ANALYSIS OF THE TRANSFORMATION OF A CADASTRAL DOCUMENTATION MADE FOR THE AGRICULTURAL LANDS FROM THE LOCAL PROJECTION SYSTEM - IASI INTO THE 1970-STEREOGRAPHIC PROJECTION SYSTEM

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Abstract: The cadastral and land registration activity from the administrative territorial unit of Iasi city was conducted in various time intervals and it was characterized by different work instruments and methods. Thus, there are mentioned the topographic measurements made between 1950-1990 when the classical measuring technique and a local system of rectangular coordinates were used. In 1950 a Local – Stereographic projection – Iasi was adopted; it had its own 2D system of coordinates and the origin in the Golia point. After 1990, in a relatively short interval, the modern measuring methods started being used. There were included, among others, the measurement of distances using waves, the automatic processing of data and transmission of topographic plans. The cartographic documentations made between 1991 – 2009 also relied on the local projection system of coordinates – Iasi. Some of the works included: the measurement and evaluation of agricultural lands, the temporary registration in the land register etc. Starting with 2010 the system of plane rectangular coordinates from the 1970 Stereographic projection became official. From 2013 the Goliath transcalculation program started being used for the transformation of the plane rectangular coordinates from the old cadastral documentations of the Local system – Iasi into the official 1970 - Stereographic projection. The way in which cadastral sectors and real estates from the Local – Iasi system was integrated into the 1970 - Stereographic projection system was analysed considering the technical cadastral documentation from 2004. The case study included a total surface of 50.1808 ha of agricultural land from the unincorporated area of Iasi city. Cartographically speaking, the area was represented by the geodetic trapeziums L–35-32-A–c–3–II-3 and L–35-32-A–c–3–II-4, scale 1:2000, identified with ”Vasile Adamachi” farm of Iasi.

Key words: agricultural cadastre, cartographic projection, transcalculation of rectangular coordinates

In time, given the improvement of measuring technology and the registration of real estates in cadastral documents the **cadastre and land registration** system experienced a dynamic evolution. For obtaining the necessary approvals, reception protocols and the registration in the cadastre and land register system, the **National Agency of Cadastre and Land Registration** (Agenţia Naţională de Cadastru şi Publicitate Imobiliară) set different land destinations and use categories (Order no. 263 of 16.02.2017).

In this context, there are mentioned five groups: *lands with agricultural destination, forests, under water land, incorporated lands, lands with special destination.*

Considering the data published by **Romania's Statistic Annual Book,** at the end of 2014 **agricultural lands** covered **14630.1 thousands ha** the equivalent of **61.3%** of Romania's total real estate.

From this category of agricultural land it stood out the surface covered by the **arable land** of **39.4%,** followed by **pastures** (**13.7%**) and **hayfields** (**6.5%**).

The unitary cadastral and land registration system is to be created for the **3,181 administrative territorial units of Romania**. In this context, the **National Program for Cadastre and Land Registration** is mentioned to be implemented between 2015 - 2023 (http://www.ancpi.ro/pnccf/).

The technical, economic and legal activity for the introduction of cadastre and land registration is regulated by **Law no.7/1996** with the subsequent modifications and completions.

The implementation of these works at the level of administrative territorial units and cadastral sectors leads to the existence of various databases with technical, economic and legal data about these real estates. Hence, for obtaining this primary database, all specialized operations need to be respected.

Some of the technical phases and operations for cadastre and land registration include: geodetic topographic and cadastral measurements; the

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cadastral delimitation of the administrative – territorial units; identification of land use categories; land quality and the registration of real property rights and other (Boş, N., 2003).

MATERIAL AND METHOD

Considering the legal provisions on topographic measurements they are conducted on cadastral sectors/real estates and, using the rectangular points of the contour points are meant to establish the real estate's *shape, dimension and characteristics.*For obtaining accurate topographic and cadastral measurements the *national geodetic support network GPS-GNSS* needs to be completed with the necessary density of points (Păunescu, C., et. al., 2015).

The topographic documentations made in the two distinct areas of Iasi city *(incorporated and unincorporated areas)* date from 1950-2009 and they were made using the local Stereographic Projection system - Golia (Moca, V., et. al., 2016).

The origin of the rectangular coordinates system of axes **XOY** is the plane image of the central point from the local triangulation network. This point is identified on the horizontal platform of the large squared tower from the entrance at the Golia Church with the following local coordinates: **X_O= 10000 m; Y_O= 10000 m** (Figure 1).

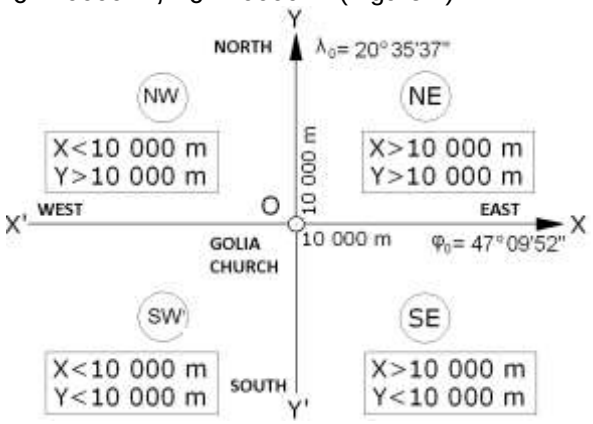

Figure 1 **The local system of axes of plane rectangular coordinates in the Stereographic projection Iasi – Golia**

The axis of abscissas (**OX**) has an east-west orientation being represented by the tangent to the parallel of latitude **φ_0= 47^0 09' 52"** that crosses the geodetic point of Golia.

The values of the abscissas increase from the origin point towards east and decrease from the origin point towards west.

The axis of ordinates (**OY**) has a north-south orientation on the geographic meridian of longitude **λ_0 = 20^0 35' 37"** that crosses the Golia geodetic point. The values of the ordinates increase from the origin towards north and decrease from the origin towards south.

The topographic documentations conducted in the local projection system Iasi - Golia included the drawing up of the basic cadastral plan at scale 1:1000 and the basic topographic plan at scale 1:2000. Between 1990 – 2009, the activity included drawing up the cadastral documentation for awarding the property titles.

The azimuthal cartographic projection, stereographic, oblique, conformal on the unique secant plane – 1970 is used at national level from 1973 and in the city of Iasi from 2010.

The system of axes of rectangular coordinates **XOY** has as its origin the plane image represented by the **geometric centre of Romania** also known as the **projection pole** (Q_0) defined by the following geographic coordinates: **φ_0= 46^0 North and λ_0 = 25^0 East Greenwich,** from the surface of the *1940–Krasovski* reference ellipsoid.

The axis of abscissas (**XX**), orientation North – South, is represented by the plane image of the meridian **(λ_0 = 25^0).** The numeric value of the abscissas, in relation to the origin of the system of coordinates **O (X_0 = 0.000 m; Y_0 = 0.000 m)** is positive in the topographic quadrants I and IV and negative in the quadrants II and III.

The axis of ordinates (**YY'**) orientation east – west is represented by the geometric tangent to the plane image of the parallel of latitude (**φ_0= 46^0**). The ordinates have positive values in the topographic quadrants I and II and negative in the quadrants III and IV (Figure 2).

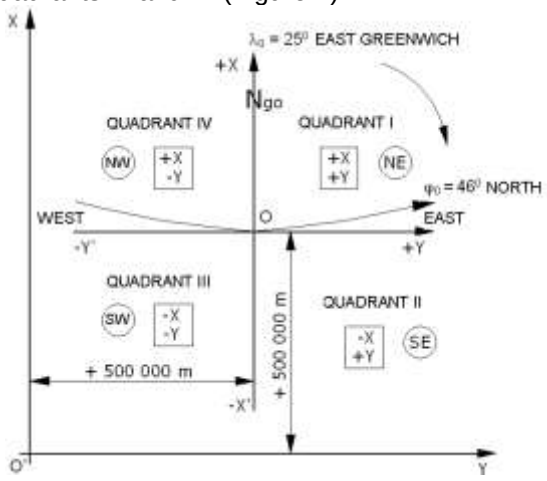

Figure 2 **The general system of axes of plane rectangular coordinates in the 1970-Stereographic projection**

For turning the negative values of plane rectangular coordinates (**X,Y**) from the topographic quadrants II, III and IV into positive values, the origin of the system of coordinates was translated from point **O (X_0 = 0.000 m; Y_0 = 0.000 m)** by **500,000** m **south** and **west**, resulting the translated origin used in the topographic and cadastral activity.

The 1970-Stereographic projection does not deform angles, but it does deform lengths and the areas represented in the secant plane.

In the central point Q_0 (φ_0, λ_0), the linear relative deformation is of **0.25 m/km** after which it decreases up to the distance that corresponds to

the beam of the **circle of null deformation (r_0=201.718 km)** and increases afterwards up to **+0.637 m/km**, at **385 km** away from **the projection pole**. (Ilieş, A., Vasilca, Doina, 2002).

RESULTS AND DISCUSSIONS

For the analysis of the transformation of a cadastral documentation from the plane rectangular system of coordinates of the Local Stereographic Projection – Iasi into the official system of the 1970-Stereographic projection system it was taken into consideration the topographic survey of 2004 for a surface of **50.1808 ha**. The area included in the case study was situated in the unincorporated area of Iasi city being part of the *"Vasile Adamachi"* farm of Iasi.

a Land framing of the property on geodetic trapeziums, scale 1:2000

The cadastral territory of Iasi city has the following bordering administrative territorial limits in the north-west and north-east areas: *Valea Lupului, Rediu, Popricani and Aroneanu.*

From the distribution and the numbering of map and plan sheets resulted the following cartographic framing for the city of Iasi: *4 map sheets* scale 1:50000; *6 map sheets* scale 1:25000; *14 plan sheets*, scale 1:10000; *34 plan sheets*, scale 1:5000; *103 plan sheets*, scale 1:2000 and *347 plan sheets*, scale 1:1000 (Moca, V., et. al. 2016)

The land classified as having an **agricultural destination** is situated in the north-west area of the unincorporated area of Iasi city.

Considering the cartographic framing on trapeziums, the property with the area of 50.1808 ha covers the following: L-35-32-A-c-3-II, scale 1:5000; L-35-32-A-c-3-II-3, L-35-32-A-c-3-II-4, scale 1:2000 (Figure 3).

The evaluation of surface deformation was conducted considering the **trapezium area** (**T**) from the Krasovski – 1940 ellipsoid, determined by the geographic trapeziums of the corners of the trapeziums and the plan of the **Local Stereographic Projection – Iasi (S)** of rectangular coordinates. From the difference from the two surfaces **(S and T)** results the value of the **total areolar deformation** for the area of the plane trapezium (**S**) in relation with the undeformed area from the reference ellipsoid (**T**), considering the relation (Moca, V., Chirilă, C., 2002):

$$\pm\Delta T_S = (S - T), \text{ in ha}$$

The study conducted for the framing of Iasi city on geodetic trapeziums, scale 1:5000 indicated only **negative values of the total areolar deformation**, ranging between **-0.1574 ha** and **-0.2097 ha** (Moca, V., et al., 2016).

The analysis conducted on the deformations from **the secant plan of the 1970 Stereographic projection** pointed out only positive values for both linear and areolar deformations, for the territory of Iasi situated outside the null deformation circle with beam of **201,718 km**.

The relative linear deformation per unit of length (1 km) ranged between **+ 7.77 cm/km** in the western extremity and **+11.16 cm/km** in the eastern extremity of Iasi city.

During the cartographic framing of the territory on the same trapeziums, scale 1:5000 resulted only p**ositive values for the total areolar deformation,** which ranged between **+ 0.0939 ha** and **+ 0.1105 ha** (Moca, V. *et al*., 2016).

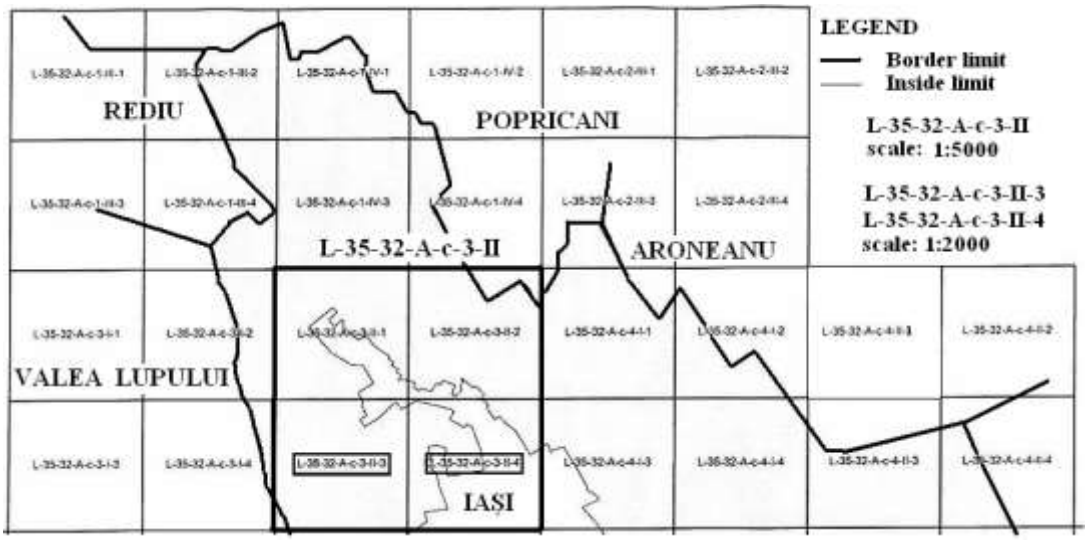

Figure 3 **Partial cartographic framing for the territory of Iasi city, on trapeziums, scale 1:2000**

b Field measurements and drawing up the cadastral plan

The technical cadastral documentation made using the plane rectangular coordinates of the **Local Stereographic Projection – Iasi** was meant for the temporary registration of a piece of land in the land register of Iasi city. For the field measurements, the local triangulation network was first thickened using the intersection method. Considering the rectangular coordinates of the local triangulation network from the territory of Iasi city, there have been identified points **51** and **52** of the thickening network. (*Table 1*).

Table 1

Inventory of plane rectangular coordinates of the support and thickening triangulation network

Point name	Rectangular coordinates	
	X (m)	Y (m)
Survey Beacon Zootechnics	7496.390	13323.556
Cetăţuia Church	9602.580	6351.680
Galata Church	8463.550	8003.460
Miroslava Church	5011.405	8432.315
Beacon Agricultural High School Iasi	6324.775	13519.779
51	**6703.213**	**13589.574**
52	**6393.693**	**13414.483**

For the field measurements it was used the **Leica Geosystems TC 705 total station** with the following specific parameters: *the standard measuring error for a horizontal and/or vertical direction of* ***15^{cc},*** *measuring accuracy of distances of* ***2 mm+2pp*** *and measuring time* (*<**0.1 sec**).

The survey of planimetric details from the property and the border points was conducted using the total station and the tahimetric traverse and radiation method.

On the property there have been identified and measured the **24 existent cadastral plots** with the surface of more than **300 m^2** for the measurements conducted on the unincorporated area. At the same time, the data referring to the use categories have been identified on field.

The property borders were established using the measurements that resulted from the planimetric and altimetric position in the **3D** system of coordinates **(X, Y, Z)** of the **165 points** on the border line.

The error of the points on the property limit in planimetric position is of ±**10 cm**, for delimited areas and **± 30 cm**, for not - delimited areas.

From the general inventory of coordinates of the points identified for the geometric contour of the property area there have been selected and presented only **the spatial coordinates (X, Y, Z) of the main border points** (Table 2)

Table 2

Inventory of rectangular coordinates and height (Z) for the main points of the border line

Point no.	Plane rectangular coordinates and height		
	X (m)	Y (m)	Z (m)
1	6063.550	13164.839	157.550
5	6095.416	13192.716	159.640
20	6066.735	13366.872	164.660
35	6385.349	13535.417	170.450
36	6404.822	13510.023	170.196
44	6455.862	13596.091	167.219
45	6452.923	13599.423	166.272
59	6569.757	13695.461	170.693
64	6597.572	13641.100	168.399
69	6702.771	13612.757	164.484
74	6720.332	13689.732	166.878
92	7008.264	13620.085	157.084
95	6956.263	13535.655	145.108
99	6936.259	13464.848	137.795
102	6914.879	13292.654	117.416
115	6792.397	13274.020	116.255
118	6833.634	13191.394	102.646
123	6799.389	13153.657	100.263
126	6875.226	13081.136	95.069
129	6898.636	13047.149	93.228
134	6929.341	12920.350	88.232
142	6703.455	12852.960	124.849
144	6678.930	12905.090	127.005
150	6634.106	12878.017	130.159
154	6462.800	13062.415	145.616
160	6289.755	12917.148	138.529
165	6110.571	13110.525	156.254

The measurements made and validated for the case study on the property area were used for drawing up the **cadastral plan**, first in a digital version and then analogic, scale 1:2000.

At principial level, the digital plan no longer depends, as accuracy and content, of the numeric scale of the graphic representation. Hence, the numeric scale refers practically to the **final product** of the graphic fund represented on paper, in analogic format.

The transfer of data from the total station to the computer's memory represents a preliminary phase after which the points representing the planimetric details need to be reported and connected with the drawings according to the field sketches. After uniting the **165 points situated on the property border line** resulted the following geometric configuration of the measured surface: 1,..., 5,..., 20,..., 160,..., 165,..., 1 (Figure 3).

The land use category represents the group of lands with the same economic destination, organized naturally or artificially, numbered with a code. This code of the cadastral parcel represents one of the identifiers that connect the graphic and alphanumeric database to the informatic system.

On the property the following parcels have been numbered with arab figures and symbols for land use categories: 1CC, 2V, 3V, 4V, 5V,..., 20L, 21L, 22L and 23L (Figure 4).

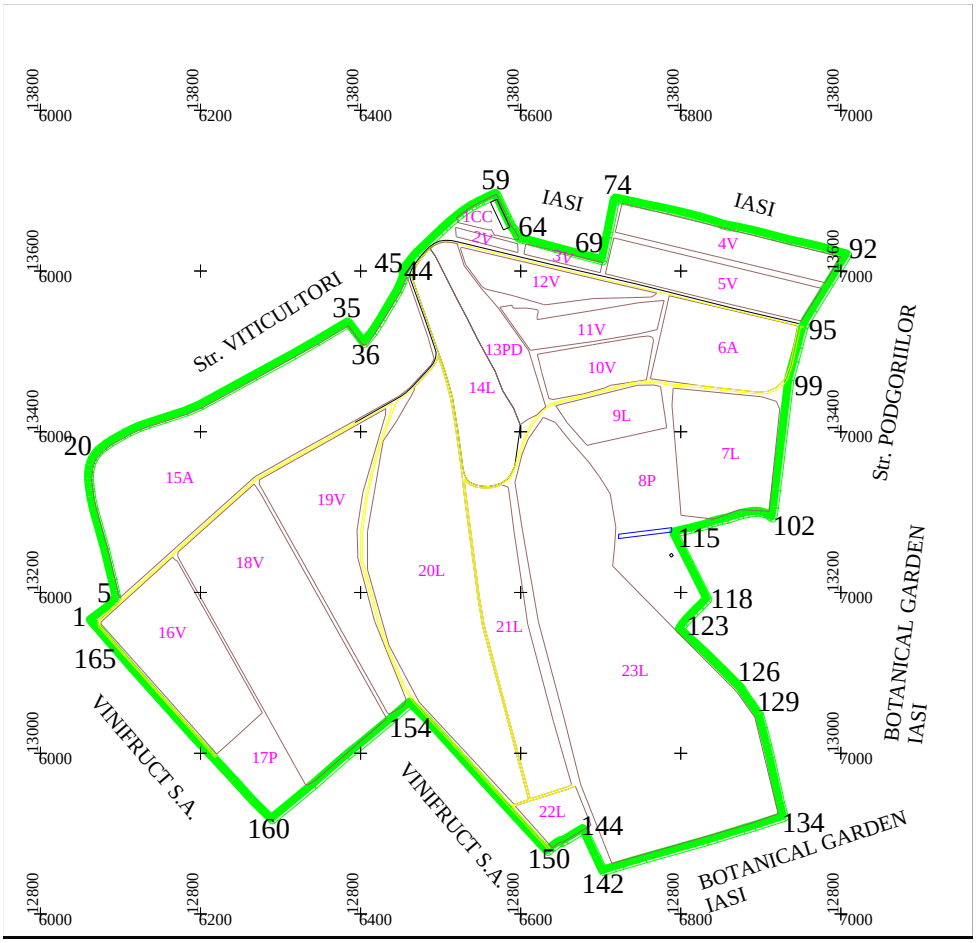

Figure 4 **Position and cadastral delimitation of the property "Vasile Adamachi" of Iasi**

Depending of the local rectangular coordinates – Iasi of the 165 points situated on the property border resulted a total surface of **50.1808 ha**. Based on the cadastral numbering process there have also been identified the surfaces of the **24 real estates**, using the general relation:

$$\pm 2S = \sum_{i=1}^{n} x_i\left(y_{i+1} - y_{i-1}\right) = \sum_{i=1}^{n} y_i\left(x_{i+1} - x_{i-1}\right) \quad (m^2)$$

The resulting areas obtained using the analytical method of local rectangular coordinates (X, Y) of the points from the contour of the real estates have been verified by comparison to the total surface of the property. The difference between the value of the areas ranged between the minimum limit of **0.0865 ha/real estate 2V** and a maximum of **8.6316 ha/ real estate 23L** (Table 3).

The spatial and textual cadastral database created in time to the city of Iasi is to be even more accurately defined in the official system of coordinates of the 1970-Stereographic projection system. Starting with 2010 it was adopted only the use of the system of coordinates of the 1970-Stereographic projection.

For the transformation of plane rectangular coordinates (X, Y) from the local – Iasi system into the official 1970-Stereographic system, the *Agency of Cadastre and Land Registration of Iasi* used the "Goliath" transcalculation programme for both legal entities and natural persons for drawing up, approving, and registering the works in the cadastral and land register records.

Depending of the plane rectangular coordinates of Stereo – 70, there have been calculated the areas of the real estates with the **total area of 50.2080 ha** (Table 3).

Table 3

Situation on real estates and the differences between the cartographic projection systems

Cadastral no. of real estate	Area for real estates and systems of plane rectangular coordinates (ha)		
	Local – Iasi Projection (S_1)	Stereo – 70 Projection (S_2)	Surface differences (S_2 - S_1)
1CC	0.2099	0.2100	0.0001
2V	0.0865	0.0866	0.0001
3V	0.1287	0.1288	0.0001
4V	1.0048	1.0053	0.0005
5V	1.1940	1.1947	0.0007
6A	1.5913	1.5921	0.0008
7L	1.8510	1.8520	0.0010
8P	1.9680	1.9690	0.0010
9L	0.6861	0.6865	0.0004

10V	0.7614	0.7618	0.0004
11V	0.7311	0.7315	0.0004
12V	0.7637	0.7642	0.0005
13PD	0.9480	0.9486	0.0006
14L	1.6586	1.6595	0.0009
15A	5.4950	5.4980	0.0030
16V	2.2037	2.2049	0.0012
17P	0.7111	0.7115	0.0004
18V	4.3022	4.3045	0.0023
19V	2.4850	2.4863	0.0013
20L	5.1496	5.1524	0.0028
21L	2.0878	2.0889	0.0011
22L	0.3970	0.3971	0.0001
23L	8.6316	8.6363	0.0047
24D	5.1347	5.1375	0.0028
TOTAL	**50.1808**	**50.2080**	**0.0272**

The technical data updated after the transformation of the cadastral documentation from the **Local – Iasi system into the official 1970 – Stereographic system** pointed out the position in space of each real estate – represented by a cadastral number (Figure 4) and the surface that resulted from the measurements (Table 3).

For the registration of technical data into the official cadastral records and land register, the real estates were grouped according to their destination and land use categories.

The group of agricultural land included 21 real estates, that is **43.911 ha** the equivalent of **87%** of the total surface of the property.

In this use category, it stood out the **orchard category of use with 20.4727 ha** and **noble vineyards with 13.6686 ha.** There have also been included in the cadastral records the three real estates with the following use categories: **constructions and yards** (1CC); **forests and other forestry** (13PD) and **roads** (24D).

The graphic representation of the position and cadastral delimitation of the property "*Vasile Adamachi*" in digital format and then analogical included two trapeziums, scale 1:2000. The trapezium L-35-32-A-c-3-II-3 includes 28.1292 ha, while the neighboring one, L-35-32-A-c-3-II-4, a surface of 22.0788 ha.

CONCLUSIONS

The **Local Stereographic Projection - Iasi** included only **negative total areolar deformations** which for the trapeziums scale 1:5000 ranged between **– 0.1574 ha** and **– 0.2097 ha**, in relation to the not-deformed area from the Krasovski – 40 ellipsoid.

The **1970 - Stereographic projection** recorded only **positive areolar deformations**, which, for the trapeziums at scale 1:5000 ranged between **+ 0.0939 ha** and **+ 0.1105 ha**, in relation to the area from the Krasovski – 40 ellipsoid.

The analysis of the differences between the areas of the real estates identified for the two projection systems indicated values between **1 m^2** and **28 m^2**, for those surfaces smaller than **5 ha**.

For the surfaces larger than **5 ha** there have been pointed out higher differences between the two projection systems, ranging between **30 m^2** and **47 m^2** (Table 3).

The differences between the areas obtained in the two projection systems for the surfaces larger than **5 ha** can lead to certain difficulties in the integration of the database from the Local – Iasi system into the Stereo-70 system.

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