

POSSIBILITIES OF IMPLEMENTING A GEOGRAPHICAL INFORMATION SYSTEM (G.I.S.) RELATING TO LAND USE CATEGORIES

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RESEARCH ARTICLE

Abstract

The creation of geographic information systems in the agricultural and forestry sectors can now be carried out efficiently, thanks to advanced technologies for positioning topographic details and for optimal processing of recorded data. Consequently, the final products that can be obtained can be alphanumeric, graphic, in analog or digital format. Also, from the results obtained in the two variants, geographic information systems - GISs and their respective spatial databases can be built. In order to optimize current and prospective activities related to the two aforementioned sectors of activity, geographic information systems and their respective databases are absolutely necessary. The objectives of this case study are represented by the possibilities of creating a geographic information system related to the categories of land use for agricultural and forestry purposes. To achieve the proposed objectives, GNSS technology, the GPS system and respectively UAV technology, drone, and a series of specialized computer programs, corresponding to the work technologies, were used. The geographic information system and the corresponding database were created using vector data, respectively rectangular coordinates in the national reference system - STEREO-1970, which were determined with GNSS technology, the GPS system, by the real-time kinematic method - RTK, using satellite recordings from the permanent GNSS station Gurahonț, Arad county. In order to achieve an efficient and objective analysis of the reality on the ground, an orthophotomap was created based on photogrammetric recordings made with a drone. The final product is represented by the database and thematic map of the use categories for agricultural and forested lands, which were studied and analyzed. The use of vector data and, respectively, of the attributes identified on the ground, for the case study location, ensures the obtaining of precise and up-to-date results, which can be used with maximum efficiency for current and prospective sectoral activities.

Keywords: Geographic Information System (GIS), database, land use categories, agricultural land, land with forest vegetation.

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INTRODUCTION

Land within the national land fund can be classified according to its use category and, respectively, according to its economic destination. The use category of the land can be natural or artificial – when it is influenced by anthropogenic action. As a result, the use category represents the main unit of land classification, being individualized by a code. This is one of the cadastral attributes of the plot, being necessary for establishing taxes and fees related to real estate (Novac, 2007).

The use category has as its superior unit the use group, and as its inferior unit the use subcategory. Land use subcategories are highlighted and recorded only in specialized cadastres. Currently, two extended use groups

are identified in the national land fund, each with several use categories - Table 1 (Novac, 2007).

In the uncollectivized hill and mountain areas until 1989, arable land, pastures and hayfields represented important means of subsistence for local populations.

Arable land is land that is plowed every year or every few years (2-6 years) and is cultivated with annual or perennial plants. The arable use category has the symbol A (Novac, 2007).

Table 1

**The land fund of Romania as of 01 01 2004
(Novac G., 2007)**

Land use category	Suprafața	
	(ha)	%
Arable	9414.341	38,35
Pasture	3354.970	14,07
Meadows	1490.384	6,25
Vineyards	230.527	0,97
Livezi Orchards	227.204	0,95
Total agricultural	14717.426	61,74
Private property	14155.954	59,38
Forests	6751.645	28,32
Water	843.710	3,54
Other land	1526.290	6,40
Total non-agricultural	9121.645	38,26
TOTAL LAND FUND	23839.071	100,00

The subcategories related to the arable category are represented by:

- arable in fallow or plowed pastures,
- arable with scattered trees,
- arable with bushes and isolated trees,
- arable with abandoned vineyards,

vegetable gardens, rice fields, greenhouses, solariums, nurseries (Novac, 2007).

Pastures are represented by grassed or grazed lands naturally or artificially, by reseeding at intervals of maximum 15-20 years, and the grassy vegetation is grazed or grazed by animals. This use category has the symbol P (Novac, 2007).

The corresponding subcategories of use are represented by:

- clean pastures,
- pastures with trees,
- wooded pastures,
- pastures with bushes and hayfields

(Novac, 2007).

Hayfields are lands that are grassed or grazed naturally or artificially, by reseeding at intervals of maximum 15-20 years. In this case, the grassy vegetation is harvested by mowing for hay, which is used for animal feed. This use category has the symbol F (Novac, 2007).

The subcategories related to meadows are represented by:

- clean meadows,
- meadows with trees,
- wooded meadows,
- meadows with bushes and brambles.

Records relating to the spatial position and various qualitative attributes related to arable land, pastures and hayfields can now be managed efficiently using geographic information systems (GIS).

A geographic information system (GIS) is an information system that allows the implementation, processing, storage, integration, manipulation, analysis, visualization and exploitation of spatially referenced data (Chezan et al, 2006).

Consequently, an information system is made up of:

- geographic data, which presents a spatial distribution;
- computing systems (hardware).
- program systems that are made up of specific processing, analysis and management algorithms (Chezan et al, 2006).

GIS products have a wide range of applications, in the most diverse fields. Practically everything related to territory falls, more or less, under the scope of the programs embedded in a GIS. We will briefly list some possible fields and applications (Chezan et al, 2006).

In order to design and implement an efficient information system, it is necessary to respect a series of basic principles, which have been deduced from practice. These are represented by:

- global modular approach;
- economic efficiency criterion;
- user orientation;
- ensuring the uniqueness of data entry;
- beneficiary training in the implementation of the system;
- possibility of further development;
- bottom-up strategy;
- top-down strategy (Chezan et al, 2006).

The areas of use of the GIS are relatively extensive, being represented by:

- management of water, gas, electricity, telecommunications networks;
- environmental protection;
- territorial planning;
- agriculture and forestry;
- natural resources;
- transport;
- demography;
- marketing;
- cadastre (Chezan et al, 2006).

For the management of water, gas, electricity, telecommunications networks with high efficiency, very precise maps, based on high-performance vector models, are necessary. Also, for the location of the transmitting-receiving stations in the cellular telephony system, the terrain configuration is extremely important, maps drawn up with raster data

being covering for solving sectoral problems (Chezan et al, 2006).

In environmental protection activities, GIS applications and products are effectively used to inventory territories affected by pollution. Also, at a higher level, studies can be made on the effect of climate change and extreme weather phenomena on the environment (Chezan et al, 2006).

For land use planning activities, GIS applications can be optimally used in land monitoring, preparing urban development plans, for communes, counties, regions and even interregionally. Geographic information systems can also be used to study the location of residential neighborhoods, using data, information and attributes from various authorized sources (Chezan et al, 2006).

In agriculture, the use of various GIS applications facilitates soil inventory, namely the collection and implementation of qualitative attribute data, on soil type, quality, fertility, exploitation method, etc. Also, GIS products can currently be used to monitor agricultural lands and those intended for fruit tree orchards, to optimize the achievement of maximum production and necessary subsidies and financial interventions (Chezan et al, 2006; Roşca et al, 2015).

In the forestry sector, the use of GIS is necessary for forest inventory, mapping of protected areas and virgin and quasi-virgin forests, and for the development of forest management plans. Also, a series of research and studies can be carried out on the accessibility of stands in mountain areas and the location of areas from which wood is exploited (Chezan et al, 2006; Crainic et al, 2021), in order to minimize the destabilizing anthropogenic impact on forest ecosystems.

Studies regarding the integrity and conservation of the national forest heritage can currently be carried out through GIS applications integrated with modern remote sensing technologies (Matei et al, 2022).

Currently, a series of projects are underway to identify natural resources (minerals, oil, gas, water) using various GIS applications and products. The efficiency of these activities is currently possible through the integration of high-performance remote sensing and digital photogrammetry applications, increasingly using UAV technology.

GIS can also be successfully used for the management and optimization of transport in general. In this context, optimal routes for

emergency vehicles can be established and selected (Chezan et al, 2006).

The creation of population databases (by age, religion, profession, education, health, etc.), integrated with administrative maps at the commune level, can ensure the obtaining of useful and efficient information for local or regional administrations (Chezan et al, 2006).

The use of a city map associated with a demographic database can be used to simulate the location of various production capacities, commercial centers, etc. (Chezan et al, 2006).

The inventory and maintenance of spatial data and attributes related to all lands, as a defining activity of the cadastre, can be efficiently carried out using GIS products. Once a computerized cadastral system is created, it ensures the management of data and information with increased efficiency. Consequently, obtaining information, especially in digital, but also analog format, relating to various lands, is achieved in record time (Chezan et al, 2006; Cienciała et al, 2021).

Large-scale GIS projects aim to obtain information for the elaboration of development strategies at regional and national level, using established management models. Consequently, modeling and simulation represent defining principles (foundations) within the spatial analysis, respectively defining algorithms of a GIS (Chezan et al, 2006; Kalisz et al, 2023)

Currently, the National Agency for Cadastre and Real Estate Advertising (ANCPI), carries out, at the cadastral sector level, systematic registration works of real estate in and outside built-up areas, with economic operators in the land surveying sector preparing parcel plans, equipped with all related attributes, in digital and analog formats (Cioflan, 2025, Cioflan et al, 2025).

MATERIAL AND METHOD

The case study was conducted in the Vîrfurile locality, Arad County Figure 1, an area that has not been collectivized, which has an area of 136 km². The locality is located at an average altitude of 231 m, reported to the Black Sea level. The research and studies were carried out within the cadastral sector no. 15, where the systematic registration of real estate in the countryside was carried out.

The objectives of the case study are to present the particularities of creating a geographic information system - GIS and the related database, for the categories of use of agricultural land and those occupied by forest

vegetation, in cadastral sector no. 15, UAT Vîrfurile, which have not been collectivized.

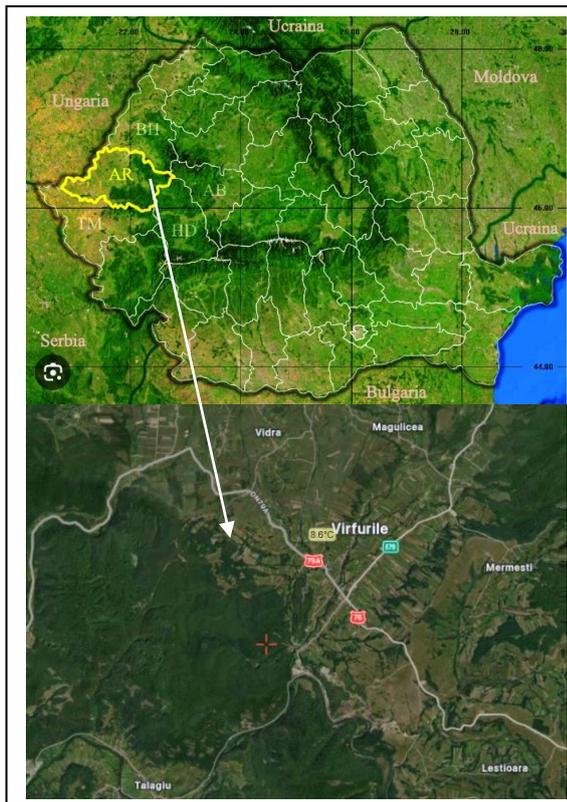


Figure 1. Location of the case study
 (<https://www.google.com/search?q=harta+satelitar%C4%99>;
https://satellites.pro/Varfurile_map.Arad_region.Romania)

The research methods used are represented by: bibliographic documentation, observation on the route, stationary observation, experiment, simulation, analysis, comparison, recording of images on digital media.

To carry out the research and studies, diversified logistics were used, such as infrastructure, hard base and software base.

The data used to create the information system, namely the database and thematic maps, were vector-type. They were recorded with GNSS (Global Navigation Satellite System) technology, the GPS system, by the real-time kinematic method (R.T.K.), during the systematic registration of buildings in the countryside.

For the study and detailed analysis of the use categories, a drone flight was carried out, using UAV technology for the photogrammetric recording of the study area. In this context, the DJI RC PRO2 drone was used Figure 2.



Figure 2. DJI RC PRO2 drone, ready for launch

The sequence of stages for carrying out the experiment related to the case study is presented in the block diagram in Figure 3, below.

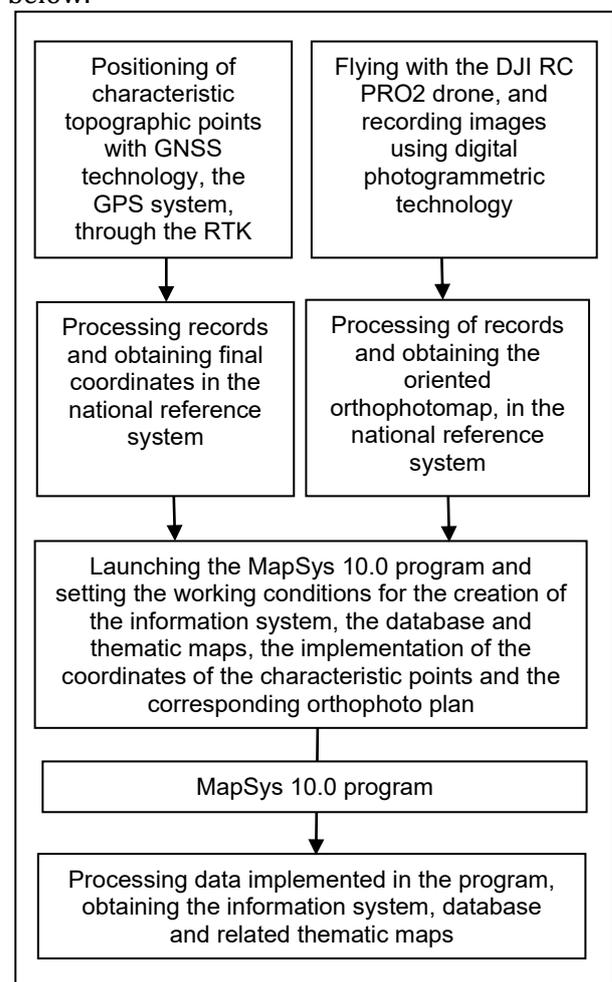


Figure 3. The stages of carrying out the experiment related to the case study

The program used to obtain the geographic information system, the database and thematic maps is MapSys 10.0, a specialized program, approved for digital cartography applications, information systems and spatial databases Figure 3, (Marton, 2007).

The actual state of the use categories related to the studied lands was analyzed on the ground and respectively on the photogrammetric material in digital format.



Figure 4. MapSys 10.0 Programme

The situation of the studied lands in the agricultural register database related to cadastral sector no. 15, within the Territorial Administrative Unit (TAU) Vîrfurile, Arad County, was also analyzed.

TipT	Localitate	Strada Nr	Localizare	CatFol	Nr/TP	Tarla	Parcela	NrCF	NrCadastral	BlocFizic	Supr/mp
Magurecea (10209)											8.099.516,00
Mermeyti (473)											4.712.177,00
Polana (616)											8.157.596,00
Vîrfurile (2928)											21.020.400,00
E (2413)											20.411.203,00
A (895)											3.046.535,00
Ape (3)											9.153,00
CC (38)											53.900,00
Fa (1277)											5.072.878,00
L (2)											9.037,00
P (14)											3.445.400,00
Pd (181)											8.757.600,00
Ta (3)											16.700,00
I (515)											609.197,00
A (14)											33.209,00
CC (487)											494.938,00
Fa (12)											41.450,00
Pd (2)											39.600,00
Vidra (1030)											10.400.048,00
TOTAL (9375)											134.671.299,50

Figure 5. Agricultural register in computer format, related to TAU Vîrfurile, Arad County

RESULTS AND DISCUSSIONS

Data processing and obtaining results was carried out in stages, depending on the logical sequence of the work stages related to the project carried out Figure , when establishing the objectives of the case study.

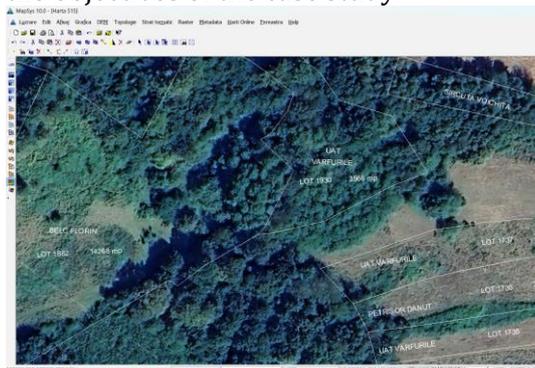


Figure 6. Extract from the parcel plan for cadastral sector no. 15, Vîrfurile ATU, Arad County

The coordinates in the national reference system-STEREO-1970, related to the characteristic detail points of the buildings (plots), were extracted (exported) from the parcel plan Figure 6, developed by the Arad Cadastre and Real Estate Advertising Office (OCPI) Arad, on the occasion of the systematic registration works of the buildings outside the built-up area (Cioflan et. al., 2025).

The orthophotomap obtained based on data recorded with UAV technology was used in digital format, with the ecw. xtension Figure 5, after previously importing the MapSys 10.0 program, within a project, to obtain the final products, which were established by the objectives of the case study.

The initializing of a new project, the implementation of the coordinates of the characteristic points and the orthophotomap, in the work program, are presented in a logical sequence, Figure 7.



Figure 7. Orthophotomap taken at the case study location, in digital format

As a result, the work stages are represented by launching a new project, setting its background color, setting the national datum, naming the project and saving it in a set location, implementing the orthophotomap, establishing the working layers and implementing the coordinates of the characteristic points of the plots.

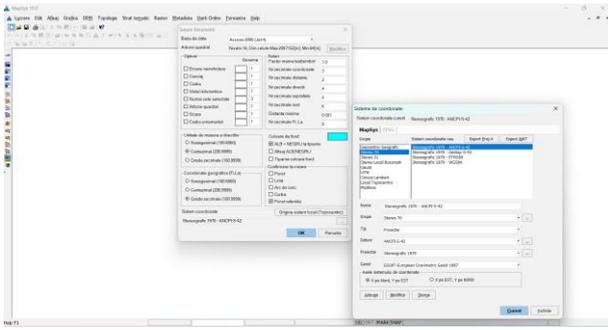


Figure 8. Initializing the MapSys 10.0 program

These stages are presented below in a logical sequence, correlated with the program's operating algorithms, through image captures.

Initializing the MapSys 10.0 program and respectively opening a new project Figure 8, involves starting the work process, requiring setting the project background, implementing the national datum and naming it Figure 8.

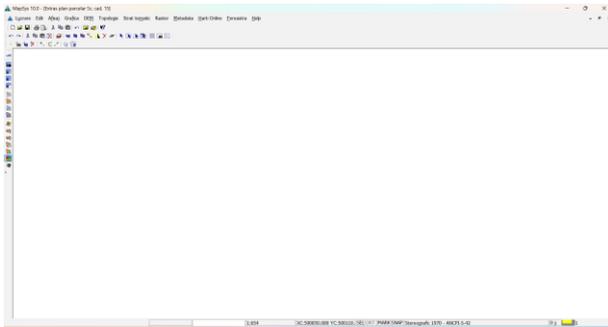


Figure 9. New project opened

To prepare for the processing stage of the recorded data, it is necessary to implement the completed autophotoplan for the study area Figure 9 and respectively the coordinates and vector corresponding to the plots positioned with GNSS technology, the GPS system - Figure 9.

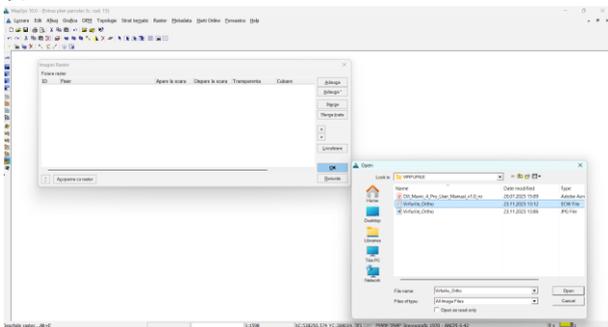


Figure 10. Importing (implementing) the orthophotomap

As a result, in these preparatory stages, the quality of the orthophotomap and, respectively, the accuracy and precision of the vector data are analyzed, by superimposing them on the orthophotomap.

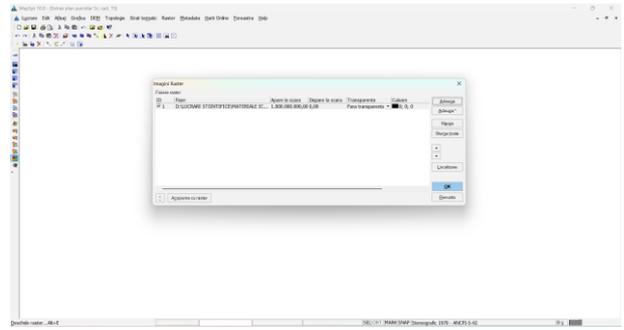


Figure 11. Imported orthophotomap

In the process of analyzing the vector superimposed on the orthophoto plane, the shadow carried and the shadow cast by the crown of trees, shrubs and fruit trees, over the boundary of the studied plots, were analyzed.

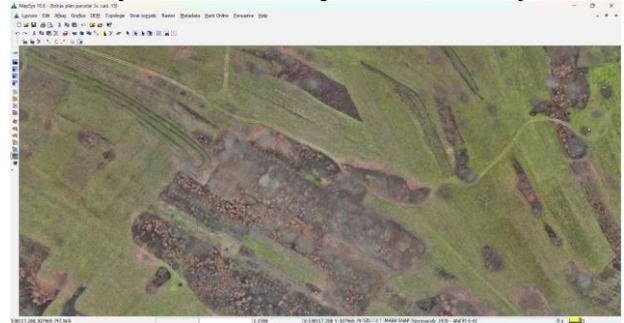


Figure 12. Visualized orthophoto plan, within the newly opened project

This aspect is particularly important in the process of establishing land use categories.

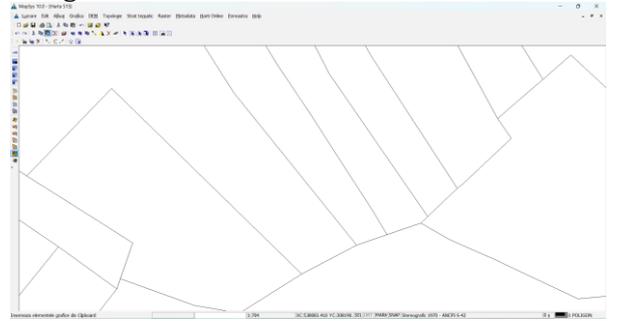


Figure 13. The vector related to the parcel plan imported into the current project

The processing of the data implemented in the project under work, within the MapSys 10.0 program, and respectively obtaining the final products, was carried out in the following stages: implementing the identifiers in layer no. 2, creating the topology, checking for non-closures and resolving them if necessary, configuring the database, establishing the attributes, implementing the attributes, checking the database, configuring and editing thematic maps.



Figure 20. Thematic map with land use categories for the studied area

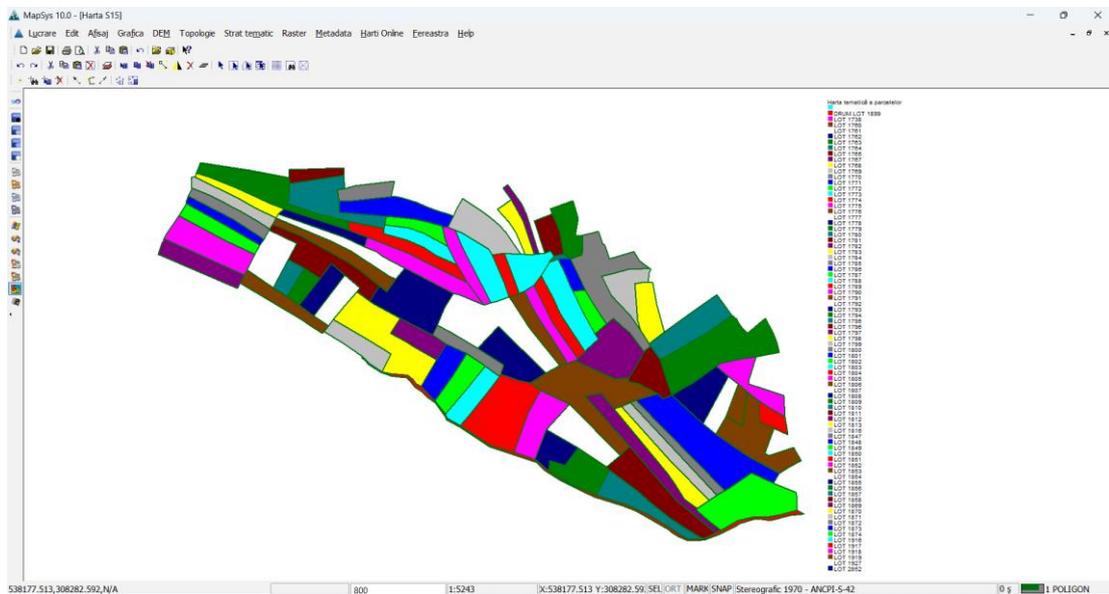


Figure 21. Thematic map with the plots (lots), for the studied area

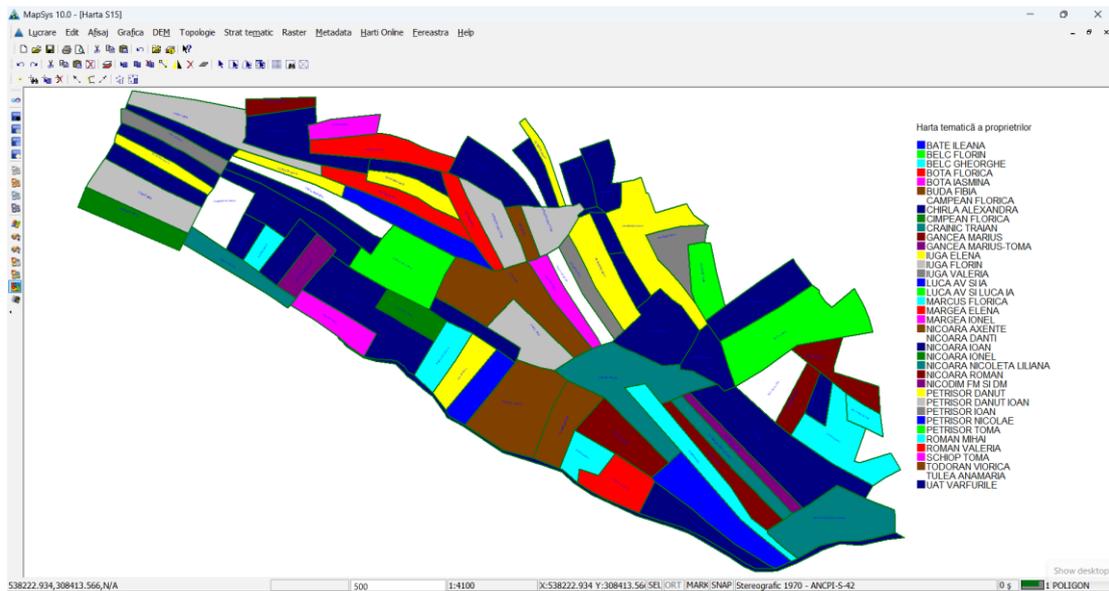


Figure 22. Thematic map of owners

Creating the database using vector elements ensures high precision when exploiting quantitative elements, such as the surfaces and perimeters of the analyzed plots.

The attributes relating to the owner and the number of the plot or lot, respectively, are generally not affected by changes, except in extreme cases, but the categories of use, over time, can change considerably.

As a result, for the studied location, which was not cooperatively managed, it was found that since 1990, the categories of land use have gradually changed, due to the decreasing interest in capitalizing on the productive potential of the lands, and even their partial abandonment.

In this context, the identification and correct establishment of the land use category requires a comparative analysis of the data from the agricultural register with those from the field.

Consequently, changing the land use category can be done relatively simply and efficiently in a properly configured database, on attribute layers, which are organized in direct correlation with the objective reality on the ground.

Geographic information systems and databases developed for various purposes in the agricultural and forestry sectors have highlighted their importance and efficiency for various current applications.

CONCLUSIONS

Currently, the management of data relating to the spatial position and a series of qualitative characteristics related to buildings in the agricultural sector can be achieved with high efficiency, through the use of advanced working technologies, which record and process data with high precision, and in record time.

The raw and processed data, together with the results obtained in this study, can be organized into databases, structured according to established algorithms, which can provide a series of information and solutions for streamlining decisions regarding the optimal use of the productive potential of the studied lands.

A possible use of the database and related information, for the studied location, is to precisely establish the location of the areas and uses related to the land for which subsidies are requested from the Agricultural Payments and Intervention Agency (APIA).

The organization of databases at the level of cadastral sector within the Territorial Administrative Units (TAU) ensures the efficiency of activities related to the agricultural sector, without interfering with the agricultural register. Consequently, it will be possible to update topographical, cadastral and agricultural records, with minimal intervention, periodically, without inducing a considerable financial effort.

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