IECG 2020

sciforum

Conference Proceedings Paper

Improving management of spatial data through spatial database

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Published: date
Academic Editor: name

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Abstract: Entering the European Union, Republic of Croatia took over INSPIRE directive called National Spatial Data Infrastructure. Large amount of spatial data can be found through National Spatial Data Infrastructure Geoportal. Data is available for view or download via different services, such as web mapping service or web feature service. Although different spatial data is available, it is hard to access useful information through Geoportal. Aim of this paper is to prepare spatial database which will gather different spatial data related to environmental engineering and present different queries and visualization of the results. Main data used is related to protected areas in Republic of Croatia, register of environmental pollutants, air quality, exploitation and research fields of mineral resources, waste management, water management etc. Alongside National spatial data, Copernicus Land monitoring service EU-DEM, digital elevation model, is used. Classification of Sentinel-2 MSI data is used to provide land cover. Remotely sensed data are used in queries where aspect, slope and land cover affect the results. Two predefined SQL queries are discussed. First query is discussing danger of landslides and second query is discussing threats from illegal landfills and affect they have on environment. Predefined SQL queries enables users to quickly access needed data, even when original data is updated. All data, database, visualization and results are presented in open access software.

Keywords: INSPIRE directive; Copernicus mission; spatial database; predifined queries; environmental engineering

1. Introduction

Today, satellite missions (Copernicus, Landsat, etc.) allow continuous monitoring of the Earth's surface, which allows us to quickly collect data on space [1]. The negative impact on the environment and ecosystems and the emergence of climate change are very current topics in the last five years. There is growing evidence that the Republic of Croatia is vulnerable to climate change because it largely belongs to the Mediterranean region where changes are most noticeable in the economic sector (agriculture, forestry, fisheries, energy, tourism) because the success of the same sectors depends on the climate factors [2].

Various tools can help us to continuously monitor the state of the environment. In this area of research, a science that can be very useful in environmental engineering, called geoinformatics, is increasingly being used. Geoinformatics is considered a profession of the future and is increasingly advancing in terms of information infrastructure. Geoinformatics technologies include the Geographic Information System (GIS), the Global Navigation Satellite System (GNSS), remote sensing and spatial databases.

In most countries, environmental management requires development projects for environmental impact assessment - EIA (Environmental Impact Assessment), which entails the need for basic research and data collection that can be useful in predicting environmental impact with respect to the proposed project. Thus, the collection of data on basic research requires a model of monitoring. [3] presented the Before-After-Control-Impact (BACI) model, a model that allows for easier assessment when deciding the impact of a particular activity on the environment at a particular location.

Due to the growth of the human population and the pressure that has a negative effect on the Earth's resources, the planet's environment is changing at an alarming rate, which requires the establishment of monitoring measures.Environmental monitoring serves to assess the effectiveness of environmental legislation or policy, to monitor and assess compliance with regulatory legislation established for environmental protection, (e.g., to monitor that the discharge from a particular plant flowing into a given river is treated as default standard) and to detect changes in the environment (e.g., vegetation change for early warning purposes)[4]. For this reason, it is important to build a solid database with all data on vegetation, soil type, fire frequency, area temperature to ensure easier monitoring and control of the area. The Copernicus Atmospheric Monitoring Service has provided the results of an atmosphere monitoring survey following a fire in the African Circle. Total carbon emissions by 2019 are equivalent to Sweden's total annual emissions of 50 megatons of CO_2. The average carbon emissions caused by fires per year are 7.7 gigatons, which is approximately 25% of the total annual carbon emissions from fossil fuel combustion[5]. The European Union's Copernicus program is designed to enable monitoring of the Earth and the state of the environment. The program's data policy ensures full, open and free access to data and information in accordance with the international principles for data exchange of the Group for Earth Observation (GEO)[6].

The Copernicus program supports a variety of applications in several domains that potentially impact companies and organizations in day-to-day activities: agriculture, the blue economy, climate change and the environment, development and collaboration, energy and natural resources, forestry; health; quality assurance and management, security and defense, tourism, transport and urban planning. The European Space Commission is responsible for the operation and safety of satellite systems, and the European Environment Agency is responsible for the in-situ component of the work [6]. With the help of spatial data taken from the Copernicus service and the PostgreSQL database system, the existing problem with waste disposal in the Republic of Croatia will be investigated and potential locations for the construction of a regulated landfill will be determined given the number of people in each county.

2. Experiments

National Spatial Data Infrastructure Geoportal (NSDI Geoportal) is the starting point for finding spatial data of the Republic of Croatia. The State Geodetic Administration of the Republic of Croatia presented Geoportal in 2014 for the first time. The portal consists of a Metadata Catalog and a spatial data viewer that facilitates the process of searching and retrieving spatial data.

The ultimate goal of the NSDI Geoportal is to consolidate the described information on all spatial data and make it accessible and shared in a simple way using the catalog service. Geoportal belongs to the category of open source technology and currently 415 sources with metadata are available through network services, which are free to download [7].

In addition to the data from the Copernicus service, data from the website of NSDI Geoportal were also colected. Copernicus service data that is downloaded is used to further visualize results, and expand queries with additional data such as digital terrain model or land cover.

The data used for this research belong to the branch of Environmental Engineering [8]:

- Air quality in the Republic of Croatia - WFS
- Central Landfill Information Management System - WFS
- Census of Population, Households and Dwellings 2011 - WMS

For the purposes of working with spatial data in PostgreSQL, the following steps were followed:

Step 1 - download spatial data;
Step 2 - format - save downloaded .wfs (Web Feature Service) data in ESRI .shp (ShapeFile) format;
Step 3 - install PostGIS and create a spatial database
Step 4 - load spatial data in pgAdmin - PostGIS ShapeFile Import, QGIS;
Step 5 - making spatial queries with real data
Step 6 - visualization of spatial data

After all the data is uploaded into spatial database, different spatial queries can be made. For the purpose of this paper only two queries will be presented. First query needs to determine which biogas plants are not licensed and are located within counties with waste volumes greater than 2000 tons during summer time. Second query should answer which landfills are currently being rehabilitated and to which counties do they belong?

3. Results

First query results are shown on Figure 1 where green dots present unlicenced biogas plants.

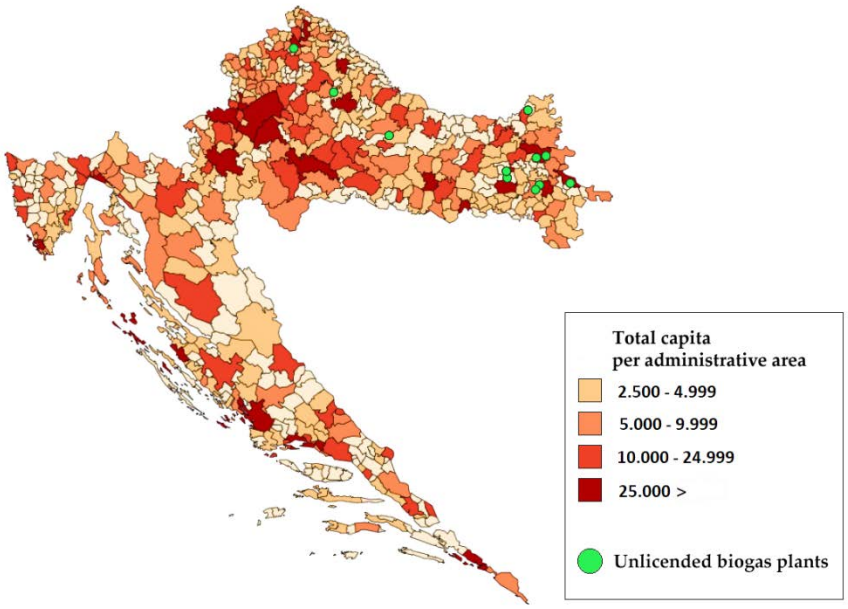

Figure 1. Biogas plants that are not licenced

Second query results are presented in Figure 2 where blue dots present landfills.

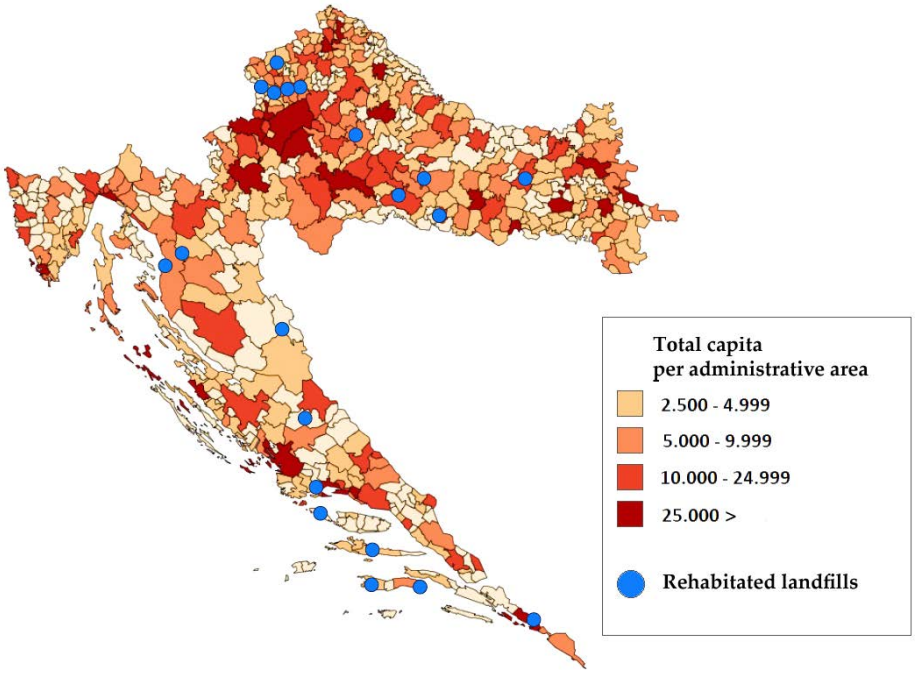

Figure 2. Rehabitated landfills

Results from the two queries show that collected data can be visually presented. However, what can not be seen from the results is that all the queries can be saved and used after the data is updated. For this types of queries users are usually administrative counties which are responsible for decision making. They can use this data in order to improve their analytics and select the best solution. Data can be updated per day, per month, or any other period of time when user consideres it is necessary to update the database. Also, the advantage of spatial database is that it can be filled with different data types and accessed from any part of the administrative area. However, there are also limitations in this type of analysis, since as mentioned before, data can be updated in various time frames. Therefore, users should be careful while using this types of data in order to provide correct decision. Spatial database, as previously mentioned, can be filled with Copernicus imagery in RGB color composition. Figure 3 presents RGB view of one of the rehabitated landfills presented in Figure 2, where red circle presents rehabitated landfill. From Figure 3 can be seen landfill and it's surroundings. In that way Copernicus data is utilized in order to provide user with visual terrain presentation, and gain more information about specific area (rivers, lakes, forests or any other objects).

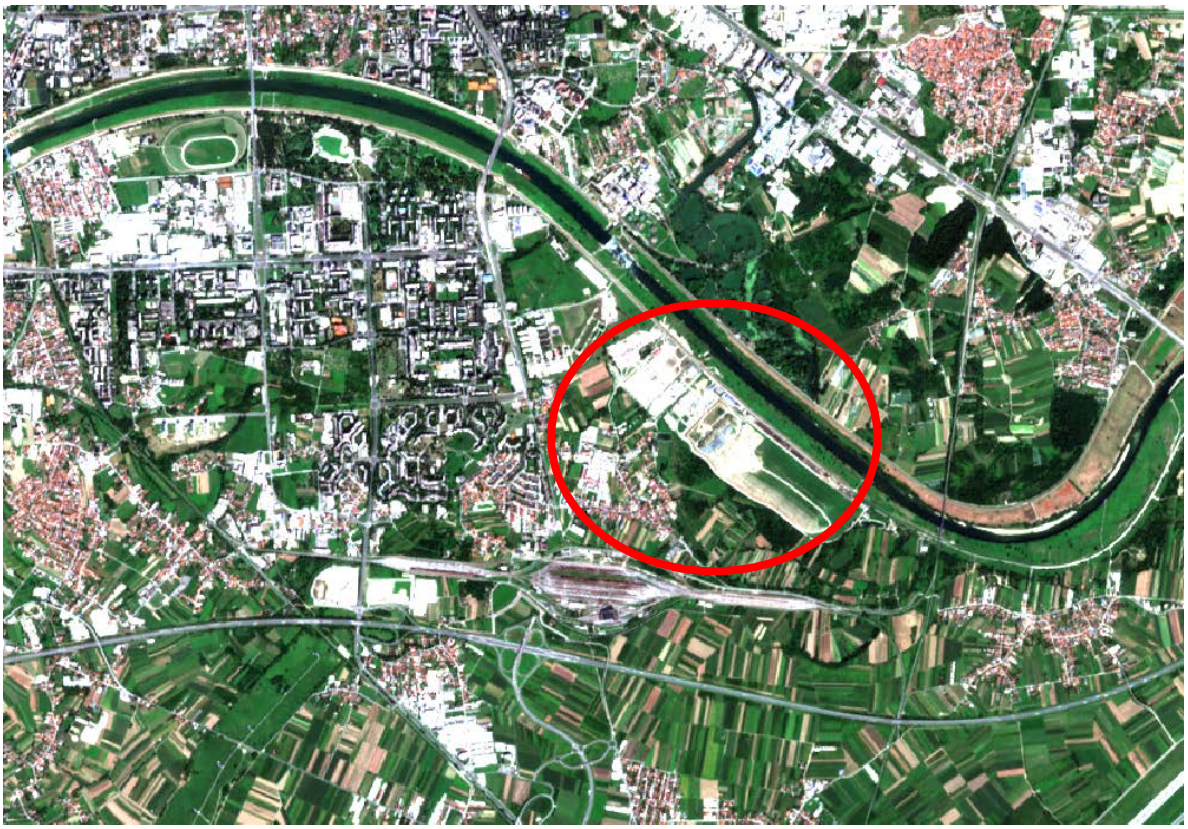

Figure 3 Copernicus Sentinel 2 RGB imagery

5. Conclusions

Given the results, we can conclude that SQL is very useful and easy to use in working with spatial data. The great advantage of this type of SUBP is that it belongs to the group of open source software and thus facilitates data loading, manipulation and visualization of spatial data. Working with spatial data is not demanding because with spatial database management systems they are treated the same as other data types. It can be concluded that PostGIS contains a very good graphical user-friendly interface. It allows easy work with the database and in a way hides the main background about working with data (e.g., indexing, coordinate notation and data display). Today, there are many tips on the Internet related to learning the basic functions of databases and types of data manipulation. Designing a database, changing the structure of a database, performing SQL queries with simple syntax are the basics that are sufficient for the purposes of creating this paper. For this reason, the PostgreSQL database system is suitable for use in practice when solving important environmental problems. In order to create useful queries that will give us an answer to a particular environmental problem, it is important to find or create quality spatial data and it is necessary to understand the syntax of the SQL programming language. Without basic spatial bases such as spatial units, settlements, counties, etc., it is difficult to imagine spatial analyzes, and for this reason data synergy is important. PostgreSQL shows with practical examples that it represents a serious competition to commercial databases in the market because it is dynamic, easy to use by users and interesting to work with.

Author Contributions:. N.K. conceived and designed the experiments; N..K. performed the experiments; N.K. and B.Đ. analyzed the data; D.D. and L.P. contributed reagents/materials/analysis tools; N.K. wrote the paper."

Conflicts of Interest: The authors declare no conflict of interest.

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