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Original Contribution

GEOGRAPHICAL INFORMATION SYSTEMS AND THEIR APPLICATION IN VARIOUS FIELDS

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ABSTRACT: *Geographic information systems are powerful tools for collecting, analyzing and visualizing geographic data to support decision making in a variety of activities. The aim of this paper is to present the basic principles of GIS and their applications in various fields ranging from ecology and urban planning to health and security. GIS plays an important role in the modern world, enabling better understanding and management of spatial processes and phenomena.*

KEY WORDS: *application of GIS, security, disaster management, criminal analysis, border control.*

1. Introduction

Geographic Information Systems (GIS) are an innovative tool for the collection, processing, analysis and visualization of geographic data. Through these systems, spatial and temporal dependencies can be explored, which is of great importance for solving complex problems in many fields. GIS plays an important role in today's world, where the need for accurate and timely data is increasing. Through GIS, they can analyze processes and phenomena related to the natural and human environment, which helps to improve decision making in various fields such as urban planning, environment, security, health, etc.

In this regard, the aim of this report is to present the basic principles of GIS and their applications in various fields, from ecology and urban planning to health and security.

2. Exposition

Fundamentals of Geographic Information Systems

A geographic information system is a system that enables the storage, management, analysis and visualization of spatial data. It consists of several main components: hardware, software, data and users [2,4].

Hardware consists of computer hardware and equipment that are needed for data collection and processing - computers, servers, GPS devices and sensors.

The software includes specialised programs and platforms, such as ArcGIS, QGIS and Google Earth Engine, which provide tools for mapping, processing and data analysis. Popular GIS platforms offer a variety of tools for map creation, data analysis and visualisation. IoT and sensors play an important role in real-time GIS, providing data on environmental and traffic conditions. Artificial intelligence and machine learning are also being integrated with GIS to enhance analyses and enable automated pattern recognition and predictions.

The data is divided into spatial and attribute data, which is collected from a variety of sources - satellites, sensors, government agencies and private surveys. Users are experts and analysts who manage and use GIS systems to perform analyses and make informed decisions.

The main GIS components use spatial data in different formats - raster, vector, satellite and GPS. Their main function is to associate data with a specific location, which allows the analysis of spatial relationships between objects and processes [2]. These systems include various visualization tools, such as map creation, terrain analysis, and modeling, which help to better understand complex spatial processes.

For example, GIS can provide data on the population of an area, air quality, geological structure of the terrain and other aspects related to space. GIS can be used to analyse terrains, zones and trends, and this data is useful for various public, commercial and research purposes.

Application of GIS in various fields

GIS systems find widespread use in many sectors of science, industry, and public management due to their ability to collect and analyze data that is critical to the planning and management of various resources and services. The following are some of the key areas in which GIS plays an essential role.

GIS is widely used in various scientific disciplines such as ecology, geology, climatology and anthropology. Through GIS, scientists can analyse environmental changes, disease distribution, migration routes and other factors that are influenced by spatial features. In climatology, for example, GIS systems allow the monitoring and analysis of climate change by collecting data on temperature, precipitation, snow cover and other climatic indicators.

In the field of ecology and natural resource management, GIS supports the monitoring of air, water and soil pollution, as well as the analysis of the impact of human activities on the environment and the development of strategies for the

conservation and sustainable management of natural resources. GIS support biodiversity conservation and sustainable management of forest resources through habitat tracking and environmental risk assessment [5].

Many industries rely on GIS to optimize logistics processes, analyze markets and plan retail outlets. In the transportation industry, GIS helps determine the best routes, traffic analysis, and fleet management [3]. In retail, GIS is used to analyze consumer habits and plan new store locations, taking into account factors such as demographics and accessibility of certain areas.

GIS plays a major role in the planning and management of urban areas. They are used for zoning, identifying locations for public facilities such as schools and hospitals, and planning infrastructure such as roads and water systems. GIS assists in identifying areas for residential, industrial and commercial development while preserving green spaces and public spaces [3,5,8]. Population, traffic, and water supply data can be analyzed through GIS, which contributes to better coordination and efficient management of the urban environment.

GIS in agriculture is used for precision farming, a method that optimises yields and reduces costs. GIS supports the analysis of soils and climatic conditions, enabling optimal use of resources such as water and minerals.

GIS also has applications in health care, supporting health resource planning, hospital allocation and the identification of high-risk health areas. GIS can be used to manage public health in tracking the spread of communicable diseases. Spatial factors affecting health, such as access to hospitals and areas at increased risk of contamination, can be analyzed. In epidemiology, GIS allow tracking disease outbreaks and assessing options for controlling infection.

GIS is a valuable tool for security and disaster management. By collecting, analyzing and visualizing geospatial data, they are used to:

- identifying crime zones and preventing crime;
- tracking natural disasters such as fires, floods and earthquakes;
- border control.

Through GIS, higher risk areas can be identified and effective methods for forecasting, planning and coordination of emergency resources can be proposed, resulting in reduced risk to the population and effective protection of critical infrastructure.

Criminal Analysis and Public Safety. GIS plays an important role in criminal analysis by allowing law enforcement to analyze spatial data about crime. By creating crime maps, GIS help identify "hot spots" or areas of increased crime. This allows law enforcement and other public safety agencies to allocate resources efficiently and plan preventative measures in areas of greater need.

Applications of GIS in crime analysis [6]:

- Identifying crime zones: GIS analyses use data on the location of different crimes (theft, assault, vandalism) and allow the detection of recurring crime patterns. This helps to identify areas where crime is most frequent, and to predict future criminal activity.
- Risk prediction: GIS systems can combine data from different sources, such as demographic and economic factors, to create predictive models. This helps security services identify potential new risk areas and plan prevention strategies.
- Patrol coordination: real-time GIS allows monitoring of the location of patrol vehicles, which supports the rapid response of law enforcement and the optimal distribution of forces in incidents.

GIS not only help to identify crime areas, but also to analyse factors that influence crime, such as proximity to urban centres, insufficient lighting or high population density. With this data, additional measures can be planned to improve security, such as installing CCTV cameras, increasing patrols at critical points and improving infrastructure.

Disaster response and crisis management. GIS play a fundamental role in disaster management, helping natural and industrial disaster response services to plan and coordinate their actions. In disasters such as earthquakes, floods and fires, GIS provides up-to-date information on the extent of the disaster and the affected areas, allowing emergency services to take swift and accurate action to save lives and protect property.

GIS Applications in Disaster Management [3,7]:

- Natural disaster monitoring: GIS systems collect data from weather stations, satellites and sensors to monitor natural disasters in real time. For example, during floods, GIS helps track water levels in rivers and dams, allowing for timely evacuation of the population.
- Risk and Vulnerability Modelling: GIS enables the creation of models that identify areas at increased risk of disaster. By analysing topography and climate data, GIS can indicate which areas are more prone to landslides, floods and fires.
- Support for early warning systems: GIS integrates with sensors and early warning systems that collect and transmit real-time data on incoming disasters. For example, when a hurricane is approaching, the system can automatically send warnings to local authorities and the public, reducing the likelihood of human loss.
- Rescue and evacuation coordination: evacuation routes can be created through GIS for use by emergency services. GIS provides information on the affected areas and suggests the safest evacuation routes for the population, taking into account the current conditions.

In disasters such as earthquakes and fires, GIS systems can combine data from different sources to provide an accurate picture of the situation. This helps coordination between different structures - the Fire and Rescue Service, the Ministry of the Interior and the Central Emergency Response Centre - to organise rescue operations and minimise the consequences [1].

Border control and national security. GIS play a key role in the field of national security and border control. By integrating data from a variety of sources - satellite imagery, sensors, drones and ground-based cameras - GIS enables border surveillance and protection. GIS also assist in tracking national security threats such as terrorist activities, smuggling and illegal human trafficking.

Applications of GIS in border control and national security [6]:

• Monitoring border areas: through satellite imagery and drones, GIS provides constant monitoring of border areas. This allows suspicious activities to be monitored and officers to be sent to the border as needed. The movement and location of people and vehicles in critical areas can be analysed in real time.

• Border risk assessment: by analysing different data, GIS support the assessment of risks in border areas, such as high traffic areas or routes used for illegal trafficking. Through these assessments, preventive measures can be taken to protect borders.

• Support for early warning security systems: GIS systems can be integrated with technologies such as motion sensors, infrared cameras and CCTV systems to enable early detection of threats at the border. In case of suspicious movements, the system can automatically send an alert to the responsible authorities.

Threat tracking and incident prevention. GIS provides tools to analyse risk areas and assist in planning counter-terrorism and security measures. The systems combine data from intelligence sources and allow real-time monitoring of potential threats, enabling timely response and incident prevention.

GIS also contribute to the protection of critical infrastructure, such as water supply facilities, electricity transmission networks and strategic sites located near border areas. Through GIS, security services can develop protection and threat response plans based on accurate and up-to-date data.

In summary, it can be stressed that the use of GIS in security and disaster management is essential for the protection of society and the environment. Through GIS, public safety and national security services are provided with dynamic information that helps them make quick and informed decisions at critical moments. GIS is establishing itself as an essential tool for identifying risk areas, coordinating resources and preventing threats, greatly enhancing emergency response capability and ensuring the security of the population and territory.

3. Conclusion

Geographic information systems play a key role in modern society, providing effective tools for the analysis and visualization of geospatial data. Through them, a better understanding of the complex spatial relationships in the natural and human environment is achieved. GIS not only support informed decision making in various fields, but also foster innovation in data analysis and management.

The use of GIS also comes with challenges such as handling large volumes of data, protecting personal information and the need for trained staff. In the future, GIS is expected to evolve with new technologies, such as 5G and augmented reality, which will expand its capabilities and enable its application in new and significant areas of the modern world (such as smart cities and precision medicine).

With the growing need for spatial analysis and real-time data, GIS is emerging as a key tool for modern society, enabling better management and planning across sectors. It is emerging as a necessary resource for sustainable development, enhancing security and improving quality of life.

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