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- Department of Land Management and Geodesy of Latvia University of Agriculture
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In the 7^{th} volume of the journal are included original articles on land administration, land management, real property cadastre, land use, rural development, geodesy and cartography, remote sensing, geoinformatics, other related fields, as well as education in land management and geodesy throughout the Baltic countries, Western and Easten Europe and elsewhere. The journal is the first one in the Baltic countries dealing with the issues mentioned above.
This scientific journal contains peer reviewed papers. For academic quality each paper has been reviewed by two independent anonymous academic reviewers having Doctors of science degree. Editorial Board has made the final decision on the acceptance for publication. Each author is responsible for high quality and correct information of his/ her article.
We believe that scientists from other foreign countries will become authors of research articles, and the topics of articles will range widely.
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CONTENT

ANALYSIS OF APPROACHES IN INTEGRATION OF COMMON SOLUTIONS OF DIFFERENT SPACE GEODETIC TECHNIQUES

Alina Khoptar
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Abstract
The role of space geodetic techniques combination is becoming increasingly important to calculate the geodetic parameters. It has an intention of using the advantages and complementarity of different techniques to achieve the best solution. Estimation of geodetic parameters from observations mainly was done by least squares adjustment within the Gauss - Markov model. The combination can be done at three different levels: observations, normal equations and parameters. This article analyses the differences between the approaches and discusses the possibility of troposphere parameters calculation from a theoretical point of view.
Key words: space geodesy, Global Navigation Satellite System (GNSS), Satellite Laser Ranging (SLR), common solutions.

Introduction

One of the main reason for improving of coordinate - time measurements accuracy are widespread implementation of different space geodetic techniques such as Very Long Baseline Interferometry (VLBI), Global Navigation Satellite Systems (GNSS), Satellite Laser Ranging (SLR) and Lunar Laser Ranging (LLR), Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS), radar observation methods and other. Nowadays the combination of different space geodetic techniques is a common procedure to calculate the precise geodetic products. Combining different observations types uses all single contributions in order to fully exploit the strengths of each space geodetic techniques.
We can apply the following projects as the main examples of combination:

- The Global Geodetic Observing System (GGOS) – the observing system of the International Association of Geodesy (IAG) (Plag, Pearlman, 2009; Web site of GGOS, 2017);
- realization of International Terrestrial Reference Frame (ITRF) (Seitz, etc., 2012);
- modelling ionospheric (Dettmering et.al., 2011) and tropospheric parameters (Krügel, etc., 2007);
- calculating gravitational field (Kern, etc., 2003).

When combining different space geodetic techniques, it is essential to be able to connect these solutions together (Altamimi, etc., 2003). A co-location site is station, which have two or more space geodesy instruments on one platform with a precision geodetic local tie. In case of opportunities of the tropospheric delay determination, in collocation sites observation signals are conducted through the same part of the troposphere and at the same time. Thus signals are these signals violated by the same physical conditions. In a simplified form, space geodesy techniques are based on measurement of distance between station and satellite. The signal delay is mainly generated by troposphere – the lowest layer of the atmosphere. The value of this error should be taken into account in the processing of all observations types. The correction can be simply applied to all methods of observation, performing measurements in the microwave range (DORIS, GNSS and VLBI). In the case of SLR situation is slightly different, because that observation was done on optical wavelengths. Thus, the signals of SLR instruments are very sensitive to water vapor content of the atmosphere, unlike radio.

Methodology of research and materials

The combination of different space geodetic techniques can be implemented at three levels of least squares adjustment: observation, normal equations and parameters, as shown in Fig. 1.
Combination is performed using parameters common to each observation types. There are three cases (Tolokonnikov, 2015):

1) identical parameters (e.g. the Earth's orientation parameters (EOP), station velocities);
2) non-identical parameters (e.g. position of stations on colocation sites). In this case, for the combination, we must use local tie information;
3) unique parameters, which is characterized only for one type of observations (e.g. quasars position for VLBI, or constant amendments to SLR). Using these options requires transformation of normal equations.

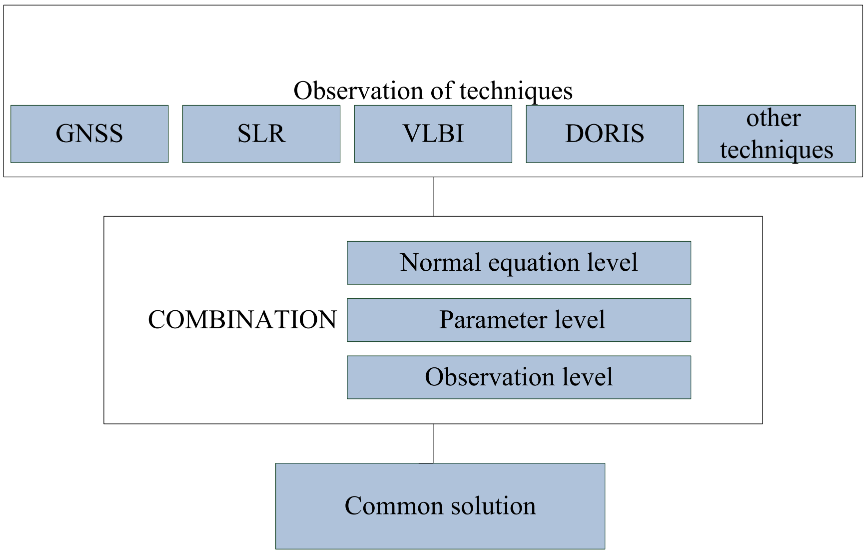

Fig. 1. Scheme for a common solution

Theoretically, if the processing is performed sequentially for each of the cases, all three common solutions should lead to the same results, but in practice, each approach provides slightly different solutions.

Combination at the normal equation level. Initial data are available system of normal equations presented without any restrictions. Preliminary data processing, in this case, is carried out separately for each technology. Before combination, observation equations are transformed in the normal equations, provided that the sum of squared residuals is minimized.

The system of normal equations of this type of observation is as follows:

$$N_k \Delta x_k = L_k \tag{1}$$

Where N_k – coefficient matrix of normal equations for observation type k;

Δx_k – normal equations vector for observation type k;

L_k – an amendments vector for observation type k.

The first step is forming system of normal equations for each type of observations. Then normal equations system combining different techniques, using connection with the same types of parameters. The result of the common solution system will look like:

$$\Delta \hat{x} = \overline{N}^{-1} - \overline{L} \tag{2}$$

where

$$\overline{N} = \sum k \frac{1}{\sigma_k^2} N_k \,, \overline{L} = \sum k \frac{1}{\sigma_k^2} L_k \tag{3}$$

where σ_k^2 – weight error of a particular type of observations k.

Combination at parameter level. The initial data are solutions that represent the covariance matrix $Q_{\hat{x}\hat{x}}$ and fixed parameters $\hat{x}_k$.

Free limited normal equations system of the form (1) is degenerate because there is a deficit rank due to the lack of necessary initial data for coordinate system determination. Defining a solution of equation (1) requires the introduction of additional conditional equations for clarification coordinate base. In general terms, it can be presented:

$$\hat{x}_k = x_0 \sigma_k^2 Q_{\hat{x}_k \hat{x}_k} (L_k + d_k), \; Q_{\hat{x}_k \hat{x}_k} = \sigma_k^2 (N_k + D_k)^{-1} \tag{4}$$

where x_0 - a vector of preliminary parameter values;

D_k - coefficient matrix of conditional equations, which added for the deficit rank matrix N_k;

d_k - a conditional equations vector;

σ_k^2 - weight error of a particular type of observations k.

Recommended minimum restrictions as they apply to the parameters of the base, and not to coordinate station that does not distort the geometry of the network. The purpose of this type of limitation - the creation of coordinate foundations around the selected as a reference. Equation minimum limitations:

$$B(x - x_0) = c \tag{5}$$

where

$$B = \left(A^T A\right)^{-1} A^T \tag{6}$$

Matrix A corresponds to seven transformation parameters:

$$A = \begin{pmatrix} 1 & 0 & 0 & x_0 & 0 & -z_0 & y_0 \\ 0 & 1 & 0 & y_0 & z_0 & 0 & -x_0 \\ 0 & 0 & 1 & z_0 & -y_0 & x_0 & 0 \end{pmatrix} \tag{7}$$

$$\left(B^T P_\theta B\right)(x - x_0) = B^T P_\theta c \tag{8}$$

where P_θ – weight matrix for transformation parameters.

In general terms:

$$D_k = B^T P_\theta B \tag{9}$$

$$d_k = B^T P_\theta B = (x - x_0) \tag{10}$$

where vector d_k – limit equation of selected TRF (x) and a priori (x_0). If $(x = x_0)$ then $d_k = 0$.

Combination at an observation level. In 2009 International Earth Rotation and Reference Systems Service (IERS) organized a working group – a combination at the observation level (COL) (Web site of COM, 2017), whose efforts were aimed at developing strategies, methods and software for combining at observations level, which in theory was the most rigorous. Unfortunately, this IERS component ceased operation in 2016.

This approach is a rigorous mathematical processing of all kinds of measurement information within a dynamic method of space geodesy theory. The essence of the method of combination at observation level involves composing a common measurement data, where different space geodetic techniques equations combined with the same parameters allowing you to take into account the correlation between all estimated parameters:

$$\begin{bmatrix} A_1 \\ \vdots \\ A_k \end{bmatrix} x = \begin{bmatrix} l_1 \\ \vdots \\ l_k \end{bmatrix} + \begin{bmatrix} v_1 \\ \vdots \\ v_k \end{bmatrix} \tag{11}$$

$$Q_{ll} = \sigma^2 \begin{bmatrix} P_1^{-1} & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & P_k^{-1} \end{bmatrix} \quad (12)$$

where A_k - coefficient matrix for observation type k;

l_k - an observation vector;

v_k - a vector of errors;

Q_{ll} - covariance matrix of observations;

σ - weight error.

The main differences' association methods. The combination at the observation level is the most rigorous approach to modelling common solutions. All types of observations are processed together from the stage of forming observation equations using the same parameters and models. In the optimal case, the analysis is performed within the same software that can handle all types of different space geodetic techniques together. Unfortunately, such software that can process data of VLBI, SLR, GNSS and DORIS at the highest level, is not able nowadays. The combination at a normal equation level is a good approximation of the combination at observation level. The combination at parameter level shows clear differences with respect to other (Seitz, 2009). Table 1 shows the main characteristics of the combination methods.

Table 1

The main differences between combination methods

	Normal equation level	**Parameter level**	**Observation level**
Preliminary analysis of observations	No	No	Yes
Additional transformation parameter	No	Yes	No
Rigorous method	Yes	No	Yes

Discussions and results

The troposphere parameters are a little different for every observation type because the measurements were made at different wavelengths (Lytvyn, 2008). In contradiction to such space geodetic techniques like GNSS, VLBI and DORIS, SLR suffers the slightest impact by variations of a beam in the atmospheric channel. Compared to the microwave frequencies used in GNSS techniques, SLR optical frequency is relatively insensitive to the two most dynamic components of the delayed passage through the atmosphere, ionosphere and the distribution of water vapor. In particular, the impact of the effect of water vapor on the laser observations is about 70 times less than for microwave measurements. Thus, the so-called "dry component" of the atmosphere is the main contribution to the error passing SLR signal (Degnan, 1993).

As mentioned earlier, one of the advantages of combining different space geodetic techniques at observation level is the ability to use additional information. The simplified equations for GNSS and SLR observations can be specified as follows (Thaller, 2008):

$$c\Delta\tau_R^{S,GNSS} = \left| r_i^{S,GNSS} - Rr_{e,R} \right| - c\delta t^{S,GNSS} + c\delta t_R + \delta_{trp,R}^{S,GNSS} + \delta_{ion,R}^{S,GNSS} + \delta_{rel,R}^{S,GNSS} + \cdots + \varepsilon^{GNSS} \quad (13)$$

$$\frac{1}{2} c\Delta\tau_R^{S,SLR} = \left| r_i^{S,SLR} - Rr_{e,R} \right| + \delta_{trp,R}^{S,SLR} + \delta_{rel,R}^{S,SLR} + + \cdots + \varepsilon^{SLR} \quad (14)$$

Where $\Delta\tau_R^{S,GNSS}$ - a phase or code observation satellite S – station R;

$\Delta\tau_R^{S,SLR}$ - time of the impulse towards station R - satellite S - station R;

c – velocity of light;

$r_i^{S,GNSS}, r_i^{S,SLR}$ – 3-dimensional position of GNSS satellite and SLR satellite in an inertial reference frame;

$r_{e,R}$ - 3-dimensional position of station R in a terrestrial reference frame;

R - rotation matrix of Earth orientation (nutation, UT1, polar motion);

$\delta t^{S,GNSS}$ - clock error of the GNSS satellite clock;

δt_R - clock error of the GNSS receiver clock;

$\delta_{trp,R}^{S,GNSS}, \delta_{trp,R}^{S,SLR}$ - correction for tropospheric delay in GNSS and SLR observation respectively;

$\delta_{ion,R}^{S,GNSS}$ - correction for ionospheric delay in GNSS observation;

$\delta_{rel,R}^{S,GNSS}, \delta_{rel,R}^{S,SLR}$ - correction for relativistic effects in GNSS and SLR observation respectively;

$\varepsilon^{GNSS}, \varepsilon^{SLR}$ - measurement error in GNSS and SLR observation respectively.

As a result of adding equations (13) and (14), we can express the value of the tropospheric delay:

$$\delta_{trp,R}^{S} = \frac{1}{2}(c\Delta\tau_R^{S,GNSS} + \frac{1}{2}c\Delta\tau_R^{S,SLR} - \left|r_i^{S,GNSS} - Rr_{e,R}\right| + c\delta t^{S,GNSS} - c\delta t_R - \delta_{ion,R}^{S,GNSS} - \delta_{rel,R}^{S,GNSS} - \varepsilon^{GNSS} + \\ - \left|r_i^{S,SLR} - Rr_{e,R}\right| - \delta_{rel,R}^{S,SLR} - \varepsilon^{SLR}) \quad (15)$$

These equations contain the impact of tropospheric correction, hence given two space geodetic techniques can be used to determine tropospheric parameters.

Conclusions and proposals

Combination of different space geodesy techniques can be implemented at three levels of regulation by the least squares method under the Gauss - Markov models: observations, normal equations and parameters. The results of the combination at the observation level is the most rigorous method, because during the whole process from the preliminary stages of processing it is performed using the full available observational data.

In this paper we suggest a method for combination of GNSS and SLR observations for tropospheric parameters calculation. It is a way to combine GNSS and SLR type of observations with common parameters, which provide a strong connection between both techniques. Many years of experiences in observation analysis and combination allow to get precise geodetic products. The proposed method has to be developed to use the geodetic data for tropospheric parameters modelling without a loss in accuracy and by aiming for the best approximation of reality.

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ANALYSIS OF CHANGES IN TRANSACTION PRICES OF UNDEVELOPED LAND IN POLAND

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Abstract
The subject of the paper is the change trends in the trade in undeveloped land and real properties designated for agricultural and forestry purposes in Poland with respect to the value and surface area of real properties sold. Another aim of the study is to present the differences between average transaction prices of undeveloped real properties designated, among others, for residential, industrial, agricultural and forestry purposes. The research covers the period starting from the accession of Poland into the European Union structures. The Polish real property market has been very active in the analysed period. The analysis of tendencies in real property sales transaction values in Poland in the time period from 2004 to 2015 demonstrates that the increasing trend prevailed from 2004 to 2008. Then, in 2009, the value of transactions decreased in comparison to the preceding year.
Key words: real property trade, transaction prices, land real properties

Introduction

The real property market is a whole set of conditions in which titles to real property are transferred. Such transfer consists of concluding agreements with the aim to define mutual rights and obligations that are inextricably linked to the right to own real property (Kucharska-Stasiak, 2016; Trojanek 2008).

According to K. Gawronski and B. Prus the real property market in Poland is still in the development phase, but it is doubtlessly an important element of economic growth. However, it is imperfect due to the fact that a small number of transactions are concluded in some regions of the country, voivodeships and communes (Gawronski, Prus, 2005).

There are certain stylized facts concerning the real property price dynamics. The first one is the statement that real property prices remain stable from one period to the following one. The main reason for that is believed to be the rationing of loans, insecurity and transaction - related costs. The second one is the fact that permanent changes in real property prices are the reason for both prosperity and downturns on the real property market (Case, Shiller, 1989; Case, Shiller, 1990; Muellbauer, Murphy, 1997; Glaeser, Gyourko, 2006; Klonowska-Matyna, Kanka, 2014).

The supply of building land is influenced by the ease of hanging the designation of undeveloped land (wastelands, agricultural land, forests) for the purposes of new development, the ease and freedom of dividing real property, access to infrastructure necessary for the construction and operation of structures, freedom of managing building land plots (regardless of their size) as well as planning and town-planning restrictions.

Agricultural policy is one of the forms of state intervention in the market mechanisms, which has been observed, to various extents, throughout the world. According to R. Sobiecki, quot. by A. Czyżewski, influencing such important parameters of the economy as: the price, profit, revenue may lead to the change in the basic macroeconomic indicators, such as the pace of development of agriculture and its relations with other sectors of the economy.

State intervention usually involves qualification control and control over the formation of the area structure of agricultural farms (Czechowski et al., 2002).

The situation on the agricultural real property market is of great importance for the development of Polish agriculture. The introduction of the principles of market economy and the privatisation of State Treasury-owned agricultural land created a basis for natural land concentration processes, formation of prices and the emergence of agricultural real property market. In Poland, the task consisting in protecting land from purchase has been vested in the Agricultural Property Agency (former Agricultural Property Agency of Treasury), which realises it by means of developing the land property of former state-owned farms and real property of the National Land Fund as well as by means of exercising the right of the first refusal to agricultural real property (Hełdak et al. 2017).

The aim of this study is to present the changes in average transaction prices of undeveloped real properties as well as agricultural and forest land in Poland after the accession to the European Union structures and to demonstrate the differences between prices obtained for real properties designated for various purposes.

Methodology of research and materials

The subject of the analysis was the changes in transaction prices in land real properties, including undeveloped land designated for development, agricultural land, as well as forest and woody land in Poland in the period following the accession into the European Union in 2004.
The research covered average transaction prices of land in the years of 2004 – 2015 with respect to the number of plots sold, transaction value and the average value of 1 m^2 of land designated for development or 1 ha of agricultural land.
The author used source material obtained from the database of the Central Statistical Office in Poland (GUS), from the Agricultural Property Agency of Treasury and databases from the European Statistical Office (Eurostat).
The research material has been gathered by information departments of the national statistical institutions. The collected information was subject to analysis by using the comparative method, by compiling information about transaction prices, surface area and value of sold agricultural land plots and real estate.

General characteristics of transactions in undeveloped land real properties in Poland

The land trade in Poland is influenced by numerous factors. Some of these factors that affect the trade in agricultural land include, among others:

- political transformation and the heritage of the previous political system,
- integration in the European Union and the common agricultural policy,
- the possibility to change the zoning status of agricultural land, usually purchased for lower prices for non-agricultural purposes, e.g. to build a house,
- speculative purposes,
- possibility to receive direct subsidies,
- lower taxes and social security contributions for individuals conducting agricultural activity (Hełdak et al., 2017).

Selling of ownership title requires concluding the agreement in form of a notarial deed and entry in the land and mortgage register.
The value and surface area of real property sold during 2004 – 2015 divided into land designated for development, agricultural and forest and woody land are listed in Table 1.
The average transaction prices of agricultural land and real estate in Poland calculated on the basis of the surface area of sold properties and the value of the sold land plots in euro currency, at the exchange rate of the National Bank of Poland as of the 01.03.2017 are listed in the tables below. The equivalent of 1 euro in Polish currency is PLN 4.30.

Table 1

Value and surface area of transactions in undeveloped land real properties in Poland during 2004 – 2015

Nr.	Year	Building land		agricultural land		forest land as well as woody and bushy land	
		value in thous, EUR	Area in m^2	value in thous, EUR	Area in m^2	value in thous, EUR	Area in m^2
1.	2004	349,450	N/A	591,843	2,096,960,000	7,984	21,571,000
2.	2005	519,198	N/A	679,798	1,824,860,000	13,217	20,217,600
3.	2006	1,005,726	N/A	879,225	2,155,894,000	10,161	17,141,400
4.	2007	1,538,572	N/A	1,674,427	10,911,110,000	15,993	23,263,800
5.	2008	1,619,105	9,6916,000	1,587,773	1,472,920,000	40,026	27,497,600
6.	2009	793,058	76,489,560	1,110,092	1,279,351,956	34,104	20,674,439
7.	2010	668,159	76,003,791	1,431,739	1,579,466,260	19,274	20,339,386
8.	2011	1,022,699	91,231,170	2,085,469	1,941,554,970	37,421	29,648,426
9.	2012	1,362,668	99,530,656	2,867,649	2,916,803,199	41,361	24,688,985
10.	2013	1,685,294	145,625,531	2,168,616	2,106,676,261	39,455	25,847,428
11.	2014	1,981,122	153,531,827	2,370,390	1,972,106,528	30,759	27,698,526
12.	2015	2,582,350	223,236,481	3,353,221	2,422,822,264	32,799	33,671,937

Source: the author's study based on data from the Central Statistical Office, calculated at the exchange rate of EUR by NBP as of 01.03.2017.

The analysis of tendencies in real property sales transaction values in Poland during 2004 - 2015 demonstrates that the increasing trend prevailed from 2004 to 2008. Then, in 2009, the value of transactions decreased in comparison to the preceding year. After a slight increase in transaction value (by approx. five per cent) in 2010, later on a strong increasing tendency was noted until 2015. On the other hand, the decrease in the value of land property in the period from 2008 to 2010 was: -142.30% for plots designated for development, -10.90% for agricultural land and -107.70% for forest land as well as woody and bushy land. After 2010, the value of all concluded transactions for land real property increased.
The trends in the change of the surface area in market trade are listed in Figure 1 and 2.

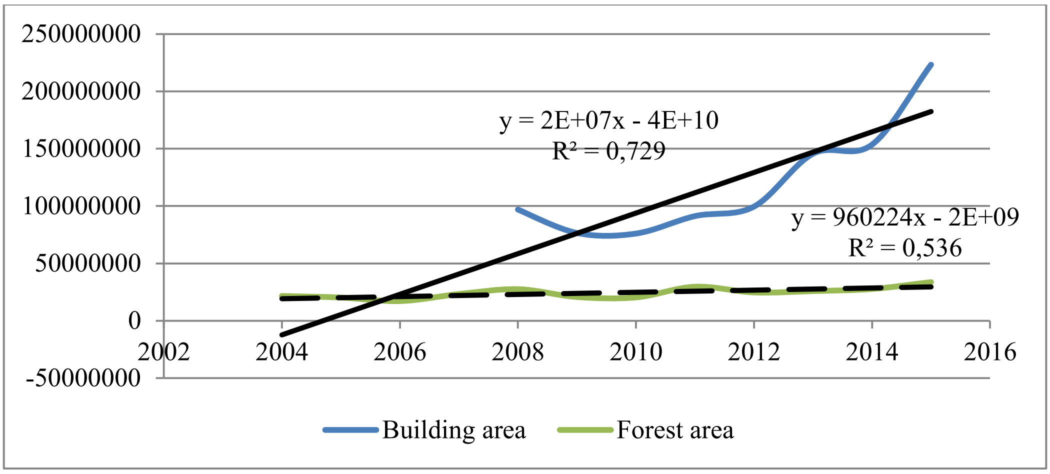

Fig. 1. The surface area of undeveloped and forest land real properties sold in market trade in Poland during 2004 - 2015

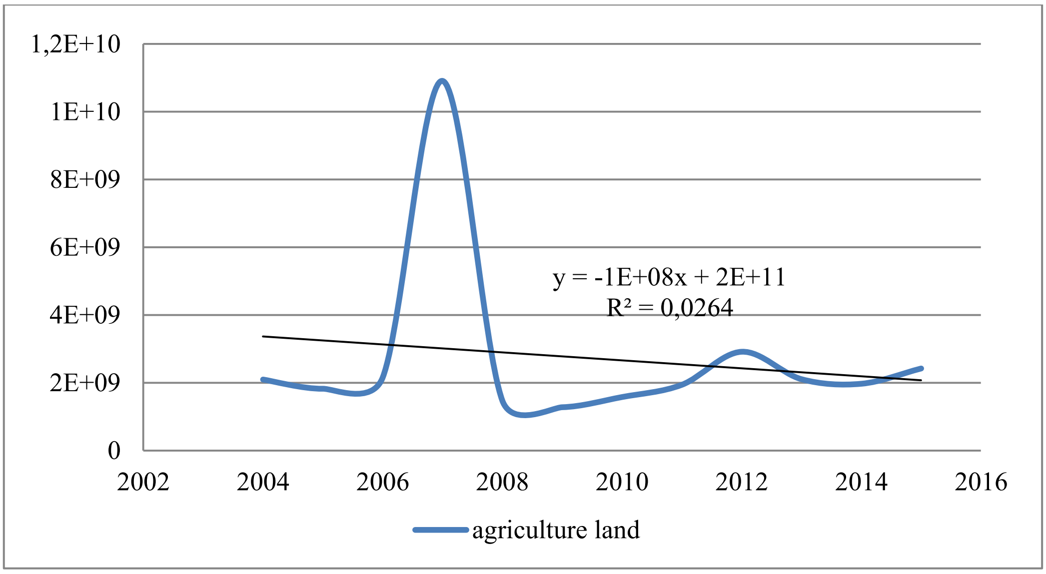

Fig. 2. The surface area of agricultural land sold in market trade in Poland during 2004 - 2015

No decrease in the surface area of undeveloped land being the subject of concluded transactions has been noted. In the contrary, there has been a noticeable significant increase in the surface area of real properties sold, while a stable trend has been noted for forest land. A decreasing tendency has been found for agricultural land, although the surface area of real properties sold has remained stable in recent years.

Average transaction prices of land real properties

The average values for sales transactions of undeveloped land properties were analysed taking into account the following designations:

- residential land,
- industrial land,
- land for cemmercial and services development;
- other building land,
- agricultural land,
- forest land as well as woody and bushy land (Tables 2, 3).

Due to the lack of access to data from 2004 to 2008, only average transaction prices from 2009 to 2015 were analysed, after dividing them into urban areas and areas located outside town borders.

Table 2

Average transaction prices of undeveloped real properties per 1 m^2 in urban areas in Poland during 2009 - 2015

Nr.	Year	residential land	industrial land	commercial land	other building land	agricultural land	forest land as well woody and bushy land
1.	2009	24.07	22.22	-	19.91	7.18	3.93
2.	2010	24.30	13.89	-	18.98	6.48	6.25
3.	2011	22.68	17.36	-	20.60	8.56	7.87
4.	2012	22.31	26.43	-	29.01	10.40	7.98
5.	2013	23.38	23.15	27.78	26.62	8.10	10.18
6.	2014	20.60	17.36	37.96	22.68	7.41	9.95
7.	2015	23.31	12.36	25.55	38.21	3.29	4.70

Source: The author's study based on the data from the Central Statistical Office calculated at the exchange rate of EUR by NBP as of 01.03.2017.

The highest transaction prices per 1 m^2 in towns were noted for "other building land" properties, followed by commercial land and residential development land. The lowest transaction prices were noted for agricultural land.

Table 3

Average transaction prices of undeveloped real properties per 1 m^2 outside town borders in Poland during 2009 – 2015

Nr.	Year	residential land	industrial land	commercil land	other building land	agricultural land	forest land as well as woody and bushy land
1.	2009	10.88	7.18	-	10.65	1.31	2.31
2.	2010	9.49	6.94	-	7.41	1.20	4.17
3.	2011	11.57	10.88	-	8.10	1.16	2.55
4.	2012	9.18	7.50	-	6.57	0.72	1.26
5.	2013	7.87	9.26	12.96	7.41	1.39	1.62
6.	2014	9.03	9.26	9.26	6.71	1.39	1.85
7.	2015	6.64	2.29	7.18	4.10	1.20	0.79

Source: The author's study based on the data from the Central Statistical Office calculated at the exchange rate of EUR by NBP as of 01.03.2017.

In non-urban areas, the highest average prices per 1 m^2 were observed for commercial land and residential development land. Here also the lowest prices are achieved for agricultural land.

Average transaction prices per 1 m^2 of undeveloped land were considerably higher in urban areas than in non-urban areas. However, a decreasing trend is noted for transaction prices of residential and industrial land and for agricultural land in urban areas (Figure 3 – 5).

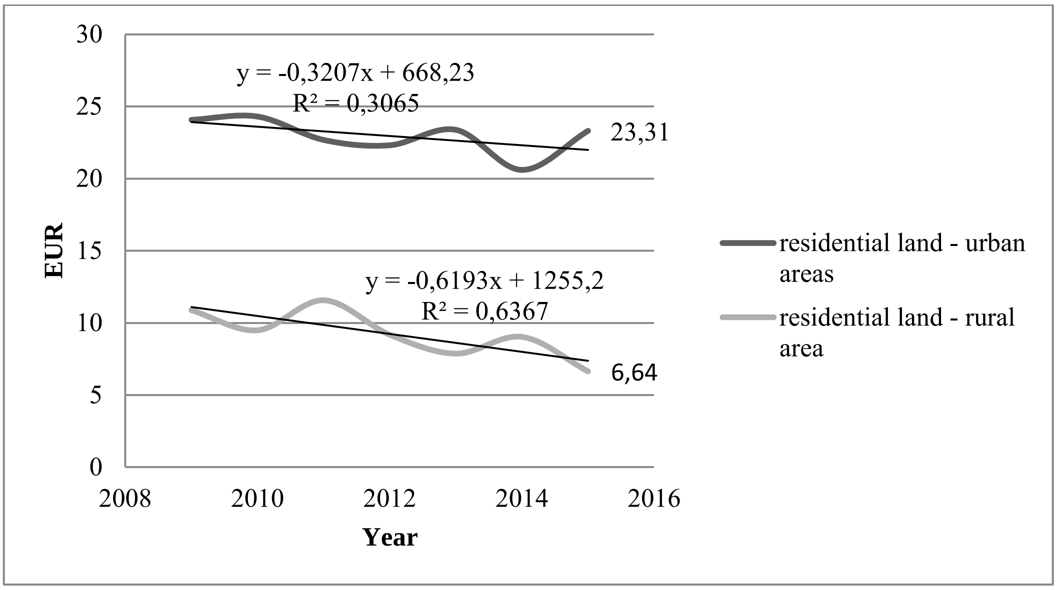

Fig. 3. Average transaction prices per 1 m^2 of undeveloped property designated for residential development purposes in Poland during 2009 - 2015
Source: The author's study based on the data from the Central Statistical Office

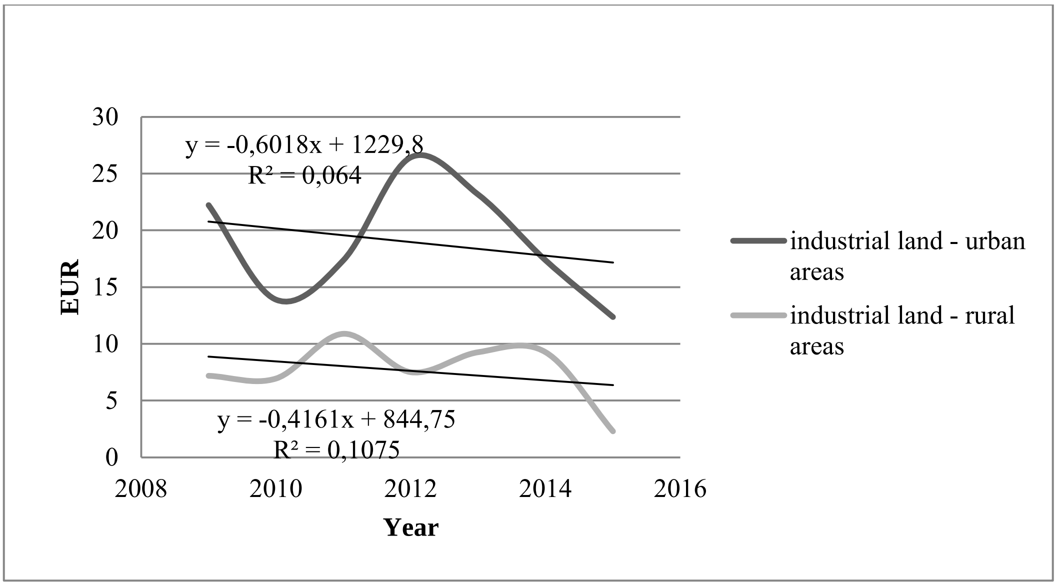

Fig. 4. Average transaction prices per 1 m^2 of undeveloped property designated for industrial development purposes in Poland during 2009 - 2015
Source: The auhor's study based on the data from the Central Statistical Office

The situation on the agricultural land market in the period from 2004 to 2012 was slightly different. The average transaction prices per 1 ha increased considerably after the accession to the European Union. This resulted also from the fact that it had become quite easy to change the function of agricultural land for building purposes. It was possible to obtain a decision on development and site management that replaces the local spatial development plan, and ultimately a building permit, for agricultural plots located in the vicinity of developed areas. On the other hand, the costs of purchasing agricultural land with investment potential were significantly lower than for a building plot and thus it was more affordable for a larger group of potential buyers. The prices presented below refer to all agricultural land in Poland (not divided into urban and non-urban areas (Fig. 5).

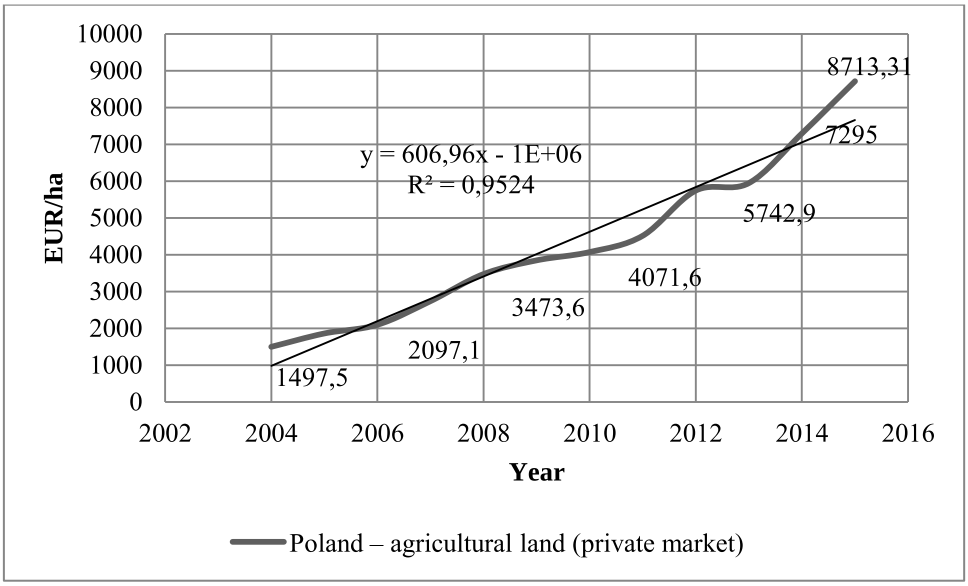

Fig. 5. Average transaction prices per 1 m^2 of agricultural land in Poland in the years 2004-2015.
Source: The author's study based on the data from the Central Statistical Office

The analysis of the aforementioned data demonstrates that in 2015 the average transaction price of agricultural land was nearly six times higher than in 2004. The growth of prices was influenced by numerous factors, including those discussed above, as well as the application of direct subsidies and the overall development of the country.

Conclusions

The conducted analysis of the average transaction prices of agricultural land in Poland allowed the author to draw the following conclusions:

1. The general recession and deterioration of the economic situation in Poland have contributed to a downturn also in the real property sector. The analysis of the dynamics of the value and surface area of real property sales transactions in Poland shows a considerable weakening of the market condition in the time period from 2008 to 2009. After the period of quite intense growth of the Polish real property market, the value of the concluded transactions began to drop and then to increase again after 2011.
2. Average transaction prices per 1 m^2 of undeveloped land in urban areas were considerably higher than in non-urban areas. This difference reached even up to 30%, depending on the designation of the property and the analysed year.
3. A decreasing trend in unit transaction prices was noted for all types of real property during 2009 - 2015. However, the research has revealed an increase in the transaction prices of agricultural land in the analysed period from 2004 to 2015.

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DEVELOPMENT AND USAGE NETWORKS OF ACTIVE REFERENCE STATIONS IN UKRAINE

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Abstract
The national geodetic infrastructure of Ukraine has developed rapidly into Ukrainian Coordinate Reference System UCS – 2000, a fully GNSS compatible coordinate reference system, which is realised through networks of active GNSS stations. They provide data for post processing and streamed raw data for real-time network (RTN) solutions. The RTN raw data are currently being used by both Trimble (ZAKPOS Network), Leica Geosystems (System Solutions Network) and Topcon (TNT - TPI Network) to provide independent RTN solutions. This study is the first in the public domain to evaluate the performance of RTN services in Ukraine and it is intended to provide guideline information for geo-spatial practitioners. Based on collecting RTN data at five locations and using standard observing and processing methods, an accuracy of 25 mm ±10 mm with respect to 2D coordinates and 34 mm ±14 mm with respect to the heights was achieved. The three systems were shown to be generally comparable although some initialization problems were experienced. The result has revealed expected ~2-5 cm (95%) precision for the horizontal and vertical components; however, large horizontal and vertical biases were observed, which can be as high as 8 cm.
Key words: GNSS, real-time kinematic (RTK), network RTK, reference GNSS stations.

Introduction

Over the past two decades, the Global Positioning System (GPS) has become ubiquitous in outdoor positioning and navigation. Other Global Navigation Satellite Systems (GNSS), such as Russian satellite navigation system (GLONASS), European satellite navigation system (GALILEO) and Chinese satellite navigation system (COMPASS) can also provide similar positioning and navigation services (Hofmann - Wellenhof, B. et all, 2008). GPS has been steadily augmented to improve performance using such techniques as Differential Global Positioning System (DGPS), relative GPS, RTK and network RTK (Seeber, G. N.,2003). This paper focuses on the performance of one of these augmentations, network RTK, in Ukraine. In Ukraine the official reference frame is UCS200 but it is important to know what version and epoch of ITRF/ETRF is required for the survey. There are only one version of the reference frame ITRF adopted in Ukraine. This is reference frame ITRF, epoch 2005.0. In addition to working with official reference frame, there may also be cases where the user is required to work in a completely different local reference system: SK - 42, SK - 63.

Since the development of a centimetre-level accuracy positioning techniques in real-time, based on the integer ambiguity resolution of the Global Navigation Satellite System (GNSS) measurements, there have been great advances in real-time kinematic (RTK) applications (Kalynych I. et all, 2014). Under the conventional RTK, raw measurements for the reference station are transmitted to the rover for the integer ambiguity resolution and final coordinate estimation. Therefore, most common errors can be cancelled out by differential techniques. However, single-base RTK baseline length should not exceed 30 - 40 km in practice due to distance-dependent biases, such as ionospheric and tropospheric delays. Approaches, such as Virtual Reference Stations (VRS), Flächen Korrektur Parameter (FKP), Multi-Reference Station (MRS), Master-Auxiliary corrections (MAX), Nearest station (NRT) were introduced in the mid-1990s. These approaches are known as network RTK (RTN) and were successfully used in many applications, especially in navigation and surveying (Takac, F.; Zelzer, O. ,2015).

A network of reference stations for real-time positioning is an infrastructure consisting of three parts: one part consists of all reference stations (more or less extended) with accurately known position that transmit their data to a control centre in real-time. The second part consists of a control centre which receives and processes the data of the stations in real-time, fixes the phase ambiguities for all satellites of each reference station and calculates the GNSS biases (e.g. ionosphere, tropospheric, clock delays). The third part is the set of network products that can be provided from the control centre to the user: these products consist of raw measurement file of each reference station that the user may require for post processing purposes or in streams (called differential corrections) that contain information related to the biases previous cited that allow the rover to make the real-time positioning. Moreover, the control centre is composed by a database that contains the calculated biases and the state of the

network (i.e. the ambiguities, ionospheric and tropospheric delays for each station, …) for post-processing purposes in order to be able to create the so called Virtual RINEX. Real time approach is instead traditionally considered when we desire to obtain a better quality, in terms of accuracy, of our positioning with respect the standalone position (i.e. with EGNOS correction) or with a centimetric level of accuracy (Berber, M.; Arslan, N., 2013, Edwards, S., P. et all, 2008). The differential corrections which are generated by each GNSS reference station are valid only in a limited area around the single site considering a limited space: the main hypothesis is that if the bias remain almost the same in the base station and rover, they can be eliminated by a process differential or relative.
The performance of a RTN infrastructure can be improved realizing a correct design of network, in terms of reference stations inter-distances and geometrical distribution. Considering the quality of the GNSS products used in a RTN as precise ephemerids and the quality of algorithms devoted to estimate the phase ambiguity, inter-distances can be extended up to 70-80 km.
The future progress and benefits due to the improvement of RTN should be very significant, but there are still some open problems, which are studied by the GNSS scientific communities in order to solve them. The main aspects are the real time quality control of the positioning in order to avoid false phase ambiguity fixed and the integrity of the solution.

Methodology of research and materials

A permanent network can be defined as a set of reference stations with the aim of a continuous data collection and coordinate estimation and data; some permanent networks distribute products. From a technical point of view, a permanent network is generally composed by the following parts:

- a network of reference stations with a proper distribution in the served area;
- a communication infrastructure that should guarantee the transmission of the data from the stations to the control centre. The latency depends on the permanent network purposes: if the network provides real time products, for example, the link must be implemented in real time;
- a control centre that:

➢ manages the stations, acquires their data and performs the quality check;
➢ performs the final network adjustment in order to compute and monitor the coordinates of the stations;
➢ if the network distributes products:
✓ estimates the network real time products and distributes them to the users;
✓ publishes data and products for the post processing applications.

The distance between the reference stations of these permanent networks, however, is rather large (100 or more kilometres) and the data are often issued with a rate of 30 s. This is useful for high-precision geodetic and very long periods of time (weeks, months or years of data), but less for topographic applications. A station that materializes the reference system could not provide real time data because it is not a primary purpose. An example of this type of network is the EUREF permanent network (http://epncb.oma.be/) or the IGS network (http://igscb.jpl.nasa.gov/network/netindex.html).
Today many RTN networks are available in terms of inter-station distance: it is possible to find a local network (with mean inter-station distance of about 15 km), a regional network (with distance between stations of about 50 - 70 km) and national networks (distances of about 80 - 100 km).
Since the global or the continental networks do not provide positioning services, these are generally fulfilled by dedicated networks at the local scale; the positioning services of many European nations were realized at the national scale with the coordination of the respective cartographic authority: for example, the AGNES network of Switzerland, the SAPOS network of Germany, the ASG-EUPOS network of Poland belong to this category.
In Ukraine, on the contrary, the first positioning services were born at the administrative scale of a region without a national coordination, only because the regional authorities, which have financial and cartographic regulation autonomy, proved interested in these aspects. In particular, the first positioning services in Ukraine were of Transkarpathian region (ZAKPOS GNSS Network); by this time, other regions activated their services and almost all the rest are either planning or realizing it. Furthermore, the two main private GNSS instrumentation firms (Leica Geosystems and Topcon) are developing their positioning services at the national scale.
A local type of network cannot be found in Ukraine. The second type of network - regional can be represented by a network of a private corporation, such as System Solutions (http://systemnet.com.ua/), with a medium inter-station distance of about 60 km. The last type - national can also be found in Ukraine: in this case, this is represented by a network of a private

company such as ZAKPOS (http://zakpos.zakgeo.com.ua/) and TNT-TPI (https://net.tnt-tpi.com/page).

ZAKPOS positioning service. Transkarpathian Region is located in West Ukraine; its population is about 1.259.000 people and its surface is of about 13.000 km2. In 2010-2012 an agreement was subscribed by Institute of Geodesy Cartography and Remote Sensing (Hungary), Geodetic and Cartographic Institute (Slovakia), National Agency for Cadastre and Land Registration (Romania), Head Office of Geodesy and Cartography (Poland) and Lviv Polytechnic National University for the realization of a regional positioning service. The network is now composed of 14 personal and more 60 affiliate permanent stations with the mean reciprocal distance of 50-100 km. The control centre is operated by Zakarpatgeodezcentr; two servers manage all the relevant processes; VRS are the network phase real time products provided to the users: the first is transmitted by RTCM 3.0; moreover the single station code corrections (DGPS) are available; the NTRIP protocol is adopted for all the real time products. The RINEX data of the permanent stations are available for post processing applications both by interactive webpage and by ftp connection; the distribution of VRS RINEX data is also available. The network management, the data and products distribution are now completely under Zakarpatgeodezcentr responsibility; beside a general role of scientific consultant, the Lviv Polytechnic runs the final monitoring of the network and the transformation to the national cartographic reference frame (Savchuk S. et all, 2007).

System Solutions. The Leica Geosystems Ukraine network, named System Solutions, represents an example of a commercial GNSS network for positioning services at the national scale. At present (March 2017), System Solutions is composed of about 110 GNSS permanent stations distributed over all Ukrainian territory, some of which are shared with the already mentioned ZAKPOS network. System Solutions services vary on the basis of the kind of registration of the users.
The products and services provided are: real time corrections from the nearest station and from the network solution (Automax, I-Max, VRS), with GPRS/GSM transmission; stations RINEX files, with a sample of 5 - 30 seconds; automated post-processing of static baselines; real time information on the network functioning.
The final network adjustment is performed at Main Astronomical Observatory (Kyiv), while an experimental quasi-real time station coordinates monitoring is performed by control centre System Solutions.

TNT-TPI. TNT-TPI GNSS Network is the countrywide GPS+GLONASS satellite positioning service and reference network in Ukraine and composed by 46 personal and more 37 affiliate reference stations. In 2010 the draft design of the network and the preliminary identification of the sites TNT-TPI were done, and from the mid 2011 the first phase of implementation of TNT - TPI GNSS Network was completed; after six months of experimental activities it has been declared operating and has started the distribution of data and products to the users. TNT - TPI GNSS Network generates and distributes corrections to GPS and GLONASS measurements and is ready for GALILEO system. Additionally, the network has been designed to support these areas in Ukraine, in which access to the other satellite positioning systems is hindered, or performance of this networks is troublesome. The user has an additional source of GNSS corrections enhanced by GLONASS signal, which profoundly improves network performance, reliability of measurement and its accuracy.
During the last years, the authors involved in the network adjustment, coordinates monitoring, transformation estimation and experimentation of two positioning services in Ukraine: the regional service of ZAKPOS and the national network of TNT - TPI. Because of their extent, the two networks represent two different case studies with different problems related to the network adjustment and the estimation of the transformation to the cartographic frame.
A network that represents a densification of the global or continental networks is adjusted using several stations of the second as reference: constraining the reference station coordinates to their estimates, in fact, allows to transfer the reference frame from the global to the regional scale. The constraint is applied in the adjustment process by the addition of some pseudo-observations to the least squares system; different kind of constraints can be chosen depending on the strength that is wanted. In particular, the constraints can be summarized: minimum constraints, where the number of conditions applied is equal to the rank deficiency. These are applied specifying the translation between the estimated and the apriori barycenter of the reference station coordinates. This is Helmert condition

on the translation; the other possible Helmert conditions (on the rotation and scale) can be applied but are non minimal: no rotation; no scale.

Discussions and results

All the network adjustments described in this paper are performed with the scientific software GAMIT/GLOBK v.10.6 (Herring, T. et all, 2015) of the Department of Earth Atmospheric and Planetary Sciences, Massachusetts Institute of Technology (MIT), following the international guidelines for a regional network adjustment. After the data processing, the extraction of reports and indexes from the huge number of GAMIT/GLOBK output is needed to check the quality of data and results; moreover, the coordinate time series should be analyzed to identify discontinuities and long-term trends.

It is necessary to pay attention to the fact that networks in Ukraine are rapidly changing and growing and an estimate based on one year of data is not possible for most of its stations: for this reason, to guarantee temporal homogeneity of all the estimated coordinates, the IGb08 coordinates were computed on the basis of the time series accumulated from GPSWeeks 1878 to 1929 (one year of data) with the general constant coordinates modelling method. The computation provided the estimates of the coordinates of the total of 132 Ukrainian reference stations (Savchuk S. H., 2015).

At the end of the elaborations the results have been stored in a database of daily coordinates. The shortness of the time series impedes the estimation of meaningful station velocities; however, in order to decorrelate the residuals, the position of each station has been computed with a linear trend estimation evaluated in the reference epoch of the five weeks of data.

A single station time series analysis has been performed: for each day d, for each component j (East - E, North -N, Up-U) and for each station i, the residuals have been computed as:

$$\delta_j(d,i) = \left| j_i(d) - j_i(d) \right| \quad (1)$$

where j_i is the coordinate estimated for the permanent station i in day d and j_i is the corresponding coordinates obtained by the linear regression. In order to obtain a daily synthetic index, a daily standard deviation has been computed:

$$\sigma_j^2(d) = \frac{1}{N(d)} \sum_{i=1}^{N(d)} \left(\delta_j(d,i) \right)^2 \quad (2)$$

where N is the number of stations estimated on the day d.

At last, to obtain a station synthetic index, a relevant standard deviation has been computed:

$$\sigma_j^2(i) = \frac{1}{N_D(i)} \sum_{i=1}^{N_D(i)} \left(\delta_j(d,i) \right)^2 \quad (3)$$

where N_D is the number of days in which the station i has been estimated.

The results are shown in Tables 1 and 2.

Table 1

Statistics of the station residuals standard deviations (A: average, Max: maximum)

(mm)	E	N	U
$A(\sigma)$	2.6	1.9	4.3
$Max(\sigma)$	4.1	3.9	7.1

Table 2

Global statistics of the time series (σ: standard deviation of all the residuals, Min : minimum residual; Max : maximum residual)

(mm)	E	N	U
σ	2.6	1.9	4.3
Min	-7.7	-14.1	-15.6
Max	9.6	8.9	16.1

The global residual statistics (Tables 1 and 2) are satisfactory with standard deviations lower than 3 mm in plane and 4 mm in Up.

Considering that 12 Ukrainian stations are in common with the official EPN network, which official ETRF2000 catalogue of coordinates was available, the transformation has been computed with the direct estimation of the similarity transformation parameters (http://etrs89.ensg.ign.fr/memo-V8.pdf); the transformation residuals are summarized in Table 3.

Table 3

IGb08(2016.394)→ETRF2000-UA transformation residuals statistics

(mm)	Δ E	Δ N	Δ U
σ	2.2	2.0	6.1
Min	-6.6	-4.1	-10.5
Max	5.4	5.9	17.0

In order to verify the time-stability of the IGb08→ETRF2000-UA transformations, the ETRF2000-UA station coordinates obtained in 2014/2015 have been compared; the differences have been computed on the subset of (57) stations. The results (Table 4) are definitely acceptable.

Table 4

Differences in the ETRF2000-UA coordinates obtained by 2014/2015 transformation

(mm)	Δ E	Δ N	Δ U
mean	0.2	0.4	-1.9
σ	2.1	3.0	5.3
Min	-6.2	-5.1	-12.4
Max	4.8	5.2	7.7

The GNSS reference stations can be considered as "active" vertices, because they are in continuous measurement and the networks RTN are periodically calculated (Jonsson, B., G. et all, 2002). This aspect changes how surveyors consider the reference system today. In a network RTN the reference system is transmitted implicitly through a stream of data, normally according to the protocol RTCM, which contains information on the coordinates of the stations and on the corrections in the reference system in which the network is framed. Consequently, the user with the rover receiver is framed in real-time in the reference frame of the network that is supported. In real-time measurements the user has even the perception of detecting in a direct "triplets" of coordinates.

Typically, for the testing of any precise positioning technique, the solutions obtained need to be compared to a reference (”truth”) solution. For kinematic applications, short baseline RTK can provide centimetre-level accuracy positioning (Grejner-Brzezinska, D.A. et all, 2005). However, in this study, due to the long distance trajectories and the unique experimental set-up, the use of short baseline RTK as the reference was not possible.

In order to examine the precision of the compared solutions, the 3D standard deviation of the baseline error is computed. Here the average baseline length between the receivers is removed from each set of solution comparisons and the standard deviation of each solution is computed. In terms of typically expected precision, as shown earlier in Aponte et al. (2008), a standard deviation (3D) of ~2-5 cm (1σ) is reasonable.

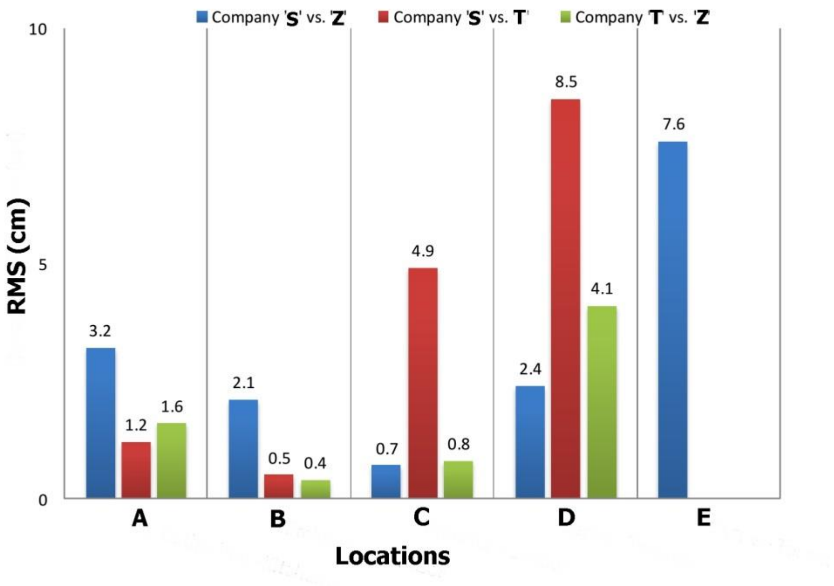

Fig. 1. Mean errors (rms) for each set of comparison (Company 'S'- test System Solutions GNSS Network; Company 'Z'- test ZAKPOS GNSS Network; Company 'T'- test TNT-TPI GNSS Network).

Figure 1 shows the 1σ precision levels for each set of solution comparison. As it can be seen, for the majority of the results, the precision values are ranging from 1 - 5 cm which is within the expected range. However, the large standard deviation shown for the comparison of Company 'S' and 'T' solutions in the northern region test D run is more than twice the expected value of ~8 cm. This unusually large standard deviation is primarily due to the lack of solution availability for Company 'T' for that particular run. Only 225 epochs of common solutions are available between Company 'S' and 'T' data sets, which means less than 4 minutes of common solutions were available for comparison. The effect of the lack of availability can also be seen for the Company 'T' and 'Z' comparison in the same test E run.

Conclusions and proposals

1. Our group is involved in the monitoring of two permanent networks aimed at positioning services: TNT-TPI GNSS Network, at the Ukrainian regional scale and composed of 46 permanent stations, and ZAKPOS, at the national scale and composed of about 85 stations (part of them are System Solutions stations). The experience matured in these collaborations (about eight years with ZAKPOS and more than five year with TNT - TPI) permitted to test and tune software and to analyse the strategies for the adjustment of regional networks.
2. The need of positioning services to compute and distribute the transformation between ITRS (at present ITRF2014) and ETRS89 (at the present ETRF2000 - UA) permitted the study of the problems related to this transformation at the regional and the national scale. The transformation from IGb08 to the ETRF2000 - UA frame is simpler: in fact, since the UCS-2000 adjustment and reference epoch is 2005.0, the transformation is well represented by a similarity even at the national scale. Two different approaches for the IGb08 - ETRF2000 - UA transformation have been presented, because they were implemented at different epochs and with different observation sets: anyway, they provide the alternative solutions for all national or regional positioning services, whether they share reference stations with UCS - 2000 network or not.
3. The precision of the static results show unified levels of short term repeatability. In both vertical and horizontal components of the solution precision, results indicate an overall precision of ~2.5 cm (95%) or better. However, one of the main issues of networks RTN in Ukraine is solution biases in the horizontal components, which can be up to 8 cm in isolated cases, which can severely undermine the accuracy of user solutions. The rms values from results showed accuracies ranging from ~2-4 cm in the horizontal and the vertical components.
4. The dominant issue that was encountered during the course of this study was the lack of a unified set of guidelines or procedures for the private networks to be integrated into Ukrainian official datum, UCS - 2000, which may account for the noticeable centimetre - level biases that are present in many of the solutions. Large network biases in some of the solutions undermine the

capability of network RTK as a whole. Another issue is the fact that not all locations within these networks were assessed. With sufficient testing, ”blind spots” can be found (as a few were found in this study), where the rover is well within the network RTK and yet no solution could be provided to the user. Comparing networks RTK in northern part of Ukraine (test D, E) with similar places such as central - southern region (test A), urban regions of Kyiv (test B) and western region (test C), in terms of both accuracy and availability, the services provided in Ukraine tend to underperform.

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IMPROVEMENT OF GEOINFORMATION TECHNOLOGIES ON THE BASIS OF SPATIAL DATA

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Abstract
Land management and improvement of computer technologies in land use are one of the most important tasks of the state; their effective implementation is closely linked to the widespread implementation of modern achievements of information technology. The achievement of the maximum transparency of the processes is vital in the field of geo-information and spatial data resources during increasing the reliability and manageability of the infrastructure.
Keywords: geo-informational resource, spatial data, land use, type of land use, sowing area

Introduction

The president of the Republic of Kazakhstan (Decree № 464, January 8, 2013) approved the State Program "Informational Kazakhstan - 2020" (Ukaz Prezidenta Respubliki ..., 2013). One of the main objectives of this program is the development of "e-government" creating a single national geo-informational environment, which will give an access to modern, high-quality and complete geo-data to the public authorities, integrated with the objects of state registration databases. It is expected that the creation of the single national geo-informational environment will significantly raise the efficiency and transparency of public authorities, as well as anti-corruption measures, because about 80% of the information environment to a great extent is related to geographic information resources and spatial data.

In order to implement the mentioned programme, the Government (Resolution №101, February 7, 2013) approved the "Plan of measures for implementation of the program", which prescribes to develop a set of measures directed to the creation of a single national geo-informational environment based on the Law "On Informatization" (Zakon Respubliki Kazakhstan ..., 2007).

The implementation of computer technologies into land surveying production provides for land information automation, storage and processing and organisation of the use of land, as well as restructuring of technologies on the basis of the use of information reflecting the spatial aspects of land use (Bekseitov, 2015). Modern software and hardware tools make it possible to resign from many of manual processes, to improve the quality of the received documents, eliminate many intermediate links of traditional technologies, facilitate the use of graphic materials due to digitization process in the computer-aided design. The purpose of research is to improve geographic information resources on the basis of the analysis of spatial data.

Methodology of research and materials

The methodological basis of the research was the investigations of leading Kazakh, Russian and foreign authors in the field of geo-information and spatial data resources, as well as the thematic materials of specific literature. The information-empirical and normative-legal base of the study included laws, presidential decrees, decisions of the Government of the Republic of Kazakhstan, normative and legislative acts. To solve the problems in the study, scientific methods of analytical, structural and comparative analysis, as well as statistical methods were used.

Discussions and results

Information systems are currently used in various spheres of human activity. However, quite often the users should to determine the spatial position of the objects under study. Any spatial information system is formed on the principles that are inherent to all information systems. Such systems are represented as automated information systems for the display and analysis of natural and man-made objects located on the earth's surface. The spatial reference objects under study served as the basis for the introduction of the term "geographic information systems". Broadly speaking, geographic information systems are seen as a model of the real world, and in the narrow sense it is a system of accumulation and storage of data attached to the earth's surface. The most promising direction of development of geographic information systems is recognized as an opportunity to support decision-making processes (Seredovich, 2008).

Currently in the field of geographic information resources, automation has reached such a level that it can meet the challenges of spatial analysis, to carry out management of graphic and attributive databases, correct the information, display it and make printouts. Thus, the main difference between the geo-information resources of computer graphics systems is that the geographical information system, in addition to the graphical display, contains comprehensive information about the objects and their elements. In addition, they also provide a calculation of the area and the distribution of land by categories, types of land use, ownership, kind of economic use, etc. Information about each object included in the geographic information system, is stored in the digital form.

Materials of automated surveying, scanning, remote sensing, for example, can be used for formation of such information. Thus, the result of operators work is essentially dependent on the accuracy of the previously entered data. Therefore, the land area and other parameters will be calculated from the information contained in the data bases. The more accurate the information is, the more reliable result will be obtained.

The current stage of development of information technology is characterized by the transition to the integration of all kinds of geographic information resources. Therefore, GIS technologies enabling users' interaction are rapidly developing along with the semantic information technologies, using a variety of digital spatial data, which are usually provided with their attributive information. Thus, the spatial data are recognised as digital data on geographic objects, including information about their location, shape and properties presented in the coordinates system, but attributive data - properties, qualitative and quantitative characteristics of spatial objects represented in digital form.

Entering data into geographic information system is an operation of data reading from a variety of information media. Data should be converted into digital format before entering into a geographic information system. This process is called "digitization" and can be automated in modern geographic information systems using scanner technologies. In modern geographic information systems models of relational data are used, which provide data storage in the form of tables. The data on the spatial location (geographical data) and associated with them attributive information are generated directly by the user or purchased from commercial suppliers, or on other basis. These data are integrated with other types and sources of information in geographical information systems. At the same time various external organizations can apply more powerful database management systems to organize and use the information which is at their disposal.

The distribution of land in Karmakshy district of Kyzylorda region according to land categories is analysed in the research in order to improve the geographic information resources on the basis of spatial data. Table 1 presents data from 2011 to 2015.

Table 1

Land distribution in Karmakshy district of Kyzylorda region according to land categories

Categories	**2011**		**2012**		**2013**		**2014**		**2015**	
	thous. ha	**%**	**thous. ha**	**%**	**thous. ha**	**%**	**thous. ha**	**%**	**thous. ha**	**%**
Agricultural land	483.5	18	486.5	18	361.5	14	362.4	14	364.0	14
Land of settlements	44.1	2	44.1	2	44.1	2	44.1	2	44.1	2
Land of industry	2.2	-	2.4	-	4.1	-	4.0	-	4.0	-
Land of especially protected areas	-	-	-	-	-	-	-	-	-	-
Forest land	429.0	16	429.0	16	429.0	16	429.0	16	429.0	16
Land under water	10.7	-	10.7	-	10.7	-	10.7	-	10.7	-
Land of state reserve	1,706.1	64	1,702.9	64	1,826.2	68	1,825.4	68	1,823.8	68
Total area	2,675.6	100	2,675.6	100	2,675.6	100	2,675.6	100	2,675.6	100

Changes have occurred in many categories in the course of time. Agricultural land has decreased by 4%, the land of state reserve, in turn, has increased by 4% over the past five years. Forest land remained at the same level, which is especially important in the conditions of Kazakhstan.

The chart analysis showed that the largest area in the Karmakshy district is occupied by land of state reserve (68%), forest land (16%) and agricultural land (14%). The small area is occupied by land of settlements, industrial land and land under water (Fig. 1).

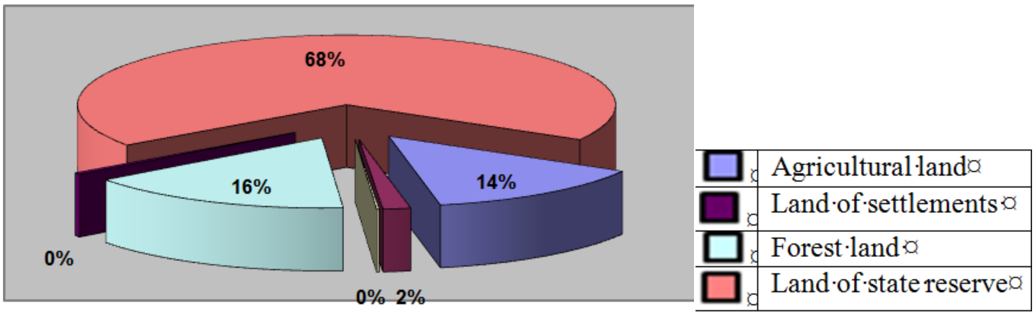

Fig. 1. Breakdown of land categories in Karmakshy district (November 1, 2015)

The analysis of the land used by partnership with limited liability “Zhanazhol” of Karmakshy district (hereinafter – the farm) was carried out for the formation of spatial data. The total area of farm is 12.9 thous. ha, agriculture land (arable land, meadows and fallow land) occupy 10.4 thous. ha or 81%, and other land (soloncs, sand, takyrs) - 2.4 thous. ha or 19%. Sowing area of the farm occupies 3.9 thous. ha. There is the reserve in the farm to increase the area of arable land at the expense of fallow land (Table 2).

Table 2

Breakdown of types of land use in farm “Zhanazhol” (on 01.11.2015)

Type of land	**2011**		**2012**		**2013**		**2014**		**2015**	
	ha	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**
Arable land	3,852	30	3,910	31	3,885	30	3,885	30	3,950	31
Meadows	658	5	658	5	658	5	658	5	658	5
Fallow land	5,923	46	5,865	45	5,890	46	5,890	46	5,825	45
Other land	2,396	19	2,396	19	2,396	19	2,396	19	2,396	19
Total area	12,829	100	12,829	100	12,829	100	12,829	100	12,829	100

Table 3 shows the dynamics of sowing areas taken up with crops and vegetables in the farm “Zhanazhol”. In the period 2011 - 2015 the greatest increase was observed in the area of spring wheat and under potatoes.

Table 3

The dynamics of sowing area in farm “Zhanazhol”

Types of crops	**2011**		**2012**		**2013**		**2014**		**2015**	
	ha	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**
Rice	2,580	66	2,600	66	2,600	67	2,600	67	2,650	67
Spring wheat	15	0.4	20	0.5	20	0.5	20	0.5	30	1
1st year lucerne	500	13	530	14	510	13	510	13	530	13
Long-term lucerne	600	16	600	15	550	14	600	15	560	14
Lucerne for seeds	150	4	150	4	200	5	150	4	170	4
Potatoes	7	0.2	10	0.3	5	0.1	5	0.1	10	0.3
Total area	3,852	100	3,910	100	3,885	100	3,885	100	3,950	100

The territory of the farm mainly was used for cultivation of rice (67%), 1st year lucerne (13%) and long-term lucerne (14%) (Fig.2).

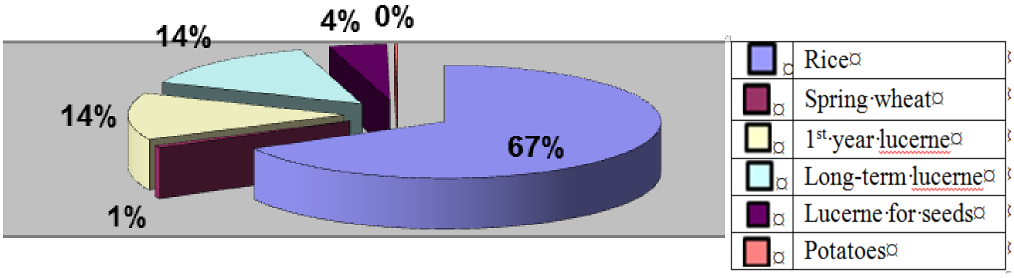

Fig. 2. Breakdown of sowing area in the farm "Zhanazhol" (on 01.11.2015)

Improvement of the geographic information system based on spatial data must include the comprehensive analysis of land use taking into account the balance of graphic and attribute data. The block scheme (Fig. 3) of improving of geographic information system was developed by the authors on the basis of requirements

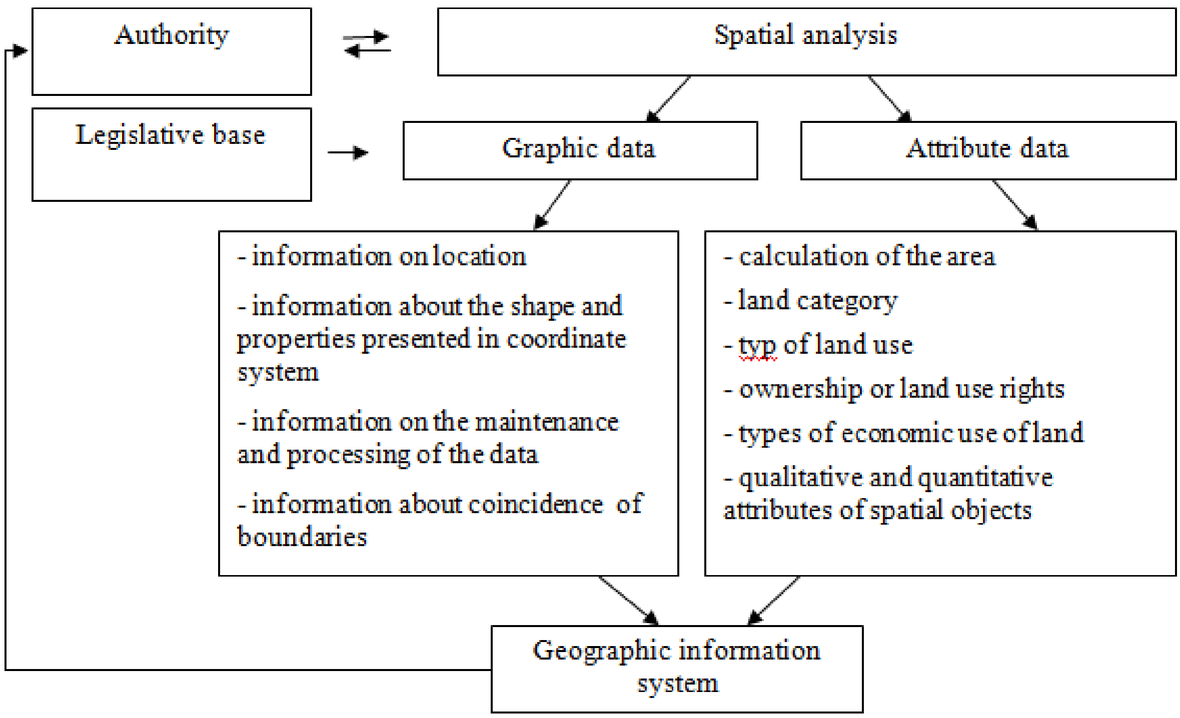

Fig. 3. The block scheme of improving of geographic information system

The graphic data are defined as spatial information, which is considered as the decision-making process, influencing the geographic information system to a large extent. In order to improve the geographic information system, attribute, the data must be performed for calculation of the area of land parcels, determination of land categories, types of land use, ownership rights, land use rights, determination of types of economic use of land, as well as qualitative and quantitative attributes of spatial objects.

GIS technology is formed and improved by technological advances and the growing amount of spatial data. Geographic information systems are being implemented and it opens new possibilities in the field of spatial planning and forecasting. Specialists in the field of land relations are expanding the scope of the use of geographic information systems to solve their specific problems and thereby contribute to the growth of GIS technologies.

Geoinformation technologies allow generating tables in any form, which can be used for database formation. To achieve the progress in geographic information technologies, it is necessary to implement:

- practical implementation of e-government;

- modern software;
- integration of spatial data;
- development of information resources;
- improvement of efficiency of local governments and planning authorities;
- systemic registration and inventory;
- visibility, accessibility and reliability of information.

The improvement of geographic information system based on graphic and attribute data is of great importance for:

- public authorities - to obtain visual information about the value of land and status of land parcels, to make data analysis based on the information on proportion of the right in land, breakdown into land categories, types of land use, etc., to prepare analytical reports on efficiency of land use;
- land services – to identify compliance between cadastral and market value, to provide information services to the public and businesses;
- commercial structures – to obtain information about land parcels and their permitted type of functional use, to form documents in standard format, including the scheme of land parcel boundaries, to perform spatial analysis of the selected territory, to form databases on particular land parcels, to provide informational services to the public and businesses.

The improvement of geoinformation technologies means the introduction and use of modern software for further nationwide development of geographical information systems by multiple approbation and progressive criteria and technologies available in the world community. It will allow to take into account digital graphic and attribute data to use land resources more efficiently.

Conclusions and proposals

1. It is necessary to develop interrelated measures allowing the accumulation of information and its generalization in the relevant geographic information databases at each level of the system based on analysis of spatial data, timely and high-quality collection of primary data on land resources: the quality, quantity, ownership and land use.
2. Formation of geoinformation resources allows not only to improve the spatial system, but also to raise its informational value increasing the interest of agricultural enterprises in geoinformation resources. Thus, further improvement of spatial data through its transfer to automated technology will create favorable conditions for land owners and land users.

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LARGE SCALE GIS MAPPING RECOMMENDATION MAPS FOR SOLVING LAND MANAGEMENT ISSUES

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Abstract
The article shows results of compiling recommendation land use maps for land use and land resources management of the university experimental farm "Velykosnitynske". Large-scale GIS mapping of experimental farms allows to improve land use and decision making, prepare recommendations to solve land management issues, planning of technology processes and efficient crop growing technology. Compiled recommendation maps are aimed to assist in rational land use planning and sustainable development of the territory.
Keywords: land management issues, GIS mapping, electronic maps of land use, land resources management, recommendation maps.

Introduction

Since the 1990s atlas electronic mapping of natural resources has become a perspective approach for both theoretical Earth science and natural resources' management practice. Methodologies for creating electronic atlases for sustainable nature use were developed by E.M.Siekierska (1986), F.J.Ormeling (1993), V.S. N. Ulugtekin (1999), Xie Chao (2005), Tikunov, F.Ormeling, M.Konecny (2008), J.Kaufmann (2014). Ukrainian scientists performing their studies in this field include: I.Levytskyy, V.Razov, A.Zolovskyy, G.Parkhomenko, L. Rudenko, V. Peresadko, T.Kozachenko, S.Poznjak, E.Bondarenko, I.Kovalchuk, Yu.Andreychuk, as described in (Bogdanets, 2016) and (Kovalchuk, Bogdanets, 2016).

Creation of the concept in addition to the development of science-based structure and the electronic atlas of land use permit: to assess the state of land resources to ensure their sustainable use, the requirements in respect of crop rotation, fertilizer application; to determine the intensity of degradation processes in soils, ground system of conservation measures for agricultural lands; to ensure the functioning of agricultural enterprises on the basis of balanced (sustainable) development areas (Kovalchuk, Bogdanets, 2016).

In this scope, recommendation maps for solving land management issues of different origin are essential.

Methodology of research and materials

QGIS software was used to process vector and raster data and compile electronic maps. Satellite imagery of territory from USGS geoservice including Landsat, EO-1, ALI, Orbview, and spatial data from ESRI, OSM and Google accessible via QGIS Quickmap services plugin, combined with existing paper cartographic materials of different scales were the basis of the maps compiled. Also the public cadastral map of Ukraine and cadastral documentation supplied by the university land resources management office were used. The research by Kurylo V., Bogdanets V., Kurylo L. (2014) may serve as methodological basis in the area of comparative territory analysis using GIS as a powerful tool (Kurylo V., Bogdanets V., Kurylo L., 2014).

The atlas itself comprises 7 chapters. Recommendation maps were included in the last chapter of the atlas. They cover such issues in land management and agricultural practice as use of eroded lands, environmentally friendly use of fertilizers, land afforestation, land use planning issues.

Thus, *the aim of our research* was to compile a series of recommendation maps within a large scale electronic atlas of land resources' current state and land use, as well as prepare materials and modern tools to assist decision-makers in their everyday activities in land management.

Discussion and results

Characterization of the object of research

The national university of Life and Environmental Sciences of Ukraine (former Ukrainian Agricultural Academy) has its experimental farms. Experimental farm "Velykosnitynske" is located in Fastiv district of Kyiv region (Fig.1). Its total area is 2,961 ha, most of it is occupied by arable land covered by fertile chernozem soil.

Fig. 1. Location of experimental territory

The farm is located in moderate humidity (about 500-550mm annual precipitation) of the forest-steppe zone of Ukraine; the main crops grown include wheat, barley, maize, fodder and vegetable.
The location of agricultural crops and territory organization in 2016 are shown in Fig.2. The territory of the experimental farm consists of two parts or subdivisions: the northern (main) and the southern, as shown in Fig.2. Most of the territory account for arable agricultural land, where different crops are shown by different colors, as seen in the legend, some part of the territory belongs to settlement, small part is covered by water, and other part are individual land parcels.

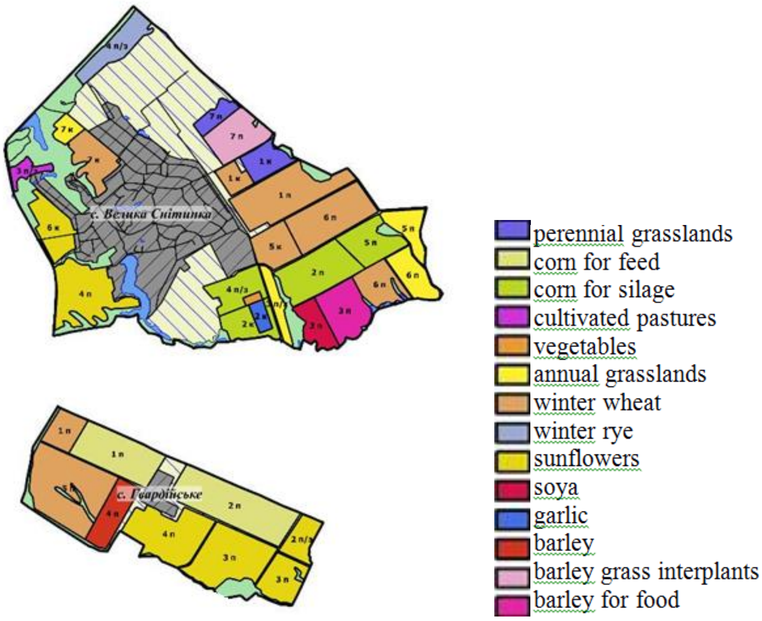

Fig. 2. Organization of territory and location of crops in 2016

Land management issues and compiling recommendation maps.
Most of farms in Ukraine are interested in application of precision agriculture technologies as well as in the use of electronic maps and tools to monitor farm's assets, however, most cartographic data were outdated, therefore it was important to develop electronic recommendation maps to serve as the basic for such activities in future.
A special part of our work was devoted to development of electronic maps for solving land administration issues, problems of management of agricultural land of the enterprise.
In our research all the issues which should be mapped are divided into *several categories.*
The first category consists of problems related to agricultural practice, e.g., use of fertilizers. It is important to maintain environmental balance of agricultural landscape when high rates of organic and mineral fertilizers are used. In this case protection zones around water bodies should be defined.
The second focuses on soil properties and regimes with taking into account soil heterogeneity. Fig. 3 shows microdepressions on fields, the places with different moisture regime due to differences in microrelief which look like small black circles visible over fields. Such heterogeneity in soil cover is widespread in this climatic zone of chernozem soils, therefore it should be considered in agronomy practice. A way to avoid crop yield heterogeneity in such fields is to provide precision agriculture machinery by maps of heterogeneity spots and precision soil properties maps.

Fig. 3. Satellite image of southern part of experimental territory, part of QGIS work project.

The third category of issues focuses on land value, land degradation and sustainable land use. The most common degradation here on sloped areas land is water erosion. Fig. 4 shows the map for eroded land management. Less than 30% of agricultural land of the territory belong to slopes. These areas are recommended to transfer to growing fodder crops, some part of this land have been already covered by perennial grasses.

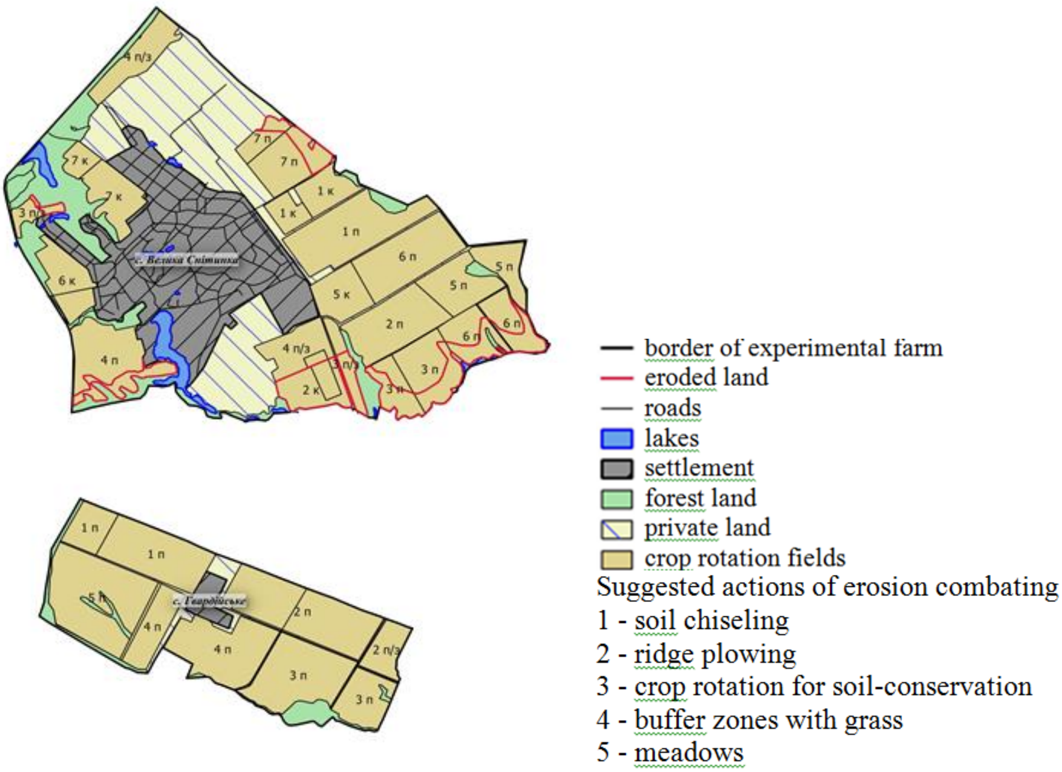

Fig. 4. Recommendations for management of eroded land

Another important problem in land use planning is disappearing of forest stripes constructed in the Soviet times in the time period of 1950-1970. Now most of them are not maintained, they have lost their structure and thus the effect; some of them have disappeared altogether. These forest stripes should prevent the so-called “wind corridors” which may cause soil loss due to wind erosion. The renewal of such forest stripes at fields’ borders with taking into account the predominant wind direction is the aim of the recommendation map shown in Fig.5.

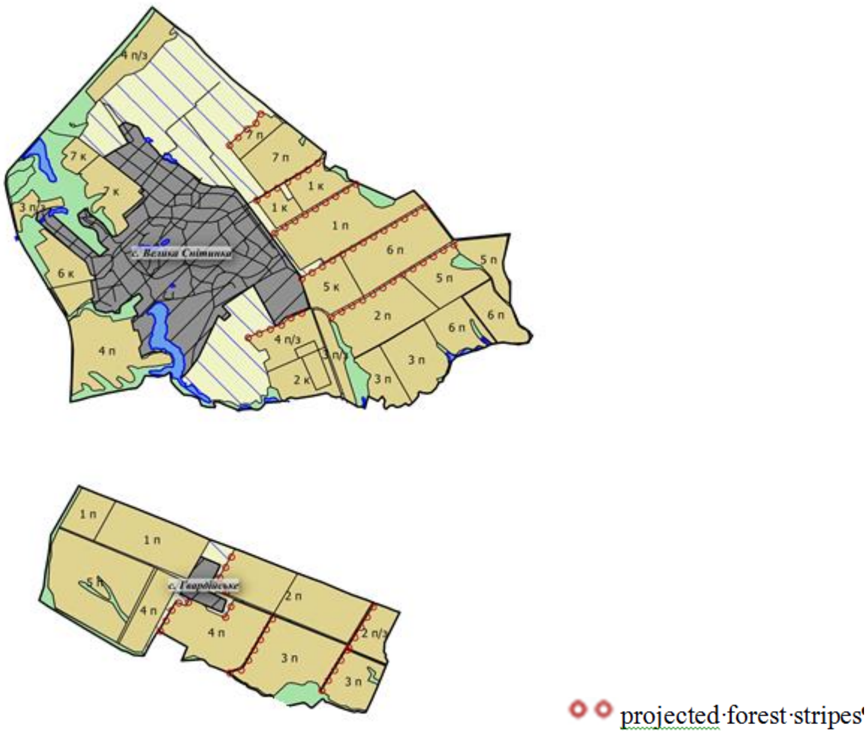

Fig. 5. Recommendations for location of new forest stripes

Now most of the forest stripes require renovation, these measures refer to long-term improvements and require a lot of costs. It may be a separate project on soil conservation measures against wind erosion.

Water protection zones should be of high importance when planning crop growing and fertilizer use. For that purpose, the recommendation map of water protection zones was compiled. The calculations were done in GIS according to water body type and area (Fig. 6). As it can be seen, corrections to field borders should be made to avoid water pollution by fertilizers or pesticides.

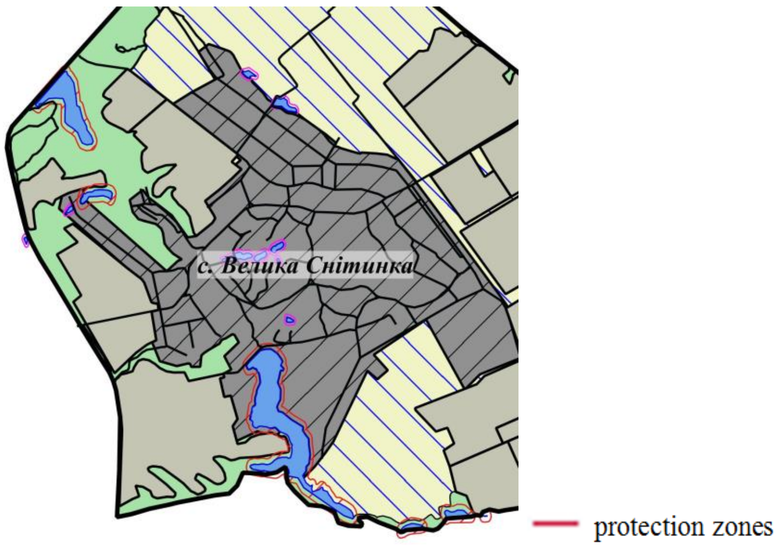

Fig. 6. Location of protection zones along the coast of water bodies

All recommendation maps were implemented in farming practice, they were probated by the enterprise's staff, some of them will become the basis for the new plan of territory organization of the farm and planning of the location of farm fields to make local agriculture more efficient and environmentally friendly.

Conclusions and proposals

Agricultural mapping of the university experimental farm was based on interpretation of up-to-date remotely sensed data of different spatial and temporal resolution, their import along with other geospatial data, including traditional paper large-scale maps, GIS, and renewal of current land organization plans as needed.

The main issues in land management and agricultural practice at the object rely on soil erosion, rational environmentally friendly use of fertilizers. These issues require change of current land management and borders of some agricultural fields.

Series of maps related to crop productivity, degradation processes, climate conditions, water-protective measures, etc. will help managers to organize agricultural production process and technological operations.

These maps are useful large-scale instrument for decision-making in agricultural practice at the university research farms. The developed maps will serve as information and analytical base for monitoring and management of land resources for development of land conservation measures.

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LEGAL ASPECTS OF STATE CADASTRAL REGISTRATION OF LAND PLOTS FOR THE ALLOCATION OF LINEAR FACILITIES IN THE RUSSIAN FEDERATION

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Abstract
There are still many drawbacks in legal regulation of construction, cadastral registration of linear facilities, as well as land management in the above-mentioned aspects in the Russian Federation, therefore this study is a theoretical overview and analysis of the existing legal framework. The definition of linear facilities had been incorporated in the City Planning Code of the Russian Federation only in 2016, thus a legal regulation of the issue at stake is of great significance at the moment. The key issues in the area of state cadastral registration and surveying are developing, including cadastral registration and registration of linear facilities and land plots as a united (integrated) complex object of real estate. The results of the research indicate the necessity of developing specific rules for the allocation, construction and reconstruction of linear facilities in addition to determining the legal status of land plots, where such placement takes place.
Key words: linear facilities, registration, cadastre, land, real estate

Introduction
In previous studies on the issue, the authors paid attention to the process of identification of a linear facility and problems connected with regulation mechanism of real burden (Averina L., Myamina I., 2016; Averina L., Vasilieva A., 2017; Averina L., 2017).
The City Planning Code of the Russian Federation implies that linear facilities include engineering and technical support networks, communication lines, pipelines, roads and other similar structures (City Planning Code, 2016). Linear facilities also include bridges, tunnels, overpasses and other objects, all included in the category of "similar structures". At the same time, the Civil Code of the Russian Federation states that linear facilities are: "railways, power lines, pipelines and other" (Civil Code, 2013).
So, there is no single approach in definitions in the legal federal acts of the higher rank (Codes), which causes practical problems in methodology of surveying and cadastral registration.
Indirect definitions of the concept of linear facilities are contained in other regulatory and legal acts, but there is no unambiguous definition in the Russian legislation, and therefore a wide range of issues arise regarding legal regulation relating to linear facilities.
There are no profound studies on the issue in Russian scientific literature, especially in English in international journals (Nikulina M., Gorobtsov D., Pendin V., 2017) and most of them have appeared recently.
At the same time, operation of linear facilities requires full ownership of the land (roads, parts of high pressure pipelines and power grids), which should be ensured by the right that excludes the right of using them by the third parties: lease, permanent (unlimited) usage or ownership. Besides, most linear facilities do not prevent the use of land for a designated purpose (underground pipelines and communication lines, aboveground cables and wires), although their presence on the site gives rise to certain inconveniences for an owner of the land. The degree of restrictions on the usage of land is different, which should be taken into consideration in deciding the issue of choosing the form of registration of rights on the occupied land: lease, property or easement as a type of land rights for allocation of linear facilities.

Methodology of research and materials
The paper is based on the analysis and summary of the scientific literature, the analysis of legal acts such as the Civil Law, City Planning Law, Cadastre Law, Real Estate Law (federal acts), methodological acts, instructions and recommendations of specialized federal agencies and bodies (such as the Real Estate Agency, Ministry of Economic Development, etc.), monographic, comparative, descriptive, and logical generalization.

Discussions and results

When deciding whether an object (facility) belongs to linear objects (facilities), it should, first of all, establish its correspondence to the main features of linear facilities (Letter of the Ministry of Economic Development of Russia, No 10571-PC / D23i, 2013):

1) the length of the object is much larger than its width;

2) the object is a structure (not a building, etc.);

3) the purpose and classification of the object depends on the connection with the land (aboveground (air), surface (surface), underground).

At present there is no legal act regulating issues of cadastral registration of linear facilities. However, the specific issues of such registration are explained in the following documents:

1) Letter from FGBU "FKP Real Estate Agency" of July 12, 2013, No. 08-2246-KL "On the direction of information";

2) Letter No. 10571-PK / D23 of the Ministry of Economic Development and Trade of the Russian Federation of May 29, 2013, "On the Procedure for Implementing State Cadastre Registration for Certain Types of Structures (Linear and Other)".

The cadastral registration of land plots under such facilities is characterized by certain features. The main problem in the formation of land plots under linear facilities is their long extension and passage through a large number of land plots.

Within the city area linear facilities are, as a rule, above or below another linear facility, they are located mainly along the streets. Besides, there can be several such objects on one street: the carriageway of the street, the sidewalk, tram tracks, the trolleybus line, the water pipe, the electric cable, the street lighting wires, the fecal and storm sewerage, communication cables, etc. In this case, there is no possibility to form a separate land plot for each of the linear objects in accordance with the requirements of land legislation. If someone tries to form and register such a land plot, then the whole land should be divided into many plots of shared ownership of the owners of different objects and a lot of plots that are rented by several persons in places where they coincide or intersect, which is practically impossible. As a result, it is practically impossible to resolve issues with all these entities uniformly and simultaneously aiming the purchase of land plots with linear facilities or making lease agreements for such land plots.

The need for mass land surveying of land plots occupied by linear facilities leads to a significant rise in the cost and time-stretching of the land surveying process. The lack of a real opportunity to formalize rights to above-mentioned land plots hinders the state registration of rights on them, because the existing procedure of state registration of rights on immovable property requires that all comprehensive data about all land plots on which the facility is located should be mentioned in documents applied for this purpose to the Real Estate Agency.

Registration of a land plot for the construction of linear facilities on land plots in private ownership or in leasing (on the rights of third parties) is carried out as follows.

It is necessary to issue a preliminary lease agreement (an offer) or sublease with the consent of the owner, where one should indicate the area of the land plot, the purpose of its formation and the location, that is, to form a part of the land plot for subsequent transfer to lease. Based on this preliminary contract, a land surveying plan is being prepared for setting up a land plot for cadastral registration. This is the simple and legally stipulated way, since the size of the land plot for construction, as a rule, does not correspond to the size of the land plot for its operation, and, after the linear object has been entered, it can be easily removed from the register after the termination of the lease agreement. Then land plots for operation of the facility should be further delimitated from the original land plot.

Consequently, owners, tenants and users demand compensation for losses, which entails additional costs for developers, not only for the compensation itself, but also for payment of services for calculating the compensation itself (loss assessment).

Large developers pay only agreed amounts determined in accordance with the legislation, since the financing of construction, reconstruction or allocation comes from the federal or regional budget and requires an independent assessment, that is, the preparation of an assessment report, as well as determining the market value of the lease. The lease or sublease for a land plot under a linear facility is conducted only after determining the cost of rent and setting the part of land for state cadastral registration.

It is not uncommon for linear objects to pass through agricultural lands that are in common ownership. In this case, it is necessary to formalize the land plot allocation, register the right to it and only then form a part on it and enter into a lease agreement (Federal Law of July 24, 2002, N 101-FZ (as amended on 03.07.2016) "On the circulation of agricultural land").

However, at present there are such "shared" lands, where the shares are not allocated, and there is no possibility to find an interest-holder. In this case, local authorities can recognize these lands unclaimed through the court, register the right of municipal property, and then lease for construction. Thus, several land plots are being drawn up for the construction of a linear facility, and, accordingly, several lease contracts.

It is possible to legislate a land plot for placing an existing linear facility in two ways: by a strip for the entire linear facility (on all its duration), regardless of the connection with the land or isolated areas, only to the elements above ground level (under supports). Most land users register land plots only to the above ground part of the structure (in order to save money on taxes, rent, cadastral engineers' services). From the point of view of the cadastre, this is a simple procedure, however, from the point of view of legal relations with rightholders of land plots, it is not entirely correct: conflicts between the parties arise quite often, because access is necessary for maintenance and repair of these elements.

In this case, the best option is to establish an easement, but in practice it is not always clear which easement is required to be established (private or public), as it is not always clear whose interests are more concerned.

In this case, a private easement is established in accordance with the civil law, i.e., an agreement on easement and a public easement - by law or other legal act.

The Department of the Ministry of Economic Development drafted the Federal Law "On Amending Certain Legislative Acts of the Russian Federation in Connection with the Improvement of the Regulatory and Legal Regulation of Easements" (2007). The principal innovation is the possibility of establishing public easements on land plots for the placement of communication lines and power lines, pipelines and other linear structures. It is also allowed not to form land plots (to produce cadastral registration) for the purposes of establishing a public easement; in this case, surveying will not be required.

It should be noted that issues with the definition of payment for easement are also resolved ambiguously. An easement cannot be established for the purpose of constructing linear facilities, but it is provided only for its repair and maintenance (Federal Real Estate Law, 2015). It is not necessary to consider easements as the only correct solution in the issue of optimal obtaining of land rights for placing linear facilities. However, in some cases they can remove existing problems.

The necessity of cadastral registration of land plots is indisputable. It is important to note the problems of cadastral registration of land plots under linear facilities. The process of their cadastral registration has some specific features. At present, it does not have a clear regulatory framework, therefore cadastral work is complicated, the terms of cadastral registration increase and problems arise with construction, reconstruction, deployment and operation of the linear facility itself.

Due to the fact that the majority of such linear facilities are elements of the infrastructure of populated areas and production, the time delays lead to a halt in the process of allocation, operation of the linear facility and other related problems, which generally reduce both the social and investment attractiveness of the territory.

Conclusions and proposals

1. It is necessary to develop specific rules for the construction and allocation of linear facilities at the federal level of the legal regulation instead of letters and instructions from different legal bodies of the state, concerning only specific matters of the process, related to the competency of such a legal body.
2. The status of land plots of different categories and formation procedures should be determined to reduce conflicts between people who use these land plots (house owners, landlords, tenants and others) and owners of linear facilities.
3. Analysis of the rules permits to conclude that an easement can be established not only for renovation and maintenance of linear facilities but also for construction purposes.
4. The Federal Real Estate Cadastre Law currently does not allow the linear facilities to be specified as an object of real estate, because the linear facilities are considered to be part of land and, thus, constitute complex (unique) real property. So, linear facilities are considered to be a real burden.
5. The definition of linear facilities should address several issues: the parameters of the facility, characteristics of connection with the land plots. The definition should be unique in all federal acts and, first of all, the Civil and City Planning Codes of the RF.

6. The degree of restrictions on the usage of land is different, which should be taken into consideration in deciding the issue of choosing the form of registration of rights on the occupied land: lease, property or easement as a type of land rights for allocation of linear facilities. The suggested at present abolishment of categories of land should decrease such difficulties in the registration procedure.

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SOCIAL ASPECTS OF RURAL DEVELOPMENT

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Abstract
The Agricultural Property Agency (APA) was founded on 16 July 2003 pursuant to the provisions of the Act of 11 April 2003 on the establishment of the agricultural system. The APA was established for the purpose of managing the agricultural property of the State Treasury in Poland. Its main tasks included the endorsement of ownership and structural changes relating to agricultural land in rural areas as well as the promotion of social goals. This article focuses on the social aspects of the APA's operations based on an analysis of the data supplied by the Regional Branch of the APA in Olsztyn. The obtained information and materials were analyzed to identify programs and activities initiated by the Olsztyn branch in pursuit of social goals. The results of the analyses were presented in the table format. Community interviews were conducted and photographs were taken during the field study. The results were used to describe the social aspects of APA's operations in rural areas.
Keywords: Agricultural Property Agency, agricultural land, social aspects of managing rural areas.

Introduction

The Agricultural Property Agency (APA) was founded on 16 July 2003 pursuant to the provisions of the Act of 11 April 2003 on the establishment of the agricultural system. The APA was a legal successor to the Agricultural Property Agency of the State Treasury which had been established on 1 January 1992 under the Act of 19 October 1991 on the management of the agricultural property of the State Treasury (Bartkowska, Nawrocki, 2011), (Dzun, 2005). The APA exercises the rights and assumes the obligations associated with the agricultural property stock (APS) of the State Treasury (Pessel, 2008). The APS is composed of:

- agricultural property, as defined by the civil code, in areas zoned for agricultural production, excluding land managed by the State Forests and national parks,
- other types of property and assets of the former State-owned agricultural enterprises, their associations and unions,
- forests that were not subdivided into land plots with a separate legal title (Article 1 of the Act on the management of the agricultural property of the State Treasury).

The property managed by the APA includes agricultural land, forests, farm buildings, residential buildings as well as equipment and devices that are part of social, technical, production, commercial and service infrastructure (Suchoń, 2007), (Marks-Bielska, 2010).

The main tasks of the APA have been set forth by the Act on the management of the agricultural property of the State Treasury (Podgórski, Świętochowski, 2014). In line with the provisions of article 6 of the above act, the APA performs various tasks prescribed by the state policy, in particular:

- establishing and improving the structure of family farms,
- fostering a supportive environment for the rational use of the productive potential of the Agricultural Property Stock (APS) of the State Treasury,
- restructuring and privatizing the property of the State Treasury intended for agricultural production,
- trading the property and assets of the State Treasury intended for agricultural production,
- administering the property and assets of the State Treasury intended for agricultural production,
- protecting the property of the State Treasury,
- initiating technical and organizational measures on agricultural land owned by the State Property and supporting the establishment of private farms on agricultural land owned by the State Treasury,
- exercising rights in virtue of the owned shares and stocks.

The APA manages the APS by:

- leasing or selling agricultural property with the aim of expanding or establishing family farms;
- leasing agricultural property to legal entities and individuals;
- contributing property and assets to enterprises and commercial partnerships where the State Treasury or a research institute holds a controlling interest;
- entrusting the management of property and assets to an administrator for a specified period of time;
- transferring management rights to property;

– swapping property (Article 24 of the Act on the management of the agricultural property of the State Treasury).

The social aspects of the APA's operations are difficult to identify based on the above list of statutory tasks. In the past, the APA initiated various measures aiming to promote employment and create new jobs, create educational opportunities for children of the former employees of state-owned farms, and provide welfare support for the inhabitants of residential estates managed by state-owned farms (Nawrocki, 2010). The legal provisions sanctioning the implemented measures were amended in 2004. As a result, selected social programs were discontinued in 2004, whereas other projects were continued in whole or in part in successive years. In this study, these programs were analyzed based on the information supplied by the Regional Branch of the APA in Olsztyn. Upon its creation, the Olsztyn branch managed 934,857 ha of land which accounted for 19.7% of the APS's property. In 2014, the assets of the Olsztyn branch decreased to 192,693 of land, i.e., 12.9% of the APS's property (Kurowska, Ogryzek, Kryszk, 2016). The Olsztyn branch oversees the APA's operations in the Region of Warmia and Mazury and the Region of Podlasie.

As part of a joint project, the authors of this study acquired numeric and descriptive data relating to the operations of the APA. The data were analyzed to select information relating to the social aspects of APA's operations. The results were processed statistically and partially verified in the field study. The outcomes were analyzed to describe the social aspects of APA's operations and to determine their influence on rural communities.

Materials and Methods

The objective of this study was to identify and analyze the influence of the APA's operations on the social fabric of rural areas. Agricultural land which constitutes Agricultural Property Stock was evaluated. The study focused on the agricultural property managed by the Regional Branch of the APA in Olsztyn. In the first stage of the study, legal acts laying the foundations for the operations of the APA were analyzed to ensure the reliability of the results. The APA's operations that directly and indirectly influence social development in rural areas were identified. The APA is legally entitled to donate agricultural land to local authorities, State Forests, registered churches and other authorized entities (national parks, housing cooperatives, Polish Academy of Sciences, Chambers of Agriculture, National Board of Chambers of Agriculture, public universities, public research and development institutions, foundations, public benefit organizations) in aid of their social activities and services.

In the following stage of the study, numeric data relating to the operations of the Regional Branch of the APA in Olsztyn were acquired. The Report on the operations of the Agricultural Property Agency (Raport z działalności… 2015) relating to the Agricultural Property Stock of the State Treasury for 2014 was analyzed. The obtained information was used to identify projects that had been implemented by the APA to address social needs and problems in rural areas, including:

– **renovation and upgrade of municipal housing resources and infrastructure**, including upgrades of water pumping stations and replacement of water pipelines to improve the quality of mains water supplied to the local residents, upgrade and construction of wastewater treatment plants, removal of septic tanks, repair of leaking sewer pipelines to prevent uncontrolled outflow of wastewater to ditches, upgrades of heating systems and boilers, replacement and recycling of old roofing materials, in particular fiber cement cladding, road and pavements repairs in residential estates;
– **educational opportunities for children and youth**, including financing meals in primary schools, financial aid for rural schools, scholarship programs for secondary school students, vocational education and training for young people, bridging scholarships for first-year students enrolled in full-time Master's degree programs in public universities;
– **promoting job creation** by reimbursing the costs associated with hiring unemployed persons, providing incentives and training for unemployed job seekers;
– **improving the health of children, youth and adults**, including medical check-ups for children in rural areas as part of the White Saturdays program.

The collected data were analyzed, and the influence and scope of the above programs were evaluated in successive parts of this paper.

The field study was conducted to evaluate the effectiveness of the programs initiated by the APA in rural areas. The researchers visited selected locations to take photographs of the developed facilities and to interview members of the local communities. The social benefits derived from the APA's programs in rural areas were analyzed. Specific measures and the relevant numeric data are presented in table format in the following chapter.

Results and Discussion

Pursuant to the provisions of the Act of 19 October 1991 on the management of the agricultural property of the State Treasury (Journal of Laws, 2012, item 1187, as amended) and other regulations, the APA is legally entitled to donate land which constitutes the APS to authorized beneficiaries. According to the Report on the operations of the Agricultural Property Agency relating to the Agricultural Property Stock of the State Treasury for 2014, the APA has donated 357,264 ha of agricultural land to various entities in aid of their social activities and services. A detailed list of donated land is presented in Table 1.

Table 1

Donated land which constitutes the Agricultural Property Stock of the APA (as of 31 December 2014)

Recipients	**Area [ha]**
Local authorities	56,078
State Forests	153,678
Registered churches	87,752
Other authorized entities (national parks, housing cooperatives, Polish Academy of Sciences, Chambers of Agriculture, National Board of Chambers of Agriculture, public universities, public research and development institutions, foundations, public benefit organizations)	59,756
TOTAL	357,264

Source: Made by the authors on the basis of the Report on the operations of the Agricultural Property Agency relating to the Agricultural Property Stock of the State Treasury for 2014.

The data presented in Table 1 indicate that 43% of agricultural land had been donated to the State Forests for the pursuit of their statutory objectives and that the State Forests are the largest beneficiary of the APA. The donated land will be afforested, which will promote favorable changes in the rural landscape, support effective management of low-quality soils and create recreational opportunities, such as forest educational trails and forest promotion zones. In the remaining portion of assets, 24.6% of land had been donated to registered churches in support of religious activities, 15.7% - to local authorities in aid of social programs and services (the programs initiated by the Regional Branch of the APA in Olsztyn are listed below), and 16.7% - to other recipients. Upon its creation, the APA's agricultural property stock comprised 4,739,338 ha of land; therefore, the donated land accounts for 7.5% of the initial APS volume. The data provided by the Regional Branch of the APA in Olsztyn were analyzed to identify land donations made to the local authorities. The relevant information and the facilities developed on the donated land are presented in Table 2.

Table 2

Projects and facilities developed by municipal authorities on land donated by the Regional Branch of the APA in Olsztyn

No.	**Year**	**Municipality**	**Plot No.**	**Cadastral district**	**Plot area [ha]**	**Designation**
1	2003	Kozłowo	22/28	Januszkowo	0.2776	community centre and fire station
2	2005	Dobre Miasto	50	Kosyń	0.139	rural community centre
3	2005	Kozłowo	10/5	Wierzbowo	0.18	multi-purpose building
4	2006	Nidzica	202/2	Olszewo	0.0300	wastewater pumping plant
5	2006	Dobre Miasto	64/56	Knopin	0.1152	wastewater pumping plant
6	2007	Nidzica	35/2	Orłowo	0.3006	playground and sports field

Source: Made by the authors on the basis of data provided by the Regional Branch of the ASP in Olsztyn.

The data presented in Table 2 indicate that the donated land has been used in its entirety for the promotion of social objectives. The projects and facilities developed on the donated land included community centres, fire stations, wastewater pumping plants, sports and recreational facilities. Information about the projects listed in Table 2 was obtained during interviews with members of the local communities. All of the completed projects had been highly praised by the local residents. The rural community centre in Dobre Miasto municipality (item 2 in Table 2) deserves a special mention. The garden surrounding the community centre had been planned and built by the residents. The community centre was a highly anticipated addition to the social life in Dobre Miasto. It is presented in Figure 1.

Figure 1. Rural community centre in Dobre Miasto municipality.
Source: M. Ogryzek

To date, the Regional Branch of the APA in Olsztyn has allocated a total of PLN 288 million to repairs and upgrades of municipal housing resources (and the relevant utilities) and infrastructure. The largest projects completed with the financial assistance of the Regional Branch of the APA in Olsztyn were:
1. Upgrade of the wastewater treatment plant in Lipowina, Braniewo municipality, financial aid in the total amount of PLN 3,024,086.26;
2. Renovation of historic buildings in Łyński Młyn, financial aid in the total amount of PLN 977,413.27;
3. Upgrade of the wastewater treatment plant in Gągławki; total project cost – PLN 720,000, financial aid in the amount of PLN 500,000.

The renovated buildings in Łyński Młyn are presented in Figure 2.

Figure 2. Renovated historic buildings in Łyński Młyn.
Source: M. Ogryzek

The data supplied by the Regional Branch of the APA in Olsztyn were also analyzed to identify projects offering educational opportunities for children and youths. The relevant projects are presented in table format below (Table 3): financing meals in primary schools, financial aid for rural schools, scholarship programs for secondary school students, vocational education and training for young people. Information about bridging scholarships for first-year students enrolled in full-time Master's degree programs in public universities are presented in Table 4.

Table 3

Educational opportunities for children and youth

Year	Financing meals for primary school students		Financial aid for rural schools		Scholarship programs for secondary school students		Vocational education and training for young people	
	Aid [PLN]	**Students**	**Aid [PLN]**	**Schools**	**Aid [PLN]**	**Scholar-ship students**	**Aid [PLN]**	**Participants**
2001	924,496	10,500	311,300	40	-	-	63,000	140
2002	2,200,000	21,200	475,900	58	-	-	125,000	196
2003	3,370,000	21,300	518,912	68	10,853	6897	181,100	190
2004	1,710,363	19,535	program was discontinued		16,039	8144	program was discontinued	
2005	program was discontinued		-	-	15,610	705	-	-
2006	-	-	-	-	program was discontinued		-	-

Source: Made by the authors on the basis of the data provided by the Regional Branch of the APA in Olsztyn

Table 4

Bridging scholarships for first-year students enrolled in full-time Master's degree programs in public universities

Academic year	Scholarship students
2002/2003	167
2003/2004	242
2004/2005	194
2005/2006	185
2006/2007	175
2007/2008	146
2008/2009	102
2009/2010	86
2010/2011	45
2011/2012	64
2012/2013	65
2013/2014	32

Source: Made by the authors on the basis of the data provided by the Regional Branch of the APA in Olsztyn

The data presented in Tables 3 and 4 indicate that programs addressing children and youth in rural areas attracted significant interest. The projects had more than 80,000 participants, and they had been implemented at the total cost of more than PLN 10 million. Unfortunately, most of the programs had been discontinued after 2004 due to legislative changes. The only exception was the scholarship scheme for first-year university students, which was continued in the following years.

The Regional Branch of the APA in Olsztyn also initiated measures aiming to create new jobs on the local markets. Funds were allocated to reimbursing the costs associated with hiring unemployed persons as well as providing incentives and training for unemployed job seekers (Table 5).

Table 5

Promoting job creation

Year	Reimbursement of costs associated with hiring unemployed persons		Incentives and training for unemployed job seekers	
	Reimbursement	Unemployed	Number of training courses	Participants
2002	100%	1,467	11	1,000
2003	50%	404	2	345
2004	100%	971	only the existing projects were continued	
2005	program was discontinued		program was discontinued	

Source: Made by the authors on the basis of the data provided by the Regional Branch of the APA in Olsztyn

The data presented in Table 5 indicate that the offered employment incentives and programs were highly popular in rural areas. Similarly to other programs, the majority of employment projects had been discontinued in 2004.

The Regional Branch of the APA in Olsztyn also allocated funds to improving the health of children, youths and adults, including medical check-ups for children in rural areas as part of the White Saturdays program. The relevant data are presented in Table 6.

Table 6

Medical check-ups for rural children as part of the White Saturdays program

Schools	Children	Cost	Purchase of medication, prescription glasses, orthopedic shoes and hearing aids	Prescription glasses
218	32,000	PLN 90,000	PLN 10,000	8000 pairs

Source: Made by the authors on the basis of the data provided by the Regional Branch of the APA in Olsztyn

The data presented in Table 6 indicate that the medical program was also very popular in rural areas and appreciated by local inhabitants. Medical assistance was provided to 32,000 rural children at the total cost of PLN 90,000, and 8,000 pairs of prescription glasses were issued.

Conclusions and Proposals

The gathered data and materials were analyzed to identify the programs and incentives implemented by the APA to promote the social development of rural areas. The main projects involved donations of agricultural land, repairs and upgrades of municipal housing resources and infrastructure, educational opportunities for children and youth in rural areas, job creation, and healthcare programs addressing children, youth and adults. The volume of financial aid allocated to individual projects and the number of beneficiaries participating in different programs indicate that the APA significantly contributes to social development in rural areas in Poland. Unfortunately, most of the programs had been discontinued after 2004 due to legislative changes. Efforts should be made to petition for the reinstatement of the former laws. Very few policy-makers are aware that rural areas are often governed by their own set of rules. Rural areas require various types of social assistance services. The APA has successfully fostered social development in rural areas, and it has the required resources and experience to continue that mission.

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THE APPLICABILITY OF ACCESSIBILITY ANALYSES IN SPATIAL PLANNING

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Abstract
Accessibility is a popular concept in many research areas, including spatial planning, where it denotes the possibility of reaching a specific location. Accessibility is not a characteristic feature of a single location: it is always measured between at least two locations (places), and it is strictly determined by the mode of transport. Subject to the evaluated parameter, accessibility falls into different categories, including physical accessibility which is defined by distance (meters, kilometers), temporal accessibility which is expressed in minutes and hours, and economic accessibility which is denoted by cost. In highly urbanized areas and their rural outskirts, spatial policies need to be coordinated to guarantee the effective distribution of functions and services. The optimization of accessibility should be the key goal of spatial policies adopted at both local and metropolitan level. The aim of this study was to analyze the applicability of public data sources and GIS tools for analyzing and improving spatial accessibility. A wide range of tools and data supports detailed evaluations of the spatial coverage and effectiveness of services (public and commercial), multi-objective optimization of planned locations and determination of the optimal service areas (with the use of gravitation and potential methods).
Spatial planning is a process of selecting the optimal and rational functions for the existing space. A very wide variety of analytical tools can be deployed to acquire and process public data and research data. The results of multi-objective analyses can be support the planning proces.
Key words: spatial planning, accessibility analysis, territorial cohesion, urbanization

Introduction

Economic and social activities take place in space and are localized in space. Space is a limited commodity, and the management of space in accordance with a specific set of rules relies on the principle of economic efficiency which states that the existing spatial resources have to be optimally allocated to maximize the desired outputs, and that costs have to be minimized to achieve the anticipated goal (Domański, 2006). The concept of space is used in many fields of research (Olenderek, 2009), and it has numerous definitions. Spatial planning focuses on geographic space, namely the surface of the Earth which constitutes the natural environment and differs in physical, biological and geochemical attributes (Meyer, 1998). These attributes are modified by infinite combinations of economic and social activities which are responsible for the unique natural and anthropogenic features of space (Kupiec, 1997). The fourth dimension, time, is an essential element of geographic space which supports analyses of past activities as well as forecasts of future events and socioeconomic needs in the future. The distribution of objects and various types of human activities in space is determined by numerous factors, including environmental conditions (Kurowska et al., 2014), social needs, economic possibilities, type of object and its parameters (Cymerman, 2011). Real space is characterized by various parameters, such as resistance, variation, limitedness, continuity, saturation, structure, accessibility, value, variability and function (Chmielewski, 2001, Parysek, 2007, Olenderek, 2008 Cymerman, 2011). Accessibility is one of the most important features of space, in particular in relation to public space, and it is defined as public access to space and its resources. Resistance is also a key characteristic of space, and it is expressed by the cost of traveling in space.
In geography, the term “accessibility” has been used in a variety of contexts without a clear definition, therefore, it is regarded as a fuzzy concept (Moseley, 1979). According to Ratajczak (1992), accessibility cannot be unambiguously defined due to a high number of mutually exchangeable synonyms. Accessibility has different meanings in various fields of science. In geography, it denotes proximity and spatial interactions between objects. In sociology, it is analyzed in the context of social limitations, whereas in economics, the definition of accessibility is linked with cost. Koźlak argued that accessibility is a relative and context-dependent concept, therefore, its definition is largely determined by the scope and context of research. The same location can be regarded as accessible in one field of research, but inaccessible in another when different considerations, such as the time or cost or travel, are taken into account (Koźlak, 2009).

Spatial accessibility has to be defined for the needs of this study. According to the most popular definition, spatial accessibility is the ease of reaching a specific location from a different location or locations (Guzik, 2013). Spatial accessibility cannot be construed as a characteristic feature of only one location – it is always measured between at least two locations, and it is strictly determined by the mode of transport. Subject to the evaluated parameter, accessibility falls into different categories, including physical, temporal and economic. A distinction is also made between relative and integral accessibility. Relative accessibility denotes the linkage (distance) between two locations or points in space (the greater the distance, the lower the accessibility), whereas integral accessibility describes the distance between the point of origin and the remaining locations in the analyzed system. Unlike relative accessibility, integral accessibility is not a reciprocal relationship (Ingram, 1971).
In practice, the accessibility of map systems for multiple users is analyzed by mapping a route between two indicated points. Regardless of the implemented algorithm, its main objective is to optimize the length, cost or time of travel. The most popular optimization solutions include an algorithm for finding the shortest paths between two nodes, which was conceived by Dutch scientist Edsger Dijkstra in 1959 (Dijkstra, 1959), as well as the more generalized A* algorithm which searches among all possible paths to the solution for the one that is characterized by the smallest total distance. The A* algorithm analyzes a smaller number of nodes and is generally much faster than other solutions (De Smith et al., 2007).
The above algorithms are also applied to develop other tools. The most popular solutions are used to determine the zones and sectors of interactions between locations. In accessibility studies, a zone is a polygon covering all road and street sections whose combined resistance, measured from a central point (along the streets), will not exceed a preset value. A sector is composed of road and street sections which are situated closer to a selected point than to any other point in the grid (De Smith et al., 2007).
Accessibility analyses are frequently undertaken in geographical research and, as of recently, also in spatial planning. The first isochrone map plotting out travel distances between locations in London was developed by Francis Galton in 1881 (Galton, 1881). In Poland, the isochrone method was first used by Włodzimierz Kubijowicz (Kubijowicz, 1923) to map parallel isochrones from the cities of Lvov and Kraków. The progress in accessibility analyses was stimulated by the need for effective spatial planning methods and the rapid development of cartography, in particular for military applications.
Isochrones are relatively easy to plot, but in the past, this process was highly laborious and time-consuming because the distances between points and the interpolation of isolines between road sections had to be calculated manually. The introduction of computer-aided methods, in particular GIS tools, significantly increased the speed and quality of isochrone generation. At present, these functions are available in numerous commercial applications as stand-alone tools or as add-ons or plug-ins in complex software systems. The existing functions support automatic isochrone plotting based on the preset criteria. License costs vary subject to the number of functions and computing power.
In accessibility studies, computer-aided methods require digital topographic maps displaying road networks. These resources are used in grid-based analyses in geographic information systems (GIS) which evaluate various travel options along different elements of the grid. A grid is defined as a set of mutually linked objects – lines representing road and street axes and points (nodes) denoting intersections (Curtin, 2007). The course and extent of a road section provide basic information about its length and location in space, however, these data are not sufficient for optimization. The second vital element is travel time, which is calculated based on the length and speed allocated to every road section.
A grid analysis is a process of formulating and solving problems that are expressed by grid structures and are generally represented by graphs. Graph theory provides abstract methods of graph analysis. Graph theory is a field of mathematics and computer science that deals with graphs – spatial structures that model the associations between data (Lange, 2012). A graph is a set of vertices (referred to as nodes in computer science in GIS) that can be connected by any number of edges or lines representing the associations between vertices (Narsingh, 2004).
Simple grid analysis does not always fully reflect the complexity of the evaluated phenomena. In simple grid analysis, a resident is unambiguously assigned to the nearest, specific location (center). The resulting monopoly is a simplified approach, whereas an evaluation of a given location's real potential and coverage requires the identification of competitive sites and their influence on the population in a given area.

The simplest and most popular method of analyzing the potential of a location is Reilly's law of retail gravitation (Reilly, 1929, 1931). Reilly's law has many variations and extensions, the most popular being the generalized Huff model which accounts for the differences in the attractiveness of other sites (Huff, 1963). The Huff model had been originally designed for retail analyses, but it is also applied in urban planning and transport. The model is used to determine the attractiveness of a trade area and the number of potential customers. In strategic planning, such as the selection of the optimal location for a new site, the Huff model is used to simulate the effectiveness of the available options.
Spatial accessibility is a key consideration which determines the extent to which the local market is accessible to outsiders and external institutions as well as the extent to which local residents have access to external markets. The above applies particularly to external labor markets and the availability of public and administrative services that are not available at the municipal level. Continuous growth is needed in the production sector, the consumer goods market, infrastructure, construction, transport and communications to improve the standard of living and increase the profitability of investments in both urban and rural areas.
The aim of this study was to analyze selected methods and tools for evaluating accessibility in spatial planning. The results of accessibility analyses provide vital information for spatial planning and decision making. The applicability of accessibility analyses for spatial planning was evaluated to justify the choice of selected analytical methods.

Methodology of research and materials

The selection of the most relevant data is one of the most important tasks before analysis. The data describing units of administrative division (Warsaw districts) and address points were used, subject to the type and scale of the analysis and the size of the analyzed area. The purpose of spatial accessibility analyses was to determine the possible development scenarios for the capital city of Warsaw and their implications for the adjacent rural areas. Rural areas provide urban residents with recreational options, therefore, their accessibility is an important consideration for city dwellers. The analyses were carried out based on public data generated by the Central Statistical Office (GUS) with the use of GIS tools.
There is a wide selection of commercial and freeware applications for the visualization and analysis of spatial data. In this study, the ArcGIS (Esri) program was used to visualize the distribution of Warsaw residents. MapInfo Professional analytical software with dedicated add-ons extending the program's functionality were used in accessibility analysis. The Vertical Mapper application supports raster data analysis. In this study, Vertical Mapper was used to generate a Huff model for shopping centers in the Warsaw metropolitan area. The ChronoMap optimization tool was applied in accessibility analyses to identify multi-objective access zones and distances for the Huff model. The results were visualized in thematic maps with the use of MapInfo Professional software.

Discussions and results

Rural areas situated in the direct vicinity of large cities undergo progressive urbanization. Urban sprawl is intensified, and metropolises exert a growing influence on the adjacent territories, mostly rural, which are part of the functional urban area. Residential construction is on the rise in rural outskirts, and rural residents spend increasingly more time commuting to work in the city. The number and size of areas that are dependent on and functionally linked with the urban core continue to increase, and the traditional model of urban-rural dichotomy is gradually disappearing. The agricultural role of rural areas is limited by their functional diversification.

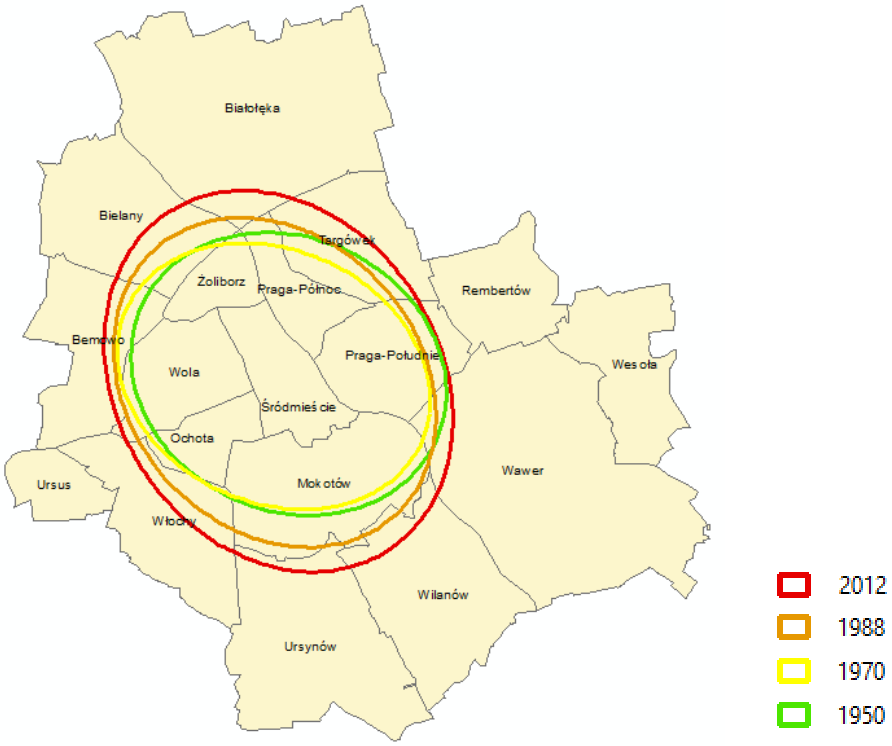

Fig. 1. Urbanization processes in Warsaw in 1950-2012.

Urbanization processes in Warsaw and the accompanying urban sprawl are presented in Figure 1. In a cluster analysis, demographic statistics for Warsaw's districts in 1950-2012 were used to analyze the growth, density and distribution of population in the Polish capital. The analysis was conducted in intervals in view of spatial changes over time. The results indicate that the urban area was significantly expanded over the years at the expense of its rural outskirts.

Until 1970, Warsaw's population was concentrated in pre-war districts where the majority of new development projects had been undertaken (Mokotów, Ochota, Wola). This trend began to disappear in the early 1970s which witnessed the construction of high-rise apartment buildings and the development of large residential estates in the remote districts of Ursynów, Wilanów, Bemowo and Białołęka.

In urban areas, new development projects are inspired by the local residents' activities and needs. They include residential estates, offices, recreational centers, shopping centers and other forms of non-agricultural land use. Most of these projects are localized in the proximity of cities, and they significantly decrease farmland area.

Despite legal regulations, urban development often proceeds in an uncontrolled manner, and it leads to dispersed development that encroaches upon open and protected landscapes. Badly planned and arbitrary expansion causes many functional problems in rural areas, including higher demand for new roads and traffic routes, higher transportation costs, deforestation and environmental pollution. These factors increase the cost of and decrease the quality and access to technical, social, commercial and transport infrastructure.

Spatial Accessibility

The time of travel between two points in space is determined by many factors which are influenced by the specific features of space, mode of transport and transport users. Optimization functions are available in a wide range of commercial applications. The appropriate database (pedestrian traffic, public transport, bicycle transport) has to be implemented in optimization software together with a set of attributes required for performing a given task.

The results of accessibility analyses are generally presented in map format (Bielecka, Filipczak, 2010). Temporal accessibility is plotted with the use of isolines which are lines connecting points with identical values on a map. The results are also presented with the use of isochrones, which are lines representing distances that can be traveled in a given timespan, and isodistance lines connecting points which are separated by the same distance from a point or a set of points.

Accessibility is measured by distance (and isochrones) to determine the maximum time of travel to a given location for the needs transport policy making. In spatial planning, accessibility should be analyzed based on various criteria. One of them is the availability of local transport between peripheral locations and a central location or other important locations, which indicates whether a given distance can be traveled within a reasonable timeframe and at acceptable cost. Such locations include urban areas with larger job markets, schools, universities, shopping centers, transport hubs or airports.

Fig. 2. Range of locations that can be accessed by car within 5, 10 and 15 minutes from the city center – road sections that are accessible within the anticipated travel time.

Infrastructure is indispensable for economic growth. The Region of Mazowsze is characterized by the greatest disparities in economic growth and infrastructure development in Poland. The high concentration of transport infrastructure in Mazowsze is linked with the economic significance of Warsaw, the capital city of Poland. The majority of heavy-traffic roads and railway lines intersect in Warsaw.

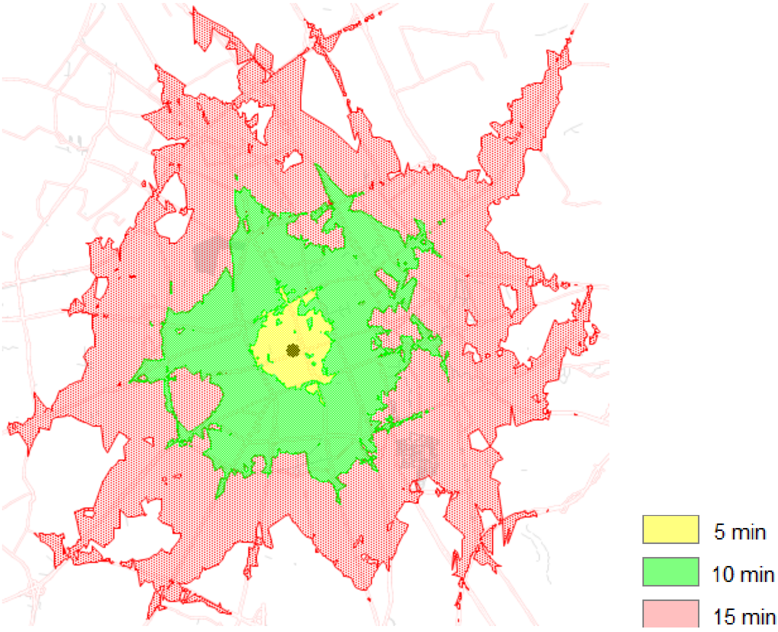

Fig. 3. Range of locations that can be accessed by car within 5, 10 and 15 minutes from the city center – visualization of successive time intervals.

Accessibility analyses are also indispensable for planning the location of new development projects. They are carried out by businesses searching for attractive locations for new service outlets, as well as institutions in the process of planning new hospitals or schools.
In the process of generating zones for new locations, the travel time required to reach service outlets in the vicinity of the planned project has to be minimized. A specific location cannot be identified during the search for attractive locations, but the criteria that will contribute to the location's attractiveness for future users can be established. For example, the criteria that are likely to increase the attractiveness of a residential project include the proximity of a health care facility, post office, bank or bus stop.
When zones have been mapped in view of the specified criteria, their applicability can be evaluated based on the information found in land use maps and other sources. This approach guarantees that the planned project will be consistent with planning requirements, and it will facilitate the selection of locations that cater to the developer's needs.

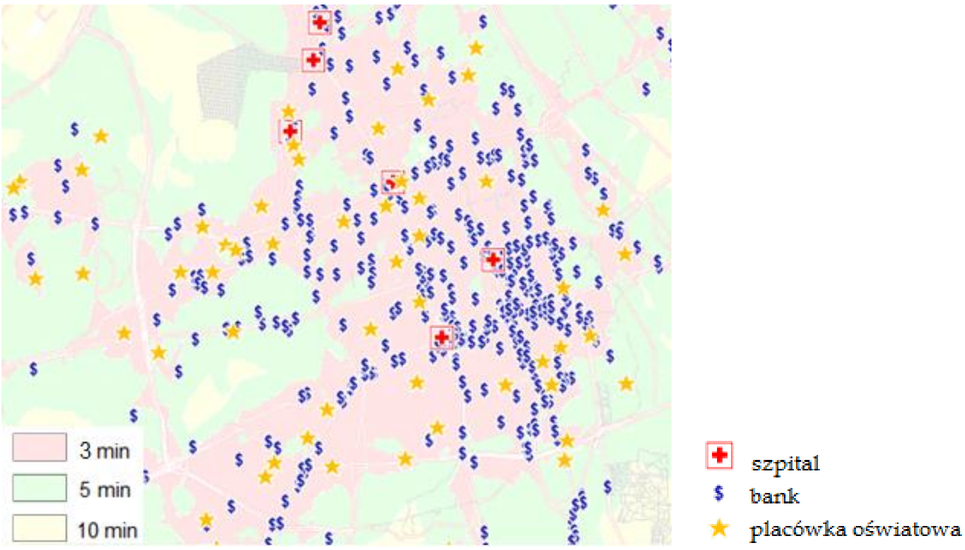

Fig. 4. Range of locations that can be accessed by car within 5, 10 and 15 minutes from the city center – visualization of successive time intervals.

The analysis was carried out based on information about the location of educational facilities, banks and hospitals in Warsaw. The analysis was performed in the MapInfo program with the ChronoMap add-on for optimizing transport routes. The applied tools support multi-objective optimization and the selection of individual weights for all criteria included in the analysis.
The above map presents the results of a multi-objective analysis, namely a zone in which specific service outlets can be reached within the timeframe defined by the user. The optimal location of a planned project is selected based on the defined and weighted variables as well as the defined localization criteria in urban and rural areas. It should be noted that large projects localized in cities strongly influence the functional urban area.
The boundaries of the analyzed area have to be correctly defined in the process of generating coverage zones for various types of projects. If the analyzed area is limited to its administrative boundaries, the results of the analysis could be highly unreliable or incorrect. For this reason, the analyzed area should be expanded to include the neighboring territories with a high growth potential. The above approach can be used to generate coverage zones of Warsaw-based shopping centers with the use of gravitation models.
The generalized Huff model is most frequently used in accessibility analyses. The Huff model had been originally designed for retail analyses, but it is also applied in urban planning and transport. The coverage of shopping centers can be determined based on their attractiveness and the distance (calculated along roads) between every residential building and every shopping center.
The results of the analysis indicate that the territorial coverage of shopping centers in the city includes mostly locations in their immediate vicinity. However, due to the absence of large retail facilities in suburban areas, the coverage of city centers extends well beyond the city's administrative boundaries.

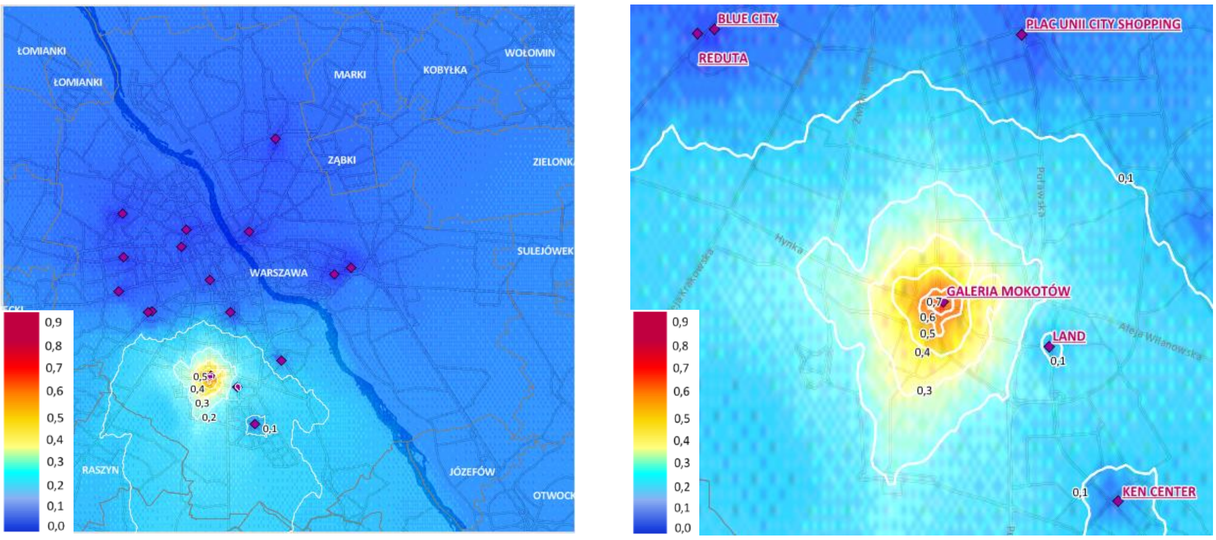

Fig. 5. Territorial coverage of Galeria Mokotów shopping center in Warsaw.

Conclusions and proposals

Spatial planning in urban and rural areas should contribute to economic growth. When spatial development in one area occurs at the expense of the neighboring municipalities, usually rural, the affected areas should also experience an improvement in the standard of living. Measures aiming to improve the standard of living in rural areas should also preserve the characteristic features of rural life, namely low population density, low economic activity rate and lower anthropogenic pressure.

Space is characterized by unique attributes, including resistance, limitedness and variation, therefore, spatial planning has to be rational and based on the principles of sustainable development. Spatial planning is a process of selecting the optimal functions for the existing space. Socioeconomic growth in urbanized space increases the demand for auxiliary services, which implies that new services have to be optimally localized in space. Local conditions have to be surveyed, and the most appropriate solutions have to be proposed in planning documents. Economic growth often leads to uncontrolled urban sprawl, both in metropolitan areas and in peripheral regions. The aim of spatial planning is to coordinate all types of activities, including economic, infrastructure development, services and the job market. In this context, spatial accessibility, which often denotes transport accessibility, is a very important criterion. Rational planning measures should also forecast changes and the demand for social infrastructure, housing and services to guarantee that the needs of the local community are adequately met. Multi-objective analyses deliver valuable information for spatial planning. A wide variety of analytical tools can be deployed to acquire and process public data and research data. The results of multi-objective analyses support the selection of the optimal planning variants.

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THEORY AND PRACTICE IMPROVING OF MATHEMATICAL PROCESSING OF GEODETIC MEASUREMENTS FOR LAND MANAGEMENT AND CADASTRE WORKS

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Abstract
The article generalizes theoretical and practical addition to the components of mathematical processing of geodetic measurements, which are the basis and used to support work in land management and cadastre. The research identifies general components of mathematical processing of geodetic measurements and components which are primarily used in the field of land management and cadastre. Completed investigation of the theoretical and practical foundations of these components and developed theoretical and practical additions improve the results of mathematical processing of geodetic measurements.

Introduction

The main means of obtaining credible and relevant information for land management and cadastre are surveying. Traditional mathematical processing of the results from geodetic measurements and methodology are not suitable for processing of the results for the needs of land management and cadastre. Existing scientific and applied problem in land management and cadastre in Ukraine is the necessity of actual and reliable information; there is incompleteness of the theoretical and practical foundations of mathematical processing of geodetic measurements which could be used and have an impact on the work of land management.

The research works devoted to the study of problems of mathematical processing of geodetic measurements of national and foreign scientists include: Bolʹshakov V.D., Viduyev M.H., Voytenkj S.P., Gauss K.F., Zazulyak P.M., Idelʹson M.I., Linnyk YU.V., Karpinsʹkyy YU.O., Kondra H.S., Mazmishvili A.I., Markuze YU.I., Mohylʹnyy S.H., Smirnov M.V., Tretyak K.R., Shulʹts R.V. etc.

The authors conducted the research on: establishing values and dependencies between parameters likelihood function and the condition of maximum probability of occurrence of random errors together, developing proposals [1, 11 - 13]; establishing patterns and dependencies between the averages, their systematization [2, 5 - 8]; definition and refinement of dependency properties of random errors, development of criteria and formulas for obtaining consideration of rounding errors [3, 4]; analysis of different types of double measurements, criteria for a systematic error, developing methods and obtaining formulas for excluding of systematic error, justification for rejection of correlation coefficient [9, 10].

Research methodology and materials

Ordinary Least Squares (OLS) is essential for adjustment of geodetic measurements. The study mainly used:

• condition of maximum probability of random errors together

$$P_{\Delta_1,\Delta_2,\ldots,\Delta_n}=\left(\frac{1}{\sqrt{2\pi}}\right)^n e^{-\frac{1}{2}\left(\frac{\Delta_1^2}{m_1^2}+\frac{\Delta_2^2}{m_2^2}+\ldots+\frac{\Delta_n^2}{m_n^2}\right)}\cdot\frac{d\Delta_1}{m_1}\cdot\frac{d\Delta_2}{m_2}\cdot\ldots\cdot\frac{d\Delta_n}{m_n} \quad (1)$$

where the highest value of probability of sets of true errors $P_{\Delta_1,\Delta_2,\ldots,\Delta_n}$ will be provided if the exponent is minimal, that expression in parentheses (1)

$$\sum_{i=1}^{n}\frac{\Delta_i^2}{m_i^2}=\min \text{ or } \sum_{i=1}^{n}\frac{v_i^2}{m_i^2}=\min \quad (2)$$

(2)

- R. Fisher’s method of maximum likelihood estimation (MLE) with function

$$L = f(y_1, y_2, ..., y_n) = (2\pi)^{-\frac{n}{2}} (\sigma_0^{2n})^{-\frac{1}{2}} [\det Q]^{-\frac{1}{2}} \exp(-\frac{1}{2\sigma_0^2}[y - M_y]^T Q^{-1}[y - M_y]) \quad (3)$$

where $y_1, y_2, \ldots, y_n$ – results of measurements,

σ_0^2 – dispersion of weight unit,

$Q = P^{-1}$ – matrix of inverse weights,

M_y – mathematical expectation of values y, when best estimates M_y and σ_0^2 are obtained on condition

lnL = max.

Also, MLE is used to study the simple arithmetic average and the total arithmetic average, dispersion by one measurement and dispersion of weight unit, respectively.

Discussion and results

As a result of mathematical transformations, expression (3) takes the following form to unequally accurate measurements:

$$L = (2\pi)^{-\frac{n}{2}} \frac{1}{m_{y_1} \cdot m_{y_2} \cdot \ldots \cdot m_{y_n}} e^{-\frac{r}{2}} \text{ or } L = (2\pi)^{-\frac{n}{2}} \frac{(p_{y_1} \cdot p_{y_2} \cdot \ldots \cdot p_{y_n})^{\frac{1}{2}}}{\sigma_0^n} e^{-\frac{r}{2}} \quad (4)$$

and equally accurate measurements –

$$L = (2\pi)^{-\frac{n}{2}} \frac{1}{m^n} e^{-\frac{r}{2}} = \frac{1}{(2\pi)^{\frac{n}{2}} \cdot m^n \cdot e^{\frac{r}{2}}}. \quad (5)$$

According to the research of dependency of functions arguments (1) and (3) and their varieties, it is found that the expression (2) will be equal $\sum_{i=1}^{n} \frac{\Delta_i^2}{m_i^2} = n$, $\sum_{i=1}^{n} \frac{v_i^2}{m_i^2} = r$ or $\sum_{i=1}^{n} \frac{p_i v_i^2}{\mu^2} = r$ [1, 11 – 13]. That is the exponent of value e function (1) and (3) regardless of the types of its records is always a half of all or redundant measurements with minus sign, and does not depend on the values of true errors or amendments and mean squared error (MSE) as well as on the value from which deviations are calculated. An increase of the number of redundant measurements does not cause increasing value of likelihood function, but instead - reduces its value.

Dispersion is derived from the expression (3) is $\sigma_0^2 = \frac{\Sigma p v^2}{n}$. When it comes to simple arithmetic average or total arithmetic average, the difference of value in denominator (n або n – 1), especially when we have large number of n will not substantially affect the value of dispersion. Instead, during adjustment of values between which there are independent functional connections, the number of excess and all measurements may be different, and the difference between them is already high. Therefore, estimation of measurement results will be displaced, and this must be considered.

The value of likelihood function (3) and its logarithm depends on three variables: number of all measurements, number of redundant measurements and value of MSE of weight unit in the case of unequally accurate measurements or value of MSE in the case of equally accurate measurements (Fig. 1) [13].

By the analysis of results of likelihood function parameters calculations and their relationships, it was found that the function and its logarithm acquire positive values only if MSE is less than 0.398942.... With the value MSE σ = 0.398942… the function depends on the number of redundant measurements, and its logarithm is equal to a half the number of redundant measurements minus sign. When increasing MSE more than 0.398942… (even when σ = 0.4), the function and its logarithm is rapidly declining as the number of redundant and all measurements (Fig. 1).

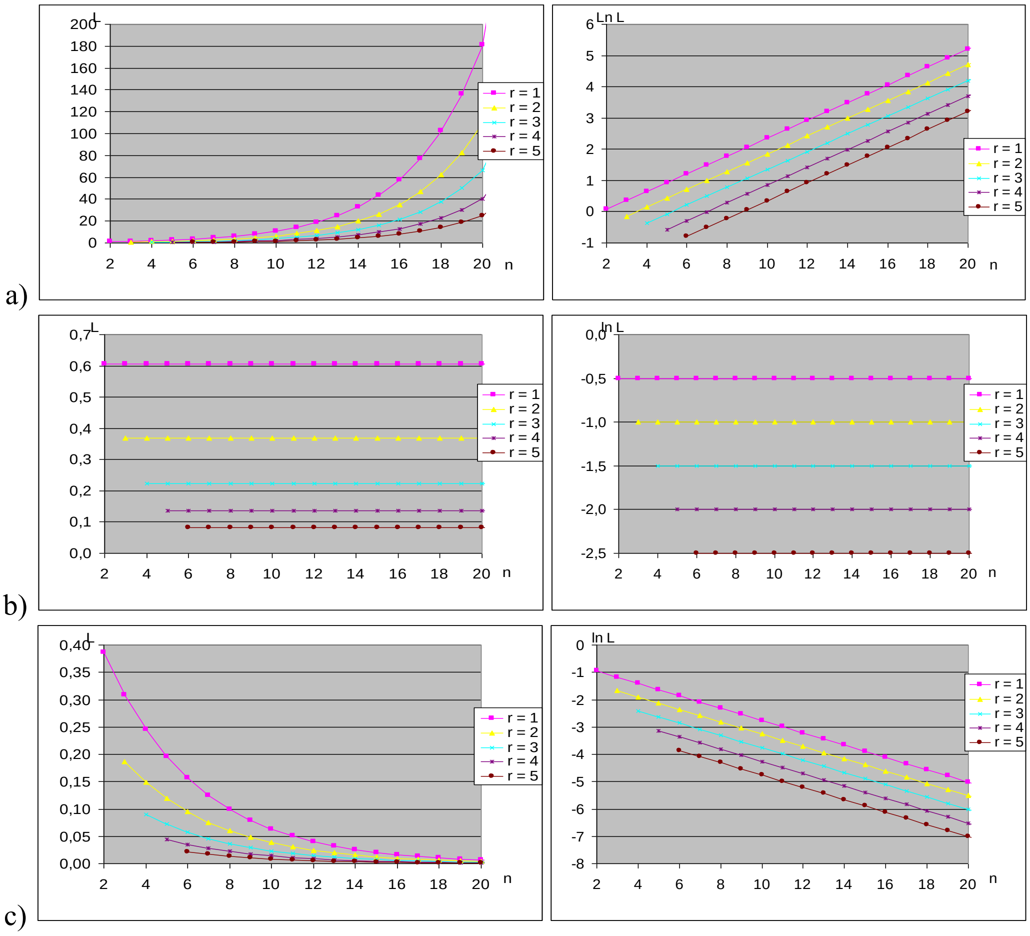

Fig. 1. Dependence of function *L* and ln*L* on number of measurements *n*
a) when σ = 0,3; b) when σ = 0,398942 ...; c) when σ = 0,5

Similar results were obtained in the study of justifying the likelihood function simple arithmetic average and the total arithmetic average. That is to say about a maximum or minimum of this function is not entirely correct. Therefore, for justification for OLS of simple arithmetic average and the total arithmetic average it is offered not to use likelihood function (3) [11 - 13].

Since the beginning of the state land cadastre, the question about the rounding of coordinates of the vertices rotation angles of land plot and of its square is important, because in case of recalculating of land by rounded coordinates, other values of square and length of land are obtained, especially during the recalculation of coordinates from one coordinate system to another. A differential approach is proposed to solving this problem depending on the value of square, configuration, the number of vertices rotation angles, boundaries of land. Three criterions of importance of systematic error rounding of coordinates [3, 4] are obtained to determine when rounding coordinates can be neglected, and when they cannot be neglected:

$$m_{S_{окр}} \le 0{,}054\, m_S\,, \qquad m_{S_{окр}} \le 0{,}031\, m_S\,, \qquad m_{S_{окр}} \le 0{,}020\, m_S\,. \tag{6}$$

The resultant functional dependence MSE of area due to rounding coordinates and calculating the threshold rounding respectively:

$$m_{S_{окр}} = \frac{a}{2\sqrt{3}} \sum_{i=1}^{n} D_{(i+1)-(i-1)}\,, \quad a = \frac{2\sqrt{3}\, m_{S_{окр}}}{\sum_{i=1}^{n} D_{(i+1)-(i-1)}}\,, \tag{7}$$

where *a* – a limiting error of coordinates rounding, equal to a half of the last mark,
D – diagonal between vertices rotation angles $(i + 1)$ and $(i – 1)$.

Theoretical and practical study of harmonious, geometric, quadratic, power average by measuring one value [6, 7] is completed. In the case of equally accurate measurements with established properties, the average values are systematized in three groups:

- group of simple arithmetic average: $\bar{x}_a = \left(\frac{x_1{}^k + x_2{}^k + \ldots + x_n{}^k}{n} \right)^{\frac{1}{k}}$;
- group of simple harmonic average: $\bar{x}_h = \left(\frac{n}{x_1{}^{-k} + x_2{}^{-k} + \ldots + x_n{}^{-k}} \right)^{\frac{1}{k}}$;
- group of simple geometric average: $\bar{x}_g = \left(x_1^k \cdot x_2^k \cdot \ldots \cdot x_n^k \right)^{\frac{1}{nk}} = \left(x_1 \cdot x_2 \cdot \ldots \cdot x_n \right)^{\frac{1}{n}}$.

The obtained results in respect of averages in the case of unequally accurate measurements are also systematized in three groups:

- group of total arithmetic average:

$$\bar{x}_з = (q_1 x_1^k + q_2 x_2^k + \ldots + q_n x_n^k)^{\frac{1}{k}} \text{ or } \bar{x}_з = \left(\frac{p_1 x_1^k + p_2 x_2^k + \ldots + p_n x_n^k}{\Sigma p}\right)^{\frac{1}{k}};$$

- group of total harmonic average:

$$\bar{x}_h = (q_1 x_1^{-k} + q_2 x_2^{-k} + \ldots + q_n x_n^{-k})^{-k} \text{ or } \bar{x}_h = \left(\frac{p_1 x_1^{-k} + p_2 x_2^{-k} + \ldots + p_n x_n^{-k}}{\Sigma p} \right)^{-k};$$

- group of total geometric average:

$$\bar{x}_g = (x_1^{kq_1} \cdot x_2^{kq_2} \cdot \ldots \cdot x_n^{kq_n})^{\frac{1}{k}} = x_1^{q_1} \cdot x_2^{q_2} \cdot \ldots \cdot x_n^{q_n} \text{ or}$$

$$\bar{x}_g = (x_1^{kp_1} \cdot x_2^{kp_2} \cdot \ldots \cdot x_n^{kp_n})^{\frac{1}{k\Sigma p}} = (x_1^{p_1} \cdot x_2^{p_2} \cdot \ldots \cdot x_n^{p_n})^{\frac{1}{\Sigma p}}.$$

If the exponent will increase or decrease, differences between the values of average will also increase or decrease accordingly. The exponent does not affect the value of a simple and total geometric average [6, 7].

The investigations of averages on equally accurate measurements and unequally accurate measurements provided an opportunity to establish relationships between them [2, 5 - 8]. Also, inequality between values of investigated averages, its MSE of weight unit, weights of averages and its MSE was established. For all averages the sum of squared normalized deviations is equal to the number of redundant measurements $\Sigma t^2 = n - 1$ [6, 7].

The third property of deviations measurement from total arithmetic average was established: sum of products of weights of measurements and squared deviations measurement results of total arithmetic average is the sum of squares products of all the unique differences and appropriate measurement of weights divided by sum of weights of all measurements, i.e.

$$\sum_{i=1}^{n} p_i v_i^2 = \frac{\sum_{\substack{i=1 \\ j=2}}^{n} d_{i-j}^2 p_i p_j}{\sum_{i=1}^{n} p_i}. \quad (8)$$

Traditionally during mathematical processing of the results from geodetic measurements MSE of weight unit is calculated by the known formula:

$$\mu = \sqrt{\frac{\Sigma p_x vv}{n-1}} \,. \tag{9}$$

Thus, the expression (9) use weight of measurements, despite the fact that weights are not equal weights of deviations [5]. MSE calculation of one measurements, in the case of equally accurate measurements, was performed by well-known Bessel's formula. But weight deviation p_v, which is used in the Bessel's formula is not equal to one because $p_v = n/(n+1)$. And, if considering weight deviations, the Bessel's formula will take the following form:

$$m = \sqrt{\frac{n\Sigma v^2}{n^2 - 1}} \,. \tag{10}$$

It is established that to adjustment is the MSE of weight unit by measured values, and after adjustment should be used MSE of weight units by aligned values. To improve the estimation of unequally accurate measurements of one measurement, weight deviations is offered to use during calculating MSE of weight unit. In the case of equally accurate measurements offered during MSE calculating (Bessel's formula) the weight deviations are taken into account, if $n < 20$ [5].

The results of the study show that different importance criteria of a systematic error give reason to make opposite conclusions about its importance, and depends on further estimation of the accuracy of double equally accurate and unequally accurate measurements [9, 10]. It is therefore proposed to use only one criterion $|\Sigma d_i| \le 0{,}25\Sigma|d_i|$ or $|\Sigma p_d d_i| \le 0{,}25\Sigma|p_d d_i|$ (here: d_i – differences; p_d – weight differences).

Systematic errors should be considered not only for the performance estimation of accuracy, but also for excluding them from the average values of double equally accurate and unequally accurate measurements. Therefore relevant dependencies are established which are described by formulas for all cases of double measurements and their usage is investigated [9, 10].

As a result of the research Abbe's criterion established dependencies by which we can calculate the parameter q, using only the difference between equally accurate measurements. In the case of unequally accurate measurements dependencies were established by which we can also calculate the parameter q herewith using the difference between their measurements and weight. These dependencies provide an opportunity to use Abbe's criterion during processing and unequally accurate measurements and testing various hypotheses.

Conclusions and recommendations

1. Failure and incompleteness of theoretical and practical bases on certain areas of mathematical processing of geodetic measurements were established that can be used to support work in land management and cadastre.

2. Theoretical and practical additions to components of mathematical processing of geodetic measurements were developed:

- it was determined that in the case justification for OLS, simple arithmetic average and total arithmetic average not using maximum likelihood condition of random errors together and the method of maximum likelihood by R. Fisher;
- criteria significance of rounding coordinate errors was established and the formulas for pre-calculating rounding precision coordinates when calculating the land area were developed;
- in accordance with specified properties averages by the results of equally accurate and unequally accurate measurements were systematized in three groups, respectively, dependency of their systematization of groups and relationship was established, averages by their MSE and weight (except simple arithmetic average and total arithmetic average) were determined, the third property of deviations from total arithmetic average was established;
- dependencies were obtained and the method was developed with using Abbe's criterion for determining systematic error and verification of various hypotheses using only differences between equally accurate and unequally accurate measurements;
- usage of only one criterion importance of systematic error in the case of equally accurate and unequally accurate double measurements, respectively was proved and proposed. The developed

formulas of exclusion systematic error for all cases of double-measurements and importance of systematic error determined not only by differences but also with average values of double-measurements, which reduce the residuals.

3. The obtained theoretical and practical research results improved the efficiency and optimized the mathematical processing of geodetic measurements not only in the field of cadastre and land management, but also in any direction of using geodetic measurements.

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THE STUDY ON THE OVERLAP OF PARCEL BOUNDARIES

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Abstract
Cadastral measurement provides cadastral data of a parcel determining its boundaries. In theory, based on the legislative regulations, the boundaries of adjacent parcels should not cross the boundaries of parcels, therefore an overlap of parcels is not possible. Yet the question arises if this requirement is met. The study has been conducted to examine the assumption regarding the possible overlap of adjacent parcels when the parcels abut a road. The study object consists of 24 parcels randomly selected from Kėdainiai district municipality, Lithuania which abut the following roads of national significance: road No. 144 (Jonava – Kėdainiai – Šeduva) and road No. 195 (Kėdainiai – Krekenava – Panevėžys) as well as regional road No. 2007 (Akademija – Šlapberžė – Berželė). The cadastral measurements of the selected roads were carried out in the period of 2013–2014. During the study, the analysis of the conditions of overlapping of boundaries and the areas of the overlap have been carried out. The results of the study indicate that the boundary accuracy of parcels is inaccurate in relation to road boundaries.
Key words: land plot, land plot boundaries, road.

Introduction

In accordance with the legal framework, having received the results of cadastral measurement from a surveyor and when recording the received cadastral data of real property into the Real Property Cadastre, a cadastral manager marks the above-mentioned property on the map of the real property cadastre in accordance with the provisions laid out by the Regulations of Cadastre. Prior to marking the real property boundaries on the map of the real property cadastre, it is checked, among other things, whether the real property boundaries indicated in the map of the real property cadastre do not cross the borders of adjacent parcels that have already been marked in the map of the real property cadastre and the roads that the parcel abuts (Lietuvos..., 2002). Furthermore, all the parcels have been formulated in compliance with the legal requirements laid out by the Rules of the Preparation and Implementation of Parcel Formation and Reorganisation. Based on the main principles of parcel formation and reorganisation, when forming a parcel near the roads of national significance and local roads with lanes, the boundaries of the parcel are formed counting from the boundary of the lane. If the parcel is formed near other roads, the boundaries of the parcel are determined as over 1 m from the road-bed, or trench, 2–3 m from road green plantations, or 1 m from the edge of the roadside ditch (Lietuvos..., 2004).

However, when determining the cadastral data, mistakes and various inaccuracies may often occur. Frequently, the cases to be coordinated do not comply with the requirements set for cadastral measurements. One of the main reasons of such problem is the fact that the plans of parcels have not been drawn and formulated following the applicable rules of standard documents (Balevičius et al., 2012). Even having corrected all the inaccuracies, when the cases of cadastral measurements comply with the requirements set by legal acts, inaccuracies and overlaps of adjacent parcel boundaries do occur on the map of the real property cadastre (Jonauskienė et al., 2011). The quality of the real property cadastral data depends on the quality of the initial data, landmark retained by the owner of the parcel as well as the competences of the surveyor that carries out the cadastral measurements, cadastral manager GIS engineer, specialists of the territorial branches of National Land Service Under the Ministry of Agriculture of the Republic of Lithuania. Therefore, all the above-mentioned conditions influence the accuracy of measurements (Živatkauskas, 2012).

Inaccuracies between preliminary and cadastral measurements are also frequent (Sinkevičiūtė et al., 2012a). The most frequent mistakes include the failure to coordinate parcel boundaries with the owners or users of adjacent parcels, partially filled-in act of marking-showing, failure to coordinate the plans of neighbouring parcels, failure of drawn plans of parcels to fully comply with the requirements, etc. and absent-mindedness of a surveyor (Sinkevičiūtė et al., 2012b).

As it can be observed, mistakes and discrepancies are quite frequent in the field of cadastral data (Vaitkevičienė, Kumetaitienė, 2010; Zakarevičius, Jonauskienė, 2007), therefore the question arises whether the parcel boundaries not only cross the boundaries of adjacent parcels, but also coincide with the boundaries of other parcels.

24 parcels randomly selected from Kėdainiai district municipality, Lithuania, which abut the road parcels (Lietuvos..., 1995) have been selected for the study. The study object consists of 24 randomly selected agricultural and other parcels which abut a regional road (Nr. 195, Nr. 144) and local roads (Nr. 2007). The study aims at determining the size of the parcel overlap and providing conclusions for the occurrence of such overlaps.

The aim of the study is to examine the overlaps of the boundaries of land and road parcels registered in the Real Property Register and to determine the compliance of the inaccuracies of parcel boundaries with the legal requirements.

Objectives of the study:

1.To carry out the analysis of the inaccuracies of parcel boundaries.

2. To carry out the analysis of the areas of overlap and to determine whether the area of overlap does not exceed the maximum amount of errors allowed by the legal acts.

Methodology of research and materials

The article provides the analysis of the inaccuracies between a few of the land parcel boundaries. 24 parcels were randomly selected from Kėdainiai district municipality, Lithuania, which abut the following roads of national significance: road No. 144 (Jonava – Kėdainiai – Šeduva) and road No. 195 (Kėdainiai – Krekenava – Panevėžys) as well as regional road No. 2007 (Akademija – Šlapberžė – Beržele).The cadastral measurements of the selected roads were carried out in the period of 2013–2014. All the selected parcels abut roads (Fig. 1):

- **67 %** – 16 out of 24 of randomly selected parcels abut local road No. 144 (Jonava – Kėdainiai – Šeduva);
- **25 %** – 6 out of 24 parcels (four out of which have been coordinated at the location) are near the local road No. 195 (Kėdainiai – Krekenava – Panevėžys);
- **8 %** – two out of 24 parcels are near the regional road No. 2007 (Akademija – Šlapaberžė – Beržele).

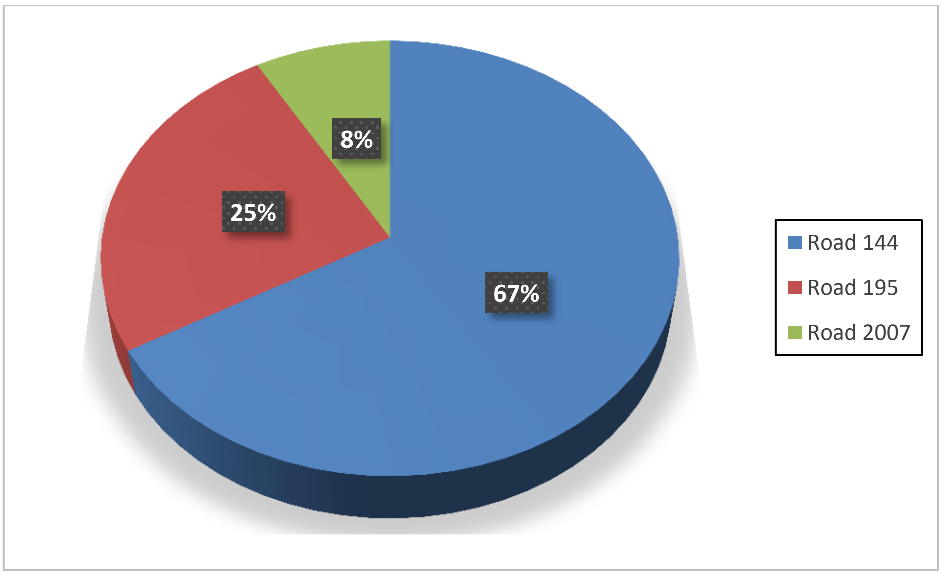

Fig. 1. The distribution of parcels which abut the roads of Kėdainiai district.

Based on the available data, the selected parcels and roads are drawn and the overlapping parcel boundaries are determined by using the programme "Geomatininkas". The overlapping areas are calculated (1, 2):

$$2P = \sum_1^n x_i(y_{i+1} - y_{i-1}), \quad (1)$$

$$2P = \sum_1^n y_i(x_{i-1} - x_{i+1}). \quad (2)$$

Where P – area,

x_i, y_i – the coordinates of the turning points of studied object boundaries.

In the Republic of Lithuania, when carrying out the cadastral measurements of the same boundaries by using more accurate measurement means, the area of parcel, which has been calculated by determining the cadastral data of the real property, may differ from the maximum permissible error (margin of error) applicable to the cadastral measurements of the parcel recorded in the Real Property Register by no more than maximum permissible area error (margin of error) regulated by the Regulations of Real Property Cadastre (Table 1) (Lietuvos..., 2002):

Table 1

Having carried out the cadastral measurements, the maximal permissible error between the area of parcel registered in Real Property Register and calculated area of parcel (Lietuvos..., 2002)

Used cartographic materials	**Area of parcel, hectare**	**Scale of plan**				
		1: 10000	**1: 5000**	**1: 2000**	**1: 1000**	**1: 500**
Orthophotographic maps	To 1	$0{,}05\sqrt{P}$	$0{,}03\sqrt{P}$	$0{,}02\sqrt{P}$	–	–
	1.1–2.0	$0{,}06\sqrt{P}$	$0{,}04\sqrt{P}$	$0{,}03\sqrt{P}$	–	–
	2.1–4.0	$0{,}07\sqrt{P}$	$0{,}05\sqrt{P}$	$0{,}04\sqrt{P}$	–	–
	4.1 and more	$0.08\sqrt{P}$	$0.06\sqrt{P}$	$0.05\sqrt{P}$	–	–
Other cartographic materials	To 1	$0.07\sqrt{P}$	$0.05\sqrt{P}$	$0.04\sqrt{P}$	$0.03\sqrt{P}$	$0.02\sqrt{P}$
	1.1–2.0	$0.08\sqrt{P}$	$0.06\sqrt{P}$	$0.05\sqrt{P}$	$0.04\sqrt{P}$	$0.03\sqrt{P}$
	2.1–4.0	$0.09\sqrt{P}$	$0.07\sqrt{P}$	$0.06\sqrt{P}$	$0.05\sqrt{P}$	$0.04\sqrt{P}$
	4.1–10.0	$0.10\sqrt{P}$	$0.08\sqrt{P}$	$0.07\sqrt{P}$	$0.06\sqrt{P}$	$0.05\sqrt{P}$
	10.0 and more	$0.12\sqrt{P}$	$0.10\sqrt{P}$	$0.08\sqrt{P}$	$0.07\sqrt{P}$	$0.06\sqrt{P}$

Since the scale applied during the study is 1/10000, the permissible error has been calculated by using the following formulas: $\mathbf{0.05\sqrt{P}}$ $\left(\text{P – Sklypo plotas iki 1 ha}\right)$, $\mathbf{0.08\sqrt{P}}$ $(\text{P} - \text{Sklypo plotas} \geq 4\text{ ha})$, the calculated overlapping area has been compared to the maximum permissible error of the area of the registered parcel.

Discussions and results

When carrying out the study, the coordinates of all 24 parcels were uploaded onto a single drawing by using the "Geomap" software. To make the situation more clear the orthophotographic view of the selected area has also been uploaded. The results of the overlap of six parcels are represented graphically in Figure 2

a) b)

c) d)

e) f)

Fig. 2. Schemes of overlapping road and land parcels (a – f)

The total areas of the selected parcels variate from 1,428.59 m^2 (14 ares) to 428,764.95 m^2 (42.9 hectares). Having analysed the overlap of all the selected parcels with road parcels, it was estimated that the overlapping areas constitute up to 338.49 m^2. The results of the analysis are provided in Table 2.

Table 2

Physical parameters of the analysed parcels

System of coordinates	**Number of road**	**Total area of the land parcel (m^2)**	**Area of the overlap (m^2)**	**Shape of the parcel (regular, irregular)**
LKS-94	Road 195	1837.79	2.85	Irregular
LKS-94	Road 144	1621.39	3.67	Irregular
LKS-94	Road 2007	428764.95	6.76	Irregular
LKS-94	Road 144	1450.95	6.85	Regular
LKS-94	Road 144	3260.23	11.56	Irregular
LKS-94	Road 144	3493.15	14.18	Irregular
LKS-94	Road 144	2219.63	14.38	Regular
LKS-94	Road 144	1428.59	17.25	Irregular
LKS-94	Road 144	4991.19	24.87	Regular
LKS-94	Road 195	2120.41	27.17	Regular
LKS-94	Road 144	2651.46	30.85	Irregular
LKS-94	Road 144	1498.82	31.44	Irregular

System of coordinates	Number of road	Total area of the land parcel (m^2)	Area of the overlap (m^2)	Shape of the parcel (regular, irregular)
LKS-94	Road 144	5183.06	32.81	Irregular
LKS-94	Road 195	4000.10	45.79	Irregular
LKS-94	Road 144	810.00	48.64	Irregular
LKS-94	Road 144	6089.52	49.76	Regular
LKS-94	Road 144	2500.08	50.40	Regular
LKS-94	Road 195	2199.78	56.86	Irregular
LKS-94	Road 144	1800.21	95.06	Regular
LKS-94	Road 144	6091.81	136.25	Irregular
Local	Road 195	3000.42	137.44	Irregular
LKS-94	Road 144	2937.26	148.44	Regular
LKS-94	Road 2007	9568.33	210.22	Irregular
LKS-94	Road 195	77410.41	338.49	Irregular

The distribution of the areas of overlapping boundaries of land and road parcels:

- < 10 m^2 – four;
- 10 m^2 < 20 m^2 – four;
- 30 m^2 < 40 m^2 – three;
- 40 m^2 < 50 m^2 – three;
- 50 m^2 < 60 m^2 – two;
- 61 m^2 and more – six parcel.

The smallest land parcel by the total area of the parcel constitutes approximately 8 ares. This parcel is near road No. 144, the intended purpose of the land is other. The biggest analysed parcel, whose area is approximately 43 hectares, is near road No. 2007, while the intended purpose of the land is agricultural. The estimated and calculated areas of the overlap fluctuate from 2.85 m^2 to 338.49 m^2. The total ratio of the areas of the analysed parcels is provided in Figure 3.

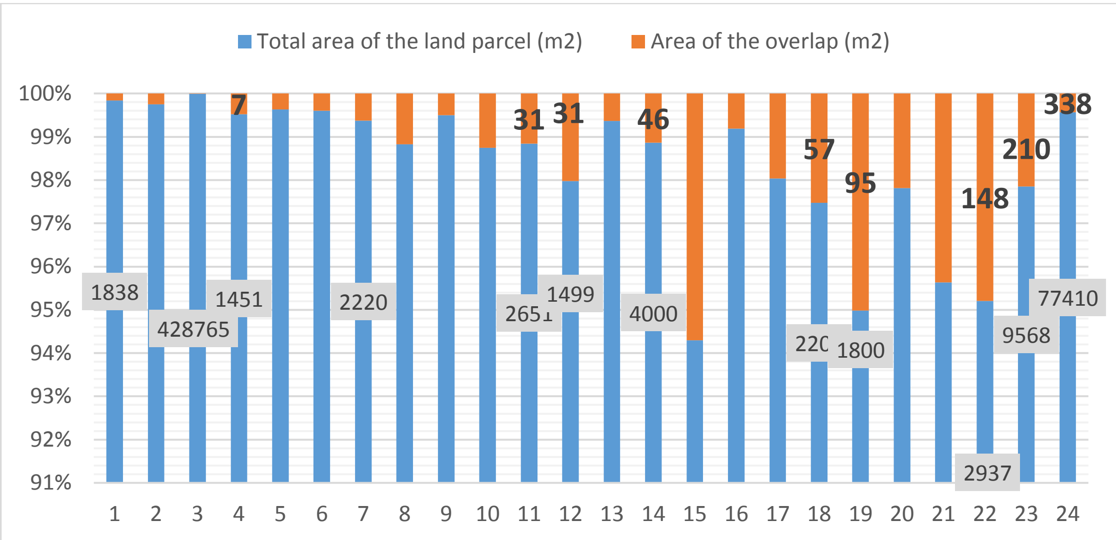

Fig. 3. The ratio of the areas of parcels

As it can be observed from Figure 3, the biggest overlaps of land and road parcels fluctuate from 48.64 m^2 to 338.49 m^2, while six of the smallest overlaps fluctuate from 2.85 m^2 to 14.18 m^2.

To check whether the discrepancies between parcel areas are within permissible limits, the maximum permissible error has been calculated for every parcel.
Since orthographic material M 1: 10 000 has been used to determine the discrepancies (based on the Regulations of Cadastre of the Republic of Lithuania, the maximum permissible error between the area of the parcel registered in the Real Property Registry and the area of parcel calculated after carrying out the cadastral measurements is provided in Table 1), the maximal permissible errors have been calculated by applying the following formulas: when the area of the parcel is (P) < 1ha – $0.05\sqrt{P}$ and when the area of the parcel is (P) > 1ha – $0.08\sqrt{P}$. The total areas of the corrected parcels have been calculated as well (by deducting the area of the parcel discrepancy from the total area of the parcel). The results of the analysis are provided in Table 3.

Table 3

The maximum permissible errors of parcels and the areas of corrected parcels

Number of parcel	Total area of the land parcel (m^2)	Area of the overlap (m^2)	The maximal permissible error P<1ha - $0,05\sqrt{P}$; P>1ha - $0,08\sqrt{P}$, (m2)
1	1,837.79	2.85	214.35
2	1,621.39	3.67	201.33
3	42,8764.95	6.76	5238.41
4	1,450.95	6.85	190.46
5	3,260.23	11.56	285.49
6	3,493.15	14.18	295.51
7	2,219.63	14.38	235.56
8	1,428.59	17.25	188.98
9	4,991.19	24.87	353.24
10	2,120.41	27.17	230.24
11	2,651.46	30.85	257.46
12	1,498.82	31.44	193.57
13	5,183.06	32.81	359.97
14	4,000.1	45.79	316.23
15	810	48.64	142.30
16	6,089.52	49.76	390.18
17	2,500.08	50.4	250.00
18	2,199.78	56.86	234.51
19	1,800.21	95.06	212.14
20	6,091.81	136.25	390.25
21	3,000.42	137.44	273.88
22	2,937.26	148.44	270.98
23	9,568.33	210.22	489.09
24	77,410.41	338.49	2,225.82

The results of calculations show that the areas of the overlap of all the land parcels and road parcels do not exceed the maximum permissible error. The permissible errors fluctuate from 142.30 m^2 to 5,238.41 m^2. The sum of all the areas of the overlaps of all the analysed parcels amounts to 1,541.99 m^2 (15 are).
Having conducted the study, an assumption can be made that the overlaps of land and road parcels occurred due to the following reasons: the boundaries of the parcel were not coordinated with the owners or users of adjacent parcels, partially filled-in act of marking-showing, failure to coordinate the plans of neighbouring parcels, failure of drawn plans of parcels to fully comply with the requirements, absent-mindedness of a surveyor, various minor mistakes during the cadastral measurements, when the boundaries of parcels have been drawn, when carrying out the marking of parcels at location, etc. (Sinkevičiūtė et al., 2012b).

Conclusions and proposals

The discrepancies of parcel areas have been investigated between the local roads No. 144, 195, regional road No. 2007 and 24 parcels which abut the above-mentioned roads. The measured and calculated areas of the overlap fluctuate from 2.85 m^2 to 338.49 m^2.

The areas of the overlap of all the land parcels and road parcels do not exceed the maximum permissible error. The permissible errors fluctuate from 142.30 m^2 to 5,238.41 m^2. Due to the areas of the overlaps (discrepancies) all the parcels lose a part of the total area, which amounts to 15.4 ares and constitutes 0.3% of the area covered by all the parcels.

The discrepancies of the parcel boundaries occur due to the absent-mindedness of a surveyor, the failure of the act of marking-showing to comply with the requirements, failure to coordinate the plans of parcels, failure of the drawn plans of parcels to fully comply with the requirements.

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