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CIVIL ENGINEERING - SCIENCE & PRACTICE

GNP 2024 PROCEEDINGS

Kolašin, March 2024

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DATABASES AND RECORDS OF PROPERTY AND NEW PLANTINGS IN THE COMPANY "13. JUL – PLANTAŽE" USING OPEN-SOURCE PLATFORM QGIS

Abstract

Today, there are few activities in which information and communication technologies do not play a direct or indirect role. In fact, they represent the 'nerves and arteries' of modern society, facilitating and supporting global flows of information, ideas, and services. In this way, geoinformation systems (GIS), as modern information technologies, directly impact the processing and utilization of spatial data.

Considering the fact that GIS is continuously expanding and improving, today it can be applied in various fields that involve information related to space, as well as in the decision-making processes related to them. It can be utilized by all institutions and companies dealing with space management and exploitation in any way, including urban planning, construction land, road and railway networks, water supply, sewage, power distribution, gas distribution, telecommunications, district heating, ecology, landscaping, agriculture, forestry, and more.

Quantum GIS (QGIS) is the leading open source GIS desktop application which belongs to and is developed by Open-Source Geospatial Foundation (OSGeo). With many plugins developed by user community, QGIS offers vast variety of different functions for working with vector and raster spatial data, and also non-geographical data.

Without delving further into this wide field, in this paper we will describe the Information System of the company "13th July – Plantaže", which main activity is wine grapes and wine production, through a specific project of new vineyards data acquisition, analysis and display, completed in the previous period using the QGIS software package, along with suggestions for its improvement.

Keywords

QGIS, vector data, plantations, vines

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1.   INTRODUCTION

Surveying and cartography in conjunction with other geospatial sciences have always carried out various tasks in the field of recording, acquisition, processing and presentation of relevant geospatial data and information. Expert opinion [1] is that special attention should be paid to the role and application of modern technologies of spatial data acquisition and processing, because they bring revolutionary changes in the way of interpreting spatial forms. Geo-intelligence, Artificial Intelligence GIS and new technologies, as well as the intensive development of open source solutions and cloud computing, led to their full integration in the field of agriculture, especially in the part of rapid adoption of solutions [2]. On the other hand, QGIS is the most popular free geospatial software in the world. QGIS belongs to the Open-Source Geospatial Foundation (OSGeo). Its main advantage is the incorporation of tools via plugins, and a community of users and developers in constant growth [3].

The company 13th July – Plantaže owns 4,060 hectares of land in eight municipalities, with approximately 2,270 hectares dedicated to vineyards, olive groves, pomegranates, peaches, apricots, and nectarines. The area under cultivation is maintained each year through the clearing of old plantations and the establishment of new ones. In the period from 2016. to 2023, 270 hectares of new vineyards and 25 hectares of peach and nectarine orchards were established, along with the planting of 650 pomegranate trees and 8,100 olive trees.

In order to improve the current practice of analogue storage of investment data and to ensure a higher level of data protection in light of personnel changes and the passage of time, the QGIS software package has, through its capabilities, provided a suitable and accessible solution for the storage and analysis of data.

2.   APPLICATION OF QGIS IN THE EXISTING RECORDS

2.1.   STUDY AREA

The plantations of the company "13th July – Plantaže" are located in Ćemovsko Polje, the central part of the Zeta Plain. Geospatially situated southeast of Podgorica, between the rivers Morača, Ribnica, and Cijevna, precisely at the tripoint of three municipalities: Podgorica, Golubovci, and Tuzi. The field is formed by fluvioglacial deposits that powerful flows of the Morača and Cijevna rivers carried during and after the Pleistocene, filling a relatively shallow and spacious depression of the karst field. The thickness of the fluvioglacial deposits ranges from 30 to 90 meters. The climate, similar to the other parts of the Podgorica-Skadar Basin, is sub-Mediterranean [4]. The plantations are distributed within six cadastral municipalities: Podgorica III, Dajbabe, Cijevna, Golubovci, Tuzi, and Vranj (Figure 1).

Depending on the type of production, they can be divided into three groups: vineyard plantations, fruit orchards, and grape plant nursery. Vineyard plantations, which constitute the majority of the company's plantations, are further divided into 11 specific units. These units represent the basic organizational entities formed with the aim of more efficient management of all necessary agro technical operations that constitute a single production season.
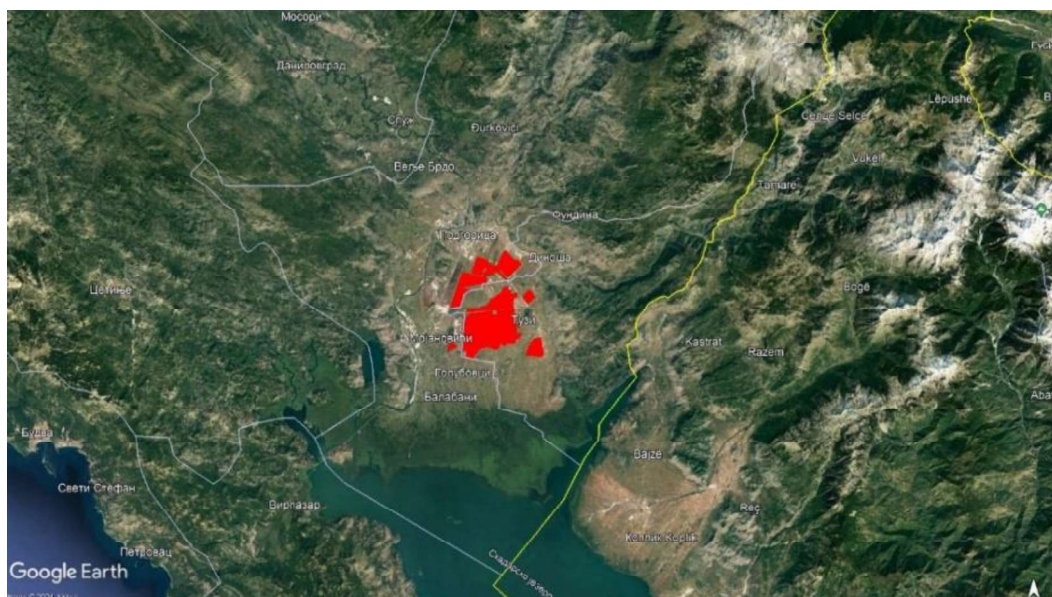
Figure 1. Plantation of "13. Jul ‒ Plantaže"

2.2. DATA ACQUISITION AND PROCESSING

In the sketches from the period before 2016, data about plantations only represent a schematic depiction of the positions of individual plots, with the name of the variety planted there and an area that was not surveyed geodetically.

After 2016, the planning of new plantations was preceded by geodetic surveying of the investment location. The available information about the plantations included a range of other data besides the variety. Therefore, this year was taken as the starting point in the analysis and processing of the available data.

Traditional GIS packages are programs that work with maps in vector format. Additionally, they possess geographic coordinate systems through which the position of individual objects on the map is tied to their real-world locations. This characteristic of GIS systems is called georeferencing and represents the essence of the GIS concept [5].

Before the actual formation of a QGIS project, it is necessary to collect and categorize all available data that will be used in further work. The geographic component of the project consists of vector and raster data.

The results of geodetic surveys, conducted with a polygonal network stabilized along the main directions within the plantations in Ćemovsko Polje, are transformed into vector data. Satellite and orthophoto images can be utilized as raster backgrounds. As a specific type of vector data, cadastral information should be highlighted. Following this, through technical reports from agricultural engineers, it is necessary to determine which information is significant and crucial for decision-making regarding the type of data and their attributes for representation in GIS.

Given that vine, peaches, nectarines, and apricots are organized into blocks and plots of simple geometric shapes with the same attributes, polygons are used to represent them. On the other hand, olive trees and pomegranates are represented as points due to the frequent mixing of plant varieties, i.e., different attributes within the same row.

3.   RESULTS AND DISCUSSION

3.1.   DATA IMPORT

In this project, raster data were exclusively used as a base map for vector data derived from geotetic surveys. Therefore, the easiest and most economical way is to acquire available satellite images and georeference them. QGIS, in addition to predefined features, has numerous plugins that can be installed later. For this purpose, the 'Tile+' plugin is suitable, and it can be installed through a ZIP file.

Raw Google satellite imagery, with approximate pixel dimensions of 15 cm × 15 cm (in nature), in this case has a file size of 13.3 GB. This is a challenge when working in QGIS because loading such large raster data into the map display window is slow. To expedite this process, raster pyramids are created, defining the number of pyramid levels and the resampling type. Pyramids reduce the resolution, enabling faster loading and manipulation of raster data. In this specific case, the nearest-neighbor resampling method was chosen, with six pyramid levels. The resolution of the final level is 1/32 of the input raster resolution (2^{n-1}).

For further processing and georeferencing of the satellite image, the 'Georeferencer' tool is used. Since control points were not the subject of field measurements, characteristic points identifiable on the image are chosen as control points. Their corresponding coordinates in the State Coordinate System (SCS) are obtained from the Interactive Web Map (orthophoto) of the Geoportal of the Administration for Cadastre and State Property of Montenegro. Control points should be distributed to cover the raster as well as possible. After the selection, transformation parameters are defined, including the type of transformation, resampling method, coordinate system, etc. The Root Mean Square Error (RMSE) value for each control point appears in the table in the control point window. This is a good way to identify and correct gross errors.

After georeferencing is complete, the resulting image can be visually checked using geodetically surveyed objects, and their vector and raster representations can be compared (Fig. 2).
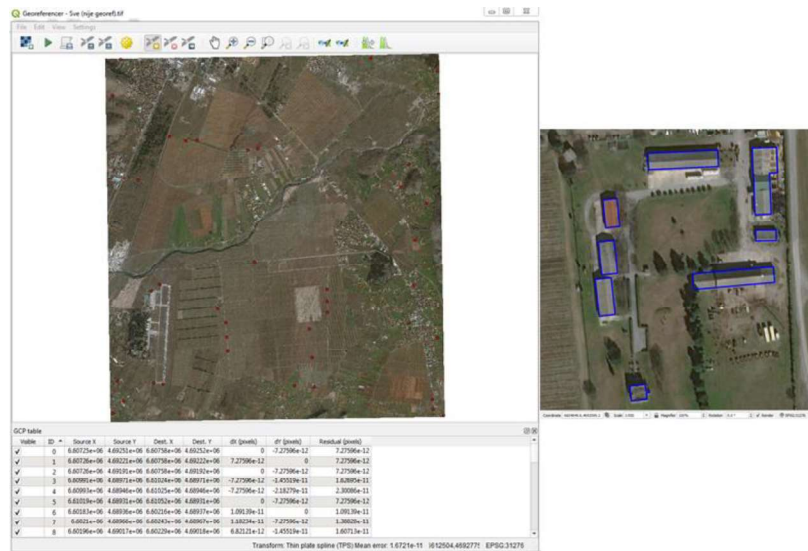

Figure 2. Software Georeferencer and visual evaluation of georeferencing

To load point entities onto the obtained base map, a CSV file can be used in a single step. In the first row of the file, the names of all columns with attributes are defined, distinguishing columns containing geographic data (coordinates in the SCS) for plotting individual entities in QGIS, from columns containing other descriptive attributes.

For polygons, the loading is done in two steps. In the first step, boundary lines of polygons are loaded in DXF format, then converted into polygons, and assigned a unique identifier (ID). The ID is necessary to connect the obtained polygons with corresponding descriptive attributes loaded via a CSV file. They are then linked using the 'Joins' option.

Attributes usually have certain relationships and constraints, which can be defined using the 'Attributes Form' option (Figure 3). Here, we can define an 'Alias,' i.e., the full name of the attribute that will be used in the 'Attribute Table' window. We can also specify the widget type and certain constraints, such as ensuring that the number of the last row cannot be smaller than the number of the first row. Additionally, for some attributes, it is useful to predefine possible values that the user can select from a dropdown menu.
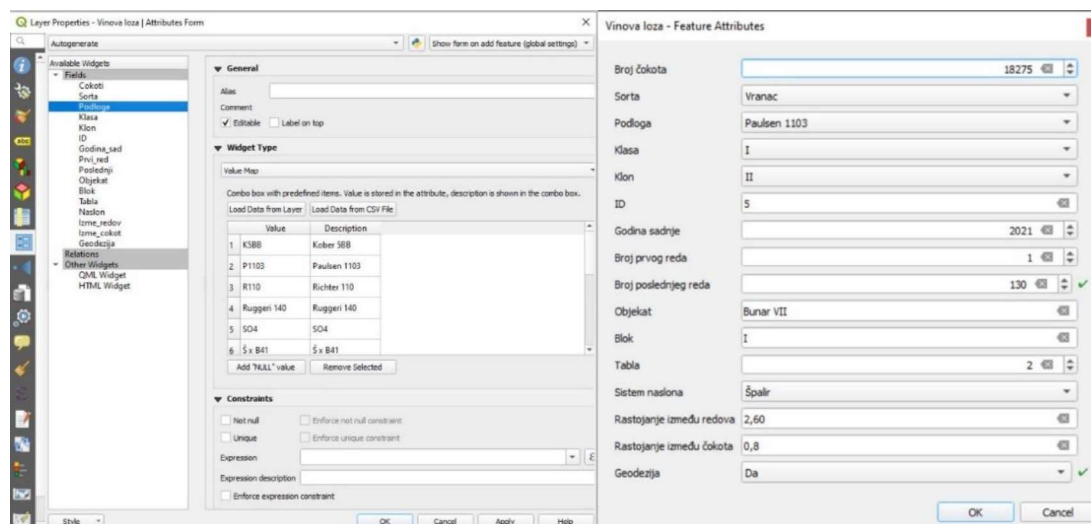

Figure 3. Attributes form

3.2. MAP CREATION AND DATA ANALYSIS

QGIS provides capabilities for creating various queries and cartographic representation of their results, ranging from simple forms, i.e., displaying entities based on the values of individual attributes, to complex representations of derived attributes and geoprocessing results.

In investment analyses, the emphasis is often on spatial planning and creating reports on completed and ongoing activities related to orchard renewal. These reports can be specific to individual objects or cover entire plantations. The goal of the QGIS project is to provide reliable data in the fastest possible way, presented in various forms, in accordance with the desires and needs of an end user. In addition to cartographic tools, QGIS also offers the option of tabular representation of the results of specific analyses. A useful tool for this purpose is the 'Group Stats' plugin, which facilitates the calculation and display of basic statistical analyses.

A high-quality investment report (Figure 4) serves as an ideal foundation for further production monitoring of orchards, as numerous data such as yield, costs, and changes in the number

of grapevine stocks can be stored in one place and linked to individual spatial entities. This information can be further displayed either at the table level or at the object level. Good communication between different sectors of the company is crucial for establishing the initial state during the first year of plantation and for regular updates thereafter.

Considering the economic lifespan of a vineyard, which is around 30-35 years, it becomes evident that renewing 60-70 hectares of vineyards annually is necessary on the existing plantation areas to maintain vineyard profitability. This represents a significant financial expense and requires careful planning of all activities over the long term.

By incorporating cadastral data, it is possible to perform analyses which results are essential as input parameters for property valuation, often required for mortgage purposes, for example determining the degree of occupancy of cadastral parcels with orchards and obtain information about the number and age of grapevines on the parcel.
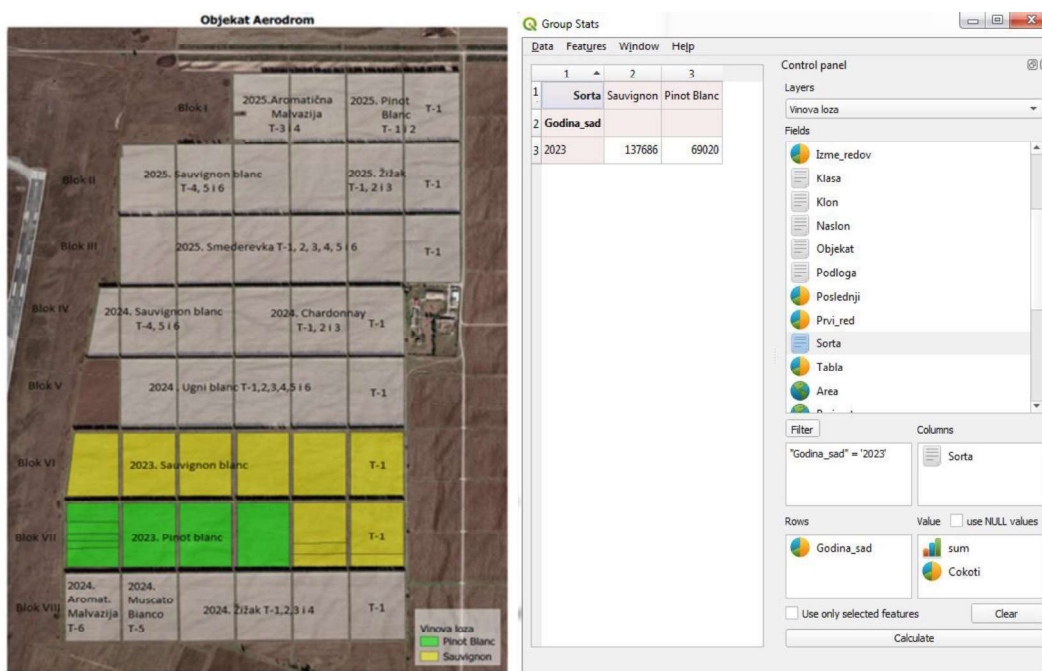

Figure 4. Report on 2023. planting, and 2024-2025. plan, unit "Aerodrom"

4.   CONCLUSIONS

GIS easily finds its application in agriculture, including viticulture. In this regard, one of the most important applications of the QGIS software package is the visualization and analysis of various types of data from different sources, aiming to make the best decisions. Multi-criteria decision-making, where multiple factors of the same or different weights are considered, leading to several alternative solutions, can find a valuable ally in QGIS.

In this project, which is limited to the period 2016-2023 (Figure 5), QGIS has taken the initial step towards comprehensive digitalization and storage of a vast amount of data that accompanies the daily work with the largest monolithic vineyard in Europe.

However, for a vineyard GIS to meet the specified requirements, it must rely on quality and reliable data. This is precisely where the huge potential for expanding the described project lies, moving from recording the existing state to actively participating in shaping the future.

In addition to further data collection on the plantations, this project can be enhanced with information on the irrigation system, which, like the plantations, is continually renewed and improved. In this context, it is necessary to first obtain data on wells and hydromelioration infrastructure, their spatial positions, and characteristics.

Data from hydrogeological, pedological, topographic studies, as well as maps of fire risk and vulnerability, can also be additional sources of information that could be integrated.

An additional branch of activity for the company "13th July – Plantaže" is enotourism, and with QGIS tools, it is possible to participate in creating necessary promotional materials aimed at promoting the tourist offer in the increasingly demanding wine tourism market.
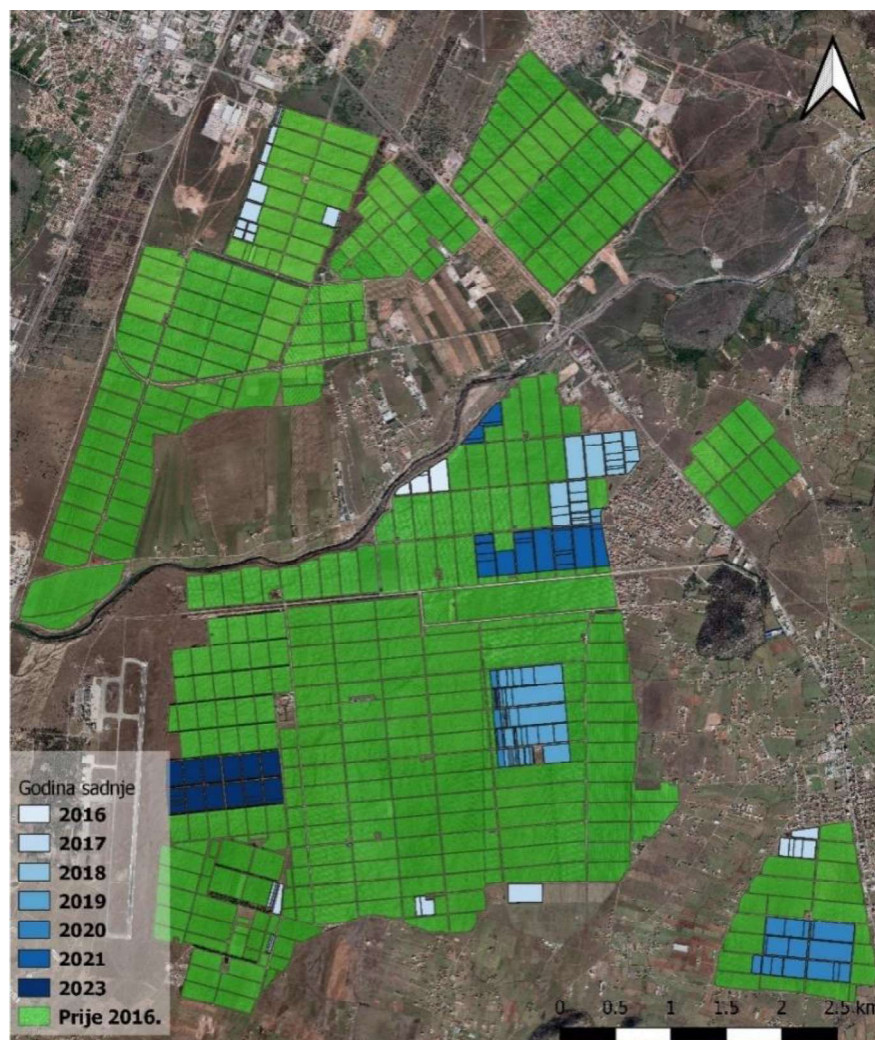

Figure 5. Overview of planting for the investment period 2016-2023.

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