

RESEARCHES ON THE IMPLEMENTATION OF THE FOREST CADASTRE USING THE GNSS TECHNOLOGY AND THE REMOTE SENSING

Ioana AGAPIE (MEREUȚĂ)¹, Mihail LUCA², Paul Marian GHERASIM³

e-mail: ioanaagapie@yahoo.com

Abstract

In Romania, about 27% of the land area is the forest fund. Sustainable development of forest involves their inventory and permanent updating in order to achieve a precise cadastral record. The land that are part of the forest cadastre are mainly represented by wooded land. The work consists in identifying and delimiting the cadastral area of a forest plot using modern ways of locating and tracking changes in time. The research aims to determine the modern aspects regarding cadastre and forest management issues, as well as how to create a database of the type of Geographic Information Systems, necessary in the context of the development of forest resources. In order to achieve the proposed objective, modern technologies for field measurements were used, such as high-precision Trimble GNSS systems, capable of providing a high degree of precision and productivity. Thanks to the built-in technology, GPS receivers, receive signals from all existing satellite constellations, ensuring a high quality of the measurements made. The studied area was also analyzed using satellite imagery which allowed the delimitation of forest boundaries through the digitization process. The use of very high resolution satellite imagery ensures high digitization accuracy, taking place in a shorter time than the terrestrial measurement method. Inventory of forests also involves the registration of plots in the Land Book. Through the ETERRA 3 application, the areas entered in the integrated national cadastre and land register can be viewed, interrogated and updated at all times. Since clearance is a major current problem, the most accurate and efficient cadastral survey and record keeping of forest enables sustainable forestry development in order to ensure a good quality of life.

Key words: forest cadastre, Eterra 3, GNSS, GIS, remote sensing.

The forest cadastre aims to efficiently manage forests, by delimiting the edges of the lands belonging to the forest fund, for their proper functioning, from the ecological, economic and social point of view. The delimitation of forest plots is part of an extensive forest inventory process, which takes place whenever changes of the managed areas occur.

Performing field measurements using GNSS technology provides conclusive results on determining the various details. For a higher accuracy of the calculated points, the distance between the GPS receivers installed at the edge of the forest must be taken into account (Crainic G. C., 2009).

The identification and delimitation of forest land is a major challenge in the administration and management of forests. The forest information system refers to the process of generating geospatial data, exchange of spatial information about forest areas, associated resources and activity management, for their sustainable management. The development of new satellite technologies allows terrestrial observations to be

made with spatial resolution of 0.60m or even 0.41m, having high speed computing and processing capabilities. High resolution satellite imagery shows its usefulness in topographic measurements, thanks to which the cadastral system and land inventory systems have undergone major changes worldwide (Mothi Kumar K. E. *et al*, 2014).

Realization of the Geographic Information System and a database corresponding to the forestry fund owned by the different administrative-territorial unit, it is necessary, in the context of sustainable management of forest resources. To achieve the quality of the final product on the information provided, it is necessary to collect and process primary data with adequate accuracy (Marincaș I. B. *et al*, 2009).

Monitoring of the forest fund, by performing topographic measurements, it is of particular importance in the context of identifying clearance forest plots, tracking the afforestation works, etc.

Disorganized forest exploitation leads to the occurrence of flood propagation phenomena and the transport of wood waste (M. Luca, L. A. Luca,

¹ "GH. Asachi" Technical University, Iași

2014).

The purpose of this paper is to determine which is the most accurate and reliable method of

MATERIAL AND METHOD

The research material consists of a forest area located on the left bank of the Bahlui river,

finding the surface of a forest plot, in the context of efficient and permanent monitoring of the national forestry fund.

In the commune of Deleni, Iași county, near the Pârcovaci dam (*figure 1*).

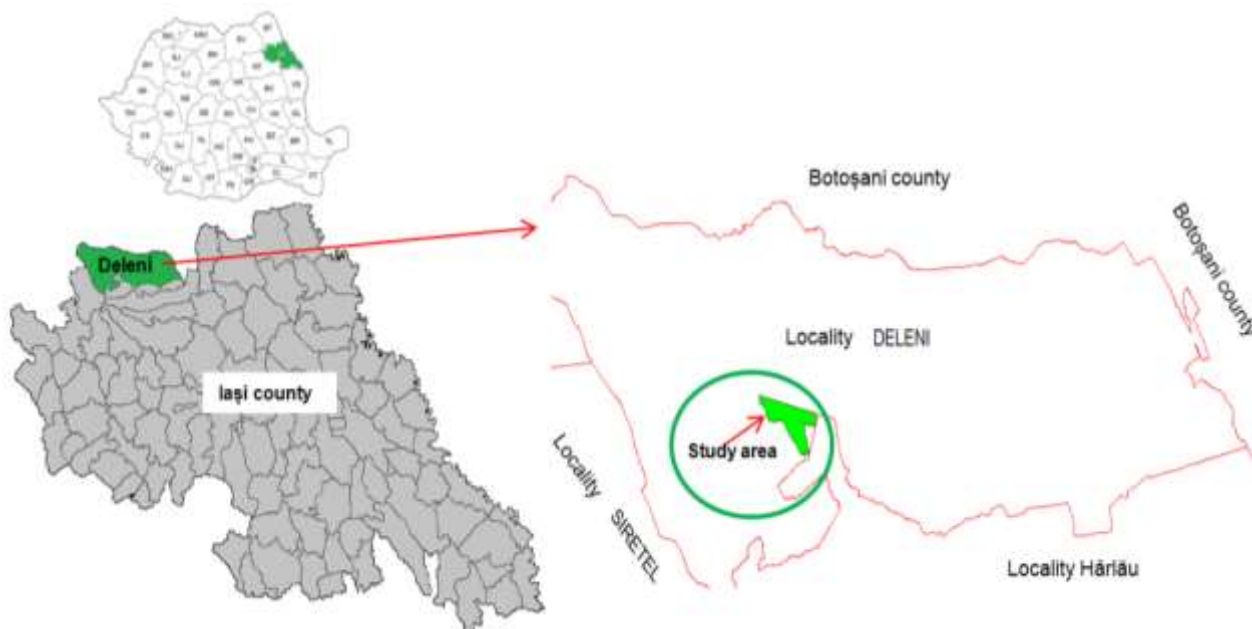


Figure 1 Representation of the North-East region of Romania with the location of the studied forest area

Introduction of the unitary system of cadastre and land book, regarding the articles of Law 7/1996, applies to all cadastral sectors and buildings in the country (V. Moca et al, 2018). Thus, the forest areas are located technically and legally and economically inventoried.

The research methodology consists of:

- Performing topographic field measurements using GNSS positioning technology. For this purpose, two high-performance receivers were used, the Trimble R2 GPS and the Trimble R8 GPS, which determined the coordinates of the points that describe the geometry of the studied area.
- Downloading data in the Autocad work environment.
- Joining the measured points and determining the outline of the study area.
- Comparison of the limits measured with the limits of the existing plot in the Eterra 3 program and taking over sectors of the boundary.
- Cartographic analysis of the studied plot by framing it on geodesic trapezoids.

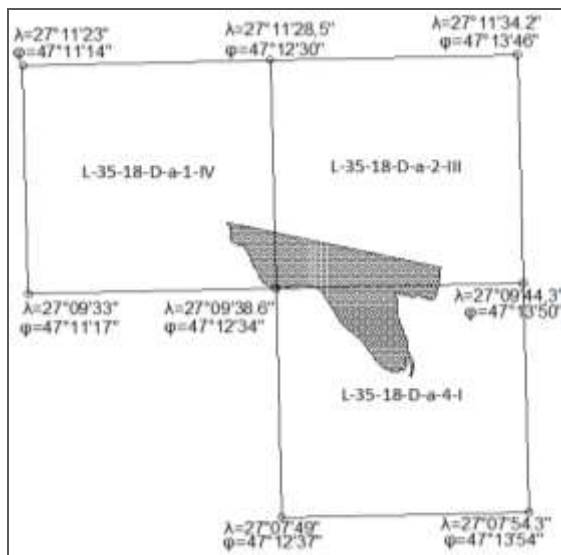
- Analysis of the plan of location and delimitation of study area by comparison with the cadastral map drawn up in 1989.

- Analysis and interpretation of satellite images taken in July, between 2016-2019.

RESULTS AND DISCUSSIONS

The forests included in the national forest fund cover a minimum area of 0.25 ha and they are covered with trees that, at maturity, reach a height of at least 5m. The studied area is located on the left bank of the Bahlui river near the Pârcovaci dam, being represented by a leafy forest area of approximately 120 ha.

For a more precise geographical location of the objective, the classification was made on geodesic trapezoids, with nomenclatures on the scale 1:5000. At the same time, the geographical coordinates of the corners of the geodesic trapezes were established (*figure 2*).



a.



b.

Figure 2 The geographical location of the study area: a. Fitting on geodesic trapezoids; b. PUG limit and the studied area

The geographical coordinates ϕ , λ of the trapezoid corners were calculated by converting the stereographic coordinates X , Y (Agapie I., Luca M., 2019).

The topographic measurements in the field were executed on a length of 1686.314m, on the forest road that delimits the studied area. The stereographic coordinates for 43 points were determined (table 1). The measurements were

performed using the GNSS positioning method (figure 3), with Trimble R2 GPS receiver, having an accuracy of 10 mm +1 ppm in horizontal determinations. The second receiver used, the Trimble R8 GPS, determined the points with an accuracy of 8 mm + 1 pp, in horizontal measurements.



a.



b.

Figure 3 Presentation of high precision GNSS technology: a. View Trimble R2 and Trimble R8 models; b. Making planimetric measurements;

Table 1 presents some of the determinations made in the field. The measured points are represented in the attached sketch (figure 4) and are compared with the determinations from the database of the National Agency for Cadastre and Real Estate Advertising. The differences between

the measured points and those extracted from the ANCPD database are in the order of centimeters, falling within the acceptable tolerances. The existing differences are due to the fact that the points in the ANCPD database are not materialized in the field.

Table 1

The coordinates of the points measured in the field

No. Point	X [m]	Y [m]	No. Point	X [m]	Y [m]
1	663137.951	637899.719	10	662796.791	637948.170
2	663114.452	637906.119	11	662772.875	637941.380
3	663043.975	637906.489	12	662784.252	637919.124
4	662996.615	637920.204
5	662947.543	637949.658			
6	662904.821	637963.980			
7	662882.553	637967.163			
8	662866.303	637967.337	41	663331.844	637262.565
9	662843.462	637961.758	42	663355.664	637247.651
			43	663400.159	637227.272

In the past, all the forest lands were under state administration (Romsilva). Due to the laws for the retrocession of agricultural and forest land, forests became 50% public state property and 50% private property (natural or legal persons). The forests belonging to the administrative-territorial units are in the form of public property: they

belong to the public domain of the locality, the municipality or the county (L. Bouriaud, 2013).

The forest plot of the case study had a total area of 1199176 mp. Following the retrocession process, its surface became 1108741 mp. So the forest lands receded totaling 90435 mp and are highlighted in *figure 4*.

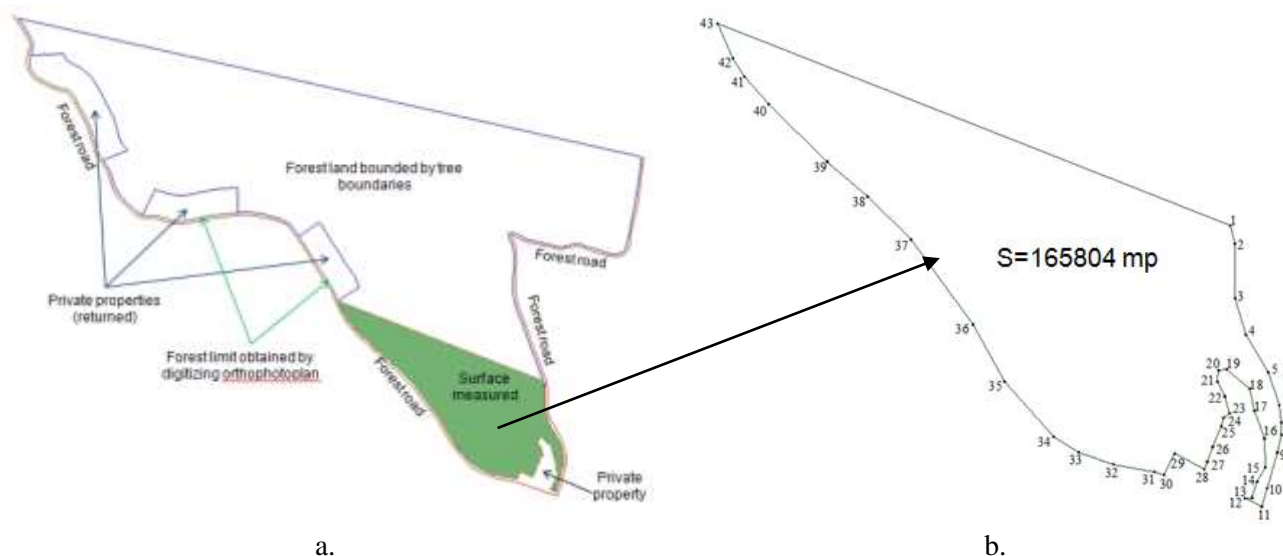


Figure 4 Identification of forest boundaries: a. Indication of forest boundaries before and after retrocession; b. Representation of the points on the contour of the measured area;

The measured surface area as well as the surface taken from the Eterra 3 database and the one obtained by digitization, they can be analyzed in relation to the cadastral map made in 1989 (*figure 5*). You can see small differences between the forest limit in 1989 and the one currently obtained by digitizing the orthophotoplan. This is mainly due to the old methods, used in the past,

with a low accuracy of measuring the contour elements of the forest spaces.

Orthophotoplanes are products of modern technology, made with the latest aerial equipment, by specialized companies who have the resources to obtain such parts. Orthophotoplan is one of the main pieces in the realization of the basic cadastral plan, for the correct and accurate inventory of the entire land fund of the country (M.D. Prața, 2012).

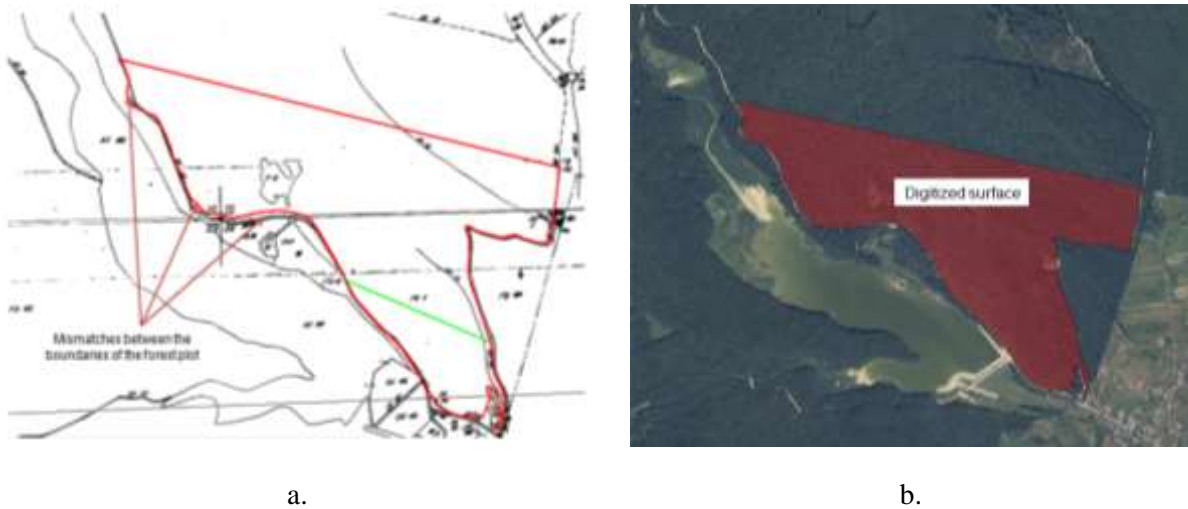


Figure 5 **Identification of forest boundaries: a. Forest limits on the cadastral plan draw up in 1989; b. Forest limits obtained by the digitization process on the orthophotoplan taken over in 2016;**

Performing measurements in the field and processing the orthophotoplanes helps to establish the topographic limits of the studied area. A more detailed method of monitoring the studied forest area is the analysis of satellite images.

Satellite platforms provide high spatial coverage, without access limitation. The data sets provided by the satellite systems, for the surfaces covered with vegetation, can be used for the purpose of obtaining different data (A.T.Nerțan și V.Panaiteșcu, 2016).

For the studied area was calculated Normalized Difference Vegetation Index (NDVI), in order to establish the density of vegetation. The

satellite images taken by the Landsat 7 satellite in July between 2016-2019 have been downloaded from the website <http://earthexplorer.usgs.gov/>.

NDVI index (Normalized Difference Vegetation Index) compares vegetation density between satellite images, using near-infrared and visible red waves (G. Costea, 2012).

The formula for calculating the NDVI index is: $NDVI = (NIR - R) / (NIR + R)$, where NIR is the near infrared band and R is the red band.

The NDVI index analysis was performed in ArcMap 10.2, the results obtained being analyzed by years, starting with 2016 and until 2019 (figure 6; figure 7).

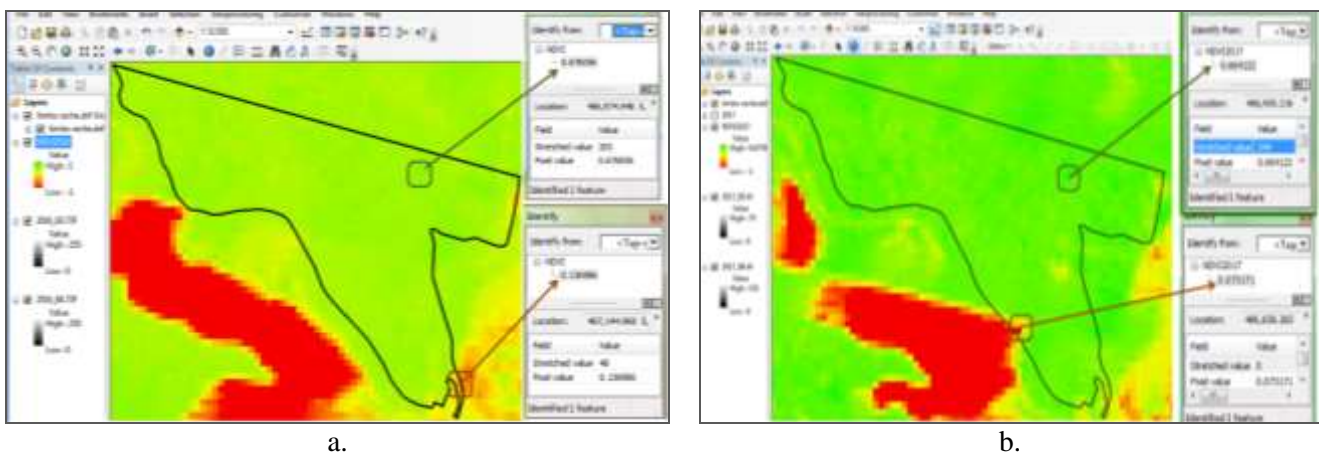


Figure 6 **Identification of maximum and minimum values of vegetation density for the studied area: a. July 2016 b. July 2017**

For satellite images taken with the Landsat 7 satellite, the near infrared is band 4 and the red band is band 3. The NDVI index values are in the range -1 to 1. For a normal vegetation the values are between 0.1 and 0.75, rarely reaching the value 1 (I. Vorovencii, 2015).

The maximum and minimum values of the NDVI index, for July 2017, are lower than those

recorded in July 2016. However, we can see an increase in the density of vegetation in 2017, compared to 2016, the average of the NDVI index registering values over 0.5 in almost the entire studied area.

In 2018, there is a marked degradation of vegetation, the minimum NDVI index reaching -0.124, well below the minimum value for normal

vegetation. In 2019, the maximum value of the vegetation density is 0.1, and the minimum value –

0.05 (figure 7).

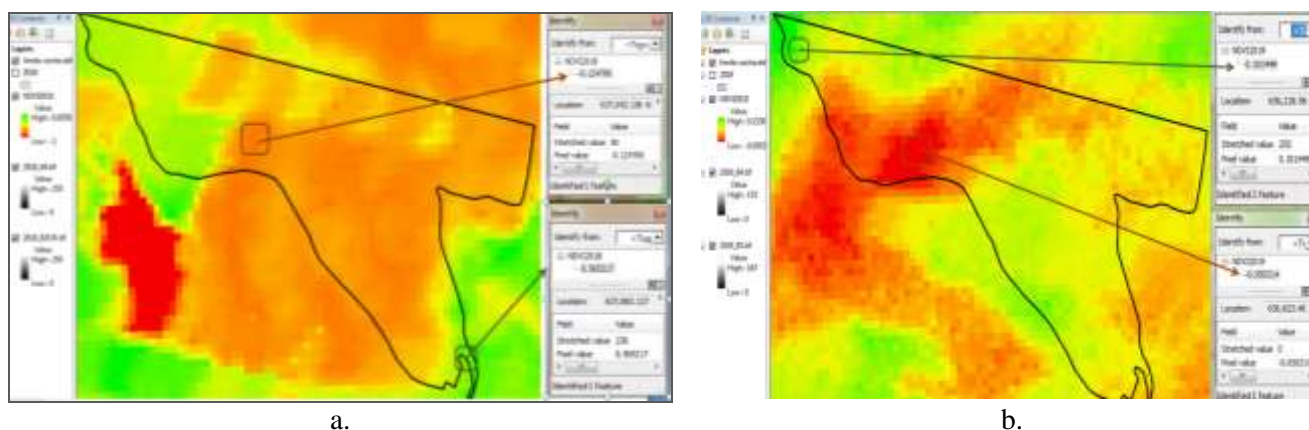


Figure 7 Identification of maximum and minimum values of vegetation density for the studied area: a. July 2018
b. July 2019

CONCLUSIONS

The study indicates the importance of topographic and satellite information in the development of a GIS database to enable the management, updating and interpretation of information on the observed forest area.

Making fields measurements with high-performance GNSS technology, accurately determines the order of the centimeters, the location of the studied forest area.

The retrieval of topo-cadastral information from old cadastral maps, orthophotoplanes but also from the ANCP database, indicates the evolution over time of the forest plot limit.

Remote sensing is the most modern and reliable way of analyzing the density of vegetation, to determine, in time, the evolution of the forest.

A future direction of study may be the realization of a complex GIS database, for the inventory and analysis of all forest areas in Romania, for making the right decisions regarding the process of deforestation and degradation of vegetation.

REFERENCES

- Bouriaud L., 2012-2013.** *Private forest management*, "Ștefan cel Mare" Suceava University, course support.
- Costea G., 2012** – *Evaluarea procesului de despădurire, prin teledetecție. Efectul despăduririi asupra schimbărilor caracteristicilor suprafețelor subiacente din bazinele superioare ale Someșului Cald și Rece*, Universitatea "Babeș-Bolyai", Cluj-Napoca, rezumat teză de doctorat.
- Crainic G. C., 2009** – *Particular realization cases of topographical details network solved using GNSS*

technology, in forestry, Lucrări Științifice, seria Agronomie, U.S.A.M.V. Iași, vol. 52, nr. 1/2009, Editura "Ion Ionescu de la Brad" Iași, pp.329-335, ISSN 1454-7414.

Luca M., Luca A.L., 2014 – *The ecological rehabilitation of Mountain Lakes*, Buletinul Institutului Politehnic din Iași, Tomul LX (LXIV), Fasc. 1-2, Hidrotehnică, Editura Politehnică, pp.9-17.

Marincaș I. B. Crainic G. C., Ștefco I., 2009 – *Studies on the possibility of realization of the Geographic Information System for forest private owners*, Lucrări Științifice, seria Agronomie, U.S.A.M.V. Iași, vol. 52, nr. 1/2009, Editura "Ion Ionescu de la Brad" Iași, pp.374-382, ISSN 1454-7414.

Moca V., Oprea R., Huțanu C., Cârdei M., Savu C., 2018 – *Present aspects of the systematic cadastral works conducted on cadastral sectors for the registration of real estates in the land register*, Lucrări Științifice, seria Agronomie, U.S.A.M.V. Iași, vol. 61, nr. 1/2018, Editura "Ion Ionescu de la Brad" Iași, pp.9-14, ISSN 1454-7414.

Mothi Kumar K. E., Singh S., Attri P., 2014 – *GIS based cadastral level forest information system using World View-II data in Bir Hisar (Haryana)*, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XL-8, 2014, ISPRS Technical Commission VIII Symposium, Hyderabad, India.

Nertan T. A., Panaitescu V., 2016 – *The importance of using Remote Sensing data for crop vegetation state monitoring*, Revista "Știință și inginerie", Vol.30, Conf. Internațională multidisciplinară "Profesorul Dorin Pavel – fondatorul hidroenergeticii românești" Sebeș-Alba, pp.249-260.

Vorovencii I., 2015 – *Identificarea, evaluarea și monitorizarea schimbărilor din mediul înconjurător folosind metode ale teledetecției satelitare*, Universitatea "Transilvania", Brașov, teză de abilitare.