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GEOINFORMATION TECHNOLOGIES IN THE FIGHT AGAINST ECOLOGICAL CRIME

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Abstract: *The aim of this paper is to show the importance of GIS in the fight against environmental crime. At the same time, the goal is to show Structure of the geophysical cybernetic system. The models used are based either on attempts to solve inverse problems accurately, or on the use of empirical regression relations, to which the output signals of sensor systems with values of environmental parameters refer, or on the use of statistical classification procedures according to reference samples within objects in the ecological and criminogenic relationship.*

Key words: *GIS, ecological crime, technological invention*

INTRODUCTION

„Over the last decades, a technological invention has allowed us to see more of the world and its breathtaking biodiversity than we ever imagined. Anyone with a good internet connection can now virtually visit endangered gorillas in the Democratic Republic of Congo, elephants in Kenya’s Maasai Mara and the Amazon rainforest. However, the same technologies that bring our eyes to almost all parts of the planet also provide an opportunity for criminals, who are looking for high earnings and the nature of low risk of environmental crime.“ (Gorr, Kurland, Dodson, 2018)

In fact, illegal environmental activities, such as crimes against wild animals, illegal exploitation of wild flora and fauna in the world, and even new methods such as carbon trading and crime in water management, have increased and are currently estimated at up to \$ 258 billion a year. „There is also evidence that environmental crimes often coincide with other serious crimes, such as human and drug trafficking, counterfeiting, cybercrime and corruption. Therefore, environmental crime is a challenge that requires both high-tech invention and coordination in great cooperation.“ (Gorr, Kurland, Dodson, 2018) Global policy makers, law enforcement and the local community must come together in a number of ways and methods to steer knowledge towards the goal of strengthening environmental security around the

world. In short, as criminals become more ingenious, law enforcement must also become more inventive.

„Every significant effort to fight environmental crime begins with monitoring and communication, and technology has improved both the techniques and tools available to the global community in this domain. A wide range of technology now allows us to scan over land and sea using satellites, air drones, remote shutter systems, which operate cameras or other surveillance and security measures, thermal imaging cameras and radio frequency identification. All of this data can be collected and shared through secure information networks that allow local, national, and international law enforcement teams to analyze, communicate, and act to create potential clients and disrupt organized networks that profit from environmental crime.“ (Gorr, Kurland, Dodson, 2018)

1. SCIENTIFIC ELABORATION OF THE PROBLEM

There are many scientific texts that represent the techniques and methods needed to map and analyze spatial data. We do not mention here the texts on statistical and mathematical theory which are the basis of the method of analysis. „Only those that focus primarily on crime-specific analyzes are listed, but differ in the level of methodological rigor (ranging from introductory texts with empirical examples, to texts that assume general knowledge of common methods).“ (Anselin, Sergio, 2009) Anselin and Rei 2009 provide an overview of the methodological issues encountered when performing the spatial analysis of both points, as well as several studies at the aggregate level. „That paper is presented on a rather sophisticated level, but it includes many applications and examples that make it much more accessible to a wider audience.“ (Anselin, Sergio, 2009) Chainey and Ratcliffe 2005 offer a comprehensive overview of data processing, theoretical foundations, and basic and advanced spatial analysis. „This book has also been supplemented by a number of case studies to demonstrate the application of GIS and crime mapping. Many examples are derived from the field of environmental criminology.“ (Chainey, Ratcliffe, 2005) Although only basic methods of mapping and analyzing crimes are presented, the significance of the collection is the connection of methods with criminological schools of opinion about the types of individuals who commit a crime and where the crime takes place. (Hart, Lersch, (2015) Boba-Santos 2017 is the basic text in crime analysis that presents evidence-based approaches for conducting crime analysis with crime mapping. In addition, Boba-Santos 2017 includes updated definitions, used by the International Association of Crime Analysts, to ensure that readers are presented with material that is recognized in the profession. (Boba-Santos, 2017) Maltz and associates in 2000 focused on the application of mapping and spatial analysis software for use in the local community. „They argue that crime mapping and crime analysis in the criminal justice system should be used primarily

to investigate crime patterns and generate hypotheses, rather than to conduct statistical tests. They show how crime mapping can be used to allocate police resources and exchange information with the local population. They provide a number of important ways in which crime mapping, as a tool, can be improved.“ (Maltz, Gordon, Friedman, 2000) Radil 2016 provides a general guide to the expansive field of spatial analysis for criminology, emphasizing the overall concepts of the basics for forensic analysis techniques. (Radil, 2016) Walker and Dwarve in 2018 presented a theoretical and methodological introduction to crime mapping that is available, connecting the foundations of environmental criminology and crime mapping with modern statistical methods. (Walker, Dwarve, 2018) In 2018, Gorr and associates created a GIS workbook, for students, of crime mapping and crime analysis, to learn and apply advanced methods for analyzing crime patterns in Esri's ArcGIS Desktop, the most commonly used GIS software. (Gorr, Kurland, Dodson, 2018)

2. CREATION OF INFORMATION AND CRIMINOLOGICAL TECHNOLOGIES BASED ON GEOINFORMATION SYSTEMS (GIS) AND THEIR ROLE IN THE FIGHT AGAINST ENVIRONMENTAL CRIME

Significant social, economic and environmental changes, as well as the rapid advancement of technology, mark the 21st century. „Characteristic landmarks of this century are climate change and its effects, a global phenomenon that directly and indirectly affects human life and the environment. The most important effects of the phenomenon are climate change in many areas, an increase in average global temperature, rising sea levels locally, melting ice, etc. and the effects of these changes, such as the ever-increasing frequency of natural hazards and disasters, changes in the biodiversity of the area, changes in natural processes.“ (www.veforum.org)



Figure 1. World disaster rates by type for the period 1995-2015. (Source: <https://www.veforum.org/>)

„An important contribution to the proper management and response to this reality are modern and highly efficient tools that have been created, developed, tested and applied in recent years through the technological and scientific explosion that has occurred in parallel with climate change.“ (www.veforum.org)

„Research, management and response to natural disasters and processes have been at the center of interest and engagement of the scientific community and decision makers over the last decade. The current environmental, social and economic challenges (Figure 2), due to climate change, are the prediction of natural disasters and the protection of vulnerable areas, unavoidable natural hazards and increasing natural processes with negative impacts.“ (www.veforum.org) „A striking example of this is the European Union Directive 2007/60, which aims to update and upgrade methods of flood prevention, management and rehabilitation in the Member States. More generally, this directive seeks to set environmental objectives for Member States' water management policies, with an emphasis on groundwater, which is also threatened by natural factors, combined with overexploitation of people, with a deterioration in their quantitative and qualitative characteristics. Appropriate initiatives have been taken around the world with very significant results.“ (www.veforum.org)

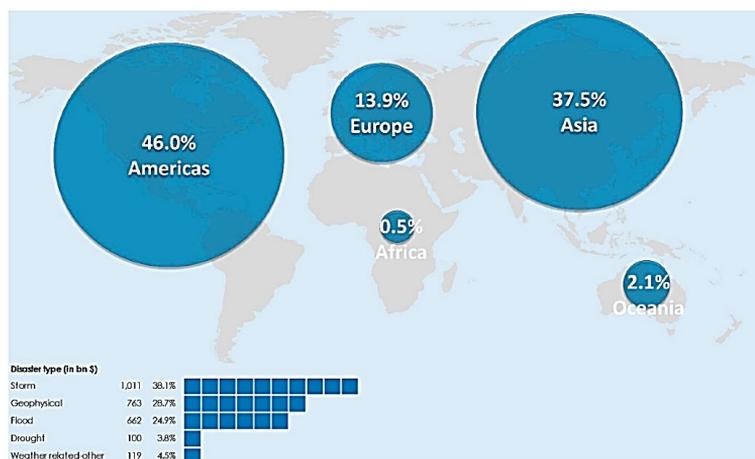


Figure 2. World disaster rates 1995-2015. (Source: <https://www.veforum.org/>)

„Modern requirements in research, design and management of these geo-ecological risks are very high. The main contribution to these efforts is the significant progress of science and rapid technological development in recent decades, which, it seems, will continue to grow in the coming years. In the fields of geoscience, and more

sporadically in natural processes, risks and catastrophes, the scientific and technological top are the Geographic Information System (GIS) and remote reading. The evolutionary explosion of recent years in these two fields has opened up new avenues, ways and methods for approaching and exploring environmental issues, which concern the lives of modern people.“ (Gorr, Kurland, Dodson, 2018)

„Globally, there is a huge boom in satellite programs to monitor the earth and natural phenomena. Many countries, either independently or cooperatively, are developing satellite systems designed for specific applications.“ (Tsatsaris, Kalogeropoulos, Stathopoulos, Louka, Tsanakas, Tsesmelis, Krassanakis, Petropoulos, Pappas, 2021)

„The main performers of these efforts are passive optical satellites (eg Landsat) and active RADAR satellites (eg Sentinel-1), which are designed for environmental applications, such as capturing vegetation, recording fluid areas, monitoring earthquakes (eg using interferometry techniques on satellite images), etc. Over time and together with the development of technology, satellite data is constantly improving in both frequency and spatial resolution.“ (Tsatsaris, Kalogeropoulos, Stathopoulos, Louka, Tsanakas, Tsesmelis, Krassanakis, Petropoulos, Pappas, 2021)

The tools for processing and analyzing spatial information are constantly improving, adopting new methods and techniques, and at the same time becoming easier to use. „In recent years, free open source software programs (e.g., C-GIS) have competed with commercial packages (e.g., ArcGIS), giving researchers the ability to create their own tools, according to their needs, in their own environment.“ (Tsatsaris, Kalogeropoulos, Stathopoulos, Louka, Tsanakas, Tsesmelis, Krassanakis, Petropoulos, Pappas, 2021)

Therefore, GIS, together with open satellite databases and other free spatial databases, covers modern research needs, significantly reducing costs as well as time for analysis and extraction of results, compared to traditional methods. „In addition, they overcome obstacles that were inaccessible in traditional field research, such as access to inaccessible areas, weather conditions, etc.“ (Matovic, 2021)

It goes without saying that the geo-ecological challenges of the 21st century, including environmental crime, can be researched and solved with the help of modern tools provided by technological and scientific progress.

Knowledge of crime, its characteristics, the complex of determination, is necessary in order to obtain information that is used in organizing the counteraction to this negative social phenomenon. Since crime prevention is done in a broad and purposeful way, reliable information on various indicators of this phenomenon is needed to optimize this activity. Such information can be obtained as a result of conducting criminological research.

Research implies the study of a certain object in order to gain new knowledge about it or the phenomena that are related to it. In criminological research, the object is concretized in accordance with the goals of studying the crime and the factors that affect it.

However, criminological information is not quality crime information, as such information can be incomplete, unreliable, and even misleading, as well as untimely (outdated or late in relation to the moment when it could be useful). Or this information could be obtained not for influencing the crime, but for some other purpose (for example, for publishing in the media).

Criminological data are those data that enable the development of adequate measures for the fight against crime on their basis. Therefore, these data should be accurate, and the process of obtaining them should be scientifically based and properly organized.

When developing measures to fight crime, reliable and complete data on the state of crime, its quantitative and qualitative indicators are needed. The analysis of these indicators enables the determination of zones and objects of the highest criminogenicity, as well as critical assessments applied so far:

- organizing the activities of the relevant entities in the fight against crime,
- means and methods of combating crime,
- efficiency and sufficiency of these measures for suppression and reduction of crime.

The study of delinquency is one of the most important conditions for the successful activity of the subjects of criminological prophylaxis, and it is realized through the organization and implementation of criminological research.

However, it is not only special subjects in the fight against crime who are interested in studying it. Addressing social issues in different government institutions implies an interest in studying crime at different levels. Only criminological research makes it possible to cover a whole range of elements that characterize them:

- a complex of factors that determine the tort,
- quantitative and qualitative indicators of delinquency,
- analysis of the personality of the offender,
- analysis of the suppression and efficiency of the activities of the subjects of crime prevention. (Tsatsaris, Kalogeropoulos, Stathopoulos, Louka, Tsanakas, Tsesmelis, Krassanakis, Petropoulos, Pappas, 2021)

When studying the characteristics of individual parts of delicts and structures at different levels of their occurrence, there is the possibility of discovering the characteristics and dynamics of delicts and their other laws. The processing of relevant information leads to conclusions, which enable the optimization of measures

for the fight against a certain type of crime, the creation and improvement of sets of preventive measures, and all that on a scientific basis.

In this regard, when considering environmental crime, it is necessary to note that, as a consequence of the development of production, and especially high technology, the system of combating this type of crime involves invoking non-traditional means and methods from a criminological point of view. This also applies to research methods and measures used in the prevention of eco-crime.

The development of computer technology has given impetus to the further dynamic development of geographic information systems - GIS, as mentioned earlier, which are used in various industries. This process will not only affect the modern development of law in general, but also the specific branches of criminology.

The demand for innovative technologies is not only dictated by the imperative of time, but primarily by the subject of criminology, its basic cognitive postulates, which prescribe the presentation of a three-layer category: tort, crime, criminal identity (with all components of the criminological triad), but not as an abstract result, but rather a concrete result.

Thus, for example, unlike philosophical anthropology, criminology must, in any case, consider the tort, not simply as the essence of negative human phenomena as beings, but as a phenomenon conditioned by certain parameters and precisely established realities caused by place and time.

Thus we can see not only the concretization of the goals that criminology faces, but also the tactics of achieving them. In this case, a certain consistency of theoretical and practical goals is necessary.

In principle, as Avanesov points out, they can be considered from the standpoint of unity, because the main goal for both criminology and anti-crime practice is crime prevention. But such a strategic goal is achieved by certain tactical goals, which are individualized both within theory and practice. (Avanesov, 2015)

This individualization will not only serve to build a reliable model of the expected result of scientific activity in the area under consideration, but by fulfilling the tasks facing criminology, it will be set as a strategic goal.

Thus, today criminologists face important tasks, on the successful solution of which the efficiency of crime control depends. Appropriate control with the help of GIS and technologies, enables obtaining objective data for conducting an appropriate analysis of the cause and legality of any crime, fully revealing its quantitative and qualitative components, including the permanent condition.

Undoubtedly, innovative technologies and their further development will serve as a basis for studying forensic investigative practice. This especially refers to the area of ensuring the efficiency of the environmental protection system, where forensic

practice is not sufficiently developed, and the technology of detection and suppression of separation compositions is poorly developed or does not exist at all.

These and other arguments had a huge mobilizing value in the development of the required scientific direction - ecocriminology, with an assigned subject, a specific object and a symbolic methodology, without whose unity everything becomes impossible. The inseparability of the links between nature and society has recently become increasingly apparent with the growth of productive forces. For the first time, the significance of these connections was examined in detail in the papers by the famous Russian researcher Vernadsky.

Humanity, as a living substance, is inextricably linked with the material and energy processes of a certain ecological envelope of the earth - with its biosphere. It cannot be independent even for a minute. Humanity, taken as a whole, is becoming a gloomy geological force. And it faces, even before its thoughts and reason, the question of restructuring the biosphere in the interest of the free-thinking human being as a whole. (Verdaski, 1987)

These words clearly emphasize the thesis of the transition from the passive study of nature and the use of acquired knowledge, to the management of processes that occur in nature, to their modification according to the will of man and the achievement of his goals. In other words, the main features of the development of nature and humanity are the following:

- the emergence of a large number of different links between society and the environment,
- the growing role of intellectual processes, ie. information processing processes in the realization of these links and
- orientation of intellectual activity of people on the control of the emerging system.

Even a simple observation of these characteristics reveals a clear resemblance to the description of objects and processes that are the subject of cybernetics research. Its founder, Norbert Wiener, defined cybernetics as a theory of control and communication of machines and organisms.

In his later books, he extended the cybernetic approach to social systems. Later, cybernetics developed as a universal methodology for studying the management of various objects and processes, regardless of their physical nature, and in the 1960s and 1970s the cyber boom covered many subject areas - technical, economic, military, biological, medical, criminological and forensic.

Vernadsky defined the biosphere as a space that is essential for human life. By isolating the geophysical environment from the biosphere, as a set of inanimate objects and the processes that take place in them, it is possible to introduce the

concept of geophysical cybernetics as a science of self-governing cybernetic system in which the geophysical environment will be subject to control.

Like any cybernetic system, this system includes, along with the object of control, a control system. In geophysical cybernetics, the control system is quite complex. It should essentially include all human activities, because, directly or indirectly, to one degree or another, any human actions affect the state of the environment and people.

At the same time, it is obvious that the chaotic actions of separated people are not capable of any significant change during natural processes. As a result, it is advisable to limit the subject of the study to the framework of direct impacts on a sufficiently large scale, which are performed by large social groups or have a natural impact on the values of environmental parameters.

Then society as a whole can be considered a system that is being governed, thus representing a cybernetic system that includes man, as well as his socio-cultural, managerial and economic sphere of activity (Figure 3).

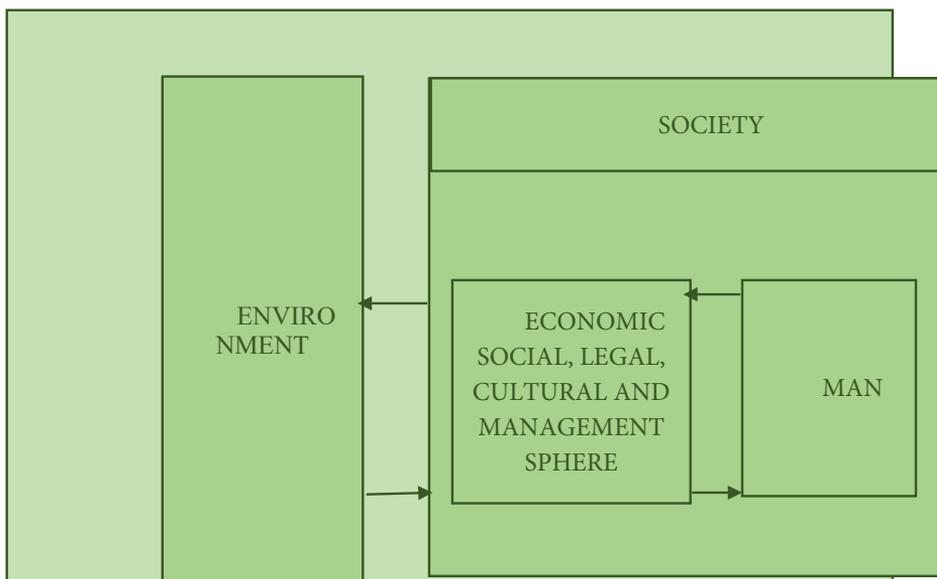


Figure 3. Structure of the geophysical cybernetic system (Author)

The structure shown in the figure is schematic. Society influences the geophysical environment not as a whole, but as a means of one or more substructures included in it. For this reason, in certain management tasks, administrative and technical services of different levels, which are created in the company to perform the appropriate functions, will appear as a control system.

In some cases, the representation of the company in the form of a specialized department is sufficient. At the same time, there are tasks of managing the geophysical environment, where it is impossible not to take into account the impact of society as a whole on the appropriate service, ie. in which the managerial influence

comes from the society as a whole, and the specialized service plays the role of mediator for the society and the geophysical environment. The structure of the control system in geophysical cybernetics tasks will be analyzed in more detail later in this paper when considering specific formulations of control problems.

Managing the state of geophysical natural resources is undoubtedly a difficult task, due to the specificity of such a unique facility. The application of cybernetic methods and approaches, developed in other areas, often encounters a number of difficulties due to the following factors:

Geophysical processes are lacking in research and are identified as management objects. There are no mathematical models of many geophysical objects adequate to real processes. Some models are either simplified or have the character of scientific hypotheses. This refers to seismic processes, the nature of earth currents, large-scale atmospheric processes, etc.

Mathematical models of geophysical processes are very complex. Practically all of them are multidimensional and are described by equations in partial derivatives. Analysis and synthesis of control systems for such systems requires the development of control theory, developed mainly for systems with grouped parameters. At the same time, the needs of national development require the creation of an appropriate methodology, and the following sections will analyze the possibility of setting tasks for the management of the geophysical natural environment and methods for solving them with a criminological reference.

CONCLUSION

The use of GIS is effective for monitoring environmental criminology, identifying causal chains and links, assessing the favorable and unfavorable consequences of environmental measures taken on the ecosystem as a whole and its individual components, making quick decisions on their correction, depending on changing external conditions. (Tsatsaris, Kalogeropoulos, Stathopoulos, Louka, Tsanakas, Tsesmelis, Krassanakis, Petropoulos, Pappas, 2021)

Mathematical modeling of qualitative changes in eco-criminogenic structure is one of the most difficult tasks of operational research. It is complex due to the need to predict trends in the development of the ecological-criminological system, ecological activities and resource saving activities in society, the possibility of creating fundamentally new technologies, etc.

Therefore, the practical application of these models requires prior determination of the complex to be recorded, parameters of spectral characteristics of the data and precise geometry of sounding. The models used are based either on attempts to solve inverse problems accurately, or on the use of empirical regression relations, to which the output signals of sensor systems with values of environmental parameters refer,

or on the use of statistical classification procedures according to reference samples within objects in the ecological and criminogenic relationship.

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