STATISTIC ANALYSIS OF THE SPATIAL DATABASE OF AN ORTHOPHOTOPLAN AND OF THE SOIL CARTOGRAPHIC UNITS

ANALIZA STATISTICĂ A BAZEI DE DATE SPAȚIALE A UNUI ORTOFOTOPLAN ŞI A UNITĂȚILOR CARTOGRAFICE DE SOL

MOCA V.[1], RADU O.[1], HUȚANU CR.[1], BRÂNDUŞ I.[2], PĂUN Corina[3]
e-mail: valmoca@uaiasi.ro

Abstract. *Drawing up the geo-spatial database of the agricultural lands from the Romanian territorial administrative units using the digital orthophotoplan, allowed the realization of multiple statistic analyses of the cadastral lots in accordance with the soil cartographic units. For correlating the spatial data base of the physical agricultural blocks with the data corresponding to the soil cartographic units it has been used the existent cartographic and pedological documentation for the administrative territory of Drăguşeni commune, Suceava County. For this purpose, the area taken into consideration was that corresponding to the agricultural land from the unincorporated area of Drăguşeni, with the surface of 2168.71 ha. On this agricultural land there have been delimited a 173 the physical blocks. On the digital support of the orthophotoplan, the soil cartographic units have been overlaid, with a spatial distribution of 89 graphic entities. The case study performed includes a statistic analysis of the surfaces occupied by the physical blocks, in correlation with the soil units, on the geodetic trapezium control area, scale 1 : 5 000.*
Key words: *orthophotoplan, spatial database, agricultural, physical block, soil cartographic units, control area of geodetic trapezium*

Rezumat. *Realizarea la nivelul unităților administrativ teritoriale din România a bazei de date geo-spațiale a terenurilor agricole sub forma digitală a ortofotoplanului, a permis efectuarea unor multiple analize statistice asupra parcelelor cadastrale, în strânsă corelație cu unitățile cartografice de sol. Pentru integrarea bazei de date spațiale a blocurilor fizice agricole cu datele corespunzătoare ale unităților cartografice de sol, s-a folosit documentația cartografică şi pedologică existentă în cazul teritoriului administrativ al comunei Drăguşeni, din județul Suceava. În acest scop, s-a luat în studiu suprafața aferentă terenului agricol din extravilanul teritoriului Drăguşeni, care ocupă 2168,71 ha. Pe această suprafață de teren agricol s-a procedat la delimitarea unui număr de 173 blocuri fizice agricole. Pe suportul digital al ortofotoplanului, s-a realizat, suprapunerea unităților cartografice de sol, cu o distribuție spațială de 89 entități grafice. În studiul de caz realizat, s-a realizat, analiza statistică a suprafețelor ocupate de blocurile fizice, în corelație cu unitățile de soluri, pe aria de control a trapezului geodezic, la scara 1 : 5 000.*
Cuvinte cheie: *ortofotoplan, bază de date spațiale, bloc fizic agricol, unități cartografice de sol, aria de control a trapezului geodezic*

[1]University of Agricultural Sciences and Veterinary Medicine of Iaşi, Romania
[2] The Office for Pedological and Agrochemical Studies, Suceava, Romania
[3] "Gheorghe Asachi" Technical University of Iaşi, Romania

INTRODUCTION

The basic cadastral entities realized at the level of all territorial administrative units of Romania are defined by the construction/building and the owner. For drawing up the spatial database of the cadastral plants content, the constructions/buildings have to be identified, measured and described. Cadastre and cadastral register represent, at the present time, the unitary and compulsory economic, legal and technical evidence system for all the buildings from the entire territory of Romania (Law no.7/1996, republished, 2013). The proper measurements are performed using graphic, numeric, photogrammetric and combined methods.

Among the types of measurements used for cadastral works, the photogrammetric method turned out to be the most used; in time, it has experienced three different stages of evolution: analogue, analytical and digital (David, 2007). Nowadays, the LiDAR technology has started being implemented; it represents a modern, complementary measuring technique which replaces the traditional aerial mapping method. The implementation of this technology allowed the realization of different photogrammetric products, using the 3D system (Voiculescu and Banciu, 2011). Between 1951-1990, period which represented the first phase of the process, the photogrammetric measuring technology was used to create the basic topographic plan for almost 85% of the entire surface of Romania, scales 1:2 000, 1:5 000 and 1:10 000 (Moca et al., 2012). The second phase, between 2001 and 2010, consisted in drawing up the digital orthophotoplan, for all the territorial administrative units of the country, scale 1:10000. These orthophotograms have previously passed through photogrammetric operations: stereo-restitution, ortho-rectifying, but by digital processing (Băluț and Blidaru, 2006).

Based on the studies dealing with the pedological mapping of the soils in Romania, operation which lasted more than 100 years (1906-2012), soil maps have been created, at low, medium and large scales. Among the major accomplishments, we can mention the Romanian soil map, scale 1:200 000, which was drawn up on 20 sheets, at first in analogic format and later on in a digital formal as well (Florea, 2002).

Practically speaking, the digital orthophotoplan includes both the demarcation of the boundaries of the territorial administrative units as well as the limits of the physical agricultural blocks, along with the alpha-numeric attributes. This is what stood at the base of the correlation between the technical and the economic function of cadastre, which is represented by the graphic entities of the land-soil cartographic units. Based on this correlation, it was integrated the spatial database of the physical agricultural blocks represented on the digital support of the orthophotoplan by the territorial distribution of the graphic entities of the soil cartographic units, which were identified on the surface of the agricultural fields.

On this agricultural surface there have been identified 173 agricultural physical blocks, on which have been overlaid 26 soil units, with a distribution of 89 graphic entities.

MATERIAL AND METHOD

The implementation of sustainable development projects for agricultural exploitations implies the existence of a rigorous inventory of the agricultural land fund and of the physical blocks, as well as knowing and promoting monitoring and management systems of soil resources. Administratively speaking, the territory of Drăguşeni commune, is part of Suceava County, which, if we consider that the total surface occupied is of 855 350 ha, is considered to be the second county in Romania. Considering the manner in which the land fund in Suceava county is used, it results that the agricultural area represents 41% of the total surface, and the non-agricultural area represents 59 % (Moca et al.,2010).

The territory of Drăguşeni commune is situated in the South-West limit of Suceava County, being delimited in the North-East and South-West by the borders of Iaşi County, in the South-West it is situated Neamţ County, and in the North – is the border of Forăşti commune. Geomorphologically speaking, the territory of Drăguşeni commune is considered part of the Fălticeni Plateau (geomorphological subunit of Suceava Plateau), being situated, geographically, in the Moldova-Siret interfluve, at the interference with the major river bed of Moldova river.

The aerophotogrammetric elevation of the Drăguşeni territory was performed based on the flight from July 2nd, 2009, conducted by Estereofoto Geoegenharia S.A., the main beneficiary of this action being the Agency of Payments and Intervention for Agriculture in Romania. In the first phase, technical data of the graphic entities of the physical blocks were collected, being then identified on the digital orthophotoplan of Drăguşeni commune (SIRSUP code 148382).

On the raster images of the digital orthophotoplan there have been overlaid ”the thematic layers” provided by both soil map drawn at scale 1:10000 as well as by the existent correlative maps. From the thematic maps used for the case study, the ones mentioned are those referring to the soil cover and the quality and/or favorability classes; they were drawn up based on the pedological mapping process and the quality assessment process of the agricultural fields in natural conditions. The soil units have been mapped according to the technical requirements pointed out at the level of the ecologic homogenous territorial surfaces for the use categories of the agricultural fields. The general structure of the relational model included collecting the primary technical data of the digital orthophotoplan and obtaining the scanned/digitalized spatial data of the soil maps from the territory of Drăguşeni commune. The conversion to the digital format of the graphic support of the soil map and/or cadastral quality assessment was made within the precision limits determined by the graphic error reference function of ± 0.2, at scale 1 : 10 000.

On the digital graphic support of the agricultural field covered by the 173 physical agricultural blocks, was overlaid the thematic plan of the soil cover map which, in the conditions in which it was analyzed, it was identified due to a total number of 26 soil cartographic units with the surface of 2168.71 ha.

The statistical analysis of the correlation between the qualitative and technical data of the agricultural cadastre was performed for the control surface of the geodetic trapezium with nomenclature L-35-30-A-a-1-III (Drăguşeni), scale 1 : 5 000.

This case study includes the calculations for the rectangular plane Stereographic 1970 coordinates, based on the ellipsoidal geographic coordinates of the trapezium’s corners considered, using the constant coefficients formulae, with a precision of ± 0.001m.

The graphic entities of the physical agricultural blocks and the soil-land cartographic units, respectively, from the lower part of the trapezium, scale 1 > 5 000, were delimited, calculated and compensated on its control area.

RESULTS AND DISCUSSIONS

The administrative territory of Drăguşeni commune, Suceava county was cartographically represented between the South latitude of 47°16'15", and the North latitude of 47°21'15", and West longitude 26°26'15" and East longitude 26°35'37".5 (Fig. 1).

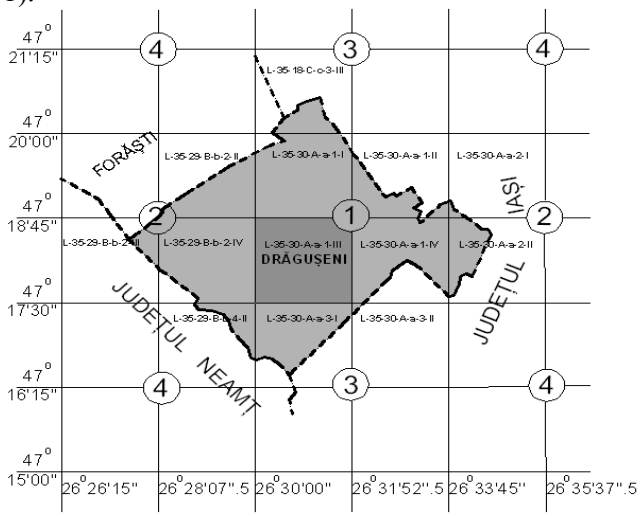

Fig. 1 - Cartographic representation of the territory of Drăguşeni

From the general scheme of the connection of geodesic trapeziums, resulted the following cartographic framing of the Drăguşeni territory: 3 map sheets at scale 1 : 50 000, 3 map sheets at scale 1 : 25 000, 6 map sheets at scale 1 : 10 000 and 13 plan sheets for the scale 1 : 5 000.

a. Calculation of the cartographic base for plan sheets

The case study was performed based on the graphic fond of the basic cadastral plan, scale 1:5 000 **nomenclature L-35-30-A-a-1-III**, which included 100% the territory of Drăguşeni commune. The calculation algorithm included, first of all, the process of determining the Stereographic coordinates from the "*tangent plan*", parallel with the unique secant plan – 1970, based on the following general relations:

$$X_{tg} = (a_{00} + a_{10}f + a_{20}f^2 + a_{30}f^3 + a_{40}f^4 + a_{50}f^5 + a_{60}f^6)\ 1.000 + (a_{02} + a_{12}f + a_{22}f^2 + a_{32}f^3 + a_{42}f^4)\ l^2 + (a_{04} + a_{14}f + a_{24}f^2)\ l^4 + (a_{06} + \ldots)\ l^6 + \ldots \quad [m]$$

$$Y_{tg} = (b_{01} + b_{11}f + b_{21}f^2 + b_{31}f^3 + b_{41}f^4 + b_{51}f^5)\ l + (b_{03} + b_{13}f + b_{23}f^2 + b_{33}f^3)\ l^3 + (b_{05} + b_{15}f + \ldots)\ l^5 + \ldots \quad [m]$$

where: $\mathbf{f = 10^{-4}(\varphi_i - \varphi_0)''}$ - the latitude difference between the given point $P_i(\varphi_i, \lambda_i)$ and the projection pole Q_0 (φ_0, λ_0);

$\mathbf{l = 10^{-4}(\lambda_i - \lambda_0)''}$- the longitude difference between the given point Pi(φi, λi) and the projection pole Q_0 (φ_0, λ_0).

The numeric values of the geographic coordinates from the Krasovschi – 1940 ellipsoid and Stereographic – 1970 of the trapezium's corners with nomenclature L-35-30-A-a-1-III and the **control surface**, respectively, are presented in Table 1.

Table 1

Coordinates of L-35-30-A-a-1-III trapezium corners and the area on the Krasovski - 1940 reference ellipsoid and in Stereo-1970 projection plane

No.	Point position	Geographic coordinates		Stereo -70 coordinates	
		φ (° ' ")	λ (° ' ")	X (m)	Y (m)
1	North - West	47 18 45	26 30 00	613401.689	646954.986
2	North - East	47 18 45	26 31 52.5	646954.986	647000.443
3	South - West	47 17 30	26 30 00	613445.784	644639.278
4	South - East	47 17 30	26 31 52.5	615809.075	644684.744
Trapezium area (ha)		**547.4066 ha**		**547.3600 ha**	

Non-spatial database (areas occupied by the cadastral parcels, agricultural physical blocks, land-soil map units) was calculated and compensated by the **control area** of **547.3600 ha** of the considered trapezium at scale 1: 5 000.

b. Delimitation of soil cartographic units on plan sheets, scale 1: 5000, and calculation of areas

Pedological mapping carried out in the area corresponding to the agricultural, outlined the classification of soils in **26 land-soil units**. On the plan sheet considered in the case study were identified a number of **9 land-soil units** with an area of **492.30 ha**, (Table 2).

Table 2

Spatial distribution of soil cartographic units from the geodetic trapezium L-35-30-A-a-1-III – Drăguşeni

Code of the cartographic soil unit	Name of the soil cartographic unit from the geodetic trapezium	Surface of the soil unit from the geodetic trapezium	
		ha	%
US 5/1	Stagnic Phaeozems	2.93	0.5
US 8/2	Haplic Luvisols	70.41	12.9
US 8/4	Haplic Luvisols	20.15	3.7
US 10/4	Luvic Phaeozems	6.58	1.2
US 10/5	Luvic Phaeozems	5.63	1.0
US 14/1	Stagnic-Luvic Phaeozems	193.37	35.3
US 16/1	Stagnic-Luvic Phaeozems	36.18	6.6
US 17/1	Stagnic-Luvic Phaeozems	27.57	5.0
US 20/4	Haplic Luvosol	11.73	2.1
US 24/1	Mollic-Calcaric Gleysols	31.94	5.8
US 24/7	Mollic-Calcaric Gleysols	1.43	0.3
US 501/1	Calcaric Regosol	84.39	15.4
Incorporated area Drăguşeni		55.06	10.1
Trapezium area	-	547.36	100.0

In the study we conducted there have been identified **12 areas of soil cartographic units**, differentiated in the surfaces from 1.43 ha (US 24/7) until 193.37 ha (US 14/1), (Fig. 2).

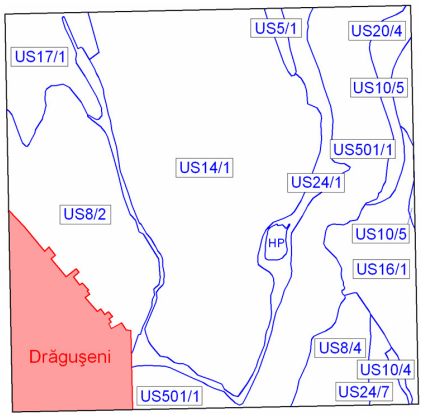

Fig. 2 - Graphic database of soil units from the trapezium L-35-30-A-a-1-III

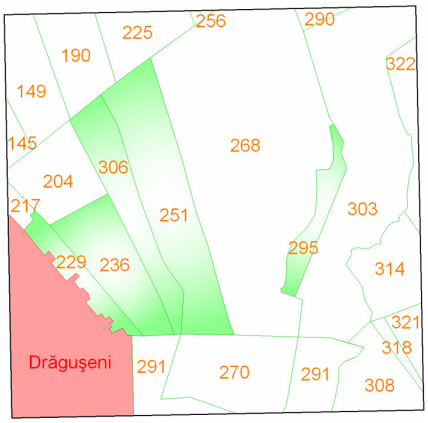

Fig. 3 - Graphic database of agricultural blocks from the trapezium L-35-30-A-a-1-III

c. Cadastral delimitation of territorial units on the plan sheets at scale 1 : 5 000, and area calculations

In accordance with the *technical norms for introducing the general cadastre*, the elaboration of the main cadastral plan in analog form has to be made on map sheets (trapeziums) in the Stereo-70 Projection System.

In order to verify the calculation method for the areas of the territorial cadastral units from the plan sheets, the known area of the trapezium is used. In the case of the digital orthophotomap, with nomenclature L-35-30-A-a-1-III, corresponding to the cadastral territory of Drăguşeni village, two separate cadastral units, namely, the residential and the unincorporated rural area, respectively, were bounded according with the current legislation. Areas calculated and compensated on the **control surface** of the trapezium of **547.36 ha** were **492.30 ha** for the unincorporated rural and **55.06 ha** for the residential.

In the inner frame of the plan sheet were bounded a number of **22 physical blocks**. The distribution of agricultural land in rural area covered **8 physical blocks** with limits of the areas between **0.50 ha** and **10.0 ha**, **12 physical blocks**, with limits from **10.01 ha** up to **30.0 ha** and **2 physical blocks**, with limits from **30.01 ha** up to **130.0 ha** (Fig. 3 and Table 3).

d. Storage of spatial data for the land-soil cartographic units on the orthophotomap digital medium

By integrating the spatial database of the land-soil maps with specific data for agricultural physical blocks from the ortophotomaps content, has resulted the database information medium. The experimental model achieved for the plan sheet L-35-30-A-a-1-III ensures the access to the database at the level of all 22 physical blocks. **For instance**, by accessing the physical block with the **cadastral number 251**, results the following types of spatial and non-spatial data: physical block area = **39.47 ha**; use: **agricultural land**; average slope = **6.40%**; land-soil units and types: (**US 14/1** and **US 24/1**); topographic elements of land; parcel owners; agricultural crops (Fig. 4).

Table 3

Delimitation of soil units on the agricultural physical blocks from the geodetic trapezium L-35-30-A-a-1-III – Drăguşeni

Code of the agricultural physical block	Surface of the agricultural physical block from the geodetic trapezium		Spatial distribution of soil unit on the surface of the agricultural physical blocks
	ha	%	
148382-145	3.11	0.6	US 8/2; US 17/1
148382-149	19.27	3.5	US 8/2; US 17/1
148382-190	18.34	3.3	US 8/2; US 14/1; US 17/1; US 24/1
148382-225	14.37	2.6	US 14/1
148382-256	0.63	0.1	US 14/1
148382-290	2.17	0.4	US 24/1; US 501/1
148382-322	10.70	2.0	US 10/5; US 16/1; US 20/4
148382-314	16.77	3.1	US 16/1
148382-303	96.52	17.6	US 8/4; US 16/1; US 20/4; US 24/1; US 501/1
148382-295	8.20	1.5	US 24/1; US 501/1
148382-268	121.77	22.2	US 5/1; US 14/1; US 24/1; US 501/1
148382-251	39.47	7.2	US 14/1; US 24/1
148382-306	21.73	4.0	US 8/2; US 14/1; US 17/1; US 24/1
148382-204	17.40	3.2	US 8/2
148382-217	2.32	0.4	US 8/2
148382-236	4.45	0.8	US 8/2; US 14/1
148382-229	21.70	4.0	US 8/2
148382-291	24.50	4.5	US 8/2; US 14/1; US 24/1; US 501/1
148382-270	25.84	4.7	US 14/1; US 24/1; US 501/1
148382-308	16.54	3.0	US 8/4; US 10/4; US 16/1; US 24/7
148382-318	1.51	0.3	US 16/1; US 24/7
148382-321	4.99	0.9	US 16/1
Drăguşeni	55.06	10.1	Incorporated area Drăguşeni
Trapezium area	547.36	100.0	-

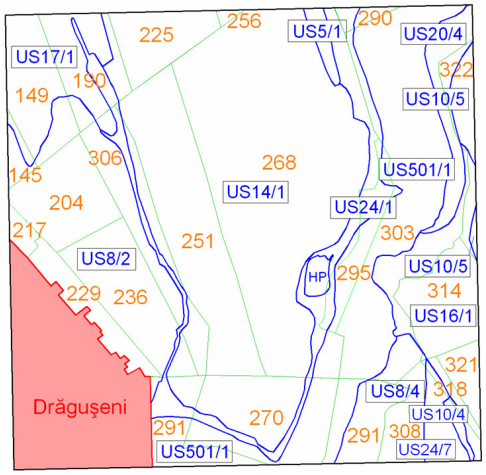

Fig. 4 - Integration of the spatial database of the soil units with the agricultural physical blocks, from the geodetic trapezium L-35-30-A-a-1-III

CONCLUSIONS

1. The integration of the graphic database of the soil units and of those taken from the digital orthophotoplan was performed on the **control area of 547.36 ha** of a geodetic trapezium, scale 1:5 000, from the territory of Drăguşeni.

2. The discrepancy between the vectored surfaces of the soil map and the digital surfaces of the orthophotoplan was compensated, at first, on the areas of the agricultural physical blocks, after which they were constrained and compensated on the **control area of 547.36 ha** of the trapezium used.

3. The experimental model of integrating the spatial database of soil cartographic units with that of agricultural physical blocks represents, from the user's point of view, knowing the data necessary for efficiently exploiting the agricultural land and taking the proper decisions, at the level of the administrative territorial units.

REFERENCES

1. **Băduț M., Blidaru G., 2006 –** *A Model of Exploiting the Ortho - Photograms for checking and Receiving the sporadic Cadastre Works and for graphical Database Completing.* RevCAD Journal of Geodesy and Cadastre, no. 6, p. 71-76, Alternates Publishing House; ISSN 1583-2279, Alba Iulia, România.
2. **David Viorica, 2007 –** *Importanța fotogrammetriei în generarea bazei de date SIG.* Revista de Geodezie, Cartografie şi Cadastru, volumul 16, nr.1-2, p. 34-42, Uniunea Geodezilor din România, ISSN 1454-7914, Iaşi, România.
3. **Florea N., 2002 –** *Hărțile de soluri la scară mică şi mijlocie.* Revista Ştiința Solului, seria a III-a, nr.2, volumul XXXVI, p. 111-123, Editura Signata, ISSN 1224-0303, Bucureşti, România.
4. **Moca V., Ilioi D., Radu O., Huțanu Cr., 2009** – *The use of digital orthophotoplans at the realization of spatial database for the cartographic soil units*. Lucrări ştiințifice, seria Agronomie, vol. 52, nr. 1, p. 383-390, Editura "Ion Ionescu de la Brad", ISSN 1457-7414, Iaşi, România.
5. **Moca V., Bucur D., Ilioi D., Curaleț Adr., Huțanu Cr., 2010** – *Soil resources and hydro - ameliorative improvements in the agricultural area of Suceava country*. Lucrări ştiințifice, seria Agronomie, vol. 53, nr. 3, p. 75-86, Editura "Ion Ionescu de la Brad", ISSN 1457-7414, Iaşi, România.
6. **Moca V., Cârdei Mihaela, Radu O., Huțanu Cr., Savu C., 2012** – *Evolution of surfaces calculation precision from the digital base of the orthophotograms and from field measurements using control areas of geodetic trapezium*. RevCAD Journal of Geodesy and Cadastre, no. 12, p. 71-76, Alternates Publishing House; ISSN 1583-2279 (www.uab.ro/reviste_recunoscute/revcad/), Alba Iulia, România.
7. **Voiculescu Florica, Banciu Ana Roxana, 2011** – *Tehnici LiDAR folosite la prelucrarea datelor şi realizarea produselor fotogrammetrice 3D*. Simpozionul "Geodezie Prezent şi Viitor", p. 243-254, Editura Conspress, ISSN 978-973-100-162-3, Bucureşti, România.
8. *****, 2013** – *Legea cadastrului şi a publicității imobiliare nr. 7/1996, cu modificările ulterioare.* Monitorul Oficial al României, partea I, nr. 83/07.02.2013, p. 3-16, 181 (XXV), Bucureşti, România.