IMPLEMENTATION OF GIS SYSTEMS IN FORESTRY MANAGEMENT

Ferenc-József UNGVÁRI, Msc stud., „1 Decembrie 1918" University of Alba Iulia, Romania, ungvariferenc@yahoo.com
Luciana OPREA, Prof. PhD. Habil. Eng., „1 Decembrie 1918" University of Alba Iulia, Romania, lucii_oprea@yahoo.com
Ioan IENCIU, Prof. PhD. Habil. Eng., „1 Decembrie 1918" University of Alba Iulia, Politehnica University of Timișoara, Romania, iienciu@yahoo.com

***Abstract**: Forests are one of the most important natural resources of Romania, having an essential role in maintaining the ecological balance, protecting soil and water, regulating the climate regime and ensuring a healthy environment for communities. Also, in addition to the ecological value, the forest has economic value due to the production of wood and other secondary products, but also has social value due to its recreational and cultural role. Based on these invaluable properties of the forest, the main problem is represented by the management of these valuable lands both for humans and for their role in environmental protection.*

***Keywords:** GIS; forest; forestry management; management units; forestry surveying*

1. Introduction

Forest management involves planning the use and conservation of forests, so that they can be exploited sustainably, without compromising their regeneration capacity and protective functions. In these conditions, the management of forest-related properties includes all planning, organization, coordination and control activities regarding the use, conservation and exploitation of forested land, in accordance with the principles of sustainable development and the legislation in force. [1]

In this context, the integration of spatial data and modern mapping and analysis technologies is an essential condition for making informed decisions.

This management involves accurate knowledge of:

- forest areas;
- species and age composition;
- phytosanitary status;
- functions assigned to each area (production, protection, recreation);
- legal status of real estate (public, private property).

2. Materials and Methods

Legislative context

The legislative framework regulating forestry activities is complex and includes [2, 3]:

- Law No. 331 of 20.12.2024 – Forestry Code, which establishes the principles of sustainable forest management, the property regime, the conditions of exploitation, regeneration, protection and sanctions for violating the forest regime;

- normative acts regarding forest arrangements, their elaboration and content;
- regulations regarding the transport of wood mass and wood traceability;
- legislation regarding protected areas and Natura 2000 sites.

In addition to the stated normative acts, the provisions of:

- Law No. 7/1996 regarding the cadastre and real estate advertising, which provides the general framework for the legal and topographical record of real estate, including forest lands;
- Regulation of Order 600 of 8 February 2023 on reception and registration in the cadastre and land registry records.

Within these normative acts, it is stipulated that the national forest fund includes:

- forests themselves;
- lands intended for afforestation;
- lands related to forestry infrastructure (roads, nurseries, forestry buildings);
- lands with forest vegetation, even if not formally classified as forest.

In this context, forest fund management involves activities that carry out:

- inventorying the forest fund;
- classifying the forest fund by destination (production, protection, recreation);
- planning fellings (short, medium and long term);
- forest regeneration (natural or artificial);
- monitoring the health of the stands.

Forest management

In order to manage the forest fund as judiciously as possible, it is organized into territorial forest management units.

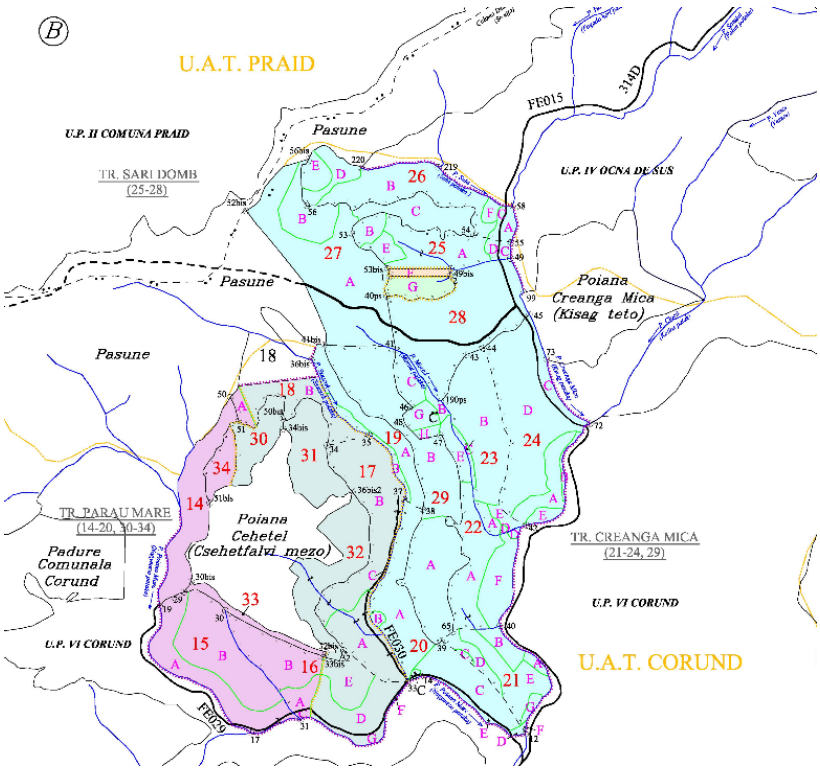

Fig. 1 The planning map, drawn up to scale 1:20000 (https://apapet.ro/harta_osppraid.php?lang=ro)

Forest management is the technical and legal document that establishes the way of managing a forest for a specific period (usually 10 years), the managed territory being divided into [4]:

- production units (P.U.) – large areas, homogeneous as management objectives;
- management units (U.A.) – smaller subdivisions, for which specific works are established;
- plots and subplots – elementary units at the land level.

For efficient management, it is necessary to generate spatial data that provides:

- data organization in spatial databases;
- periodic updating of information;
- comparative analysis over time (historical series).

The utility of GIS in forest management

In a GIS, these units are represented as polygons with attributes (dominant species, average age, timber volume, accessibility, etc.), and through thematic analyses of the stored information, a series of analyses can be performed, including [5, 6]:

- maps of volume by management units;
- maps of age classes;
- work planning models (e.g. priority areas for thinning or regeneration).

3. Results and Discussion

Forestry surveying has been significantly modernized. While in the past the classical topographic method prevailed, today GNSS measurements, aerial photogrammetry with aircraft or drones, and LiDAR scanning for detailed 3D models of the canopy and terrain have been successfully implemented. [7, 8]

The working methodology included a series of stages that will be briefly described below.

a. Data collection and preparation

The Integrated Cadastre and Land Registry System (Eterra3), analog maps located in the OCPI Odorheiu Secuiesc archive, and analog forest plans were used to collect data. [9]

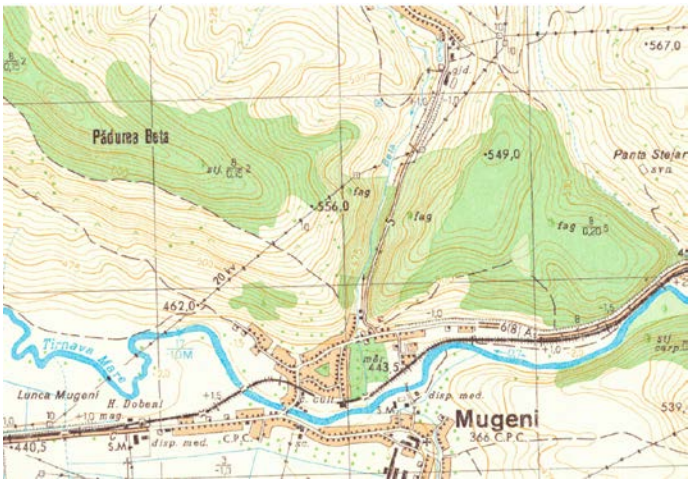

Fig. 2. Topographical plan of administrative-territorial unit UAT Mugeni
(Cadastral and Real Estate Advertising Office - OCPI Odorheiu Secuiesc)

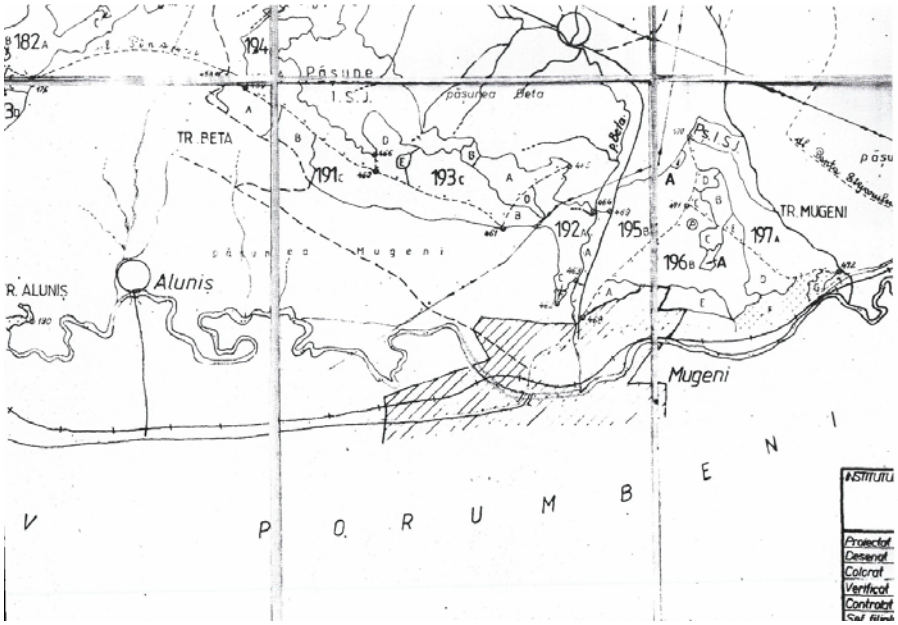

Fig. 3. Forestry plan of production unit UP II
(Forest District Homorod)

b. Digitization and verification of boundaries

The boundaries of the forest district and compartments were verified by overlaying them on the orthophoto map and on the boundaries of the properties registered in the land registry. At the same time, any discrepancies were corrected and the contour lines on the topographic map were vectorized to create a DTM. [10]

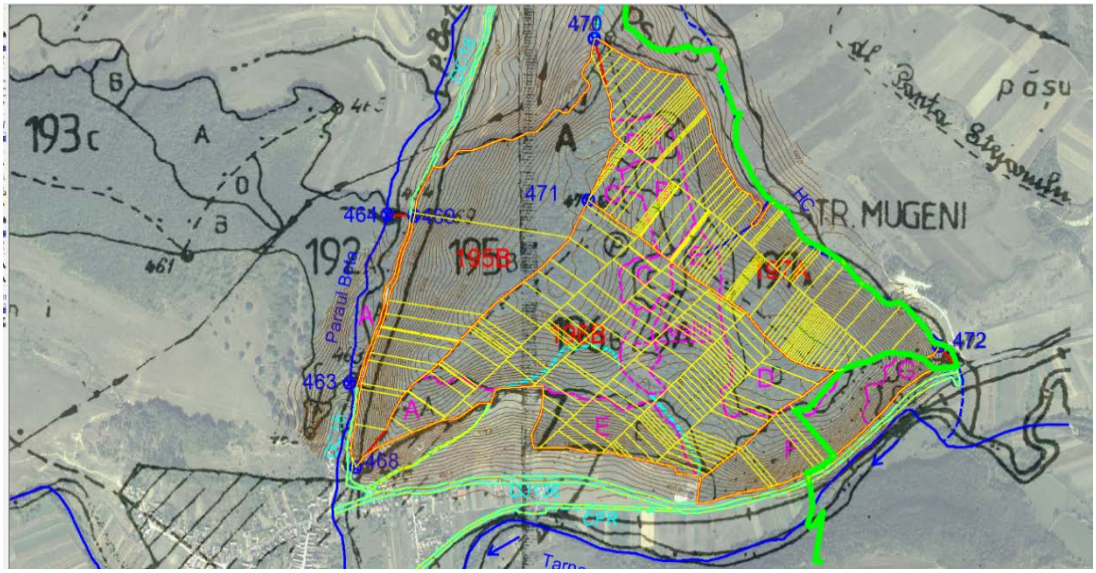

Fig. 4. Suprapunerea datelor în Mapsys

c. Data analysis

In order to generate the thematic map of the studied forest area, all data obtained from OCPI Odorheiu Secuiesc, Homorod Forest District, and those obtained by vectorizing contour lines were analyzed. [11]

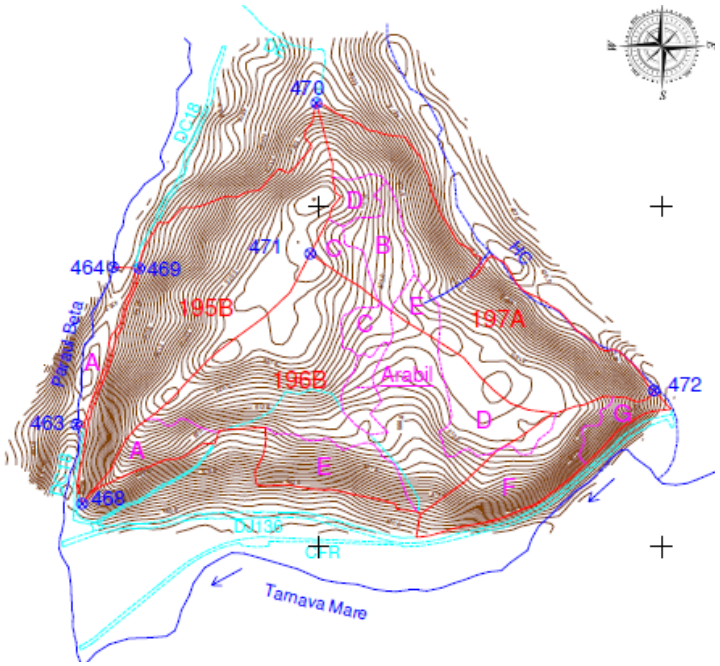

Fig. 5. Digital model of the analyzed forest area

In addition to the land survey, data related to the forest fund cadastre can be integrated. The forest fund cadastre is a specialized component of the general cadastre that deals with the registration of land covered by forest vegetation [10]. It contains:

- identification data (UAT, cadastral number, use category);
- the area and boundaries of the property;
- the legal status of the property (public or private ownership).

The integration of the forest cadastre into the Mapsys application has enabled:

- rapid updating of data in the event of changes in ownership or use;
- verification of consistency between cadastral and forestry data;
- generation of statistics and reports at local, county, or national level.

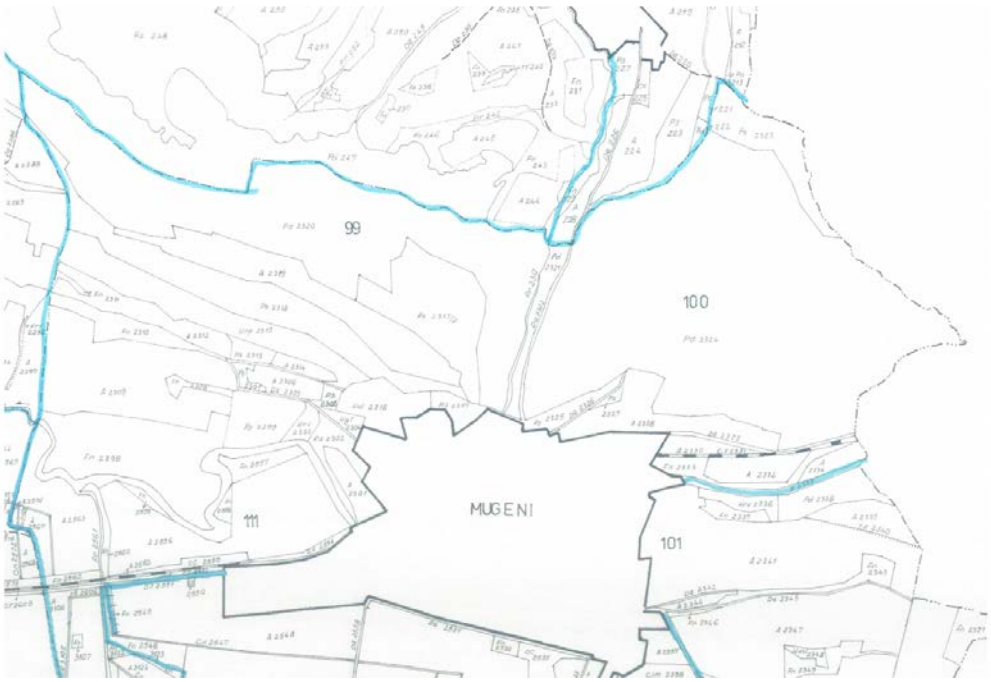

Fig. 6. Old Cadastral Map UAT Mugeni (OCPI Odorheiu Secuiesc)

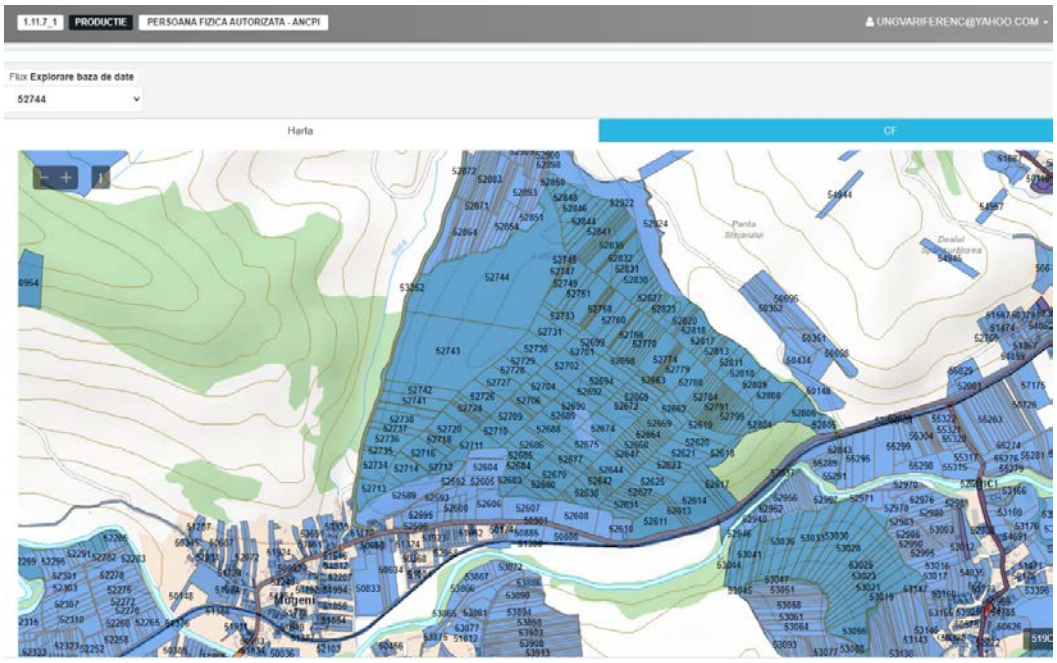

Fig. 7. Digital Cadastral Map UAT Mugeni
(sursă: Sistem e-Terra3)

The result of forest area measurement campaigns can be quantified in the following cartographic products: [12]

- high-resolution orthophoto map;
- digital terrain model (DTM) and digital surface model (DSM);
- 3D point sets (point cloud).

Within the GIS application, these products are used to accurately delimit land parcels, calculate slopes and exposures, or estimate timber volume.

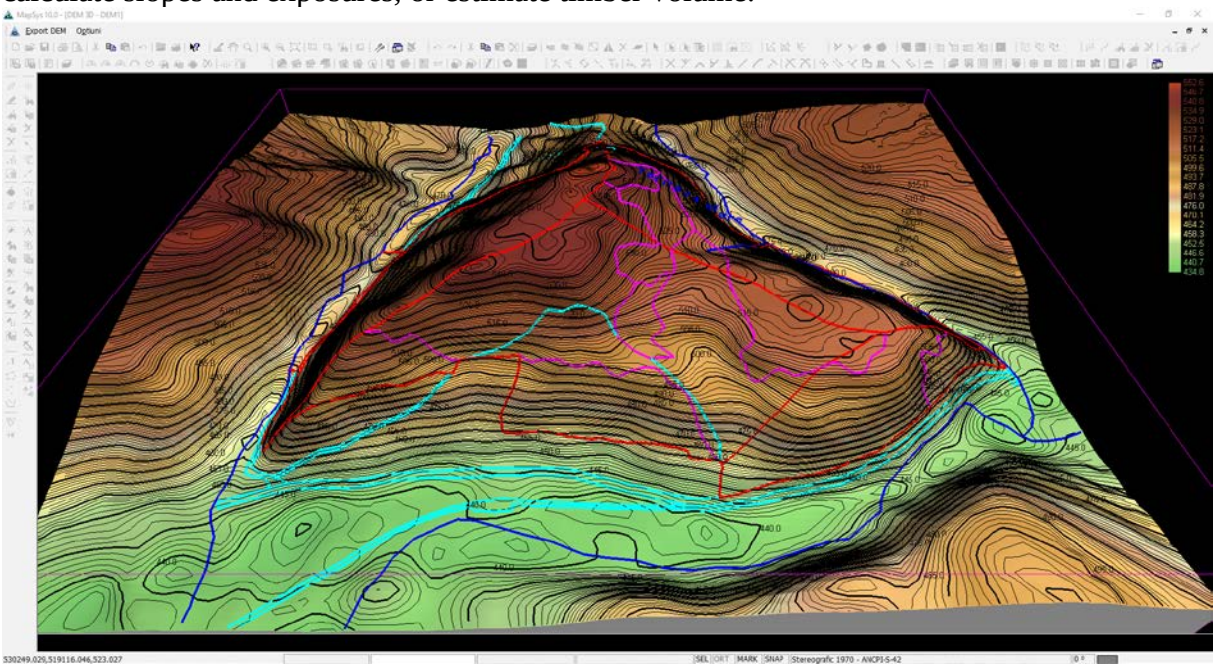

Fig. 8. DEM generation in Mapsys

The types of analyses that can be performed in forest management using GIS include: [13, 14]:

- calculation of areas by age class and species;
- modeling of the vegetation index (NDVI) for assessing canopy condition;
- analysis of slopes and exposure for forest road planning;
- identification of areas at risk of erosion or landslides;
- detection of changes between sets of images from different years.

In particular, the following were highlighted for the analyzed area:

- areas with steep slopes (>25°) where the protective function of the forest is essential and where logging must be planned with great care;
- a network of forest roads that provides access to most compartments, but which can be optimized to reduce the impact on soil and water.

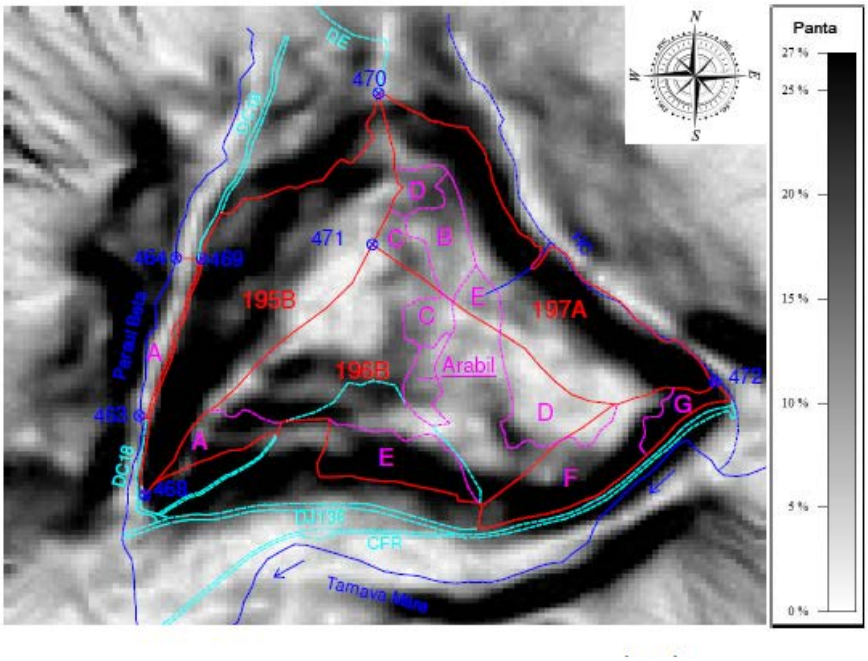

Fig. 9. Generate slope map in Global Mapper

Based on the above, the results obtained confirm the usefulness of GIS in: [15]

- continuous monitoring of forest conditions;
- rapid identification of problem areas;
- supporting management and protection decisions.

4. Conclusions

Geographic Information Systems have become important tools for modern forest management. Their ability to integrate diverse data (topographic, cadastral, forestry, ecological, satellite imagery) into a single analysis environment gives them a central role in forest planning and monitoring.

Analysis of the elements shows that almost every component of forest management has a clear spatial dimension, which can be represented and analyzed in GIS.

The case study carried out for the Homorod Forest District clearly demonstrates that:

- by processing and combining data from official sources (ANCPI, management plans, satellite images), thematic maps relevant to the state of the forest can be obtained;

- GIS facilitates the identification of problem areas (cutting, drying, erosion) and the prioritization of interventions.

In conclusion, the implementation of GIS systems in forest management is not just a technological option, but a necessity, given that the main objective is the sustainable management of forests, in harmony with economic, ecological, and social requirements.

5. References

1. *Strategic planning guide for the responsible management of forest resources, with respect to biodiversity values; (https://ananp.gov.ro/wp-content/uploads/Ghid_managementul-padurilor.pdf)*
2. *Law No. 331 of 20 December 2024 on the Forestry Code;*
3. *Law on the Cadastre and Real Estate Advertising No. 7/1996;*
4. *M. Drăgoi: Amenajarea pădurilor, Editura Universității din Suceava, Suceava, 2004;*
5. *A.C. Badea, G. Badea, D. Vasilca, C. Semen: Aspects about deforestation areas using GIS, International Multidisciplinary Scientific GeoConference SGEM, Vol. 3, 2016;*
6. *M.V. Herbei, F. Sala: Using GIS technology in processing and analyzing satellite images – case study Cheile Nerei Beusnița National Park, Romania, Journal of Horticulture, Forestry and Biotechnology, Volume 18(4), 2014;*
7. *G. Badea, A.C. Badea: Analysis on the Dynamics and Vulnerability of the Areas Covered by Forests, Harghita County, RevCAD Journal of Geodesy and Cadastre, no. 32, 2022;*
8. *T Borşan, L Dimén: CAD-GIS interoperability, Pangeea,no. 21, 2021;*
9. *A.C. Badea, G. Badea, D. Vasilca: The analysis of Romania cadastral records dynamics in GIS using open data, International Multidisciplinary Scientific GeoConference SGEM, Vol. 19, iss. 2.2, 2019;*
10. *L.O. Dragomir, C.A. Popescu, M.V. Herbei, G. Popescu, R.C. Herbei, T. Sălăgean, S. Bruma, C. Sabou, P. Sestras: Enhancing Conventional Land Surveying for Cadastral Documentation in Romania with UAV Photogrammetry and SLAM, Remote Sensing, Vol. 17, No 13, 2025;*
11. *L. Dimen, T. Borsan, I. Vintan, L. Găban: Creating and managing a database for planning and monitoring the achievement of the objectives of sustainable development in Zlatna Locality, Alba County, Journal of Environmental Protection and Ecology, vol. 16, no. 4, Pages 1414-1421, 2015;*
12. *G.E. Voicu, F. Voicu: Urban Development of the Touristic Area Poarta Raiului Through the Implementation of GIS, International Multidisciplinary Scientific GeoConference: SGEM 2 (2), p. 1183-1190, 2015;*
13. *F. Voicu, G.E. Voicu: The Tourism Development of the Sureanu Massif by Valorisation of the Natural Potential, Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering, vol. 11, 285-292, 2022*
14. *M. Teodor: Aplicații GIS pentru proiectarea, dezvoltarea si managementul domeniilor schiabile din România, Editura Universitară, București, 2017;*
15. *G.E. Voicu, F. Voicu: Evaluation of Natural Potential and Vulnerability of Territory to Risks. Case Study: Sântimbru Commune, Alba County, Pangeea 18 (1), 2018.*