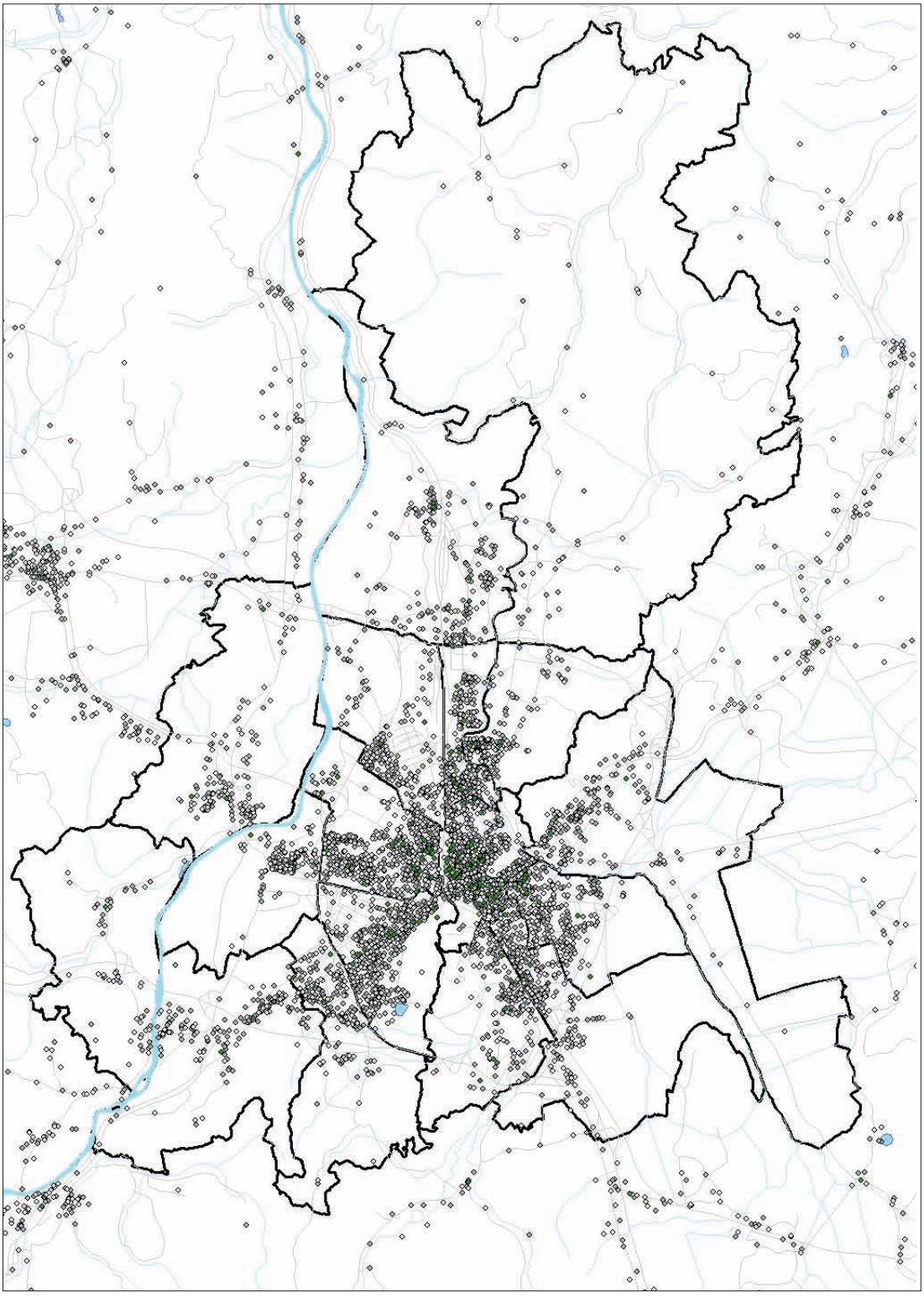

Figure 6: *Property crime in Ljubljana in 2010.*

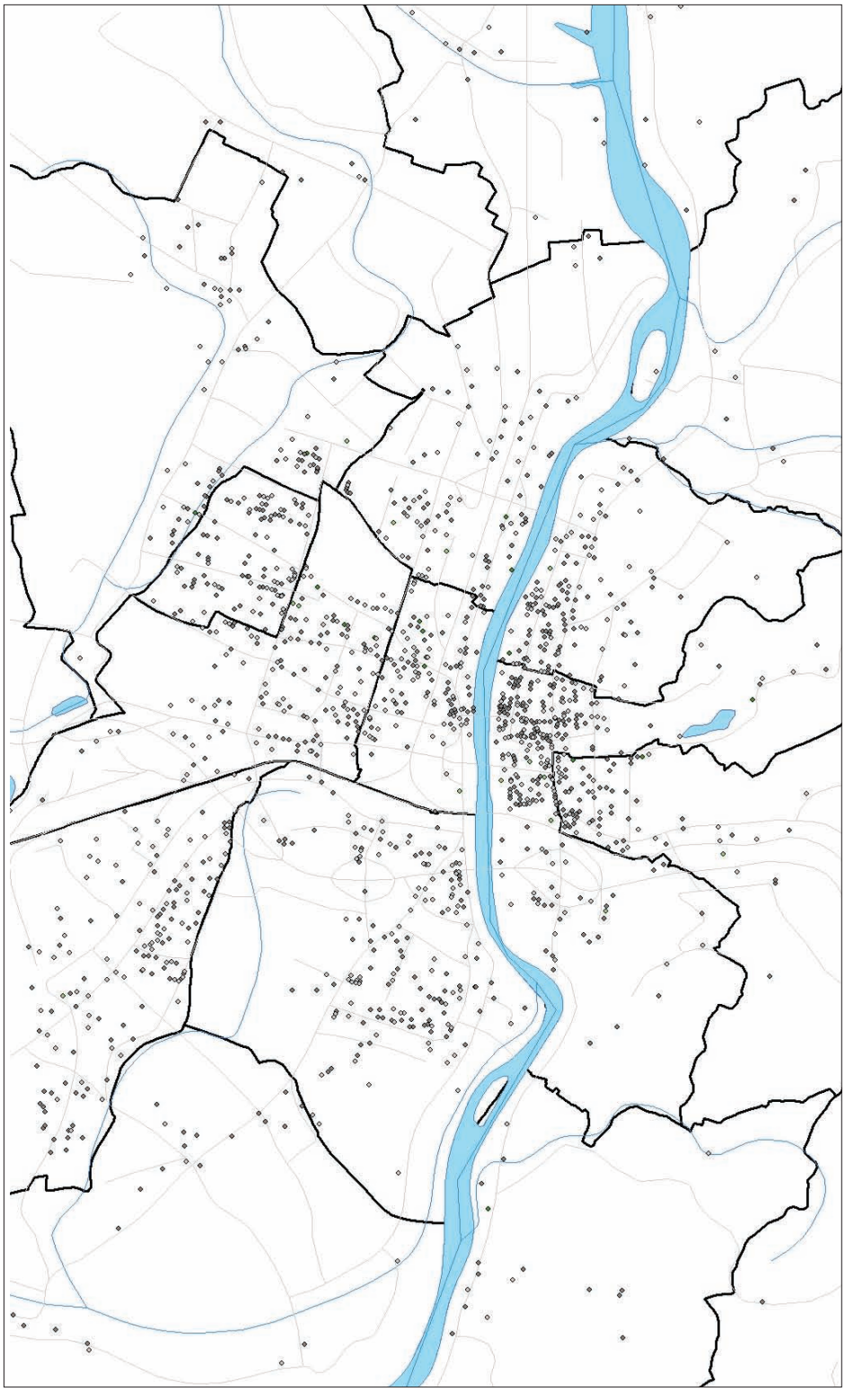

Figure 7: *Property crime in Maribor in 2010.*

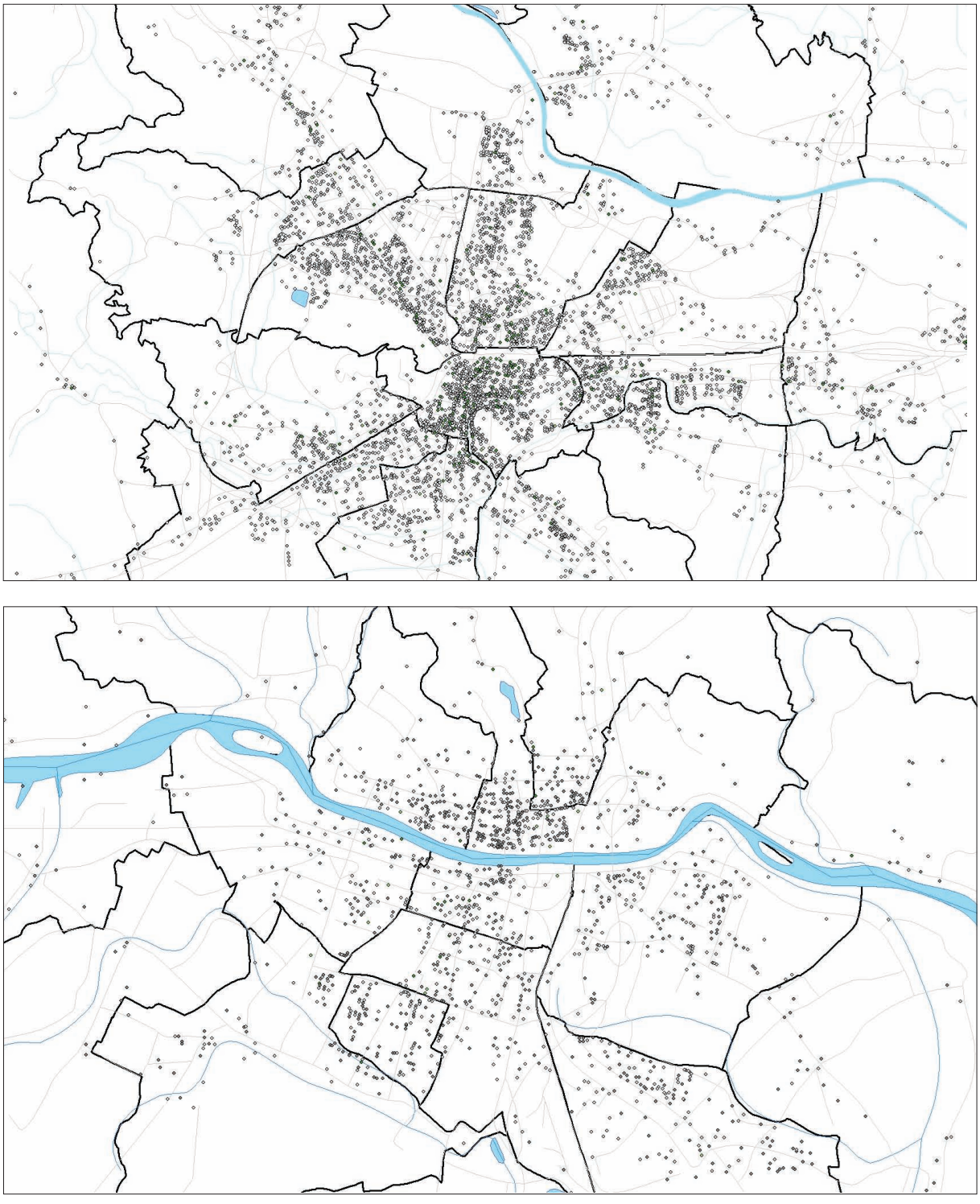

Figure 8: *A closer look on density of the property crime in Ljubljana and Maribor in 2010.*

numbers of citizens and tourists migrate daily. Finally, the number of robberies in other community districts (e.g., Šiška, Rožnik, Trnovo and Moste) around the city centre is low.

The map of spatial distribution of property crime in Maribor in 2010 shows a very similar picture as Ljubljana. The analysed criminal offences are concentrated in the centre of the city of Maribor and in the community districts around the city centre known as ordinary residential areas: Center, Ivan Cankar, Koroška vrata, Studenci, Magdalen, Pobrežje, Tezno, Tabor, Radvanje and Nova vas. A closer look at the crime map shows that the theft and larceny events are more or less equally distributed in the described area around the city centre thus no specific crime hot spots can be identified on the map. In case of spatial distribution of robbery events in Maribor, again the situation is similar as in Ljubljana - robberies and thefts occurred around the city centre (community districts Center, Koroška vrata, eastern part of the district Studenci, Magdalena, and northern part of the district Tabor).

As already stated by Meško, Dobovšek, and Bohinc (2003), analysis of reported crime distribution and crime hotspots based on by GIS drawn crime maps is one of promising method of crime analysis. Slovenian researchers pointed out that in the analysis, the fact that the distribution and density of crime depends on the number of reported offenses with questionable validity and reliability, always has to be taken into account. However, this is an important starting point for the analyses of the spatial components and planning of the measures. Besides, »crime maps enable fast and efficient identification of the geographic locations of potential crime hot spots« (Klinkon & Meško, 2005: 144), that in majority of cases is extremely important for assisting the police and others. While such maps and data contribute very little to the explanation as to why the concentrated hot areas appear in the identified locations, knowledge of the study area and the use of the cognitive models make it possible to better understand and more correctly interpret the research results. Nevertheless, crime mapping is more and more often in addition to crime analytical and research purposes, used by public in form of (police) web-pages, where people can daily follow happenings in the field of criminality in their city. An attempt to create such a public portal in Slovenia is a Krimstat.si project and is presented in detail in the next section.

3 The Krimistat.si project and the use of crime mapping in Slovenia for public use

In the Krimistat.si project, a web-application that enabled the presentation of the police statistics database and Google maps platform, seeks to make crime mapping analysis easier and perhaps more appropriate for public use. The idea was to use and present the police data in the Google maps environment through the use of interface.

3.1 Diverging outturns of data visualization

Effects of data visualization are often surprising when different media is subsequently used. In the context of this discussion, media is used to indicate public sector data in different formats of which each can be used autonomously, e.g. database/spread-sheet, visual presentation, and synthetic preformed query based presentation.

Public sector information (hereafter PSI) is a great resource for data visualization and provides examples of other forms of data presentation. European Directives regarding the re-use of public sector information was instituted at the end of 2003 (European Commission, 2003). It provides a common legislative framework for a previously unregulated European public sector information market. Transparency and fair competition are the key pillars around which this Directive is built. In the European Union member states, the implementation of the Directive on the national level followed immediately or even paralleled what was occurring in Slovenia where legislation had already been adopted in March 2003 (Public Information Access Act, 2003).

In the beginning, however, transparency was stressed when applying the national law. In the next few years, more and more the economic aspects will become more and more visible. More activity could be expected both in the public bodies (by delivering PSI) and the business sector (reusing PSI by adding value). The position of Slovenia in the PSI scoreboard is extremely low; this is surprising for one of the ICT pioneering (formerly) countries in the region. The European Public Sector Information Platform Scoreboard ranked Slovenia in the group of countries with the lowest PSI score (European Public Sector Information Platform, n. d.). It is quite embarrassing and calls for more attention in this field. In aggregated scores, zero points are gained for PSI on local data, on events and activities, formats and exclusive arrangements in delivering PSI. Even we can argue with zero-point-status, it is evident that existing initiatives are rarely systematic at the top level.

3.2 The Krimistat.si project

Following the challenges of the reuse of PSI, the presence of this topic in undergraduate and postgraduate university study courses was intensified. In this contribution, a case study for visualizing PSI on criminal acts is shown that required multidisciplinary cooperation of various institutions. The web-based software programme Krimistat.si can serve both as a public awareness information service (the PSI part) and as a tool for the police (the internal aspect of data reuse). A full version view of the Krimistat.si programme with the possibility of zooming into specific groups of criminal acts is presented in Figure 9 below. In the Republic of Slovenia, Krimistat.si is (for now) is

available only in Slovene language. Additionally, *forming the hypothesis* was based on the following premises: 1) reuse of public sector information (PSI) principles should be applied; 2) personal data must be protected, so only anonymous data should be used; and 3) there are use-cases in reuse of PSI with anonymous personal data where anonymity becomes jeopardized.

- Consulting the Information Commissioner on personal data related observations;
- Audience differentiation with respect to the advice of the Information Commissioner;
- Further applications and research.

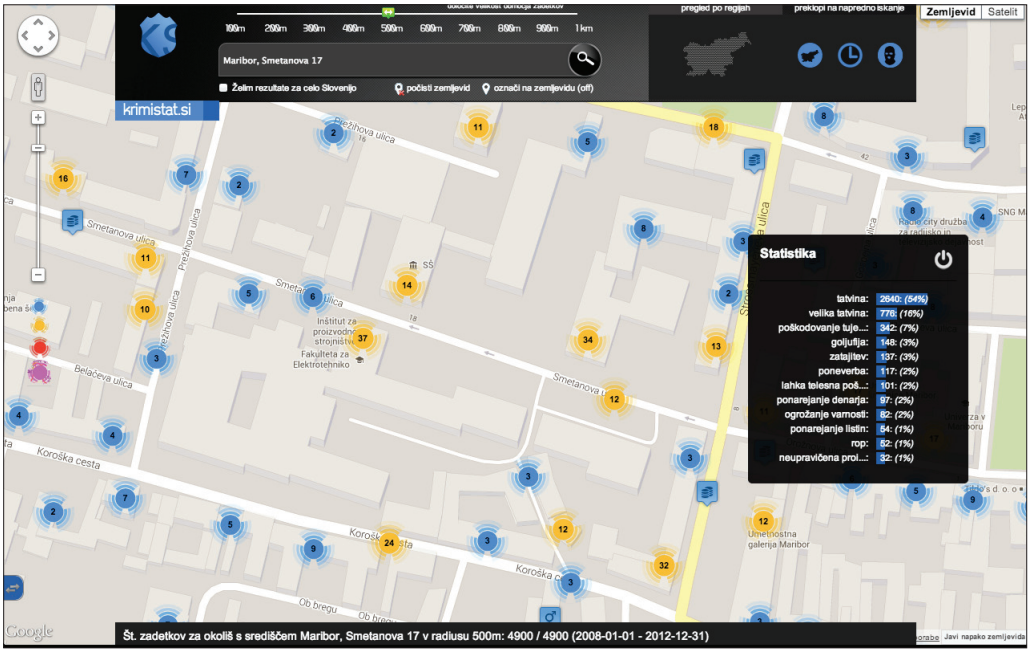

Figure 9: *Snap-shot of the distribution of the groups of criminal acts by the Krimistat.si programme prepared analysis in part of Maribor.*

A clear and relatively attractive case of visualizing geo-located data of criminal acts recorded by the police in certain period of times was used for this research. Related works in this area existed approximately since the past decade, but our research addressed two intriguing aspects: 1) an open technology platform from the view of the user, like no proprietary GIS system use is needed, and 2) aspects of personal data protection should be carefully examined.

The process of studying results of data visualization consisted of the following steps:

- Definition of the PSI reuse project and the hypothesis;
- Obtaining an anonymous database (PSI) on criminal acts for 2008–2012 from the General Police Directorate of Republic of Slovenia;
- Development of Data-Visualization web-oriented software;
- Testing and studying the effects of the use of visualized data from the aspect of accuracy, user-friendliness and personal data protection;

3.2.1 Backgrounds of the implementation – technical and legal perspectives

The software programme operates on an Apache 2.0 web server using a combination of SQL database and PHP general-purpose scripting language, and JavaScript is used for the client. The system is integrated with Google Maps using the appropriate APIs that enhances the ultimate visualized user experience. The main problems in implementation appeared when converting geo-locations from the legacy database system World Geodetic System (WGS 84 - longlat projection, MGI/Slovene National Grid-Transverse Mercator Projection) to the target format (Google Maps API based) that had to be developed for Krimistat.si. The database structure consists of criminal act records (374,491 in the observed time period) and of related official standardized classification of criminal activities and of regional geospatial data of Slovenia. Details on implementation will be published separately.

In the process of studying outturns of data visualization, we faced the effect of de-anonymization of data. Even the names of the individuals were not available, and in some cases there was a possibility to rebuild it easily using other publicly available databases (e.g. phonebook) or knowing the terrain. This effect is emphasized in rural areas with low-density settlements and consisting mostly of individual houses (imaginary e.g., at the location Gregorčeva 16c in the city of Maribor violence in family criminal acts were processed; the name of the family living there can easily be found in the phonebook). As the source data deals with announced and processed criminal activities without any information on further processing of these acts, in some cases derived information can be discriminatory.

These observations led us to formulate a letter to the Information Commissioner (ICRS) of Republic of Slovenia regarding competences on personal data protection and access to information. One of the primary activities of the ICRS is issuing and publishing *non-obligatory opinions, explanations, positions and recommendations with regard to personal data protection* (Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data, 1995). The letter to the ICRS was based on the following observations and concerns about wide public use of the Krimistat.si system:

- The Krimistat.si is based on an anonymous database containing more than 300k records in flat-table data on criminal activities in Slovenia during the period from 2008 to 2012;
- When geo-location data points to individual houses, the possibility of discovering the identity of individuals involved is significant;
- The status of criminal acts regarding further police and/or juridical processing is not known, discriminatory interpretation cannot be excluded;
- For public use, criminal acts should be shown in an aggregated group of prescribed radius, e.g. 500m;
- From the aspect of PSI re-use, we have a desire for information processing and visualization to keep the system as it is; however we feel obliged to eventual non-obligatory opinion of the ICRS;
- Since we expect that Krimistat.si case is the first one addressed to the ICRS, we hope that it will serve as a test case.

It should be noted that for all studied areas additional surveys including socio-demographic and economic factors are possible that enable a more focused and detailed analysis. As described above and presented in the Figure 10 below, the limited (public) version of Krimistat.si grouping the criminal acts in the provided radius (500m in this case), only generalized statistics is shown in the right hand side box.

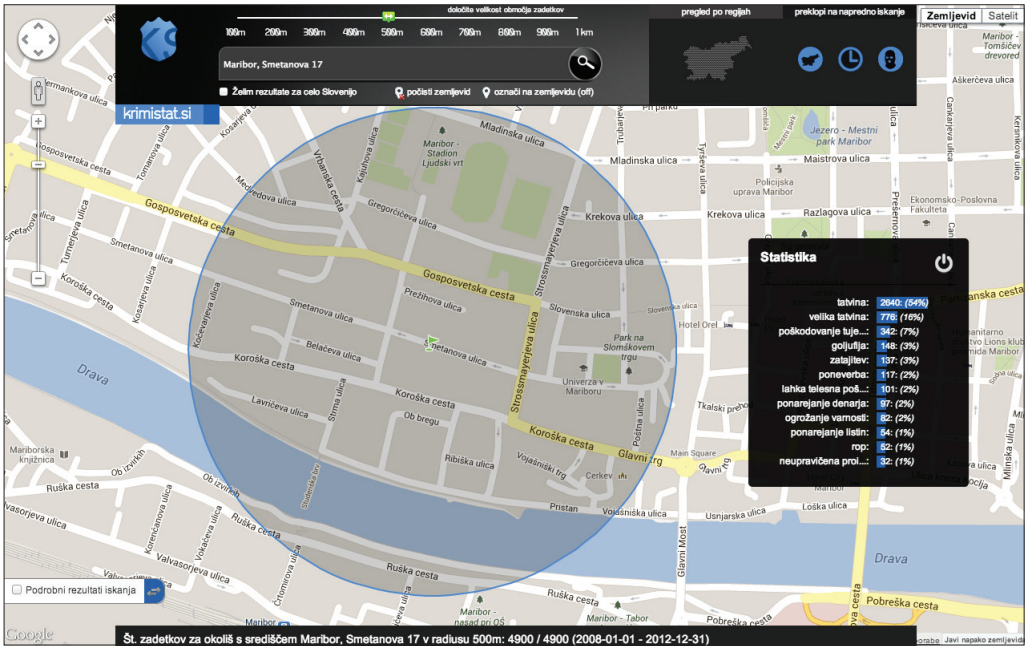

Figure 10: *The limited (public) version of Krimistat.si.*

When concerns about personal data protection were noted, access to the Krimistat.si was limited but was made available to the ICRS office, and they replied promptly and acknowledged our concerns. The practicality suggested solutions and eventual disadvantages as to the aim of the projects needs to be addressed further.

In replying, The ICRS stressed the following:

- Concerns regarding economization of personal data are valid; and
- The proposed view of the aggregated group of criminal acts in prescribed radius ICRS has concerns on the radius itself that could be appropriate for urban areas but less for rural ones.

In the explanation, the ICRS references Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 regarding the protection of individuals as to the processing of personal data and on the free movement of such data (1995) using recital 26, where »principles of protection must apply to any information concerning an identified or identifiable person; whereas, to determine whether a person is identifiable, account should be taken of all the means likely reasonably to be used either by the controller or by any other person to identify the said person«. We could argue about the means of data presentation almost two decades after the Directive was adopted but according to the discussions of the reform of data protection (European Commission Justice Newsroom, 2012), basic principles will be kept or even more, the 'right to be forgotten' principle is added. How it can be implemented in indirect personal data use is not only a significant juridical question, but also an information processing related one as well.

4 Concluding remarks

Crime mapping can be described as a tool for the evidence based responses and crime control of contemporary police forces. Additionally, crime mapping as a method of crime analytics generally has two goals: first of all, responding to crime and deviance, and secondly, knowledge-based prevention responses to crimes in the future. The greatest advantage of GIS is the possibility to see and recognize a new relationship between the analysed crime and other data via the created map. For the police, crime mapping enables precise placement of hot spots or hot areas, and consequently more efficient planning of police operational activities. Moreover, GIS not only enables the analysis and understanding of crime occurrences and with it related social problems, such as distribution of poverty, drug abuse, public disorder, it also provides information about crime statistics and trends (Filbert, 2008); therefore the use of crime mapping in crime analysis makes criminal investigation easier and ultimately more successful. Nevertheless, it is very important to be aware that the data we use in the analysis is highly valid and reliable, otherwise we face the »GIGO - Garbage In Garbage Out« phenomenon and all our work and efforts were in vain and the results useless.

When speaking about the use of crime mapping for the purpose of policing, it must be mentioned that crime mapping and hot spot analysis is one of five police measures that were by identified by Welsh and Farrington (2006: 407) as effective in preventing crime: 1) police patrols in areas identified as hot spots of crime; 2) proactive arrests of dangerous repeat offenders; 3) proactive drunk driving arrests; 4) arrests for domestic assault; and 5) problem oriented policing. The authors emphasize a constant need for further research if successful and promising crime prevention programs and methods are to be identified, including cost-benefit and cost-effectiveness analysis.

As noted by Sherman, Farrington, Welsh, and MacKenzie (2006: 1) »effective public policy and practice needs to be based on scientific evidence«, thus evidence-based policing presents the right way for decision making regarding crime issues. Moreover, it gives systematic feedback to the police and enables them to continually improve their operating methods. Sherman et al. (2006: 9) emphasize that from the scientific and research aspect, effectiveness of the methodology utilized always needs to be evaluated. Therefore, we have to set and discuss three crucial questions (Welsh & Farrington, 2006: 405): 1) What works?; 2) What does not work?; and 3) What is promising?

The challenge for us in Slovenia is that the web-application Krimistat.si, on one hand, can be used for research purposes and also by the police in their analyses as part of the overall criminal investigation. We faced the obstacle in our attempt for the public use of the created web-application, as we encountered the problem posed by the protection of personal data. Although we implemented a process to assure that the data obtained would be anonymous, in some parts of Slovenia there is still a possibility to identify the origin of personal data; therefore, the Information Commissioner dissuades the public use of our web-application. The fact is that 'Public bodies hold a wide array of information and content ranging from demographic, economic and meteorological data, to works of art, historical documents and books.' (Vickery, 2011). Krimistat.si is an academic pilot that follows the concepts aimed toward reusing public sector information. The evident dichotomy of available legislation and its poor facilitation in business solutions initiated the project. While the economic value of our effort is not a goal in the present

form of the project, it enabled us to study cases with outcomes that can serve also to further commercial PSI initiatives. One of the most important lessons learned (in addition to some technical solutions) is related to the lack of anonymity of PSI data. After consultation with the Information Commissioner of Republic of Slovenia, the Krimistat.si will turn in two directions having audience segmentation in mind. The first is the called full version and depicts the exact location of criminal acts on the map; however, this version might use the Police internally (the owners of data). We can discuss if this is really about re-use or just a visualization of data. The second use is the abstracted version with geo-locations limited to a certain radius, municipality or region. Following the non-binding opinion of the ICRS, Krimistat.si became more limited in the sense of data-visualization possibilities but still surpasses the existing level of criminal acts user-friendly and visually attractive demonstration. Finally, the project can serve as a platform for discussion on disproportion of available technologies and data protection rules. The authors decided to systematically contribute to the public debate on reform of data protection in the future, using domain and technology knowledge. Nevertheless, we believe that the use of GIS tehnology is promising. Despite several obstacles and consideration we believe that responsible use of the modern technology can contribute to the quality of formal social control in Slovenia.

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Kartiranje kriminalitete za policijsko delo v Sloveniji – novejša spoznanja

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Razvoj in uporaba geografskih informacijskih sistemov (GIS) kot metode za analizo kriminalitete je relativno nova analitična metoda, kjer zemljevidi predstavljajo sestavni del analize kriminalitete. Pregled preteklih študij o kartiranju kriminalitete v Sloveniji je potrdil, da GIS omogoča hitro, učinkovito in z uporabo analitskih metod podprto odločanje o problemih v proučevanem okolju. Cilj te študije je predstaviti uporabo GIS kot orodje za kartiranje pojavov kriminalitete v Sloveniji za namene policijske in kriminalistične preiskave. V članku je predstavljena uporaba GIS za analizo kriminalitete v dveh študijah: 1) analiza premoženjske kriminalitete z uporabo analize kriminalnih žarišč za leto 2010 v dveh največjih slovenskih mestih, Ljubljani in Mariboru in 2) projekt Krimistat.si, kjer sta bila policijska statistična podatkovna baza in aplikacija *Google maps* združena z namenom izdelave nove spletne aplikacije, ki bi bila uporabniku prijazna in dostopna vsakomur, ki uporablja internet. Rezultati analize premoženjske kriminalitete v Ljubljani in Mariboru za leto 2010 z uporabo kartiranja kriminalitete kažejo podobne situacije kot v raziskavah, opravljenih v letih 2003 in 2004. Največja gostota premoženjske kriminalitete je v središču mesta obeh mest in se širi vzdolž glavnih cest na obrobje mesta. Prav tako je bilo zaznano povečanje premoženjske kriminalitete na območjih nakupovalnih in zabaviščnih središč. Na koncu prispevka avtorji razpravljajo o prednostih in ovirah, s katerimi so se srečali. Krimistat.si je nov projekt, ki omogoča, da je javnost obveščena o porazdelitvi obravnavanih dejanj kriminalitete. Vendar obstaja pravna ovira, povezana z varstvom osebnih podatkov, ki preprečuje javno uporabo te spletne aplikacije. Kljub temu pa spletna aplikacija in druge analize kartiranja kriminalitete predstavljajo napredek na tem področju, saj sledijo sodobnim policijskim trendom v kriminalistični analitiki. To je začetek raziskovalnega dela na tem področju z uporabo sodobnih analitičnih orodij in tehnik v Sloveniji.

Ključne besede: kartiranje kriminalitete, analiza kriminalitete, kriminalistične preiskave, projekt Krimistat.si, Slovenija

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