LATVIA UNIVERSITY OF LIFE SCIENCES AND TECHNOLOGIES
ALEKSANDRAS STULGINSKIS UNIVERSITY (Lithuania)
UNIVERSITY OF WARMIA AND MAZURY IN OLSZTYN (Poland)

# BALTIC SURVEYING

## INTERNATIONAL SCIENTIFIC JOURNAL

**2018**

**Volume 9**

ISSN 2255 – 999X (online)

ISSN 2255 – 999X (online)

LATVIA UNIVERSITY OF LIFE SCIENCES AND TECHNOLOGIES
ALEKSANDRAS STULGINSKIS UNIVERSITY (Lithuania)
UNIVERSITY OF WARMIA AND MAZURY IN OLSZTYN (Poland)

# BALTIC SURVEYING

## INTERNATIONAL SCIENTIFIC JOURNAL

**2018 / 2**

**Volume 9**

**Published since 2014**

Technical Editor: Vita Cintina, Mg.sc.ing. (Latvia)

The English Language Editor: Vilnis Auziņš (Latvia)

# THE EDITORIAL COMMITTEE

# REVIEWERS

| | |
|---|---|
| **Aleknavicius Audrius** | Doctor of technology sciences, Aleksandras Stulginskis University, Lithuania |
| **Celms Armands** | Dr.sc.ing., Latvia University of Life Sciences and Technologies, Latvia |
| **Gurskiene Virginija** | Doctor of technology sciences, Aleksandras Stulginskis University, Lithuania |
| **Khasaev Gabibulla** | Doctor of Economics, Samara State University of Economics, Russia |
| **Ievsiukov Taras** | Dr.hab. in Economics, National University of Life and Environmental Sciences of Ukraine |
| **Jankava Anda** | Dr.oec., Latvia University of Life Sciences and Technologies |
| **Jankauskiene Dainora** | PhD, Klaipeda State University of Applied Sciences, Lithuania |
| **Liba Natalja** | PhD, Estonian University of life Sciences, Estonia |
| **Maasikamäe Siim** | Ph.D, Estonian University of Life Sciences |
| **Marian Madalina** | PhD, University of Pitesti, Romania |
| **Mamai Oksana** | Doctor of Economic Sciences, Samara State Agricultural Academy, Russia |
| **Marks-Bielska Renata** | Dr habil., University of Warmia and Mazury in Olsztyn, Poland |
| **Parsova Velta** | Dr.oec., Latvia University of Life Sciences and Technologies, Latvia |
| **Popov Andriy** | PhD in Economics, Kharkiv National Agrarian University named after V.V. Dokuchayev, Ukraine |
| **Rekus Donatas** | Doctor of Technology science, Kaunas University of Technology, Lithuania |
| **Savchuk Stepan** | Dr.Sc., Lviv Polytechnic National University, Ukraine |
| **Sidelska Anita** | Dr.oec., Latvia University of Life Sciences and Technologies |
| **Valciukiene Jolanta** | Doctor of technology sciences, Aleksandras Stulginskis University, Lithuania |
| **Vesperis Vladislavs** | Dr.oec., Latvia University of Life Sciences and Technologies |
| **Zrobek Sabina** | Dr habil., University of Warmia and Mazury in Olsztyn, Poland |

# FOREWORD

BALTIC SURVEYING is international scientific journal issued as online (ISSN 2255 – 999X) edition. The periodicity of the journal is 1 or 2 volume per year.
It is jointly issued by consortium of:

- Department of Land Management and Geodesy of Latvia University of Life Sciences and Technologies, Latvia
- Department of Real Estate Management and Regional Development of University of Warmia and Mazury in Olsztyn, Poland
- Institute of Geodesy of University of Warmia and Mazury in Olsztyn, Poland
- Institute of Land Use Planning and Geomatics of Aleksandras Stulginskis University, Lithuania

The journal includes 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 mentioned issues.
Journal disseminates the latest scientific findings, theoretical and experimental research and is extremely useful for young scientists.
Scientific journal BALTIC SURVEYING contains peer review articles. International reviewing of articles is provided by Editorial Committee. For academic quality each article is anonymously reviewed by two independent anonymous academic reviewers having Doctors of science degree. Names of reviewers are published in the reviewer's list. Articles have passed cross-ref test as well.
Editorial Committee makes the final decision on the acceptance for publication of articles. Each author himself is responsible for high quality and correct information of his/ her article.
Scientific journal BALTIC SURVEYING is indexed in databases:

- Agris (http://agris.fao.org/)
- CABI CAB Abstracts

(https://www.cabdirect.org/cabdirect/search/?q=Journal%20%22Baltic%20Surveying%22), and

- EBSCOhost Applied Sciences Ultimate

https://www.ebscohost.com/academic/applied-science-technology-source-ultimate

Information about the journal is placed on the website: www.balticsurveying.eu

**Editorial Committee**
(baltic.surveying1@gmail.com)

# CONTENT

DOI: 10.22616/j.balticsurveying.2018.013

# TENDENCIES OF DEVELOPMENT OF LOCAL GEODETIC NETWORK IN RIGA CITY

**Armands Celms[1], Velta Parsova[1], Ilona Reke[1], Janis Akmentins[1,2]**
[1]Latvia University of Life Sciences and Technologies
[2]Riga City Construction Board, Construction Control Department

**Abstract**
Local geodetic network is very important in harmonic development of city territory. On the base of the local geodetic network, cadastral and topographic surveying works, engineering geodetic works and executive measurements of newly built buildings and engineering networks are carried out. In the territory of Riga, the local geodetic network was started to create in 1880, and in the course of time, as the city expanded, necessity to have wider reference network emerged. In 2005, in the territory of Latvia, network of continuously working base stations LatPos was launched, which ensured completely new trends in execution of measurements and accuracy reached. One year later, base station network EUPOS-RIGA was launched in the territory of Riga. It can be regarded as consistent part of Riga local geodetic network. The purpose of the research was to state, what are differences between historically used coordinates of points of the local geodetic network, and coordinates that are determined by use of real time corrections of LatPos and EUPOS-RIGA base station network. Measurements were made in the territory of Riga in period from December 2016 until April 2017. In the framework of the research, 61 point of the local geodetic network was inspected and in 38 cases GNSS observations in RTK mode were completed. In the research, catalogues of coordinates of polygonometry points of sixties and eighties were used in order to compare what differences of coordinates existed historically. The main conclusion drawn during the research – historical points of the local geodetic network shall not be used for surveying works of any kind before improvement of them and before they comply with requirements of normative acts.
Key words: geodesy, LatPos, EUPOS-RIGA, network, survey.

## Introduction

In 1880 – 1882, in the territory of Riga City, according to order of Building Board of Riga City, the first triangulation network was created. This triangulation network can be considered as beginning of contemporary local geodetic network in the territory of Riga City, which served as a base for further works of establishment of the local geodetic network (Silabriedis, 2010). Till 1990, in the territory of Riga, six polygonometry network establishing works and eight leveling network establishing works can be distinguished. All above-mentioned works of establishing of the local geodetic network were carried out by such methods and technical base, which do not ensure accuracy complying with contemporary requirements (Biezak uzdotie jautajumi…, 2018). As usage of global navigation satellite system (GNSS) was started in geodesy, mismatches between historically calculated coordinates of points of the local geodetic network and coordinates determined by use of GNSS technologies emerged. Also change of height system introduced its corrections (Balodis et al., 2016). This difference of coordinates creates problems in determination, inspection and restoration of land boundaries, in production of topographic plans and performance of engineering geodetic works.

The purpose of the research is to clarify differences of coordinates of local geodetic network determined in different periods, to determine their coordinates by use of contemporary technologies.

## Methodology of research and materials

There are historical catalogues of coordinates and heights of Riga polygonometry network used:

1. catalogue of coordinates and heights of polygonometry network of 1963, volume 16,
2. catalogue of coordinates and heights of polygonometry points of class 4 of 1985, object Riga-1,
3. catalogue of coordinates and heights of polygonometry points of class 4 of 1987, object Riga-2,
4. catalogue of coordinates and heights of polygonometry points of class 4 of 1989, object Riga-3.

In the catalogue of 1963, coordinates and heights of polygonometry points of class 1, 2, and 3 with higher accuracy can be found, which are obtained in the period 1958-1962. Coordinates are given in the coordinate system of 1942, in 3° zone of Gauss projection, mean meridian - 24° from Greenwich.

Heights are given in the Baltic height system. Works of establishment of polygonometry network were performed by Leningrad City Planning Institute "Lengiprogor". For measurement of angles, theodolites of high precision were used (Table 1).

**Table 1**

Characteristics of theodolites used

| Type of instrument, producer | Main spyglass | | | Diameter of arc, mm | | Value of marking of optical micrometer | | Value of marking of level | |
|---|---|---|---|---|---|---|---|---|---|
| | Focal length, mm | Diameter of objective | Magni-fication | Horizontal | Verticals | Horizontal arc | Vertical arc | Horizontal arc | Vertical arc |
| Big Wild, Nr. 5227 | 350 | 60 | 30 | 140 | 95 | 0.2″ | 0.2″ | 6″ | 12″ |
| Little Wild, Nr. 3848 | | 40 | 28.4 | 90 | 50 | 1″ | 1″ | 20″ | - |
| OTC-2A | | 40 | 28.4 | 85.9 | 75.8 | 2″ | 2″ | 16″ | 19″ |
| ТБ-1 | | 40 | 28 | 85.9 | 75.8 | 1″ | 1″ | 16″ | 16″ |

The local geodetic network consists of traverses.
Mean square error of angles in the whole network was calculated according to formula:

$$m_\beta = \sqrt{\frac{\left[\frac{f_\beta^2}{n}\right]}{N-K}} \qquad (1)$$

Where $f_\beta$ denotes angular deviation of traverses,
*n* denotes amount of measured angles in traverse,
N denotes number of traverses,
K denotes number of nod points in the network.
Mean square error of measured angles was within interval from ±2.9" to ±8.9", depending on the category of polygonometry traverse. Edge lengths of polygonometry traverses were measured by use of baseline measurement device БП-3 with three 24m long sets of wires: one of steel and two of invar. Error of locations of polygonometry points in relation to used triangulation points was in interval from ±32 mm to ±118 mm.
In the next poligonometry network surveying works, theodolites of similar accuracy were used for measurement of angles, but distances were measured by use of light rangefinder 2CM2, which ensured mean square error of measurement ±2 cm.
In catalogue "Riga-1" of 1985, coordinates and heights, which were determined in period 1982-1984, can be found. Coordinates are given in Riga local coordinate system and heights – in Baltic height system. Works were performed by Latvian geodetic and topographic expedition "Sojuzmarkstrest".
In catalogue "Riga-2" of 1987, coordinates and heights, which were determined in period 1983-1986, can be found. Coordinates are given in Riga local coordinate system and heights – in Baltic height system. Works were performed by Latvian geodetic and topographic expedition "Sojuzmarkstrest".
In catalogue "Riga-3" of 1989, coordinates and heights, which were determined in period 1985-1987, can be found. Coordinates are given in Riga local coordinate system and heights – in Baltic height system. Works were performed by Latvian Geodetic Centre "Latvgeokarta".
In the framework of the research, measurements were performed by use of GNSS receiver Leica GS 14, with real time corrections in order to determine coordinates of polygonometry points in Latvian geodetic coordinate system of 1992 (LKS-92) and heights in Latvian normal height system in epoch 2000,5 (LAS-2000,5). Cordinates and heights of polygonometry points selected for the research were determined by use of GNSS base station networks LatPos and EUPOS-RIGA, in cases, when it was possible.
As we can see, in different periods, different coordinate and height systems were used. In order to compare coordinates of 1942 and coordinates determined in Riga local system, simple transition from

coordinate system of 1942 to Riga local coordinate system according to following formulas shall be performed:

$$X_{RV} = X_{1942} - 6320000.000 \quad (2)$$
$$Y_{RV} = Y_{1942} + 4000.000 \quad (3)$$

Where $X_{RV}$ denotes X coordinate in Riga local coordinate system,
$X_{1942}$ denotes X coordinate coordinate system of 1942,
$Y_{RV}$ denotes Y coordinate in Riga local coordinate system,
$Y_{1942}$ denotes Y coordinate coordinate system of 1942.
In order to transform coordinates of points of Riga local coordinate system to LKS 92TM system, coordinate transformation program elaborated of National Surveying Centre of State Land Service in 1996 - 1998, which is publicly available (Transformacijas programmas, 2018).

Riga continuously develops, and changes. Active construction takes place in the territory of city, as a result, Riga local geodetic network, which is built more than century ago, also experiences changes. In period 2012-2013, City Development Department of Riga City Council carried out inspection of the local geodetic network. In total, 4712 points of the local geodetic network were inspected and it was found out that somewhat more than half are preserved in normal condition (see Fig. 1.).

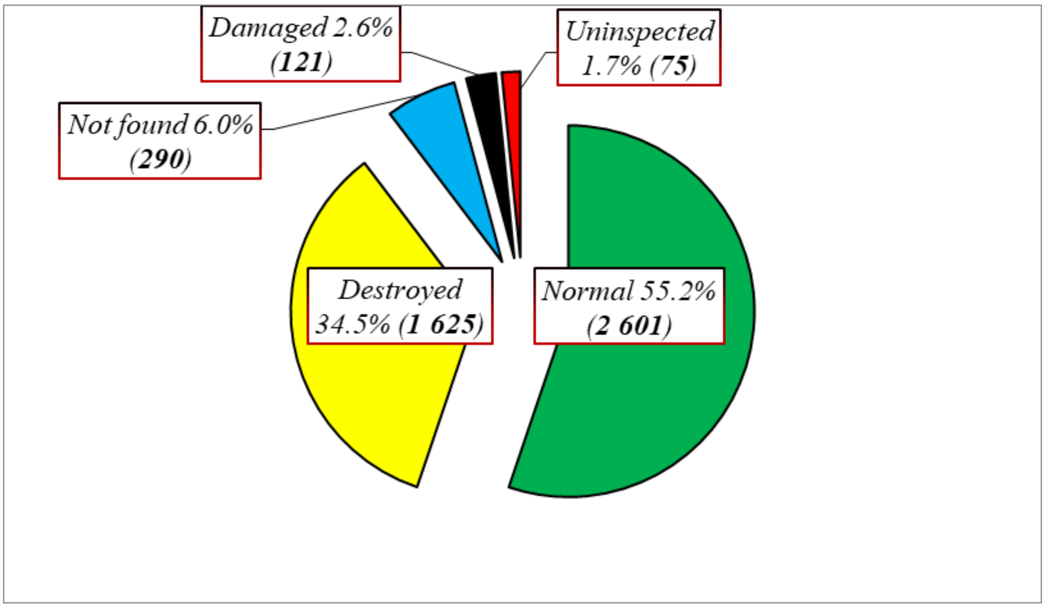



**Fig. 1.** Results of local geodetic network inspection according to The City Development Department of Riga City Council.

After the inspection of the local network, in the period 2012-2015, Descriptions of improvement of the local geodetic network of Riga City for following neighborhoods of Riga were compiled: Vecriga (2012), Skanste-Brasa (2013), Tornakalns-Agenskalns (2013), Mezaparks (2014), Vecaki (2014), Bergi (2015), Kipsala (2015). The aims of the improvement of the local geodetic network are to ensure compliance of geodetic reference points existing in the local network with requirements of accuracy of Regulations of Cabinet of Ministers of 24 July, 2012 No. 497 “Regulations of Local Geodetic Network” and they could be used for performance of geodetic works. Points of local geodetic networks are linked to state geodetic reference network with accuracy 3-6 cm, heights are determined with standard deviation to 1 cm, coordinates – to 2 cm (Vieteja geodeziska tikla..., 2012). Improvement works include establishing and measuring of new geodetic points and preparation of improvement report, where methodology of performance of measurements, measurement data and results are summarized. Territories with densely populated build-up area, areas of new development and build-up areas with dense high vegetation are considered as prioritary territories. It is foreseen to improve the local gedetic network only in those territories of Riga, where performance of measurements by use of GNSS technologies is encumbered. During the execution of the research, improvement works of 248 Riga local geodetic network points in center of Riga and Grizinkalns were done (Vietejais geodeziskais tikls, 2018).

Despite the fact that Latvia is relatively small state with small population, services of several GNSS base station network are provided in Latvia. The most popular of them are: LatPos and EUPOS-RIGA (Kluga et al., 2013). LatPos is consistent part of state geodetic network, in framework of it, 25 continuously working GNSS base stations are operated at present (see Fig. 2.). In the LatPos system, also 5 Estonian borderline stations un 5 Lithuanian borderline stations are included, in order to ensure homogenous base station network coverage in border areas. Maintenance of LatPos is provided by Latvian Geospatial Informations Agency (LatPos, 2018). In territory of Riga, base station "Ojars" is located.

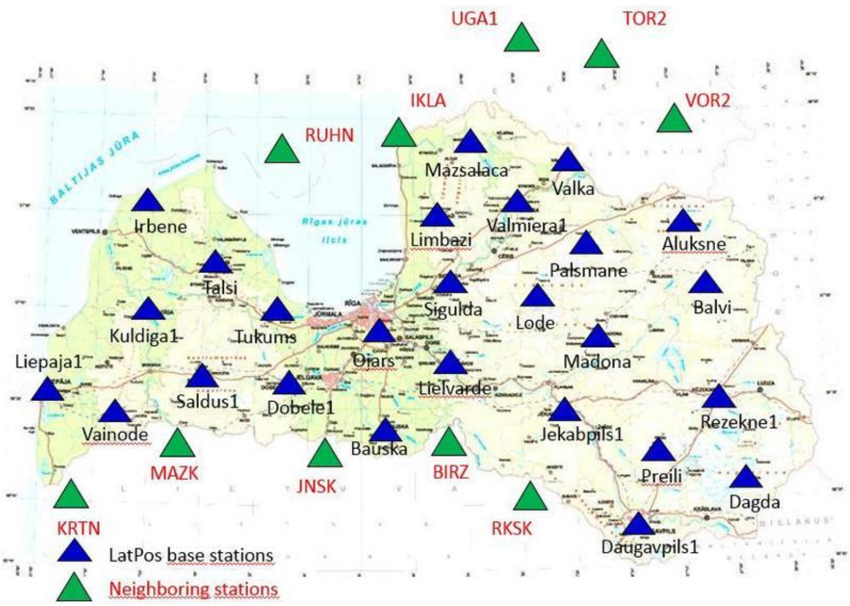



**Fig. 2.** Continuously Operating Reference Network System LatPos-positions and names of base stations (Dobelis et al., 2017).

EUPOS-RIGA is network of Global Navigation Satellite Systems (GNSS) continuously operating base stations owned by Riga municipality, which calculates GNSS signal corrections for geodetic measurements of high accuracy in Riga City and in surroundings. Network is maintained and served by City Development Department of Riga City Council. Network consists of 5 base stations (see Fig. 3), which are located in center of Riga, Vecmilgravis, Jugla, Salaspils and Jurmala, coverage of network is territory with area more than 2590 km$^2$ (EUPOS-Riga, 2018). At present, EUPOS-RIGA can be considered as consistent part of Riga local geodetic network, which together with LatPos for several years comprised the only legal geodetic base for performance of surveying works. So it is still at present in the territories of Riga, where improvement of the local geodetic network has not taken place.

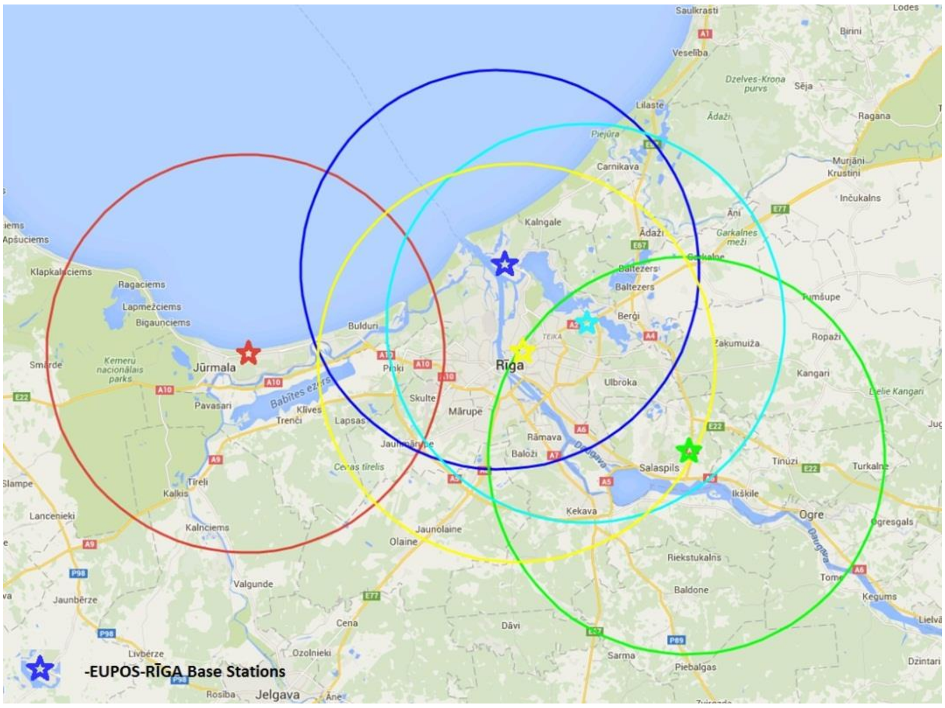



**Fig. 3.** EUPOS-RIGA - positions of base stations.

At the beginning for the performance of research, 50 points of the local geodetic network in the whole territory of Riga, which can be found in the field according to inspection data of 2013, were selected. However, as GNSS measurements in the field were made, it was found out that a part of polygonometry points is destroyed or it is impossible to make measurements due to the situation in the field. As a result, amount of selected points was supplemented by 11 points. Out of 61 selected polygonometry points GNSS measurements succeeded for 38 points (see Fig. 4.).

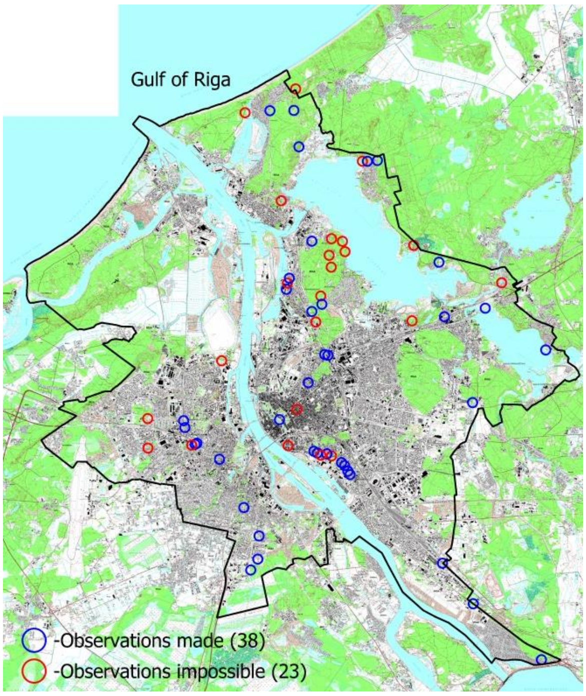



**Fig. 4.** Local geodetic points selected for the study.

## Discussions and results

Out of polygonometry points selected for the research, for 45 points coordinates were found in catalogue of 1963 and for the same points coordinates were found in catalogues of eighties. If we compare coordinates determined in these periods, we can find out that for 8 out of 45 points coordinates do not differ. It can be explained with the fact that these polygonometry and triangulation points were used as origins for new polygonometry traverses, and coordinates determined in sixties were assumed as input coordinates.

For polygonometry points, which are included in traverses in both periods and for which coordinates are recalculated differences reach even 0.20m (see Fig. 5.).

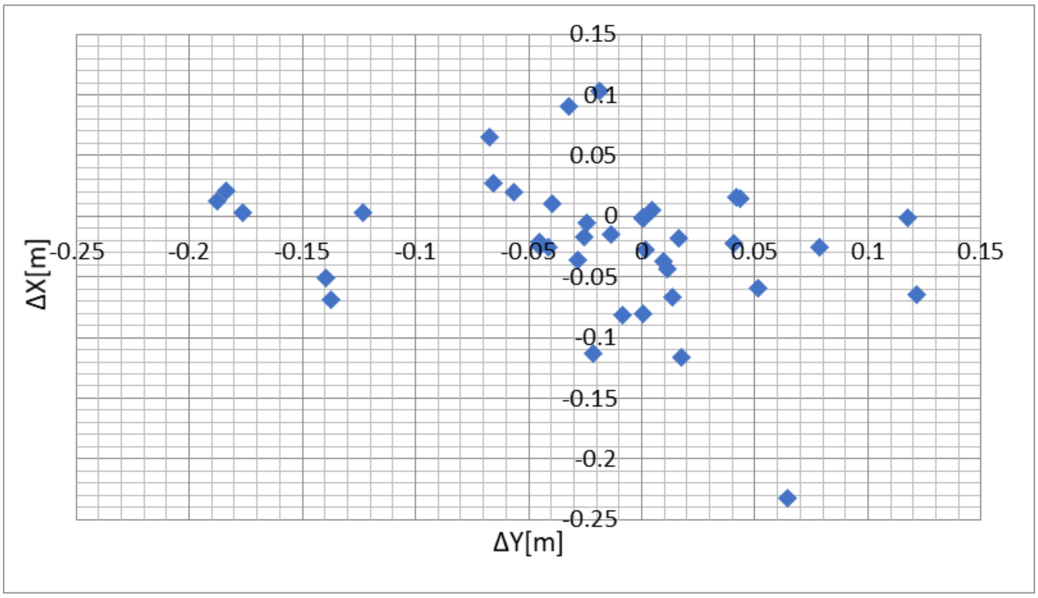



**Fig. 5.** Differences between coordinates calculated in 60ies and 80ies.

As we can see, the recognized differences of coodinates have not a certain system and they can be explained with accuracy of technical means used for measurements. During the land reform until 2006, when usage of LatPos with real time corrections started widely in Latvia, surveying works of any kind were carried out by use of the existing Riga local geodetic network as geodetic base. Due to this reason, it was interesting to clarify how the coordinates of polygonometry points from catalogues Riga-1, Riga-2, Riga-3 differ from the coordinates determined by use of LatPos in RTK mode (Dobelis, Zvirgzds, 2016). It is found out in the research that differences can reach 0.15 m (see Fig. 6.).

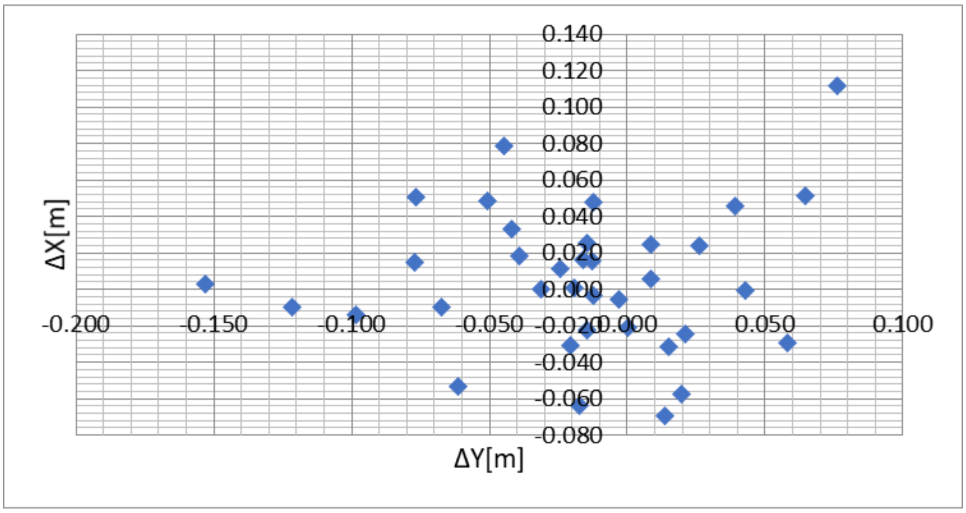



**Fig. 6.** Differences between coordinates determined in 80-ies and using LatPos.

Such differences of coordinates influence directly cadastral surveying works, when it is necessary to inspect or restore boundary marks that are surveyed by use of the local geodetic network. Likewise, in the data base of topographic information of high degree of detailing of Riga City, data obtained by measurements using unimproved geodetic network are accumulated for a long time.
Taking into account the fact that in Riga City two GNSS base station networks can be used legally, in the course of the research, it was clarified, what are the differences between coordinates determined in EUPOS-RIGA and LatPos network (see Fig. 7.).

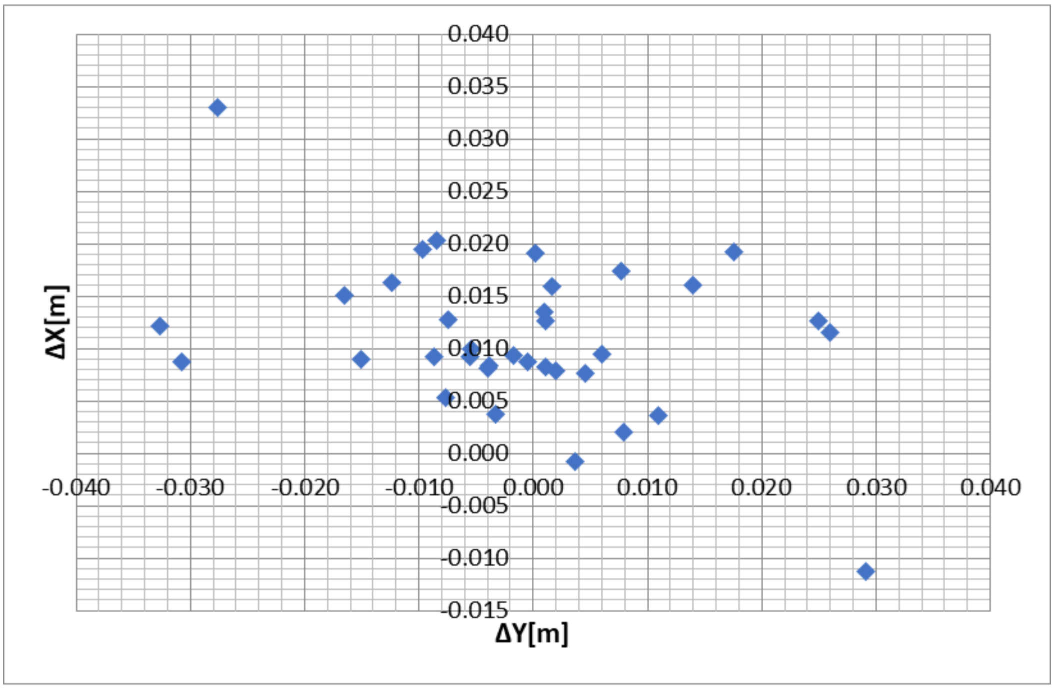



**Fig. 7.** Differences between coordinates determined using EUPOS-RIGA and LatPos.

In 84% measurements, differences of coordinates do not reach 0.020 m, which complies with accuracy ensured by both LatPos and EUPOS-RIGA for measurements by use of real time corrections.

**Conclusions and proposals**

1. The differences found out in the research between coordinates of poligonometry points determined in sixties and eighties are within limits from 0 to ±188 mm. There cannot be observed equal trends in the recognized differences, therefore we can draw conclusion that they have emerged as a result of some systematic error sources.
2. It is clarified that differences between the coordinates of polygonometry points determined in eighties and coordinates determined by use of LatPos base station network is within limits from 0 to ±154 mm. This testifies that the historical local geodetic network does not comply with requirements of accuracy of regulations of Cabinet of Ministers of 24 July, 2012 No. 497 “Regulations of Local Geodetic Network”.
3. For surveying works of any kind in the territory of Riga, both LatPos and EUPOS-RIGA GNSS base station network in RTK mode can be used. They ensure the accuracy requirements defined in normative acts.
4. Usage of Riga local geodetic network points for surveying works is not permitted until they are improved.
5. The created GNSS base station networks play an important role in Riga City local geodetic network. They will serve as the only geodetic base for performing of surveying works in the territories of the city, where the local geodetic network will not be improved.

## Acknowledgements

The research was supported by the project "Strengthening Research Capacity in the Latvia University of Agriculture" (agreement No 3.2.-10/46; Z6).

Authors are thankful to Riga City Council City Development Department for cooperation and Sergey Plotnikov personally, Jekabs Lielmanis and Karina Akmentina for help with field work during the research.

## References

1. Balodis J., Morozova K., Silabriedis G., Kalinka M., Balodis K., Mitrofanovs I., Baltmane I., Jumare I. (2016) Changing the national height system and GEOID model in LatviaGeodesy and Cartography Volume 42, Issue 1, p. 20-24.
2. Biezak uzdotie jautajumi saistiba ar vietejo geodezisko tiklu. Viewed 15 March, 2018, (http://map.lgia.gov.lv/index.php?lang=0&cPath=2&txt_id=119&ap=1). (In Latvian).
3. Dobelis D., Zvirgzds J. (2016) Network RTK performance analysis: a case study in Latvia. Geodesy and Cartography Volume 42, Issue 3, p. 69-74.
4. Dobelis D., Zvirgzds J., Kaļinka M. (2017) High ionospheric activity effects on LatPos RTK network performance in Latvia. IOP Conference Series: Materials Science and Engineering. Viewed 18 June, 2018, (http://iopscience.iop.org/article/10.1088/1757-899X/251/1/012064/meta).
5. EUPOS-Riga. Homepage of Riga City Council City Development Department. Viewed 18 June, 2018, (http://www.rdpad.lv/geotelpiska-informacija/eupos-riga/). (In Latvian).
6. Kluga A., Kluga J., Bricis A., Mitrofanovs I. (2013) Multiple Frequencies Precise GNSS RTK System Research in Dynamic Mode. IFAC Proceedings Volume 46, Issue 28, p. 95-98.
7. LatPos. Homepage of Latvian Geospatial Information Agency. Viewed 15 June, 2018, (http://map.lgia.gov.lv/index.php?lang=2&cPath=2&txt_id=13).
8. Silabriedis G. (2010) Rigas geodeziska vertikala tikla vesture un nakotne. Scientific Journal of Riga Technical University 2010. Viewed 15 March, 2018, (https://ortus.rtu.lv/science/lv/publications/8896/fulltext). (In Latvian).
9. Transformacijas programmas. Viewed 15 March, 2018, (http://www.vzd.gov.lv/lv/pakalpojumi/profesionaliem/merniekiem/noderigi-materiali/#Transformacijas-programmas). (In Latvian).
10. Vieteja geodeziska tikla noteikumi (2012) Regulations of Cabinet of Ministers No 497 24.07.2012. Viewed 25 June, 2018, (https://likumi.lv/doc.php?id=250460). (In Latvian).
11. Vietejais geodeziskais tikls. Homepage of Riga City Council City Development Department. Viewed 25 June, 2018, (http://www.rdpad.lv/geotelpiska-informacija/vietejais-geodeziskais-tikls/). (In Latvian).

## Information about authors

**Armands Celms,** Dr.sc.ing., assoc. professor, Department of Land Management and Geodesy, Faculty of Environment and Civil Engineering, Latvia University of Life Sciences and Technologies. Address: Akademijas Street 19, Jelgava, LV–3001. E-mail: armands.celms@llu.lv

**Velta Parsova**, Dr.oec., professor, Department of Land Management and Geodesy, Faculty of Environment and Civil Engineering, Latvia University of Life Sciences and Technologies. Address: Akademijas Street 19, Jelgava, LV–3001. E-mail: velta@parsova.lv

**Ilona Reke**, PhD student at Department of Land Management and Geodesy, Faculty of Environment and Civil Engineering, Latvia University of Life Sciences and Technologies. Address: Akademijas Street 19, Jelgava, LV–3001. E-mail: ilona.reke@gmail.com

**Janis Akmentins**, Bc. student at Department of Land Management and Geodesy, Faculty of Environment and Civil Engineering, Latvia University of Life Sciences and Technologies. Address: Akademijas Street 19, Jelgava, LV–3001. E-mail: janis.akmentins@riga.lv

DOI: 10.22616/j.balticsurveying.2018.014

# POSSIBILITIES OF USE OF REMOTE SENSING TECHNOLOGY IN SURVEY PROCESS IN THE TERRITORY OF PILS ISLAND IN JELGAVA

**Armands Celms[1], Vivita Pukite[1], Ilona Reke[1], Jolanta Luksa[1, 2]**
[1]Latvia University of Life Sciences and Technologies
[2]GeoLux Ltd.

**Abstract**
In the study, creation of 3D surface relief model in Jelgava, for southern part of the Castle Island is depicted. Information about remote sensing, its historical development, as well as directions of remote sensing, development of photogrammetry and laser scanning is summarized and analysed. Principles of work and methods of photogrammetry and laser scanning. Information about creation of surface relief model from planning of unmanned aircraft, data capture and alignment to the end product – surface relief model. Application of evaluation of data obtained. The purpose of the study – to create 3D surface relief model in Jelgava, for the southern part of the Castle Island.
Tasks of the study – to consider development and improvement of photogrammetry and its processes, as well as development of laser scanning and principles of its work; to research, analyse and describe technological processes of laser scanning; to create 3D surface relief model in Jelgava, for the southern part of the Castle Island; to perform comparison of surface models obtained and describe application of laser scanning.
Preparation of surface relief model is time-consuming process, which includes flight planning and preparation of end-product. End-products obtained in data processing of laser scanning have very broad usage in many sectors related to geodesy and construction.
Key words: remote sensing, photogrammetry, laser scanning, relief, 3D model.

## Introduction

Already long time ago, mankind interested, what is shape of Earth. We can look to it best from satellite images. These images give visual outlook to shape of Earth, relief, situation of various objects. From satellite images we can forecast, as well as model diverse situations, which could emerge on region of Earth, or endanger existence of individual regions or towns, as well as natural disasters, volcano eruptions, tornado.
Satellite images are as the big brother for smaller photographs, which can be taken by diverse methods of photogrammetry. New technologies enter the sector of land surveying. By them work can be done safer, faster and more interesting. One of the newest technology is laser scanning, result of which is point cloud, from which diverse 3D models can be created.
The purpose of the study – to create 3D surface relief model in Jelgava, for the southern part of the Castle Island.
Tasks of the study – to consider development and improvement of photogrammetry and its processes, as well as development of laser scanning and principles of its work; to research, analyse and describe technological processes of laser scanning; to create 3D surface relief model in Jelgava, for the southern part of the Castle Island; to perform comparison of surface models obtained and describe application of laser scanning.

## Methodology of research and materials

For the preparation of the study, diverse databases of scientific papers, materials from Internet resources, normative acts included, publications and books were considered. In order to examine, study and analyse the available literature, monographical (descriptive) research method was used. In order to research and analyse remote sensing methods and usage, abstractly logical method and technique of the method – analyse was used.
Photogrammetry and remote sensing is art, science and technology for obtaining of reliable information about the Earth, surrounding environment and other physical objects and processes, by

data capturing by non-contact imaging and other sensor systems and measuring, analyse and depiction of them (Vanags, 2003).
Photogrammetry can be regarded as one of remote sensing methods, the main task of which is geometrical reconstruction of objects. It is possible to make photogrammetrical measurements in images. They can be done in one image, in pair of images or in several images or in block of images. Images can be photographic or digital. Measurements are usually performed by special instruments or on screen of computer. There was stereoscopical vision and measuring principle used on these measurements. They can be performed also automatically, by use of special correlation algorithms. Depending on the fact, how the photogrammetrical surveying and geometrical reconstruction of objects is performed, photogrammetry can be classified into analogic, analytical and digital photogrammetry (Casagli et al, 2016).
Depending on distance to the object, of which photo shall be taken, and location of photocamera aerial photogrammetry and terrestrial photogrammetry are distinguished.
Aerial camera with unmanned aircraft is lifted in some specific height that depends on location of the object, features of the relief. Thus possibility to fix situation from top is created. Main sector of usage of aerial photogrammetry is production of topographical maps and plans, as well as production of orthophoto maps (Mulder et al., 2011). Data obtained for purposes of topographical maps and plans in the photogrammetrical way is called digital terrain model, which can be the base of geographical informations systems. The necessary accuracy can be obtained, if corresponding scale of the image is selected (Zarrabeitia, 2013).
In the terrestrial photogrammetry, distances to the object, photo of which shall be taken, are relatively small. In this case, camera is installed on tripod and situation can be fixed in arc of 360 degree. It is used in architecture, in surveying of buildings and other engineering objects, in monitoring of construction etc. (Vanags, 2003).
Systematical observation of large territories and even of whole surface of Earth became possible only due to artifical satellites. One of the first examples, but still globally important civil remote sensing tools are USA multispectral satellite series „Landsat" with spatial resolution within 15 – 30 m, out of which „Landsat-1" was launched 1972, but „Landsat-8" – 2013. Later civil satellites with considerably greater spatial resolution were launched, as French series „Spot" (the newest satellites „Spot-6" and „Spot-7" have 1.5 m or 6 m resolution depending on work mode), „WorldView-3" (multispectral images with 1.24 m resolution), „RapidEye" (5 m resolution) etc. (Talizpete, 2017).
French colonel A.Losedo is considered as founder of photogrammetry. 1859 he gave lecture to the commission of Academy of Science of Paris on the method, how from a pair of images by a spatial crossing of rays it is possible to determine coordinates of the object (Lillesand, 2014).
In Latvia, geodesist Alvils Buholcs has given large contribution. He developed method of determination of deformation in stereophotogrammetry, has invented aerial photograph transformation apparatus in aerial photogrammetry and has improved radialtriangulation method (Kletnieks et al., 2000).
Electronic data processing created large changes in photogrammetry. It allowed to replace many optically mechanical components in stereoinstruments and to develop analytical photogrammetry, as well as aerial triangulation, which considerably allowed to reduce number of support points, which are to survey geodetically (Vanags, 2003).
The first technology of 3D scanning was created in sixties of 20th century. Original scanners used lights, cameras and projectors, in order to execute this task. Due to limitations of the equipment often much of time and efforts was necessary for exact scanning of objects. After 1985 they were replaced with scanners, which could use white light, lasers and shadows in order to depict certain surface (Lillesand, 2014).
3D laser scanner works, firstly by projecting laser light to object or surface, then the reflected light is determined. Based on that, where lighting is one-to-one, scanner calculates their positions and creates data points. These points help to computer renew visually (Nerlich, 2012).
Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to on-site observation. In current usage, remote sensing refers to use of aircraft-based sensor technologies in order to determine and classify objects on surface of Earth, in atmosphere and in oceans, by use from satellite, aircraft emitted, and then from

object reflected and accrued electromagnetic radiation or also dissipated solar light (Lillesand et al., 2014).
The contemporary remote sensing of Earth surface is carried out mainly in diverse ranges of electromagnetic radiation – in visible light, infrared radiation, radio waves. In specific researches, gamma ray range is also used, however we shall not consider them more. The used instruments usually are installed on artifical satellites, aeroplanes or unmanned aircrafts. Remote sensing as branch of science researches data processing methods, by which it is possible from image obtained by the instrument to get valid information (Hadj Kouider, 2017).
Data processing methods of the remote sensing are gradually developed for several decades, still practical usage of them causes difficulties. In uncountable potential application sphere, remote sensing data are not used in practice due to results that can be difficultly interpreted. For obtaining of valid, practically usable results it is optimally, if in the research remote sensing specialists, which have a good knowledge of all nuances of image processing methods, and specialists of science sectors, which know end usage sectors in details, are working (Talizpete, 2017).
In order to reconstruct position and shape of objects from images, you have to know geometrical laws, which makes a base for formation of photographical image.
Photographical image emerges, when in plane of image light rays coming through camera objective are projecting, where light-sensitive film emulsion detects them. After developing and copying, image is obtained, where measurements can be done. Similarly, digital image is obtained in digital sensor, which is saved and which can be displayed in monitor of the computer. As measurements are made in photogrammetry, the obtained picture and also camera shall be described geometrically. In cameras, images are obtained, which with sufficient accuracy can be regarded as central projection of spatial objects depicted there. Map, however, is ortogonal projection of terrain on projection plane in certain scale. Every object is projected in straight angle according to this plane. All rays of projection are parallel. Such projection could be obtained theoretically, if distance to camera is infinity. Main task of photogrammetry is to convert the central projection into ortogonal projection (Vanags, 2003).
Aerial laser scanning allows to obtain information also about soil under plants, which is not provided by aerial photography, because part laser rays among plants comes to the surface of Earth. Accuracy is provided in decimeters (Vanneschi et al., 2017).
Accuracy and quality of results of laser scanning depends on many circumstances, for example, on device and method chosen, on basic network and number, configuration and accuracy of control points, from weather etc. Knowledge and experience of performer of the work are the most essential factors. We shall count on the following – the more accurate are results, we wish to obtain, the more expensive it will cost. There is often desire to receive data with 1 mm accuracy in the practice, although in reality 1 cm accuracy would be completely sufficient (Smilga & Partna, 2016).
As it was afore-mentioned, the purpose of the research was creation of 3D surface relief model in Jelgava, for the southern part oft he Castle Island.
In order to create 3D surface relief model, not only rather broad technical equipment, but also skills and knowledge in the sector of data capture, processing and preparation is necessary.
In order to be capable to execute tasks of remote sensing, rather large technical equipment is necessary. Firstly, unmanned aircraft with camera is necessary, by help of which photoimages are taken and by processing of them photo visualization is created. In the same way, unmanned aircraft with laser scanner is necessary, in order to perform scanning and to prepare surface relief model from data obtained. Certainly, software will be necessary in the area of data alignement and for further work with aligned data. It is necessary to perform control measurements; this can be done by GPS.
In order to give broader insight into application of laser scanning data and possibilities in general, two surface relief models were prepared. As well as they were compared mutually. Data for preparation of the first relief model were obtained by organization of laser scanning, i.e., laser scanning was performed on 9 March 2018 (see Fig.1).

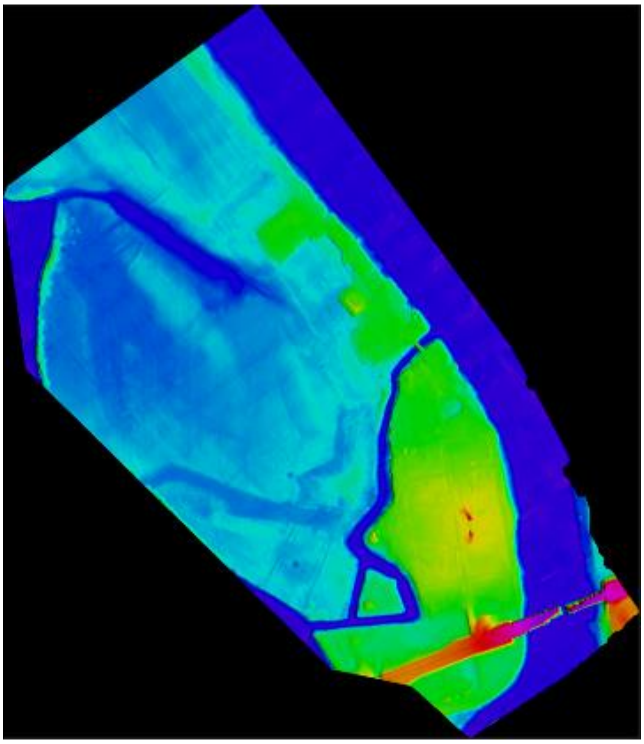


**Fig. 1.** Surface relief model of 9 March 2018. *(Source: prepared by the author)*

Data for second relief model were obtained from measurements performed on 1 May 2018 (see Fig. 2).

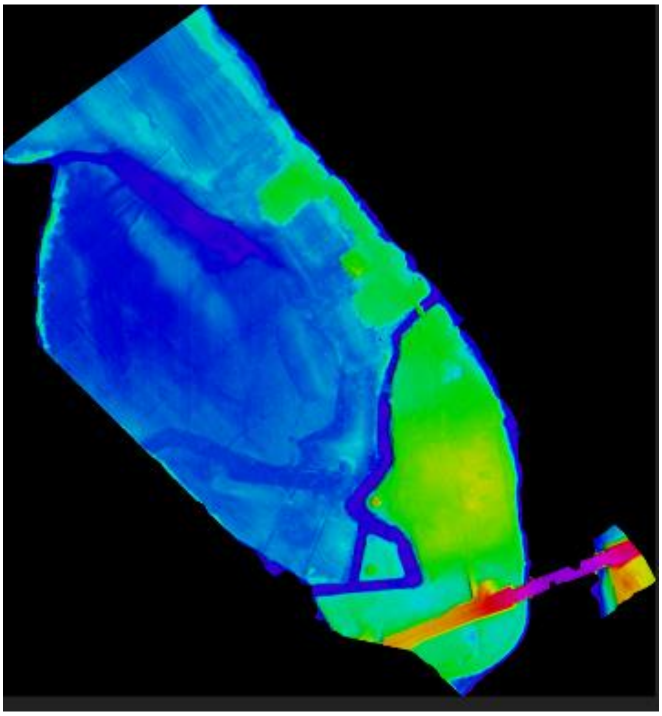


**Fig. 2.** Surface relief model of 1 May 2018. *(Source: prepared by the author)*

**Discussions and results**

As it was said before, two surface relief models were prepared in the framework of the research. They are different, because data are obtained in different time; data of the first relief model were obtained, when, ground was covered by snow and water was covered by ice, but data of the second relief model were obtained, when vegetation has started to bud or has finished budding practically.

On 9 March 2018, air temperature was plus 4 degrees. Deapth of snow in object of scientific research was 15 – 20 cm. Wind speed 3 – 5 m/s. Water bodies were covered by ice (Weather forecast, 2018).
On 1 May 2018, air temperature was plus 20 degrees. Sunny day, without clouds. Wind speed 10 – 15 m/s (Weather forecast, 2018).
In order to perform laser scanning for the southern part of the Castle Island in area of 58 ha, mission or plan of flight of unmanned aircraft was prepared. Totally three flights were planned and carried out, in order to prepare one relief model. So, 6 flights in total for both relief models. Both relief models had equal flight plans.
In the result of laser scanning, point cloud is obtained, which in the course of processing is created into point cloud model and georeferenced. Point cloud consists of millions points, each point contains information on coordinates of its location and intensity of the reflected signal (Catalucci et al., 2018).
Processing of point cloud and preparation of surface relief model was realized in Bently MicroStation with add-in of TerraSolid programm package.
In surface relief model of 9 March 2018 we can see that model is in the whole boundary of the object. This means that laser scanner has scanned surface of the Earth in whole boundary. Also in place, where is river Lielupe, the reflection is received, because river then was covered by ice. This concerns all water bodies within the boundaries of the object. Accuracy of measurements can be influenced by the snow existing in the object. Mutual flight trajectory shift after their alignment can be seen in Table 1.
Mean magnitude after data processing of laser scanning performed by 9 March 2018 was 0.1094 m. The largest magnitude was observed for trajectory 9 – 0.1856 m, but the least for trajectory 3 0.0695 m. The largest difference of heights was for trajektory 8 -0.1202 m. After the alignment of trajectories, it is necessary to perform alignment of points to performed control measurements, thus elevation differences are precluded and aligned.

**Table 1**

Trajectories of flight of 9 March 2018 after alignment

| Trajectory | Point | Magnitude | Height, m |
|---|---|---|---|
| 3 | 163721 | 0.0695 | -0.0004 |
| 4 | 62139 | 0.0801 | -0.0133 |
| 5 | 223799 | 0.1171 | +0.0300 |
| 6 | 192260 | 0.1319 | -0.0140 |
| 7 | 188104 | 0.1702 | +0.1237 |
| 8 | 183728 | 0.1799 | -0.1202 |
| 9 | 18444 | 0.1856 | +0.0052 |
| 12 | 67124 | 0.0785 | +0.0568 |
| 13 | 300121 | 0.0915 | +0.0273 |
| 14 | 283102 | 0.0977 | -0.0295 |
| 15 | 225977 | 0.0824 | +0.0467 |
| 16 | 199588 | 0.1003 | -0.0525 |
| 17 | 171652 | 0.0724 | -0.0203 |
| 18 | 120055 | 0.1179 | +0.0558 |
| 19 | 98940 | 0.1124 | +0.0147 |
| 20 | 111366 | 0.0772 | +0.0166 |
| 21 | 18144 | 0.0703 | +0.0107 |
| 25 | 113961 | 0.1523 | -0.0572 |
| 27 | 102555 | 0.1068 | -0.0241 |
| 29 | 103772 | 0.0934 | -0.0335 |

In surface relief model of 1 May 2018 we can see that model is not in the whole boundary of the object. This means that laser scanner unfortunately could not to scan surface of Earth in the whole boundary. Reflection is not received from the large water bodies, therefore there are empty places in the model. The Channel at the Jelgava Castle situated in the object is filled-in, because software has performed mutual triangulation of points. Mutual shift of flight trajectories after alignment can be see in Table 2.

According to processed data of 1 May 2018 we can see that trajectory 25 0.1012 m has the greatest magnitude, but trajectory 12 0.0590 m has the least one. Differences of heights for all trajectories is below 0.02 m. The mean magnitude was 0.0756 m.

When we compare data obtained in laser scanning, we can conclude, that the second flight (on 1 May 2018) was more successful and also more accurate, which facilitates further activities for preparation of the model.

**Table 2**

Trajectories of flight of 1 May 2018 after alignment

| Trajectory | Point | Magnitude | Height, m |
|---|---|---|---|
| 3 | 15385 | 0.0692 | +0.0170 |
| 4 | 4992 | 0.0667 | +0.0028 |
| 5 | 12121 | 0.0783 | -0.0130 |
| 6 | 13631 | 0.0850 | -0.0110 |
| 7 | 12371 | 0.0825 | +0.0038 |
| 8 | 17663 | 0.0770 | +0.0043 |
| 9 | 19080 | 0.0740 | -0.0063 |
| 10 | 15161 | 0.0773 | -0.0164 |
| 11 | 16840 | 0.0659 | -0.0023 |
| 12 | 21132 | 0.0590 | +0.0046 |
| 13 | 16998 | 0.0701 | -0.0142 |
| 14 | 20639 | 0.0633 | -0.0076 |
| 15 | 15895 | 0.0620 | +0.0018 |
| 16 | 17159 | 0.0631 | +0.0127 |
| 17 | 14564 | 0.0698 | +0.0129 |
| 18 | 9505 | 0.0962 | -0.0025 |
| 19 | 8084 | 0.0979 | +0.0102 |
| 20 | 9175 | 0.1007 | -0.0101 |
| 21 | 3241 | 0.0783 | +0.0052 |
| 25 | 9499 | 0.1012 | +0.0029 |
| 27 | 8630 | 0.0911 | +0.0111 |
| 29 | 103772 | 0.0934 | -0.0335 |

Additionally to preparation of surface relief models, also photo fixation by unmanned aircraft, to which camera is connected, was performed. After obtaining of photoimages, the images were processed by software Pix4D, and photo visualization plan as visual viewing material was produced (see Fig. 3).

When both surface relief models were compared, it was clarified that heights in the both models differ. There can be several explanations. Firstly, different weather conditions, in which laser scanning was performed. Rather many things are influenced by the wind speed during flight. The stronger is wind, the more difficult for unmanned aircraft is to maintain its route. Similarly, snow existing in March influences the result, because laser rays cannot break through snow and direct reflection from the surface of the Earth is not received.

**Fig. 3.** Photo visualization. *(Source: prepared by the author)*

End products obtained as a result of laser scanning data processing have broad usage, e.g., topography mapping, mapping and visualization of built-up areas, territorial planning, environment and nature management, monitoring included, monitoring of mining sites, information for planning of construction works, geology, hydrology and pedology, as well as other sectors, where geospatial information is necessary.

## Conclusions and proposals

1. Remote sensing is complicated and complex science sector, nevertheless it gives versatile knowledge about geodesy, photogrammetry a.o. related sectors.
2. Laser scanning gives multiform possibilities for improvement of contemporary land surveying sector, as well as for facilitating human work, by allowing work be done faster and more securely.
3. Preparation of surface relief model is a time-consuming process that includes flight planning and preparation of end-product.
4. There are several factors that can influence the end result, for example, weather – snow or wind speed, also magnetic fields, therefore it is necessary to take all them into account and avoid as much as possible from impact of these factors by performing planning part correctly.
5. From data processing of laser scanning performed on 9 March 2018 we can draw conclusion that the accuracy of data obtained is not in the highest level, because the mean value of magnitudes is 0.1094 m. It may be for the reason of weather, e.g., wind speed.
6. From data processing of laser scanning performed on 1 May 2018 we can draw conclusion that data are more accurate than data obtained from the first laser scanning, the mean value of magnitude is 0.0756 m.
7. End products obtained in laser scanning data processing have very wide usage in many sectors related to geodesy and constructions.

## Acknowledgements

The research was supported by the project "Strengthening Research Capacity in the Latvia University of Agriculture" (agreement No 3.2.-10/46; Z6).

Authors are thankful to GeoLux Ltd. company for technical support.

### References

1. Casagli N., Cigna F., Bianchini S., Hölbling D., Füreder P., Righini G., Del Conte S, Friedl B., Schneiderbauer S., Iasio C., Vlcko J., Greif V., Proske H., Granica K., Falco S., Lozzi S., Mora O., Arnaud A., Novali F., Bianchi M. (2016) Landslide mapping and monitoring by using radar and optical remote sensing: Examples from the EC-FP7 project SAFER. Remote Sensing Applications: Society and Environment 4 (2016). Elsevier. p. 92-108
2. Catalucci S., Marsil R., Moretti M., Rossi G. (2018) Comparison between point cloud processing techniques. Measurement: Journal of the International Measurement Confederation. Volume 127, October 2018, p. 221-226

3. Hadj Kouider M., Nezli I. E., Belhad H. (2017) The use of spectral responses of surface in the discrimination of siols surface by remote sensing. Energy Procedia 119 (2017) p. 622-631
4. Kletnieks J., Timsans S., Lerha R. (2000) Par geodezijas izglītības un zinatnes pamatliceju ne tikai Latvija — prof. Dr. ing. Alvilu Buholcu (1880—1972). Latvijas Vestnesis 27.06.2000., No 240/241 (2151/2152). Viewed 10 May, 2018, (https://www.vestnesis.lv/ta/id/8485). (In Latvian).
5. Lillesand T., Kiefer R. W., Chipman J. (2014) Remote sensing and image interpretation, John Wiley & Sons, p 1-4, 41-49.
6. Mulder V. L., Bruin S., Schaepman M. E., Mayr T. E. (2011) The use of remote sensing in soil and terrain mapping - a review. Geoderma Volume 162, Issues 1–2, 15 April 2011, p. 1-19
7. Nerlich B. (2012) 3D Laser scanning history. Viewed 5 May, 2018, (http://artescan.net/blog/3-d-laser-scanner-history/).
8. Smilga R., Partna J. (2016) Musdienigas uzmerisanas tehnologijas. Viewed 5 May, 2018, (https://abc.lv/raksts/musdienigas-uzmerisanas-tehnologijas). (In Latvian).
9. Talizpete (2017) Homepage of Institute of Engineering "Ventspils International Radio Astronomy Center" Viewed 6 May, 2018, (http://virac.eu/petnieciba/petniecibas-virzieni/talizpete/tradicijas/). (In Latvian).
10. Vanags V. (2003) Fotogrammetrija. Musdienu Latvijas topografiskas kartes. Riga: Valsts zemes dienests. 275p. (In Latvian)
11. Vanneschi C., Eyre M., Francioni M., Coggan J. (2017) The Use of Remote Sensing Techniques for Monitoring and Characterization of Slope Instability. Procedia Engineering 191 (2017). p. 150-157
12. Weather forecast on 9th March and 1st May, 2018. State Ltd "Latvialn Environment, Geology and Meteorology Centre". Viewed 9 March and 1 May, 2018, (https://www.meteo.lv).
13. Zarrabeitia L. A., Mederos V. H. (2013) Multiresolution terrain modeling using level curve information. Journal of Computational and Applied Mathematics 240 (2013) p. 87-98

**Information about authors**

**Armands Celms,** Dr.sc.ing., assoc. professor, Department of Land Management and Geodesy, Faculty of Environment and Civil Engineering, Latvia University of Life Sciences and Technologies. Address: Akademijas Street 19, Jelgava, LV–3001. E-mail: armands.celms@llu.lv

**Vivita Pukite**, Dr.oec., assoc. professor, Department of Land Management and Geodesy, Faculty of Environment and Civil Engineering, Latvia University of Life Sciences and Technologies. Address: Akademijas Street 19, Jelgava, LV–3001. E-mail: vivita.pukite@llu.lv

**Ilona Reke**, PhD student at Department of Land Management and Geodesy, Faculty of Environment and Civil Engineering, Latvia University of Life Sciences and Technologies. Address: Akademijas Street 19, Jelgava, LV–3001. E-mail: ilona.reke@gmail.com

**Jolanta Luksa**, Bc.sc.ing. Representative of "GEO LUX" Ltd. Address: Baznicas Street 45-25, Riga, LV-1010. E-mail: luksa.jolanta@gmail.com

DOI: 10.22616/j.balticsurveying.2018.015

# LEGITIMATION OF "SPECIAL VALUE" AS A TOOL OF LEGAL PROTECTION OF LANDS: THE CASE OF UKRAINE

**Taras Ievsiukov**
National University of Life and Environmental Sciences of Ukraine

**Abstract**
The main factors that influence the rational land use, conservation and protection of land resources are global ecological and food security, world's population growth, climate change, land acquisition by large world agricultural corporations etc. In this process a priority of attention is protection of the important agricultural lands (in Ukraine, these lands are called especially valuable lands - EVL). Besides, lands with highly productive soils, areas with undisturbed ecosystems, territories with objects of cultural heritage, natural therapeutic resources are a part of EVL. This paper focuses on new approaches to the legal protection of EVL in Ukraine. The special value of these lands in Ukraine is legalized and is means of their legal protection (Art. 150 of the Land Code of Ukraine).

The main idea of this paper – studying of problems of legal protection of EVL and development of new approaches to their protection. These approaches will be based on introduction of economic regulators at withdrawal of EVL or change their intended use for needs that don't correspond to nature protection value.

The reseach is based on case study method and statistical method. Approaches for cartographic modeling for assessment and mapping of EVL are offered.

Results of this reseach are an obtaining of practical experience in the field of protection of EVL in Ukraine, development of suggestions for improving of an organizational and legal mechanism the use of EVL through their registration, monitoring, evaluation, development of their State Register. These measures can increase competitiveness of EVL, prevent Land-Grabbing and provide sustainable development of the rural territory.

Key words: especially valuable lands, special value, legal protection, land, important agricultural lands.

## Introduction

In the 21st century, many countries in the world implement a rigorous policy of preserving the capacity of arable land while simultaneously intensive use. The main reasons for introducing such land policy are: 1) aggravation of the global food crisis, deepening of geopolitical, environmental problems, loss of productive lands as a result of negative human activity and the growth of the global deficit of agricultural land, which leads to the global scale of their accumulation by world financial corporations, and in some cases states ("land grabbing"); 2) unsystematic urbanization and transformational processes in the agrarian sector and, as a result, dynamic changes in land use; 3) the key role of productive lands in ensuring sustainable social and economic development of society; 4) the need to introduce new effective barriers to the conservation of high-yielding lands, valuable natural components, objects of historical and cultural heritage; 5) lack information regarding the proliferation of productive lands, parameters of their condition and land use; 6) the need to provide state authorities and local self-government, interested in enterprises' and institutions and citizens with information on land availability.

The most valuable lands play a important role in ensuring stable social-economic development in growing global threats to human development. In countries such as Greece, China, Germany, the USA, France and others, there are examples of the allocation of special value land as the basis for maintaining their uniqueness or high productivity. Such land include to the national registers, which is a serious barrier when withdrawing them for non-agricultural needs (K. Hennenberg et. al., 2008; P. Pointereau et. al., 2007). P. Loiko (2009) study of valuable high-yielding agricultural lands with the aim of their protection. At the level of administrative-territorial units, these approaches are deepened O.Golodnaya and N. Kostenkov. The scientists have developed proposals for the allocation of particularly important and valuable agricultural lands and the establishment of boundaries of these territories in order to create a special regime for their use (2010). Examples of studies of land-resource capacity of a whole Ukraine and its regions, administrative and natural geographic regions may serve as a researches of S. Doroguntsov, V. Rudenko, M. Hvesyk. Concentrated their attention on

the study of the problems of land use and land protection D. Babmindra, D. Dobryak, O. Kanash, A. Martyn, L. Nowakowskiy, A. Tretiak, M. Fedorov.
It should be noted that the relevance of this paper focuses on approaches to the legal protection of especially valuable lands (EVL) in Ukraine. This paper is study of the problems of legal protection of EVL and development of new approaches to their protection. These approaches will be based on the introduction of economic regulators in the seizure of EVL or changing their intended use for needs that don't meet the conservation value.

**Methodology of research and materials**

The main research methods were the following: statistical (when processing the results), mapping (during development and conclusion of cartographic models (maps) that displays available spatial information on the distribution of EVL and their evaluation, and their subsequent processing methods mathematical and cartographic modeling will provide a new (original) information). The materials for research were data from the State Service of Ukraine for Geodesy, Cartography and Cadastre. In particular, we used statistical information on quantitative land accounting, land evaluation materials and other data.

**Discussions and results**

Ukraine is one of the largest countries in Europe, its area is 60,4 million hectares. More than 53,6% (32,4 million hectares) of the Ukrainian territory is used for arable farming. About 1/3 of the arable land has such characteristics as to which these lands are classified as EVL.
They are the most valuable part of a national wealth of Ukraine. EVL concentrate in itself as the most productive lands available for natural and acquired properties, and can generate high yields of crops, the environment, recreational area; lands wich are subject of researches in the long-term, lands of historical and cultural significance etc.
In Ukraine the "special value" of these lands is legitimized at the state level and is tool of their protection. Thus, this is the main mechanism for the legal protection of EVL. Author's classification of legal protection of EVL includes the following types:
1. Especially valuable productive soils on agricultural land. Their area is 11950.65 thousand hectares (19.8% of the territory of Ukraine). They divided on especially valuable soils national level, especially valuable regional soils (http://zakon1.rada.gov.ua/laws/show/z0979-03).
This model allows us to include in the first group are EVL, which are determined by the highest fertility within all countries, despite their geographic location. That is their productive potential and it is highly compared to other soils. The second group includes soils that are the quality indicators. They are the most fertile in a particular region (appropriate single out in the context of natural agricultural provinces), but in other areas can be yield substantially by different productivity in fertile soils (O. Kanash, A. Martyn, 2003). In the development of these approaches at agricultural natural areas may produce locally most valuable soils (O. Kanash, 2009).
The EVL dominate the structure of agricultural land in the Forest-steppe and Steppe areas, where, depending on the province's natural and agricultural province, they make up from 15.0% (Stepovaya Danubian) to 40.2% (Steppe arid Left Bank). The estimation of these lands, as well as indicators of quantitative distribution in the regions of Ukraine is presented in Table 1 and Figure 1.

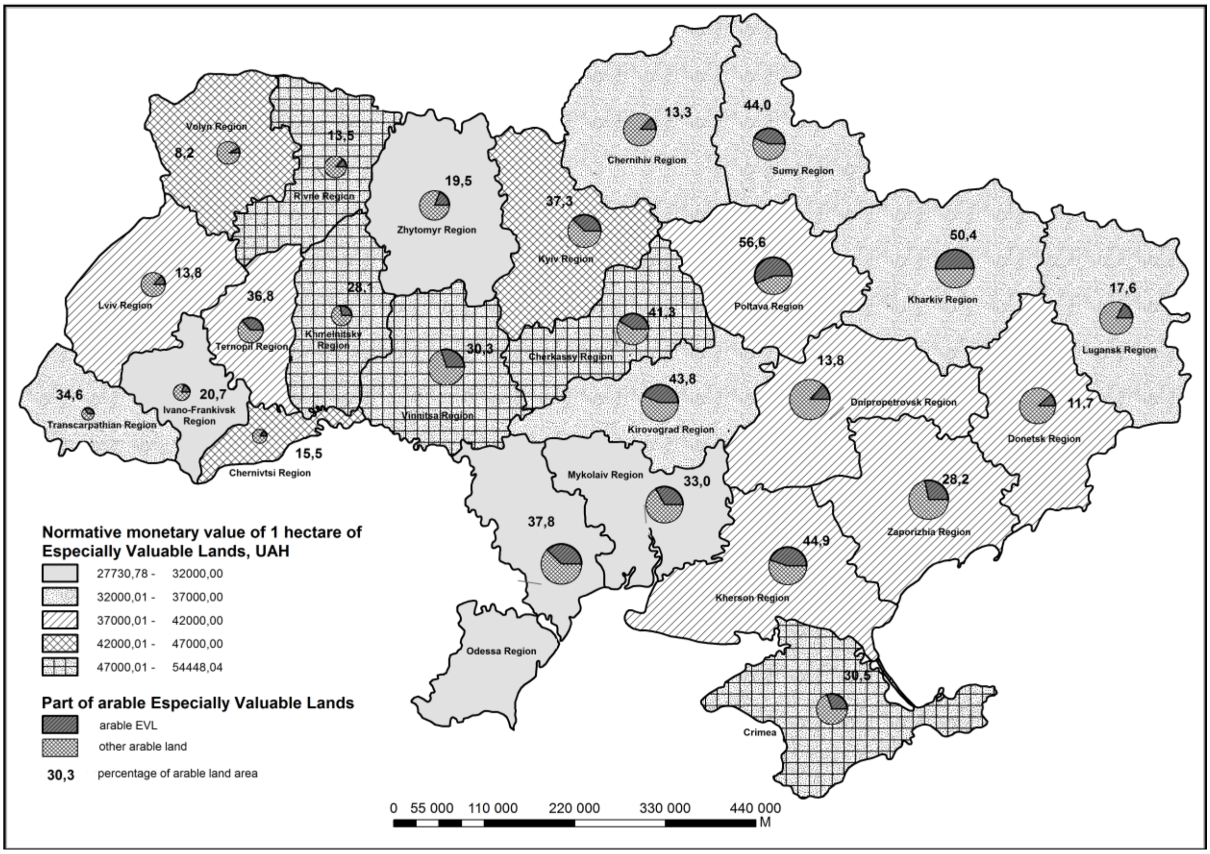



**Fig. 1.** Normative monetary value and part of arable EVL in the structure of arable land of Ukraine

The cost of EVL is 39.0% of the total cost of arable land in Ukraine. This is despite the fact that the area of these lands is 9.4 million hectares, or 31.5% of the total arable land of Ukraine.

2. Lands of nature conservation and other nature conservation purposes. Their area, according to the operational information of the State Service of Ukraine on Geodesy, Cartography and Cadastre, is 3326.4 thousand hectares (5.5% of the territory of Ukraine), including 655 objects of national level on the area of 1590.6 thousand hectares and 7513 objects of local level on the area of 1735.8 thousand hectares. They are mainly concentrated in Kherson Region (13 objects of national level and 66 local level on the area of 272.7 thousand hectares), Chernihiv Region (22 objects of national level and 633 local level in the area of 240.2 thousand hectares), temporarily occupied by the AR Crimea (44 objects of the national level and 137 local level on the area 178.4 thousand hectares).

The modern structure of the nature reserve fund of Ukraine includes 11 categories of territories and objects of national and local level. About 90% of all existing objects belong to nature monuments, preserves and protected areas, while up to 80% of the nature reserve fund is made up of nature reserves, national natural and regional landscape parks.

More than half of the lands of the nature reserve fund of Ukraine include territories and objects of national level, including 17 natural and four biosphere reserves (13.9% of the total area of the nature reserve fund), 17 national natural parks (25.0%), 303 nature reserves (12.6%), 132 natural monuments (0.2%), 17 botanical gardens, 19 dendrological and seven zoological parks (0.1%), 88 park-monuments of garden art (0.2%).

3. Lands of historical and cultural purpose occupy a relatively small area – 45.9 thousand hectares (0.1% of the territory of Ukraine). However, they accumulate in themselves the vital and aesthetic ideals of past generations and are an important part of the national cultural treasury. At the same time, about 143 thousand immovable cultural heritage sites that require special protection from the state are recorded on the territory of Ukraine. Today one of the important issues is inventory of lands of historical and cultural purpose and registration of rights to use them.

**Table 1**

The cost of arable EVL in the structure of arable land of Ukraine

| Region | Arable land area | | | Normative monetary value of arable land as of 01.01.2016, UAH / ha | | | Difference in the cost of 1 hectare of arable EVL and other arable land, UAH / ha |
|---|---|---|---|---|---|---|---|
| | Total, ha | Including EVL | | Arable land of the region | Arable EVL | Other arable land (except EVL) | |
| | | ha | % | | | | |
| Crimea | 1144594 | 348933 | 30,5 | 36947,60 | 47143,84 | 32476,09 | 14667,75 |
| Vinnitsa | 1572768 | 476439 | 30,3 | 33073,42 | 47378,11 | 26856,93 | 20521,18 |
| Volyn region | 623606 | 51149 | 8,2 | 29940,42 | 44428,48 | 28645,91 | 15782,57 |
| Dnipropetrovsk | 1955004 | 270628 | 13,8 | 32525,99 | 37045,07 | 31799,91 | 5245,16 |
| Donetsk | 1568553 | 183691 | 11,7 | 34854,68 | 39730,71 | 34207,91 | 5522,80 |
| Zhytomyr | 1062258 | 207127 | 19,5 | 20580,98 | 31726,66 | 17881,31 | 13845,36 |
| Transcarpathian | 180297 | 62346 | 34,6 | 26377,87 | 36634,77 | 20956,33 | 15678,44 |
| Zaporizhia | 1868442 | 526173 | 28,2 | 33838,40 | 41043,92 | 31013,82 | 10030,10 |
| Ivano-Frankivsk | 326606 | 67468 | 20,7 | 28567,62 | 30625,89 | 28031,74 | 2594,15 |
| Kyiv region | 1304213 | 486480 | 37,3 | 31970,15 | 45409,83 | 23974,71 | 21435,11 |
| Kirovograd | 1641518 | 719250 | 43,8 | 32096,51 | 36170,27 | 28919,51 | 7250,76 |
| Lugansk | 1301940 | 229668 | 17,6 | 26520,22 | 33652,13 | 24992,65 | 8659,48 |
| Lviv | 711164 | 98033 | 13,8 | 26622,12 | 39991,79 | 24484,46 | 15507,33 |
| Mykolaiv | 1629194 | 536968 | 33,0 | 26361,05 | 27730,78 | 25687,66 | 2043,12 |
| Odessa | 1987976 | 752312 | 37,8 | 28112,83 | 31263,21 | 26194,77 | 5068,44 |
| Poltava | 1691902 | 956851 | 56,6 | 34252,51 | 38682,46 | 28485,83 | 10196,63 |
| Rivne | 571069 | 77086 | 13,5 | 31405,86 | 54448,04 | 27810,13 | 26637,90 |
| Sumy | 1222434 | 537233 | 43,9 | 29426,66 | 35699,23 | 24508,64 | 11190,59 |
| Ternopil | 776136 | 285496 | 36,8 | 30040,16 | 39536,30 | 24514,50 | 15021,81 |
| Kharkiv | 1793876 | 904735 | 50,4 | 32506,62 | 35583,73 | 29375,54 | 6208,20 |
| Kherson | 1727884 | 776288,2 | 44,9 | 34698,86 | 38441,90 | 31645,38 | 6796,51 |
| Khmelnitsky | 499190,9 | 140032,8 | 28,1 | 34496,74 | 48702,21 | 28958,14 | 19744,07 |
| Cherkassy | 1203120 | 496346 | 41,3 | 39811,13 | 48746,11 | 33536,36 | 15209,75 |
| Chernivtsi | 243793 | 37863 | 15,5 | 33999,84 | 44308,87 | 32104,39 | 12204,48 |
| Chernihiv | 1264192 | 168533 | 13,3 | 24422,96 | 36088,32 | 22628,61 | 13459,71 |
| **Total** | 29871730 | 9397129 | 31,5 | 30927,77 | 38340,34 | 27525,66 | 10814,69 |

Source: made by the author by using the data of the State Service of Ukraine on Geodesy, Cartography and Cadastre (http://land.gov.ua/)

4. The land of experimental fields of research institutions and educational institutions occupy almost 458.7 thousand hectares (0.8% of the territory of Ukraine).
5. The land wich will be included to EVL in the future. These lands include lands of other categories and today their allocation is not provided by law, but in the future it will be possible: forestry purpose (especially protective forest areas, plots with positive trees, etc.); recreational use (territories with unique natural recreational use); health resort (territories with unique natural therapeutic properties); lands of public and residential buildings (land plots of urban development, etc.); water fund (coastal protective strips, land of water protection zone).

On the one hand, as a result of the analysis of the legal basis for the protection of EVL, a high level of their legal protection has been established. Since these lands can be seized solely by the decision of the supreme legislative body of the state - the Verkhovna Rada of Ukraine. On the other hand, the practice of land relations shows a large-scale seizure of EVL without proper procedures.

The priority of agricultural land is fixed in the land legislation of Ukraine (Art. 23 of the Land Code of Ukraine), but on the facts these lands are a reserve for other land use, first of all, housing, public and industrial development. One of the peculiarities of EVL is their placement in plain areas or areas with a slight inclination. If such land is located near the city (village, settlement), the probability of their extraction for non-agricultural use in the future will be very high.

In the first place, the economic benefits of using land for development will exceed the economic benefits of its agricultural land use. Secondly, the demand for land for development is formed due to the demand for housing and the lack of settlements free of land development. As a result, unbuilt land will be considered as reserve areas to expand the boundaries of settlements. The increase in real incomes of citizens, observed before the financial and economic crisis of 2008, has contributed to the growth of such demand and, accordingly, the increase in housing prices. As a result, the investment attractiveness of land for development has increased. In the suburban areas of large cities, demand for land plots and agricultural land purpose, including EVL, have been growing in order to change their intended use for non-agricultural needs and to develop in the future by resale or development.

One of the ways to protect EVL from construction, we offer the economic and legal mechanism of their protection. It includes compensation by the person concerned of the market value of the land plot (estimated as built up) as well as losses of agricultural production caused by the seizure of agricultural land for use for non-agricultural purposes. Such actions will substantially reduce the economic motivation of those who are interested in changing the special purpose of EVL and their development.

The formula for calculating the amount of compensation for losses of EVL with a change in their intended use is proposed as follows:

$$L = Mv + \left( Ap \times Sl \times \frac{Bp}{Bl} \times Ki \right) \times Ks \qquad (1)$$

Where $L$ denotes amount of losses of agricultural production after seizure the plot (change of intended use) of EVL, UAH;

*Mv* denotes market value of the land with EVL, which is seizured, calculated as the cost of this land for building, UAH;

*Ap* denotes plot's area of the agricultural land, ha;

*Sl* denotes standard of losses of agricultural production, UAH;

*Bp* denotes soil bonitet of the agricultural land plot which have to seizure;

*Bl* denotes soil bonitet of agricultural lands in the Autonomous Republic of Crimea, the Administrative Region, the cities of Kyiv and Sevastopol;

*Ki* denotes the intensity coefficient of agricultural land use (the ratio of the indicator of differential income of the evaluation of arable land of the land valuation district, in which the land plot is allocated, to a similar indicator in the whole Autonomous Republic of Crimea, Administrative Region, cities of Kyiv and Sevastopol);

*Ks* denotes the coefficient that takes into account the integrated index of EVL values in the structure of land in the administrative district.

High compensatory payments for changing the special purpose of valuable land will be an important economic fuse for their urbanization. The funds received as a result of the payment of the corresponding reimbursements should be directed solely to the implementation of measures related to the implementation of land protection.

**Conclusions and proposals**

The parts of organizational and legal mechanism for the land use of EVL are as follows: high compensatory payments for their seizure, inventory and monitoring of EVL, the State Register of EVL. This register will become a tool of increased control by the state and the public for the adherence to the special regime for the use of EVL, protection of them from unjustified seizure and change of the intended purpose.

Information about the EVL should be made public on the public cadastral map of Ukraine. This will help to use the information when planning the territory and organizing the rational land use. Publicity of information about EVL will help to limit the "shadow" redistribution of EVL, the implementation of state, self-government and public control over their use and protection.

These measures can increase the competitiveness of EVL, prevent Land-Grabbing and ensure the sustainable development of rural territory.

**References**


1. Golodnaya O., Kostenkov N. (2010). Espessially Valuable and Valuable Agricultural Lands of Primorski Krai Territory. Herald Buryat State Agricultural Academy. V.R. Filippova, 4, 73-78 (in Russian).
2. Kanash O., Martyn A. (2003). Some approaches to compiling regional lists of especially valuable land. Land Management. 4, 45-48 (in Ukrainian).
3. Kanash O. (2001) Basic problems of agricultural land evaluation zoning. Land Management, 4. 35-38 (in Ukrainian).
4. Kanash O. (2009) Especially Valuable Lands: there is construction and real essence. Land Surveying Journal, 2. 44-45 (in Ukrainian).
5. Martyn A. (2011). The problem of sovereign Land Cadastre in Ukraine. Land Management and Cadastre, 3, 33-50 (in Ukrainian).
6. State Committee of Ukraine for Land Resources. On the use, protection and monitoring of valuable land on November 3, 1997 № 55. Internet site: http://www.uazakon.com/documents/date_7b/pg_iynkwl.htm (in Ukrainian).
7. State Committee of Ukraine for Land Resources. On approval of the list of most valuable groups of soils. on October 6, 2003 № 245. Internet site: http://zakon4.rada.gov.ua/laws/show/z0979-03 (in Ukrainian).
8. Nowakowskiy L., Oleshchenko M. (2007). Socio-economic problems of modern land management. Kyiv: Urozhai (in Ukrainian).
9. Dobryak D., Babmindra D. (2006) Ecological and economic principles of land reform in market conditions. Kyiv: Urozhai (in Ukrainian).
10. Dobryak D., Kanash O., Rozumniy I. (2001) Classification and ecologically safe use of agricultural land. Kyiv: Urozhai (in Ukrainian).
11. Tsarenko, A.A., Schmidt, I.V., Tarbaev, V.A. (2017). Actual aspects of cadaster relations in the monitoring system of land and rural areas. Journal of Environmental Management and Tourism, Volume VIII, Spring, 1(17): 116-122. DOI: 10.14505/jemt.v8.1(17).12
12. The Land Code of Ukraine, No. 2768-III, 25, October 2001 Internet site: http://zakon4.rada.gov.ua/laws/show/2768-14 (in Ukrainian).
13. Ievsiukov, T. (2013) Protection of Highly Valuable Land: Experience of Foreign Countries. *Land management, cadastre and land monitoring*. Volume 3, p. 19-26
14. Loiko P. (2009) *Land Use: Russia, the World (View to the Future).* Moskow. 332p.
15. Criteria and Indicators to Identify and Map High Nature Value Areas (2008) / K. Hennenberg, U. Fritsche, K.Wiegmann et al. // Joint International Workshop on High Nature Value Criteria and Potential for Sustainable Use of Degraded Lands, Paris, June 30-July 1, http://www.bioenergywiki.net/images/1/1e/OEKO_CI_RSB_2008_Joint_Issue-Paper_Criteria_WS_Paris_2008.pdf.
16. Definition, Identification and Monitoring of HNV Farmland in Germany. http://www.bfn.de/fileadmin/MDB/documents/themen/monitoring/Conferenc_Vilm_HNV_ind_final.pdf.
17. Pointereau P. Identification of High Nature Value farmland in France through statistical information and farm practice surveys / Philippe Pointereau, Maria Luisa Paracchini, Jean-Michel Terres et al. // [Електронний ресурс]. – Режим доступу: http://ams.jrc.it/publications/pdfs/JRC_HNV_France.pdf.
18. Prime and Unique farmlands. Agriculture / Jurist.com http://law.justia.com/cfr/title07/7-6.1.3.6.27.html.


**Information about author**


**Taras Ievsiukov**, Dr.Hab. in Economics., Assoc. Prof., Dean of the Faculty of Land Management, National University of Life and Environmental Sciences of Ukraine. Address: 17, Vasylkivska street, Kiev, 03040, Ukraine. phone: +380979088214, e-mail: ievsiukov_t@nubip.edu.ua . Fields of interest: land use management, rational land use land cadastre, land-use planning, land evaluation, mapping.

DOI: 10.22616/j.balticsurveying.2018.016

# PROPOSALS FOR CLASSIFICATION AND EVALUATION OF LAND DEGRADATION IN LATVIA

**Anda Jankava, Velta Parsova, Eva Laizane, Maija Berzina, Aina Palabinska**
Latvia University of Life Sciences and Technologies

**Abstract**
Land degradation is one of the most pressing problems ensuring sustainable use of land. In order to provide a clear understanding of land degradation and its risks, as well as to implement unified measures for prevention of land degradation in Latvia, the Land Management Law came into force in 2015. It individually defines the concepts of land and soil degradation, thus separating them from each other, as well as clarifying the term "degraded territory". However, despite these solutions in the regulatory framework of the land degradation, till now criteria for identifying land degradation have not been developed and approved, therefore their determination is very subjective and not comparable between municipalities and at the state level. The aim of the article is to develop and approbate degradation criteria for assessing land degradation in particular territory. In the article, based on the author's previous studies on the classification of land degradation, characterised one type of land degradation - the abandoned agricultural and forestry activity territory, as well as proposed subdivision of criteria classification into three levels – low, medium and high. As result of the study, it was concluded that the classification of degraded territories into three degradation levels is justified for the purpose of more objective identification and evaluation of land degradation.
Key words: degradation level, degraded territory, land degradation, land management, land use

## Introduction

Attention to land use and land management issues is being paid all over the world, because land is limited resource and its rational use is the foundation of the prosperity and development of every country. Land degradation is pending matter affecting sphere of land management. It is a process caused by human activity or climatic conditions, which reduces the useful properties of the land and, hence, the area of land used. Land degradation has become one of the biggest challenges not only in Europe but worldwide. This is also indicated by the soil scientist P. Buloks, who bases his view on statistics - about six million hectares of land are lost every year due to soil erosion, desertification affects about one sixth of the world's population and one fourth of the world's land, while the salinity of the soil affects about 20 millions of hectares of irrigated land (Bullock, 2005).

Although land degradation problems have been recognized for decades, government of Latvia started to focus seriously on this issue only in 2006, which by UN was announced as international year of deserts and land degradation. In the same year, the Ministry of the Environment of Latvia started to implement land degradation measures appointed in the Development Program of UN and Global environment facility project "UN Convention on the development of sustainable capacity and responsibility for implementation of the elimination of land degradation in Latvia", conducting investigation on changes of land quality and land degradation in several municipalities (Puce, 2006). Since then, several research and practical projects have been developed (Degradeto teritoriju izpēte..., 2004; Degradeto teritoriju un..., 2012; Jackson et al, 2012), which confirmed the fact that the problem of land degradation, defined both at international and European level, is very topical in Latvia as well. Latvia is not affected by the problem of desertification, however, land degradation is observed in various ways.

Both foreign and Latvian scientists have paid considerable attention to soil and land degradation in their studies, however, as pointed out by some scientific sources (Klavins et al., 2008), it is reasonable to pay attention to the fact that in most of the publications mainly is described soil degradation, its impact and prevention measures. However, soil degradation is just one of the causes of land degradation (Kasparinskis, 2014). When reading special literature, can be concluded that there is not one single definition of what is land degradation. In different sources it is defined in different ways, and conditions that affect land degradation are defined differently. However, many authors describe

land degradation as a reduction of the natural and beneficial characteristics of the land, or even loss resulting from natural processes and human activities (Sklenicka, 2016).
In order to provide a clear understanding on land degradation and its risks, as well as to implement unified measures for its prevention, in Latvia relatively recently (since 2015) the Land Management Law was promulgated. It defines the soil degradation and land degradation as separate terms, thus separating them from each other. There is provided an explanation of degraded territory - it is a territory with destroyed or damaged upper layer of ground or an abandoned territory of construction, extraction of mineral resources, economic or military activities (Zemes parvaldibas likums, 2014). However, despite these solutions in the regulatory framework of the land degradation process, till now criteria for land degradation identifying have not been developed and approved, therefore their determination is very subjective and not comparable between municipalities and at the national level. Similarly, does not exist adequate classification of degraded territories, there is no regulation on the procedure for identifying and assessing the current level of land degradation and its feasibility, as well as for measures to prevent land degradation.
Solving this issue and making interviews and inquiries with specialists, considerable number of experts pointed out that degraded territories should be classified according to their characteristics or criteria, and to pay more attention to the degree of degradation (low, medium, high) that could facilitate their assessment and prevention. Based on the definition of degraded territory given in the Land Management Law and previous researches of the authors, there are developed proposals of classification of degraded territories and set of land degradation criteria (Parsova, Jankava, et. al., 2017) (Table 1).

**Table 1**

Proposals for classification of degraded territories

| No | The type of degraded territory | Criteria for the determination of degraded territory |
|---|---|---|
| 1. | Degraded built-up territory | Depreciation of the buildings |
| | | Built-up territory overgrown with bushes |
| | | Pollution |
| | | Dump-site |
| | | The abandoned production territory or facility |
| | | Abandoned military territory or object |
| 2. | Non-recultivated territory of mining of mineral deposits | Abandoned territory of extraction of peat and construction materials |
| 3. | Unmanaged agriculture and forestry activity territory | Agricultural land overgrown with bushes |
| | | Dump-site |
| | | Abandoned production territory or object |
| | | Abandoned military territory or object |
| | | Invasive plants |
| | | Bogged-up land |
| | | Pollution |

On the basis of classification given in Table 1, this paper proposes to analyse one of the types - unmanaged agriculture and forestry activities territory, as well as breakdown of each criterion for the determination of degraded territory into degradation levels.

## Methodology of research and materials

**The aim** of the article is to develop proposals for degradation levels of each degradation criterion, to give characteristics (parameters) of each degradation level, as well as approbate these parameters. To achieve the goal, the following tasks have been set:

- to identify and describe degradation levels of each degradation criterion;
- to approbate land degradation parameters in a particular territory, surveying it, identifying and evaluating degraded areas in accordance with degradation levels.

Based on scientific publications, inquiries of experts, as well as authors' considerations (Sklenicka, 2016; Kust et al., 2016), has been made the subdivision of degradation criteria of unmanaged agriculture and forestry activities territory into three levels – low, medium and high. Description of degradation levels has been made taking into account land degradation volumes, surveying feasibility and priorities of its elimination (Table 2).

**Table 2**

Description of levels of degradation criteria of unmanaged agriculture and forestry activities territory

| **Degradation criteria** | **Degradation level** | | |
|---|---|---|---|
| | **low** | **medium** | **high** |
| Agricultural land overgrown with shrubs | 10 – 39 % of agricultural land | 40 – 69 % of agricultural land | 70 – 100 % of agricultural land |
| Uncultivated dump-site | area up to 50 $m^2$ | area 50 $m^2$ to 200 $m^2$ | area above to 200 $m^2$ |
| Abandoned territory or object of production | economic activities does not take place for 3 years | economic activities does not take place for 3 to 7 years | economic activities does not take place for more than 7 years |
| Abandoned territory or object of military purpose | X | X | the objects has not been demolished, the territory has not been reclaimed |
| The invasive plants (hogweeds) | hogweeds occupies up to 30 % of the area | hogweeds occupies 31-50% of the area | hogweeds occupies over 51 % of the area |
| Bogged-up land | insignificant bogging-up, there are drainage systems requiring maintenance | significant bogging-up, there are drainage systems requiring maintenance or reconstruction | bogging-up is in territories without drainage systems, construction of them is necessary |
| Pollution | X | X | if the polluted territory is registered in the Register of Polluted and Potentialy Polluted places |

Further in the article is given a description of levels of degradation criteria and characteristics (parameters) of their assessment.

**Agricultural land overgrown with shrubs**. Abandoned or unused agricultural land is considered agricultural land which is not used for agricultural production, as well as land overgrown with shrubs, except forest land. In future for unused agricultural land can be two options – gradual natural or artificial afforestation, or removal of shrubs. If agricultural land is slightly overgrown with shrubberies it would not be considered as degraded territory, but if the territory is covered with shrubs in the amount of 10% to 39% of total area, it could be considered as low degradation level, medium degradation level could be in the amount of 40% to 69% and high - 70% to 100%.

**Uncultivated dump-site**. An uncultivated dump-site is a place where no measures have been taken to prevent the negative effects of waste on human health and the environment (Atkritumu poligonu ierīkošanas..., 2011). It is foreseen to arrange dump-sites only in building areas where the purpose of land use is "building area of waste management companies", therefore, any waste disposal site in agricultural or forest land is considered illegal (Nekustama ipasuma lietošanas..., 2006). Even small uncultivated dump-site in agricultural or forest land is considered to be an expression of land degradation. Low degradation level could occur if dump-site occupies an area of up to 50 $m^2$, medium degradation level - if dump-site occupies an area from 50 $m^2$ to 200 $m^2$ and high – if more than 200 $m^2$.

**Abandoned territory or object of production**. There are six land use purposes of industrial land building areas, which are specified in Cabinet Regulation No.496 (20 of June 2006) "Classification of purposes of use of real property and order of their determination and change":

- industrial enterprise building area;
- warehouse building area;

- agricultural enterprise building area;
- fish farm and nursery building area;
- waste management company building area;
- unreclaimed industrial object building area (Nekustamā īpašuma lietošanas...., 2006).

On the other hand, the abandoned production area is the land in which production no longer takes place, and the buildings intended for production are abandoned. Abandoned production facility is an object where production has taken place in the past, but at the moment it is abandoned. For assessment of this degradation criterion we recommend to use the time factor – low degradation level could be observed in sites where the economic activity has not occurred for up to 3 years, medium degradation level – where the economic activity does not take place 3-7 years, but high - in the objects where the economic degradation does not take place for more than 7 years.

**Abandoned territory or object of military purpose**. Territories of military purpose belong to the group of land use purposes "Building areas of objects of national defence, security, police, fire fighting and rescue, border guards and penal institutions". To this group of land use purposes belongs built-up land on which intended use of the existing buildings is "Other, previously unclassified buildings", if they are used as buildings of penal institutions, defence forces, police and fire service buildings and yards, as well as land under these buildings and related auxiliary buildings, internal transport and maintenance of utilities these territories, land under car parking areas and garages, etc. Also, this group includes land without buildings but used land, which according to legally established use, spatial plan or detailed plan, are intended for construction of such buildings, including construction of local utilities and structures, as well as improvement elements of building areas (Nekustamā īpašuma lietošanas...., 2006).

In turn, the military contaminated area is explained in the Law "On Pollution". It is the territory where an explosive objects and materials, or toxic or otherwise hazardous substances used or intended to be used for military purposes are located (Par piesārņojumu, 2001). However, it should be noted that existing firing grounds of National Armed Forces of Latvia where the military trainings takes place, cannot be observed as degraded territories or objects. Only territories that during soviet period were used for military purposes but now are abandoned can be attributed to criterion "Abandoned territory or object of military purpose" (Priekslikumi zemes un.., 2016). In all areas where military actions have taken place, is possible pollution and in any case there revitalisation is necessary. Therefore, we recommend that this criterion of land degradation not divide into levels but in all cases to determine high level of degradation.

**The invasive plants (hogweeds).** The "Plant Protection Law" of Latvia defines invasive alien plant species as species non-characteristic to the nature of Latvia which endangers local species and their habitats or cause economic losses, damage to the environment or human health (Augu aizsardzibas likums, 1998). The Law defines only one kind of invasive plants – Sosnovsky's hogweed (*Heracleum sosnowskyi Manden*) in the territory of Latvia (Invazivo augu sugu..., 2008). It spreads very quickly and it is not easy to exterminate it. Evaluating land degradation we recommend to observe low degradation level if hogweeds occupy up to 30% of the total area, medium – if hogweeds occupy 31-50% of the total area, and high - if hogweeds occupy over 51% of total area.

**Bogged-up land**. In Cabinet Regulation No.281 (24 April 2012) "High-detail topographical information and its central database regulations" bogged-up land is characterised as wetland with less moisture than transient swamps, with moisture-grassland and with thin peat layer or without it (Augstas detalizacijas topografiskas..., 2012). Due to the fact that the bogged-up land is not a swamp yet, the land can be returned to normal humidity by means of drainage. On land where drainage systems already exist, it is easier to restore required humidity regime, but where they do not exist, they should be created. Therefore, we recommend evaluate this land degradation criterion according to the existence and quality of drainage systems. Land with existing drainage systems which require maintenance activities should be classified as land with low degradation level, if bogging-up is significant and existing drainage systems require maintenance or reconstruction activities, land should be classified as land with medium degradation level, but land should be regarded as land with high level degradation, if bogging-up is in territories without drainage systems, construction of them is necessary.

**Pollution**. The purpose of the Law "On Pollution" is to prevent or reduce harm caused to human health, property or the environment due to pollution, to eliminate the consequences of harm caused, to prevent pollution resulting from polluting activities or, if it is impossible, reduce emission into soil, water and air, as well as to specify measures for investigation of polluted and potentially polluted sites and remediation of polluted sites. Polluted place within the meaning of mentioned Law is soil, subsoil, water, sludge, as well as buildings, factories or other objects containing pollutants (Par piesarnojumu, 2001). The Center for Environment, Geology and Meteorology collects information on polluted and potentially polluted places. Pollution itself is a significant factor in land degradation, regardless of its size. Therefore, all places that already are registered in the Register of polluted and potentially polluted places are considered to be with high degradation level.
In order to carry out the approbation of land degradation parameters and to evaluate degraded areas in accordance with degradation levels in the territory of agricultural and forestry activities, the field survey of the Sauka Nature Park was carried out. In order to identify land parcels affected by land degradation, the data from Cadastre information system were used. Before the field survey the spatial plan of the Sauka Nature Park was investigated and the data from following registries were used:

- the Register of spread of hogweeds;
- the Register of polluted and potentially polluted places;
- the Register of Field blocks;
- the Register of Mineral Resources and others.

Conducting field survey the data about Sauka Nature Park in mentioned registers were updated, new degraded areas and land degradation levels were determined. For determination of land degradation criteria and their levels descriptions showed in Table 2 were used. For assessment and survey of the area, additional materials - orthophotomaps and other cartographic materials were used.

**Discussions and results**

For approbation of research results there was selected an object - specially protected nature area - Sauka Nature Park, established in 1987. The status of Natura 2000 - protected nature territory of European significance has been awarded to this park. Sauka Nature Park is located in the south-eastern part of Latvia in the central part of Viesite municipality and its total area is 5635 hectares. The park is located in the highest part of the hillock Selija (Dabas parka "Sauka"..., 2010), the highest top is Ormankalns (167 m). There are three densely populated areas in the park - the villages Lone, Sauka and Klauce, as well as several lakes. The largest one is Sauka Lake with area 718 hectares. There are many grand-trees and separately standing trees - oaks, ash-trees, pines, rowan-trees, as well as stands of briar-roses. Important and attractive elements of the ecological landscape also are orchards with apple trees in Lone municipality. The protected area and its adjoining territories are rich with archaeological objects - cult places, castle mounds, ancient burial grounds and cemeteries, historic villages, etc., and with elements of cultural and historical landscape as such farmsteads, manorial estates, churches, roadside pubs (*krogi*), mills etc., constructed in the building traditions of this area.
Most part of Sauka Nature Park (52%) is occupied by agricultural land; about 31% of area is covered by forests and 14% - by land under water. There are more than one and a half hundred real properties in the park area, which consist of 613 land parcels. The average area of land parcel is 9.37 hectares. The area of smallest land parcels is about 400 $m^2$, and they mostly are located in densely populated areas, while the area of largest land parcel is more than 700 hectares, and it is Sauka Lake. 71% of the total area of the Sauka nature park is owned by physical persons, 14% are owned by state institutions, 10% are owned by legal persons, and only 4% are owned by local municipality (Dabas parka "Sauka"..., 2010).
Conducting the survey, in the territory of the Sauka Nature Park, four degradation criteria of unmanaged agriculture and forestry activities territory were not found:

- pollution;
- uncultivated dump-site;
- abandoned territory or object of military purpose;
- abandoned territory or object of production.

This is understandable because the Sauka Nature Park is a protected area, whose status is incompatible with nature polluting activities. However, three types of land degradation criteria were identified:

- agricultural land overgrown with shrubs;
- invasive plants (hogweeds);
- bogged-up land (Table 3, Fig. 1).

The largest degraded area consists of the land with bogging-up indicators. The investigation showed relatively large number of land parcels with over-moist soil in different degradation levels. 56 over-moist land parcels with total area of 1250 hectares were found, which makes more than 20% of total area. Low bogging-up level was detected in 33 land parcels in which existing drainage systems require maintenance and tidying up activities. There are 12 land parcels with significant bogging-up, and existing drainage systems require maintenance or reconstruction activities. High bogging-up level is detected in 11 land parcels without drainage systems, there its construction is necessary (Table 3, Fig. 1).

The agricultural land overgrown with shrubs was found in 17 land parcels with total area of 363 hectares, which makes more than 6% of the total area of park. In 14 land parcels, low level of land degradation was detected and in 3 land parcels - medium level of land degradation. In territory survey no land with high degradation level (shrubs cover more than 70% of the territory) was detected (Table 3, Fig. 1).

There also an invasive plant - Sosnovsky's hogweed was found in the territory of the Sauka Nature Park. Before field survey the information from Database about distribution of invasive plant species according to the park territory, where the presence of hogweeds were previously detected was obtained (Karte, b.g.). During the field survey the land parcels in which the hogweed vegetated wild were identified, as well as information about annihilated hogweed. Summarizing the results, it was determined that there are 8 land parcels, where hogweeds were found. The total area of invaded land is 143 hectares or 3% of park area, the presence of hogweeds was estimated with low land degradation level. At the same time it was found that within 9 land parcels hogweeds are annihilated or their active destruction was carried out (Fig. 1).

There were identified 5 land parcels which were affected by complex of land degradation criteria for example, agricultural land overgrown with shrubs together with bogging-up. Such land occupies 90 hectares or 2%.

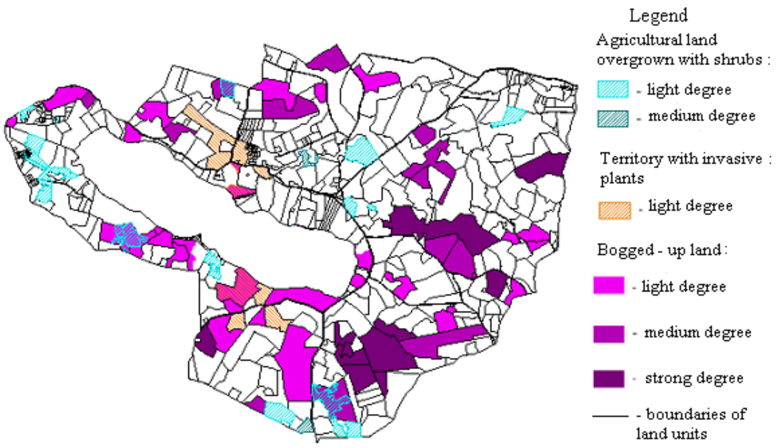



**Fig. 1.** Degraded territories in Sauka Nature Park

Altogether in Nature Park Sauka 86 land parcels with some features of degradation criteria were fixed. Such land takes up about 1846 hectares or almost 33% of the total territory of the park (Fig. 1, Table 3).

Although the above figures are quite alarming, however, bearing in mind fixed degradation degree, it can be seen that the largest part of degraded land is assessed in low or medium categories. This means that the land degradation in particular area is not comprehensive, its elimination is possible, and revitalization of these territories is a further task for its owners. Furthermore, fixed reduction of area of hogweeds already demonstrates the results of landowner's activities. Not providing division of degradation degrees there are difficulties to assess and compare extent of land degradation.

**Table 3**

Summary of land degradation in the territory of Sauka Nature Park

| **Land degradation criteria and its level** | **Land parcels** | | **Proportion of degraded territories (%)** |
|---|---|---|---|
| | **number** | **area, ha** | |
| Agricultural land overgrown with shrubs, including: | 17 | 363.48 | 6,4 |
| - low degree | 14 | 350.80 | 6.2 |
| - medium degree | 3 | 12.68 | 0.2 |
| Presence of invasive plants (hogweeds), low degree | 8 | 143.51 | 2.5 |
| Bogged-up agricultural land, including: | 56 | 1249.20 | 22.2 |
| - low degree | 33 | 630.00 | 11.2 |
| - medium degree | 12 | 308.76 | 5.5 |
| - high degree | 11 | 310.44 | 5.5 |
| Overlap of several degradation criteria | | | |
| Agricultural land overgrown with shrubs together with bogging-up, low degree | 1 | 15.59 | 0.3 |
| Agricultural land overgrown with shrubs (low degree) together with bogging-up (medium degree) | 2 | 27.62 | 0.5 |
| Bogged-up agricultural land together with invasive plants, low degree | 2 | 46.91 | 0.8 |
| Total | 86 | 1846.31 | 32.7 |

## Conclusions and proposals

The results of the research showed that in agriculture and forestry activity territories the main criteria of land degradation are overgrowing with shrubs and bogging-up of agricultural land, as well as presence of invasive plants.

Taking into account the relatively large area of the Sauka Nature Park (5635 ha), the results of the research can be generalized as the most characteristic degradation criteria for Latvia in the areas of agricultural and forestry activities.

The approbation of land degradation criteria and their evaluation in the Sauka Nature Park suggests that a more objective view of this problem is important for the classification of degradation criteria in several degrees and justifies the assessment of land degradation.


## Acknowledgement

Research has been performed in frame of Interreg Latvia – Lithuania project «Innovative brownfield regeneration for sustainable development of cross-border Regions (BrownReg)» No 325.


**References**


1. *Augstas detalizacijas topografiskas informacijas un tas centralas datubazes noteikumi*: Cabinet of Ministers of the Republik of Latvia, regulation No. 281, adopted 24 April, 2012. Vieved 13 June, 2018. (https://likumi.lv/doc.php?id=246998) (in Latvian).
2. *Plant Protection Law*: law of Republic of Latvia (1998). Viewed 12 June, 2018, (https://likumi.lv/ta/en/en/id/51662-plant-protection-law).
3. *Regulations Regarding the Construction of Landfill Sites, the Management, Closure and Re-cultivation of Landfill Sites and Waste Dumps:* Cabinet of Ministers of the Republic of Latvia, regulation No. 1032, adopted 27 December, 2011, *Latvijas Vestnesis*, No. 205 (4603), 30th of December, 2011.
4. Bullock P. (2005) *Climate change impacts*. In: Hillel D. Encyclopedia of Soils in the Environment. UK, Silsoe: Cranfield University – Silsoe, p. 254 – 262.
5. *Dabas parka "Sauka" dabas aizsardzibas plans* (2010) / SIA "Estonian, Latvian & Lithuanian Environment", projekta vadītājs V.Vilnitis. Riga. 127p.(in Latvian).
6. *Degradeto teritoriju izpete Rigas pilseta*. Petniecibas darbs (2004). Atskaite. SIA "Grupa 93", Rigas Domes Pilsetas attistibas departaments, Riga. 66 p. (in Latvian).

7. *Degradeto teritoriju un objektu apsekojums Riga* (2012). SIA „Datorkarte”. Viewed 7 June, 2018, (http://www.sus.lv/lv/petijumi/degradeto-teritoriju-un-objektu-apsekojums-riga) (in Latvian).
8. *List of Invasive Alien Plant Species*: Republic of Latvia Cabinet, regulation No. 468, *Latvijas Vestnesis*, 100 (3884), 2th of July, 2008.
9. Jackson J.B., Finka M., Hermann G., Kliucininkas L., Lemesenoka N., Petrikova D., Pletnicka J., Teirumnieks E., Velykiene D., Vojvodíkova B., Zahnasova M., Zubkova M. (2010) *Degradetas teritorijas. Rokasgramata*. Starpdisciplinars macibu lidzeklis degradeto teritoriju atjaunosanai. Macibu lidzeklis Latvijai un Lietuvai. VSB-Ostravas Tehniskas universitates Buvniecības fakultate, Ostrava. 140 p.(in Latvian).
10. Karte/ Valsts augu aizsardzības dienests. Viewed 13 june, 2018, (http://karte.vaad.gov.lv/) (in Latvian).
11. Kasparinskis R. (2014) *Zeme, udens, cilveks – ko sesi, to plausi!* Viewed 21 May, 2018, (https://www.slideserve.com/gyda/zeme-dens-cilv-ks-ko-s-si-to-p-ausi) (in Latvian).
12. Klavins M., Nikodemus O., Seglins V. u.c. (2008) *Vides zinātne*. Riga: LU Akademiskais apgads. 599 p.(in Latvian).
13. Kust, G., Andreeva, O., & Cowie, A. (2016). Land Degradation Neutrality: Concept development, practical applications and assessment. Journal of Environmental Management. Vieved 7 June, 2018, (https://doi.org/10.1016/j.jenvman.2016.10.043).
14. Latvanu izplatiba: Valsts augu aizsardzibas dienesta majaslapa. Viewed 12 June, 2018, (http://www.vaad.gov.lv/sakums/informacija-sabiedribai/par-latviju-bez-latvaniem/meklet-latvanu-invadeto-teritoriju.aspx)(in Latvian).
15. *Nekustama ipasuma lietosanas merku klasifikacija un nekustama ipasuma lietosanas merku noteiksanas un mainas kartiba*: Ministru kabineta 2006. gada 20. jūnija noteikumi Nr. 496. *Latvijas Vestnesis*, No. 108 (3476), 11th of July, 2006 (in Latvian).
16. *On Pollution*: law of Republic of Latvia (2001), *Latvijas Vestnesis*, No.51 (2438), 29 th of March, 2001.
17. Parsova V., Jankava A., Kukule I. (2017) *Determination of land degradation for sustainable development of municipal territories.* BGC Geomatics 2017: Baltic Geodetic Congress (Geomatics): proceedings, Gdansk, Poland, 22-25 June 2017 / Gdansk University of Technology. Gdansk, p. 158-162.
18. *Piesarnoto un potenciali piesarnoto vietu reģistrs* / LVĢMC. Viewed 13 June, 2018, (https://www.meteo.lv/lapas/vide/piesarnoto-un-potenciali-piesarnoto-vietu-registrs/piesarnoto-un-potenciali-piesarnoto-vietu-registrs?id=1527&nid=373) (in Latvian).
19. *Priekslikumi zemes un augsnes degradacijas klasifikacijas, kriteriju un novertesanas kartibas izstrade*i (2016). VARAM, etapa Nr. II, priekslikumu gala redakcija 2016. 98 p. (in Latvian).
20. Puce A. (2006) *Centisies mazinat Nicas zemes degradaciju*. Viewed: 04 June, 2018, (http://www.tvnet.lv/zinas/ekologija/171279-centisies_mazinat_nicas_zemes_degradaciju) (in Latvian).
21. Sklenicka P. (2016). Classification of farmland ownership fragmentation as a cause of land degradation: A review on typology, consequences, and remedies. Land Use Policy, 57, 694–701. Viewed: 04 June, 2018, (https://doi.org/10.1016/j.landusepol.2016.06.032).
22. *Land Management Law*: law of Republic of Latvia (2014). *Latvijas Vestnesis*, No. 228 (5288), 15 th of November, 2014.

**Information about authors**

**Anda Jankava,** Dr.oec., professor, Department of Land Management and Geodesy of Latvia University of Life Sciences and Technologies. Address: 19, Akademijas str., Jelgava, LV-3001, phone: +371 29356448, e-mail: Anda.Jankava@llu.lv

**Velta Parsova,** Dr.oec., professor, Department of Land Management and Geodesy of Latvia University of Life Sciences and Technologies. Address: 19, Akademijas str., Jelgava, LV-3001, phone: +371 29118285, e-mail: velta@parsova.lv

**Eva Laizāne,** Bs.sc.ing., Department of Land Management and Geodesy of Latvia University of Life Sciences and Technologies. Address: 19, Akademijas str., Jelgava, LV-3001, phone: +37129193752, e-mail: eva-laizane@inbox.lv

**Maija Berzina,** Mg.sc.ing., assist. professor, Department of Land Management and Geodesy of Latvia University of Life Sciences and Technologies. Address: 19, Akademijas str., Jelgava, LV-3001, phone: +37129193752, e-mail: maija.berzinaaa@gmail.com

**Aina Palabinska,** Mg.oec., lecturer, Department of Land Management and Geodesy of Latvia University of Life Sciences and Technologies. Address: 19, Akademijas str., Jelgava, LV-3001, phone: +37126358542, e-mail: Aina.Palabinska@llu.lv

DOI: 10.22616/j.balticsurveying.2018.017

# CONCEPTUAL ISSUES OF MODERN LAND MANAGEMENT OF BELARUS

**Andrey Kolmykov**
Belarussian State Agricultural Academy

**Abstract**
The purpose of this scientific research is to reveal the theoretical foundations of modern land management and determine its tasks. The patterns of land management, its tasks and principles are formulated in the conditions of modern agrarian reform. The system of interconnected forecasting and design of land management development is proposed. The methodological and theoretical basis of research is a dialectical method and a systematic approach to the cognition of economic phenomena and processes. According to this method, all objects are viewed not in isolation, but in a reciprocal relationship and in the process of constant development. In the course of the research, monographic, abstract-logical methods, a system approach, comparative analysis, and expert assessments were used. The scientific research is based on the development of domestic scientists, the experience of land management in the Republic of Belarus, land-cadastral data, normative and reference literature. As a result of the research, it was established that in the conditions of the agrarian reform carried out in the Republic of Belarus land management is an effective mechanism for implementing state policy in the field of land management, regulation of land relations, organization of use and protection of land. Modern land management, based on the state strategy of land reforms, should have a concept of its development based on the laws, which were set in the work, as well as successful solve these problems. For the successful solving of the problems, it is important to revive the previously existing system of forecast and project of land management development in an improved form.
Key words: land reform, land relations, land management, regularities, project design.

## Introduction

In conditions of the ongoing agrarian reform in the Republic of Belarus, land management remains the most important part of its economic mechanism. Land management is an instrument of state land resource administration, redistribution among sectors of the national economy, land relations reforming, introduction of new forms of land management, formation of new land users, organization of effective use and protection of land, and intra-farm organization of the territory of agricultural organizations.

General coordination of land use activities in the Republic of Belarus is effected by the State Committee on Property of the Republic of Belarus, and direct land use-planning is handled by land surveying organizations, head departments of land development of administrative areas and land resource management agencies of administrative districts. Land use activities aim at regulating and improving land matters, efficiency improvement of use and protection of land.

The number of employees engaged in land-use system, enterprises under the command of the State Committee on Property of the Republic of Belarus accounts for 1542 people, and that of local land-use offices comes to 1344.

Land management provided in the Republic can be divided into interfarm and intrafarm one. Objects of land-use planning and control include all lands of the Republic of Belarus, land boundaries as well as plots of land irrespective of the form of their ownership (The Code…, 2008).

In the process of land management, specialists develop relevant planning documentation including geography-specific land-use and land conservation patterns, land management schemes of administrative-territorial and geographical units as well as territories under state protection, interfarm and intrafarm land regulation schemes, organization and arrangement of land areas of different territorial entities, projects connected with land protection and land reclamation.

At present works associated with interfarm land tenure prevail in the Republic. They consist in developing schemes of granting of land plots, execution of technical documentation, establishment of the site boundaries of land plots due to formation of agricultural and nonagricultural land utilization. However, the development of intra-farm land tenure aimed at organization of efficient agricultural

production, utilization and protection of lands within the boundaries of particular agricultural organizations, farm enterprises, household plots, instructional and other farms should be of prime concern.
Land use planning theory and methods are articulated in scholarly papers of number of scientists (Volkov, 1998; Komov, 2001; Wild, 2003; Chigbu, Kalashyan, 2015; Cowell, Owens, 2016; Harrison, 2017), but they do not make much of conceptual issues of modern land utilization ensuring a higher efficiency of land use. At the same time, within a market economy accompanied by changing market conditions, increase in technogenic character of agricultural production, growth of energy consumption and environmental spoiling a need arises to enhance methodological background of land management, to adjust it to current economic environment and land relations.
The purpose of the study is to show theoretical background of modern land management of the Republic of Belarus and the challenges facing it.
Application of the proposed methodological provisions in land management will provide scientific validation of carrying out land reforms, will be instrumental in laying the organizational-territorial, economic and ecological groundwork for efficient land utilization.

**Research methodology and materials.** The dialectical method and systematic approach to the cognition of economic phenomena and processes, according to which all objects are considered not in isolation, but in mutual connection and in the process of constant development, is the methodological and theoretical basis of research. While conducting the research, the following methods were used: monographic, abstract-logical, systems approach, comparative analysis, expert assessments.
Studies of domestic and international scientists on land economies and land management, experience of the republic in the development of land-use project documentation, land-cadastral data, statutory and information materials, guidelines for organization of agricultural production, use and protection of lands, first-hand observations of the author were taken as a basis for the scientific inquiry.
The research work was based on the analysis of land use records, land surveying documentation, data of opinion polls and other information.

**Discussion and results**

According to the Land Code of the Republic of Belarus, land management is a set of measures for land inventory, land use planning, establishment (restoration) and fixing of boundaries of land management facilities, and other land management measures aimed at increasing the efficiency of land use and its protection (The Code…, 2008).
Modern land management as a socio-economic phenomenon has deep historical roots. Already in the XVII century, it solved boundary, statistical, cartographic, land-registration and other problems (Shuleikin, 1933). Despite the socio-economic changes in the society, the solution of these issues remains important.
At present, with the transition of the national economy of Belarus to the market economy, the role of land management in the country is growing. The solution of new land management challenges requires the perfection of scientific approaches, consideration of theoretical aspects of modern land management.
The implementation of land reform in Belarus is ensured by the Land Code of the Republic of Belarus (1999 and 2008) (Code of…1999; The Code…, 2008), Presidential Decree № 667 of December 27, 2007 "On seizure and allocation of land plots" (Decree…, 2009) and other normative and legal acts. They formulate in general terms the content and procedure for conducting land management activities. It is emphasized that land administration remains an effective mechanism for implementing land reform, although a separate law on land management has not yet been adopted in the republic.
The most important conceptual provision that governs the regulation of land relations and the implementation of transactions with land is Article 13 of the Constitution of the Republic of Belarus, which states that "... subsoil, water, forests constitute the exclusive property of the state. Land for agricultural use is in a state ownership "(The Constitution…, 2006).
The study of the features of land management in various socio-economic conditions showed that at all stages of land relations it developed on the one hand as a scientific direction studying the patterns of functioning and organization of land use and on the other hand, as a practical branch. It always

defended the existing land system in the state and was an important tool for regulating land relations. The source and motivating force for improving land management were socio-economic needs, the development of productive forces and the scientific and technological progress of the society.

The overall success of the land administration in implementing its primary role in managing land resources, regulating land relations, organizing the use and protection of land was provided by appropriate legislative acts and technical instructions, supported by reliable financing.

It was revealed that from the historical point of view there are certain regularities in the development of land management, which are as follows:

– conformity of land management to the stage of development of productive forces and social and economic relations;
– maximum consideration of socio-economic and natural conditions, existing settlement, location of economic centers, main roads and other engineering facilities of the territory when organizing the use and arrangement of lands;
– as the socio-economic relations that determine the conditions of management on the land are constantly changing, so land management as a planned reorganization of land relations and organization of land use is also changing, that is, it is in constant motion, will never end or cease. Continuity of land management in general and intra-farm land management in particular is achieved by the introduction necessary changes and clarifications into its projects in connection with the changes in socio-economic conditions in the development of agricultural production in a certain period;
– complexity of land management. Land management not only organizes the use and protection of lands, creates territorial conditions for conducting effective agricultural production, introduction of advanced systems and methods of management, but also arranges people on the territory, creating favorable working and living conditions for the rural population;
– inheritance and continuity of land management. Current land management does not reject the previously existing material forms of the arrangement of engineering facilities of the territory, and the settlement, but, on the contrary, seeks to inherit and adapt everything valuable for use in the new socio-economic conditions.

Considering the importance of modern land management in the regulation of land relations and land management, it is possible to formulate the tasks of modern land management:

– implementation of state policy in the field of land relations, organization of use and protection of land;
– maintaining the legal order in the field of land use;
– activities aimed at increasing the efficiency of land use and protection; ensuring the targeted use and protection of lands, the formation and location of economically and environmentally sound land use;
– creation of territorial conditions for effective agricultural production;
– conservation of sustainable natural landscapes and environmental protection;
– updating of planning and cartographic materials, land inventory and maintenance of reliable qualitative and quantitative accounting;
– the use of geo-information technologies in land management;
– the development of the theory and practice of land management and methodological support for its implementation;
– scientific substantiation of land reforms and forecasting of consequences of land redistribution;
– establishment (restoration) and fixing the boundaries of land management objects.

The solution of the tasks is provided by land management actions, stipulated by the Land Code of the Republic of Belarus (The Code…, 2008), Decree of the President of the Republic of Belarus (Decree…, 2009), which include:

– "the development of regional project schemes for the use and protection of land resources, schemes for the land management of administrative-territorial and territorial units, territories of special state regulation;
– the development of inter-farm land management projects, including land allotment projects, registration of technical documentation and establishment (restoration) of the boundaries of land

management facilities on the terrain;
– the development of projects for in-farm land management of agricultural organizations, including peasant (agricultural) farms, projects for organizing and arranging settlements, horticultural associations, country cooperatives, special protected natural areas and other territorial units;
– the development of projects for land reclamation, soil protection from erosion and other harmful impacts, conservation and improvement of soil fertility and other useful properties of lands, as well as other projects related to the protection and improvement of land;
– the inventory of lands, systematic identification of unused land or used for non-designated purposes;
– geodesic and cartographic works, soil, geo-botanical and other studies and surveys carried out for the purposes of land management, preparation of cadastral and other thematic maps (plans) and atlases of the state and use of land resources;
– author's supervision over the implementation of land management schemes and projects;
– the implementation of land management activities in land monitoring, state land cadaster, including the cadastral valuation of land, land parcels, the implementation of state control over the use and protection of land;
– implementation of research and development activities, as well as the development and modernization of the hardware and software required for land management activities;
– preparation of land management materials to resolve land disputes".

Assuming that land management is a "complex of measures for inventory of land, land use planning, establishment (restoration) and fixing the boundaries of land management objects, conducting other land management measures aimed at increasing the efficiency of land use and protection" (Decree…, 2009), and includes the relevant pre-planning, pre-project and project developments for the organization of land use and protection, and summarizing the existing theoretical developments and many years of land management experience, it is possible to formulate the following main methodological principles:

– a nationwide nature of land management;
– public need for land management as part of the economic mechanism of the Republic in restoring order on the land, regulating land relations, organizing and structuring the territory;
– the rule of law when carrying out land management;
– public interests and interests of land users when carrying out planning activities;
– consideration of natural, economic and social conditions;
– priority of conservation and agricultural land uses of land redistribution;
– integrated nature of planning and production;
– sustainability of land use;
– creation of favorable working and living conditions for the rural population;
– reorganization of land use and reorganization of the territory of agricultural organizations should be carried out on the basis of schemes and land management projects;
– land management should link land reforms with the mechanism of economic incentives for the effective use and protection of land;
– economic, environmental and social efficiency of land management activities.

All of the above principles should be respected in a comprehensive and interrelated way.

In order to solve successfully the tasks faced by modern land management and to deepen the scientific substantiation of land management measures, it is necessary to develop further the proposed methodological foundations of modern land management in Belarus, taking into account changes in the social and economic conditions of the Republic.

The important component of the theoretical provisions of modern land management is organizational territorial, economic and ecological-energy basis for increasing the efficiency of agricultural land use in the agro-industrial complex of the republic.

Organizational and territorial conditions presuppose the optimization of land use of the agricultural organization, the elimination of its territorial shortcomings, the establishment of the optimal size and rationalization of land use of economic and production centers, other elements of the engineering facilities of the territory, determining the optimal composition and ratio of agricultural land and crop rotation, establishing their territory, ratio of the size of the territory and the production of the organization.

The economic background for increasing the efficiency of agricultural land use includes optimization of the agricultural production specialization, measures to increase land fertility and crop yields and reduction of the production costs by improving the organizational and territorial conditions of land use.
Ecological and energy principles contribute to the solution of ecological land use in the organization of land and crop rotations and the introduction of ecological and technological energy efficient crop rotations.
According to the Register of Land Resources of the Republic of Belarus (as of January 1, 2018), the total area of the country's lands amounted to 20760.0 thousand hectares. State property is 20683.2 thousand hectares, or 99.6% of the country's land fund, in private ownership – 76.8 thousand hectares, or 0.4% (Register…, 2018). Consequently, the objects of land management are the land and land plots of these forms of ownership.
The land reform carried out in the country touched mainly agricultural land. At the same time, in the last decade, the focus of land management has been on the formation of new land uses, the consolidation of their boundaries on the terrain and legal registration, the creation of the information database on land (IDL), the optimization of land use, cadastral valuation of lands, the development of the Geoportal of the land information system of the Republic of Belarus.
Without denying the importance of carrying out these land management measures, it should be noted that, in economic significance, they are inferior to actions related to land use optimization, territorial organization of agricultural production and land protection.
It is obvious that modern land management of the Republic as a whole should be based on a clearly developed strategy of land reforms and have a scientific concept of its development, be an effective tool of identification of the state in managed land resources, regulating land relations, reforming agriculture, resolving a complex of environmental, social, economic and other tasks and be carried out in a planned manner by use of the latest cartographic materials, soil data, geo-botanical and other surveys, cadastral valuation of land and geo-information technologies.

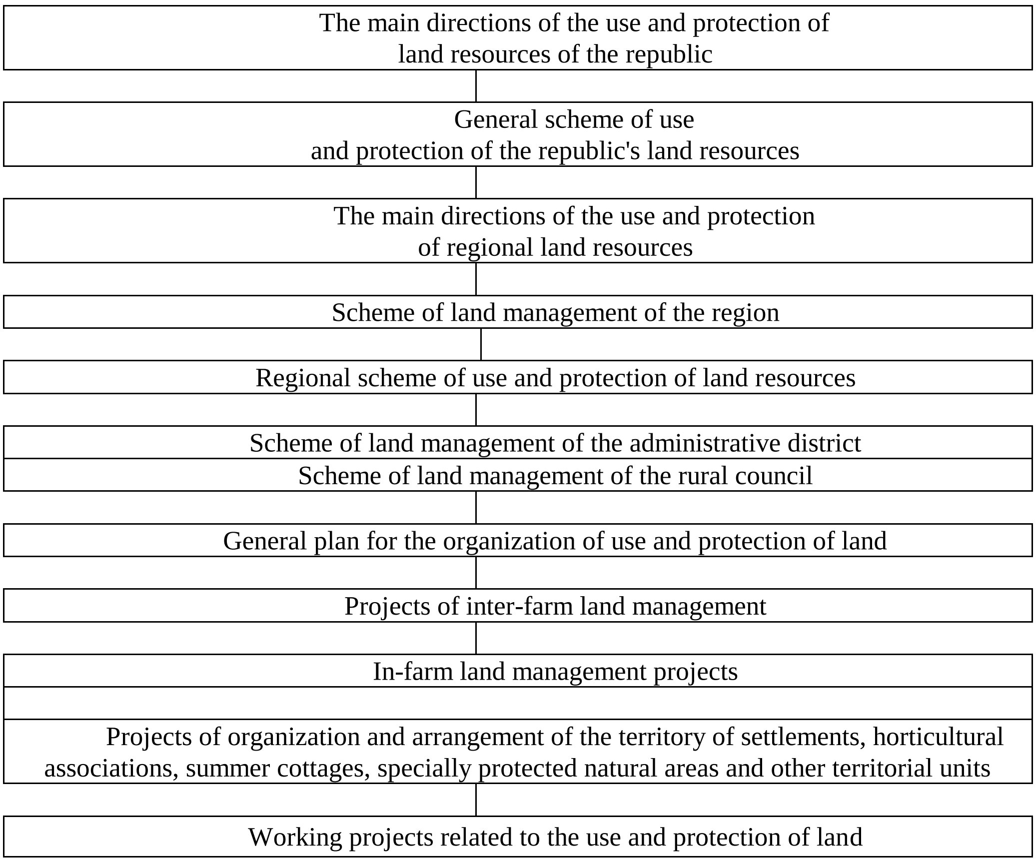



**Fig. 1.** The system of forecasting and project land management developments

The on-farm land management system should play an important role in the organization of rational land use and protection, increasing the efficiency of agricultural production, in the process of which territorial conditions for rational management, energy and resource saving, green land use, improvements in working and living conditions of the rural population are created. Almost every agricultural organization should have modern designs for on-farm land management, which in most cases doesn't exist currently.

To improve the land management of the Republic, to organize the rational use and protection of agricultural land, it is necessary to restore the existing system of land development measures in an updated manner, including the issues of ecological land use and bioenergy approaches to the organization of land use, which will exclude negative impact on the results of land management decisions, market and disparity of prices on agricultural products and material and technical resources consumed in agriculture.

The updated system of land-use forecasting and design development can be presented in the following form (Figure 1).

National strategy of sustainable economic and social development of the Republic of Belarus (National strategy…, 2004), government programs in the field of use and protection of land and other forecast pre-plan documents are to become the methodological framework of building such a system.

The presented system of land management development will provide the informed solution of both general and specific tasks of modern land management and its improvement.

Thus, conceptual issues of modern land management of the Republic involve maintaining of the State Land Cadastre, developing land relations, improving the system of long-range and project-oriented land surveying schemes, designed to enable land use planning; carrying out of measures aimed at enhancement of efficiency of government control and administration in the field of use and protection of land at the primary and basic administrative-territorial level, as well as improving land utilization and land protection efficiency. Priority growth area of information technologies in the field of land management for the next few years is improving the Geoportal of land management information system of the Republic of Belarus.

**Conclusions and suggestions.** Summarizing the above, the following should be said. 1. In the context of the agrarian reform, which is being carried out in the Republic of Belarus, land utilization system is a practical mechanism of implementing the state policy in the field of land management, land regulation, organization of the use and protection of land. 2. Modern land utilization system based on the national strategies of land reform should have a development concept centered around the above mentioned regularities and take into account tasks and methodological principles of its implementation. 3. To solve the problems faced by modern land utilization system it is important to revitalize the previous system of prognostic and project-oriented land use engineering in better form. 4. Using up-to-date system of prognostic and project-oriented land use engineering will contribute to improving land utilization system of agricultural organizations of the Republic of Belarus.

## References


1. The Code of the Republic of Belarus on Land No. 425-3 of July 23, 2008 (as amended on January 22, 2013) (as amended and supplemented, effective from December 31, 2014).- [Electronic resource] (National legal Internet-portal of the Republic of Belarus -09.01.2015 - No. 2/2228) (in Russian).
2. Code of the Republic of Belarus on land (1999). Goskomzem, Minsk. 72 p. (in Russian).
3. The Constitution of the Republic of Belarus of 1994 (as amended and supplemented, adopted in 2004) (2006) Amalfea, Minsk. 48 p. (in Russian).
4. Decree of the President of the Republic of Belarus, December 27, 2007 No. 667. (2009). On the seizure and provision of land. Center for training, advanced training and retraining of personnel in land management and cartographic-geodesy services, Minsk. 104 p. (in Russian).
5. Kolmykov A.V. (2013). Land management in organization of rational use of agricultural land: monograph. BGSHA, Gorki. 337 p. (in Russian).
6. Shuleikin I.D. (1933). History of land relations and land management. "Selkhozizdat", M.-L., 448 p. (in Russian).
7. Register of Land Resources of the Republic of Belarus (2018) State Property Committee of the Republic of Belarus, Minsk. 57 p. (in Russian).

8. National strategy of sustainable economic and social development of the Republic of Belarus for the period until 2020 (2004). *National Commission on sustainable socio-economic development of the Republic of Belarus*; ed. board: Ya.M. Aleksandrovich [et al.]. “Yunipak”. Minsk. 202 p. (in Russian).
9. Volkov S.N. (1998). Land utilization system under the conditions of land reform (economy, ecology, law). “Bylina”, Moscow. 528 p. (in Russian).
10. Komov N.V. (2001). Guide to land use planning: manual of practice. N. V.Komov, A.Z. Rodin. “Yuni-press”, Moscow. 394 p. (in Russian).
11. Wild A. (2003). Soils, land, and food: managing the land during the twenty-first century. Cambrige University Press. New York. 246 p.
12. Chigbu U. E., Kalashyan V. (2015). Land-use planning and public administration in Bavaria, Germany: Towards a public administration approach to land-use planning. *Geomatics, Landmanagement and Landscape*. Number 1. p. 7-17.
13. Cowell R., Owens S. (2016) Land use planning. *The EU Referendum and the UK Environment: An Expert Review*. p. 57-68.
14. Harrison A. J. (2017) Economics and land use planning. Routledge. 252 p.

**Information about author**

**Andrey Kolmykov** is a Doctor of Economic Sciences, Professor, First pro-rector of Belarusian State Agricultural Academy. Contact details: Faculty of Land Management, Belarusian State Agricultural Academy, Michurina 5, Gorki, Mogilev region 213407, Republic of Belarus, e-mail: kolmykov@tut.by , tel.: +375 029 6921766 (mobile); +375 2233 79656 (office).

DOI: 10.22616/j.balticsurveying.2018.018

# POSSIBILITIES USE TO SELECTED METHODS OF SPATIAL DATA MINING IN DEMOGRAPHIC DATA ANALYTICS

**Krystyna Kurowska, Ewa Kietlinska, Hubert Kryszk**
Faculty of Geodesy, Geospatial and Civil Engineering
University of Warmia and Mazury in Olsztyn, Olsztyn, Poland

**Abstract:**
The main purpose of data mining in private and public sector institutions is to process and analyse data with the aim of generating reliable information for decision-making. Decision-making performance is determined by the availability of the relevant data and the user's ability to adapt that data for analytical purposes. The popularity of spatial statistical tools is on the rise owing to the complexity of the analysed factors, their variation over time and their correlations with the spatial structure.
Popular models should be applied in demographic analyses for the needs of the spatial planning process. The availability of high-resolution data and accurate analytical tools enhances the value of spatial analyses, and the described models can be universally applied to support the decision-making process.
The aim of this study was to present the applicability of selected spatial statistical models for analysing demographic data in the planning process and to identify the main advantages of these models.
Keywords: spatial data mining; spatial statistics; autocorrelation; demographic analysis.

## Introduction

Cities play a key role in human settlement systems and they are the main hubs of economic activity. Depending on their rank in the settlement systems, cities are local, regional or national growth centres whose development influences the surrounding areas (Kowalczyk 2015). Large urban areas drive demographic changes and, consequently, changes in population structure. For this reason, the economic status of cities and the economic processes that take place in urban areas are of vital significance for the national economy (Lee and Rinner, 2015).
Demographic processes such as natural population growth and migration are directly responsible for changes in the size and structure of the urban population. According to the literature, the rate of these processes is influenced by changes in the standard of living and quality of life, growing levels of social mobility, the situation on the job market, income levels, the quality of health care services and educational attainment (cf. Cigno, 1991; Cliquet, 1991; Kotowska, 1999).
Purely demographic processes evolve at different rates and with different intensity, and they exert a growing influence on various areas of life, including the economy, the job market and the spatial management of territorial units. The above increases the demand for data analyses and forecasts based on various phenomena (Kurowska and Kietlińska, 2017).
According to Gaździcki (2001), information systems cater to the growing demand for the accumulation, processing and dissemination of data. Data that are in any way related to space are processed in spatial information systems which are defined as systems that process, accumulate, verify, integrate, analyse, transfer and disseminate spatial data.
Information systems provide users with a wide range of research tools, beginning with the simplest descriptive and statistical methods to complex mathematical models that support accurate analyses and forecasts of demographic processes and the associated economic processes.
Spatial data have a multidimensional structure. In addition to the basic information describing the location of an object in space (geographic coordinates), other types of data can also be taken into account during the analytical process, including variations in the observed phenomena over time and/or other qualitative or quantitative attributes describing the attributes of the analysed object. In view of the multidimensional character of this process and the complexity of the analysed data, statistical methods for describing, investigating and analysing object attributes should be developed based on classical statistical measures that have been suitably modified for this purpose (Sunmin et al., 2018).

In analyses of spatial databases, the investigated phenomena not only have to be quantified, but the mutual relations and interactions between the neighbouring objects also need to be described (Ramirez, Loboguerrero, 2002).

Spatial analyses can be performed on any type of objects localised in space. Spatial objects do not exist in isolation; therefore, their interactions with the surrounding space need to be investigated. According to Tobler's law (Tobler, 1970), objects that are separated by a smaller distance are characterised by stronger interrelations and more significant mutual interactions than distant objects.

Therefore, the definition of mutual interactions should be based on the definition of neighbourhood. In practice, this is accomplished with the use of spatial weights matrices to evaluate the impact of environmental factors on the processes investigated in a given region (Salamon, 2008).

**Methodology of research and materials**

The aim of the study was to analyse the applicability of the existing analytical models for analyses of demographic data. The results of such analyses provide highly valuable inputs for spatial planning and decision making. Special attention was paid to the availability of software and data for the proposed analyses.

There is a broad selection of commercial software and shareware programs for the visualisation and analysis of spatial data. Esri-ArcGIS, a popular mapping and analytics platform, was used in this study. The analytical packages in Esri-ArcGIS have different functionalities. Spatial Statistics tools are particularly useful for spatial analyses of demographic data. In this study, they were used to determine the dispersion of spatial phenomena and to perform multicriteria similarity analyses. Local and global statistics were described, and the results were visualised on thematic maps in the Esri-ArcGIS environment.

The applicability of demographic data in GIS programs was evaluated to determine whether the use of such solutions in this study was justified. The research was based on the case study of Warsaw – the biggest city and capital of Poland.

The selection of the relevant data is one of the greatest challenges facing the user before analysis. Data relating to the units of administrative division (Warsaw districts), census districts and address points were selected depending on the type and scale of the conducted research and the size of the analysed area.

**Discussions and results**

***The applicability of spatial data mining methods for analyses of demographic data***

Information is one of the most valuable commodities in the modern world. Computer users are bombarded with vast amounts of electronic data on a daily basis. The potential benefits of the accumulated data are determined by the user's ability to process that data and develop reports, identify similarities or trends. Skilful decision-making based on the results of statistical analyses, inference and data use supports the achievement of business, operational and scientific goals.

Knowledge Discovery in Databases, an emerging field of research, supports the extraction of useful knowledge from the rapidly growing volumes of data. KDD is closely related to statistics, in particular data mining methods. According to Gregory Piatetsky-Shapiro (1995, 1996, 2007), the co-founder of the KDD, knowledge discovery is "the non-trivial extraction of implicit, previously unknown, and potentially useful information from data".

Data mining is a stage of knowledge discovery. Large datasets are analysed with the use of selected algorithms to discover data patterns. A data model is developed, and its ability to accumulate useful knowledge is evaluated during the interactive KDD process which usually relies on subjective human judgement.

Spatial data mining is a specific process due to the unique character of the analysed data. Spatial data are often characterised by complex interactions and non-homogeneity, and observations that are separated by a small distance in geographic space are mutually related (are similar or different, depending on the observed phenomenon). Many geographic processes have a local character, and they are characterised by spatial non-homogeneity and instability relative to location.

Various models can be used to capture the above phenomenon and analyse spatial data. Standard deviation is the basic statistical measure for analysing clusters of the observed data. However, spatial units are not distributed uniformly in all directions from the central tendency; therefore, classical distribution analyses do not fully reflect the nature or dimensionality of the described objects. This problem can be resolved by calculating the standard distance separately for every direction to accurately determine the distribution of objects in space. The resulting values denote the axes of a standard deviational ellipse whose shape and direction reflect the orientation of object distribution. The axes of symmetry of the ellipse are rotated by a given angle to reveal the direction of dispersion around the central tendency and the direction and extent of minimum and maximum dispersion (Suchecka, 2014).

The directions of dispersion and object clusters can be examined globally for the entire set of points, or in intervals based on the spatial variability of objects in time. In demographic and behavioural studies, this tool is highly useful for analysing changes in population distribution. It can be used to describe the degree of clustering and dispersion, but when time is factored in as an additional factor, the discussed tool supports a comprehensive description of the analysed phenomena, which is of utmost importance in spatial planning.

In addition to analyses of data dispersion and data variation over time, GIS tools can also be used for more detailed and sophisticated analyses of demographic data. However, this process is fraught with many difficulties due to the complex nature of demographic data as well as the influence of social, environmental, technical and spatial factors. Such analyses should involve the largest possible volume of data, both quantitative and qualitative.

Demographic analyses involve numerous factors, and GIS tools seem to be well suited for comprehensive analyses of spatial data with the aim of identifying the searched attributes.

However, despite the wide availability of modern tools and complex analytical techniques, users often have to choose between several alternatives when making spatial decisions. The main aim of multicriteria analyses is to select the optimal variant, which incorporates difficult to compare criteria that significantly influence a given solution.

In demographic and spatial studies of population distribution, multicriteria analyses can be used to plan the location of objects (schools, healthcare facilities), administer territorial units and plan transportation routes.

Suitability (similarity) maps are an interesting solution in multicriteria analyses. This tool supports the identification and ranking of similarities between objects. In analyses that rely on a reference object, objects whose parameters are most similar to the reference parameters can be selected from a set of potential objects. A reference object can be an individual object as well as a group of objects with the desired attributes.

Similarity is determined based on a set of selected attributes with the use of one of three methods. Objects can be classified based on attribute values, the sequence of attributes in a series, or the relationships between variables (ESRI, 2010). In the classical approach, the attributes of the candidate objects are merely compared with the parameters of the reference object. The attributes are always determined by the type of analysis, and when standardised appropriately, they can be used in evaluations of similarity. The applicability of a conventional similarity analysis can be expanded by developing a continuous map of the investigated area. The map is used to identify objects that are most similar to the reference object in terms of the specified attributes.

Objects can be analysed not only for the presence of similarities, but also mutual relations. There are two measures of spatial autocorrelation in spatial statistics: global measures and local measures. Global autocorrelation denotes the presence of spatial relations between variables in the entire unit, whereas local measures indicate spatial relations between the variables in a given location and the variables in the neighbouring locations (Ord and Getis, 1995, 2011).

In line with the above definition, global spatial autocorrelation supports the determination of the mutual relations between objects in the entire unit, and it is usually investigated with the use of global Moran's I statistic (Siano, D'Uva, 2011). Moran's I has a positive value when the studied objects are similar and a negative value when similarities are not found. The value of Moran's I approximates zero when objects are randomly distributed (no autocorrelation). The main disadvantage of global autocorrelation is that its values are determined by the aggregation of the entire dataset into regions.

Both global and local attributes of the evaluated dataset are taken into account in detailed spatial analyses. The correlations in the entire studied unit are determined in a global analysis, but the significance of an individual object in its immediate neighbourhood can be determined only in a local analysis.

Local Indicators of Spatial Association (LISA) statistics are the most popular and widely used measures of local autocorrelation. These indicators are applied to determine the similarity of a spatial unit relative to its neighbours and the statistical significance of the observed relationship (Anselin, 1995). Local indicators of spatial association include local Moran's I, which supports the determination of the spatial effects of agglomeration, and local Geary's C which reflects spatial similarities and differences (Geary, 1995). Moran's I is applied to determine whether the investigated area neighbours regions with similar values of the studied variable relative to the random distribution of these values in space. Similarly to global statistics, local Moran's I has a negative value if the neighbouring area differs significantly from the analysed area. Positive values of Moran's I denote similarities between the investigated region and its surroundings.

***A demographic analysis of the Warsaw area***

The rate of population growth in Warsaw was determined by analysing changes in the population of Warsaw districts between 1950 and 2012. An analysis of changes in the observed trend over time supports preliminary data mining, identification of data patterns and, consequently, in-depth data analysis.

The results of the analysis indicate that until 1970, the local population was concentrated mainly in the pre-war districts of Warsaw (Mokotów, Ochota, Wola) that had been reconstructed after the war. Beginning in the early 1970s, the construction of high-rise residential districts contributed to the gradual spread of the local population to other parts of the city.

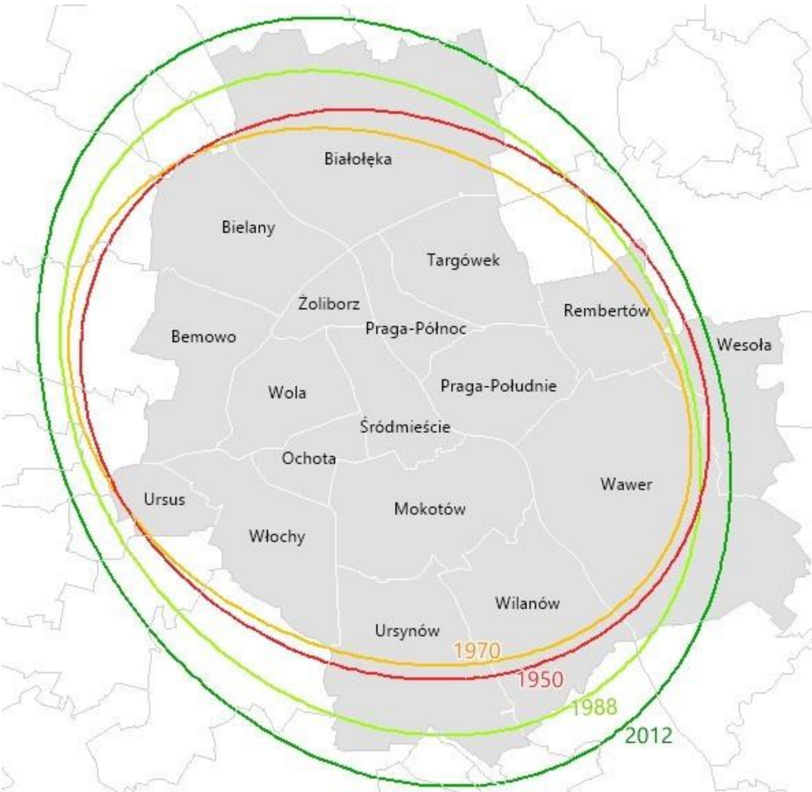



**Fig. 1.** Concentration of Warsaw's population between 1950 and 2012 (Kurowska and Kietlińska, 2017).

The political transformations of 1989 initiated profound economic and demographic changes in Poland. The availability of mortgage loans, rapid economic growth and rising incomes in urban areas contributed to suburbanization. The liberalization of the real estate market and the reinstatement of land rents were also important drivers of urban to suburban migration (Słodczyk, 2001). Suburbanization produced a negative net migration rate in large cities and a positive net migration rate in the surrounding areas. Research indicates that not all metropolitan municipalities develop at the same rate. The highest population growth and the highest migration rates are noted in the municipalities adjacent to the urban core, whereas the urban population increases at a modest rate (Kasanko et al., 2006; Pardo-García and Mérida-Rodríguez, 2018; Sroka et al., 2018). Uncontrolled migration to suburbia changes the function and appearance of those areas (Kajdanek, 2011). The concentration ratio of Warsaw's population in the past 60 years has been calculated by Gawryszewski (2010).

**Table 1**

Lorenz concentration ratio for 18 districts in Warsaw in 1950 – 2010

| | Year | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1950 | 1960 | 1970 | 1978 | 1988 | 2002 | 2010 |
| Lorenz concentration ratio (0≤ k ≤1) | 0.590 | 0.605 | 0.618 | 0.589 | 0.531 | 0.474 | 0.438 |

Cities undergo constant change. Their architecture, infrastructure, public spaces and the quality of human resources continue to evolve over time. The availability of services, including public transport and culture, significantly contributes to a city's appeal. Good living conditions improve living standards in a city and the entire metropolitan area. However, not all urban residents have equal access to infrastructure, services and public spaces. In many cities, social polarisation leads to spatial segregation. These problems often stem from inadequate spatial development policies which focus on improving living standards in downtown areas, environmentally-friendly housing estates, business parks and shopping centres, but disregard areas that are less attractive for investors.

For this reason, demographic analyses should not only investigate the distribution of populations, but also the spatial distribution of different social groups. Various tools can be used for this purpose.

Similarity analyses are highly useful for in-depth evaluations of urban demographics. They support the identification of population groups characterised by various attributes. Given the nature of the analysis and the type and detail of the available data, the incomes of Warsaw residents were mapped on the assumption that wealth can be evaluated based on two factors: the type of residential building and per-capita buying power.

For continuous visualisation of the analysed data, address points were aggregated in a 250x250 m grid to evaluate the degree of similarity in the studied area. This approach was adopted to analyse microdata and to avoid errors resulting from excessive data aggregation. Per-capita incomes were expressed in Polish zloty (PLN) in a grid cell. The proportion of the population inhabiting various types of buildings (single-family or multi-family housing) was expressed as a percentage. The reference point (grid cell) was a point characterised by the highest value of the per-capita buying power index (PLN 22896/year/person) where 100% of the population inhabit single-family houses. Uninhabited grid cells were excluded from the analysis.

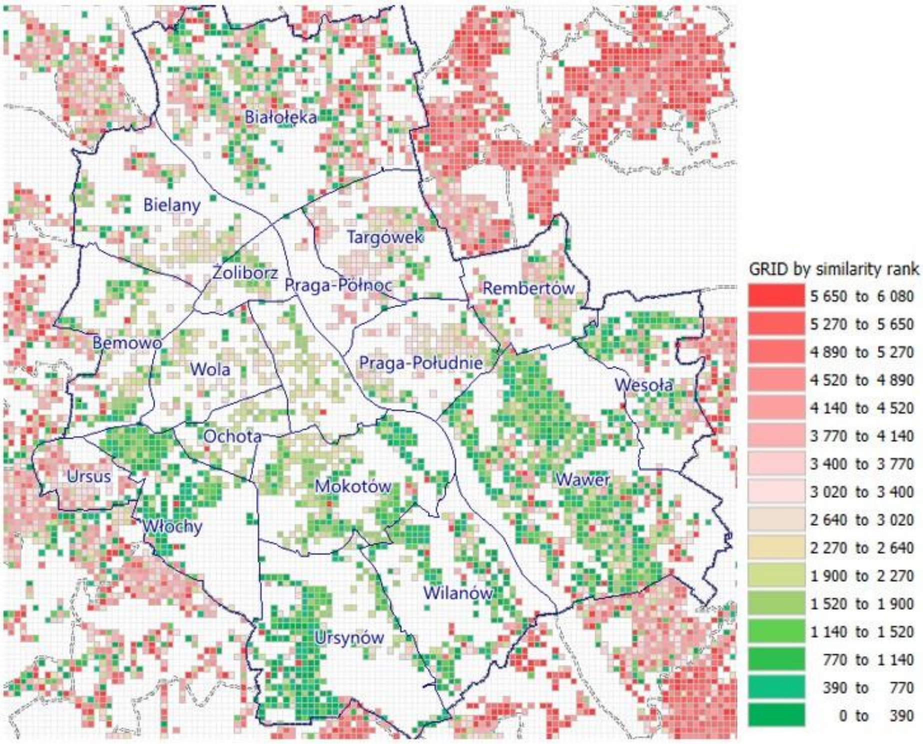



**Fig. 2.** A map of similarities in the incomes of Warsaw residents (data for 2014).

All observations in the dataset (grid cells) were ordered based on their similarity to the reference point and were assigned a similarity index (the closer the examined value to the reference point, the lower the value of the similarity index). The resulting values were used to map incomes in different districts of Warsaw. South Warsaw was characterised by the highest levels of affluence (green grid cells).

The presented tool is highly useful for analysing demographic data. Only two values were analysed in this study (income, type of residential building), but the developed tool is highly versatile and it supports the implementation of diverse variables. Demographic data can be used as the main variable or as one of many variables in a complex analysis. When the extent of data aggregation and the range of attributes (income, age group, working age) are selected accordingly, the proposed tool can be used to identify target groups, including outside the context of spatial management and planning.

The demographic structure not only reflects income levels, but also the distribution of age groups in a population. Residents belonging to different age groups form distinct clusters in urban areas. These areas are strongly correlated and mutually related. Local and global statistical data were used and districts with the highest proportion of the working-age population inhabiting single-family homes were selected to determine the distribution of various age groups in Warsaw. The adopted method can be used to identify areas with a predominance of target groups characterised by selected attributes.

The choice of the optimal reference unit is a very important consideration. The proposed aggregate largely determines the extent to which the examined phenomenon can be accurately described. Artificially generated boundaries do not fully reflect the character of the analysed area or the existing limitations to human activity.

Census districts were used in this study. These units are generated artificially, but their main advantage over automatically generated statistical grids is that the shape of every census district is highly dependent on topography, the distribution of transportation routes and other obstacles (the human tendency to form groups was taken into account). A census district is defined as a spatial unit, which is created for the needs of a census or statistical research. To ensure that census operations are conducted efficiently, the size of a census district should not exceed 500 persons and 200 apartments. The analysis relied on demographic data for 2014.

In view of the above, it can be assumed that every census district has similar demographic potential regardless of its area. However, Warsaw is a highly urbanised area and, according to Central Statistical Office requirements, census districts have to incorporate entire buildings (regardless of the

number of apartments in a building); therefore, the criteria associated with the number of inhabitants and the number of apartments are often exceeded. For this reason, the proportion of the working-age population in the total population of a census district was used as a variable in the analysis.
The absolute value of single-family homes also varies in census districts and does not constitute a conclusive point of reference; therefore, the percentage of residential units in single-family homes in the total number of residential units in a census district was calculated for the needs of the analysis.
Spatial autocorrelation in census districts was analysed with the use of a queen contiguity-based weights matrix. These spatial weights were selected because they are completely independent of the size of census districts and because they focus on and significantly influence units in the immediate vicinity of the analysed object.
The results of spatial autocorrelation analyses involving Getis-Ord G and Moran's I statistics revealed the presence of strong spatial autocorrelations. The p-value was zero in both cases; therefore, the probability that objects were randomly distributed in space was negligible.

**Table 2**

The results of a spatial autocorrelation analysis

| | | **Single_perc** | **Work_perc** |
|---|---|---|---|
| **Global Moran's I** | Moran's I | 0.735642 | 0.261534 |
| | z-score: | 154.514681 | 54.959793 |
| | p-value: | 0.000000 | 0.000000 |
| **Getis-Ord General G** | Observed General G: | 0.001014 | 0.000435 |
| | z-score: | 113.493413 | 5.976728 |
| | p-value: | 0.000000 | 0.000000 |

The maps created based on the Getis-Ord statistic present the distribution of clusters with high and low values of the analysed variables in Warsaw. The maps reveal distinct clusters of high values: a predominance of the working-age population in the districts of Tarchomin, Bemowo and Wilanów, and a predominance of single-family homes in the peripheral districts and suburban areas. Areas with a low proportion of single-family homes (cold spots) are found mainly in central Warsaw and, to a much lesser degree, in the neighbouring urban areas.

a) b)

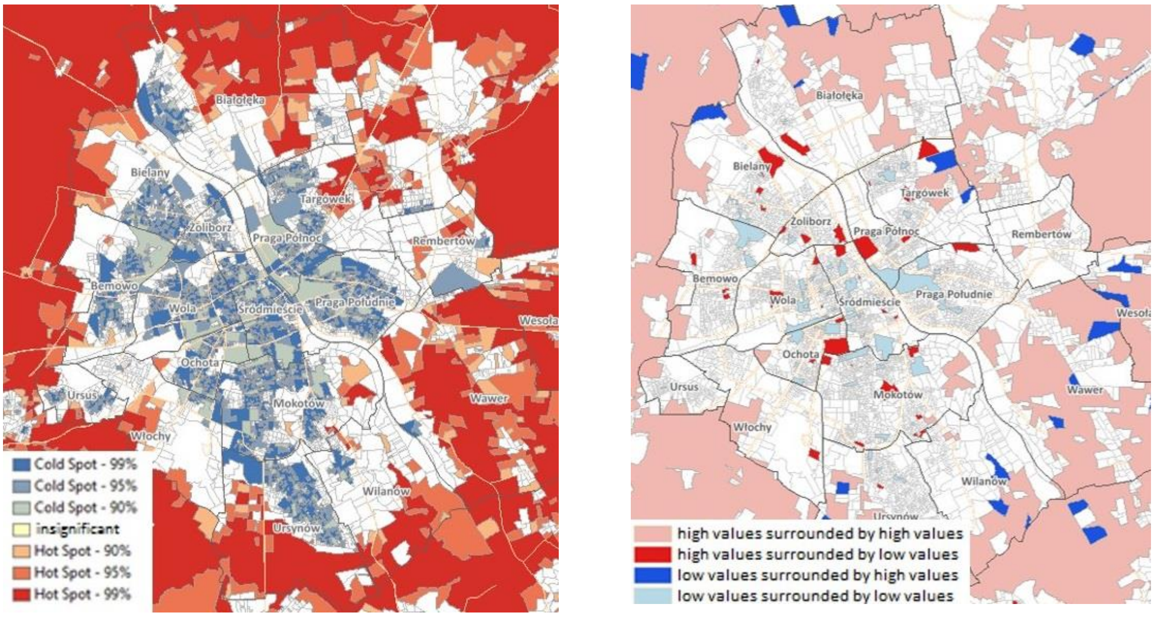



**Fig. 3.** Visualisation of clusters with high and low proportions of single-family homes: a) global correlation coefficients, b) local correlation coefficients (own elaboration).

The high values of global Moran’s I were confirmed by LISA statistics. A queen contiguity-based weights matrix was also used in an analysis of local statistics. A global analysis supports a general overview of the data and facilitates preliminary statistical analyses, but spatial structure and mutual relations can be evaluated in detail only in a local analysis. Local correlation coefficients were mapped to reveal the presence of individual units with a predominance of single-family homes in areas where clusters of multi-family buildings were identified in the global analysis.

a) b)

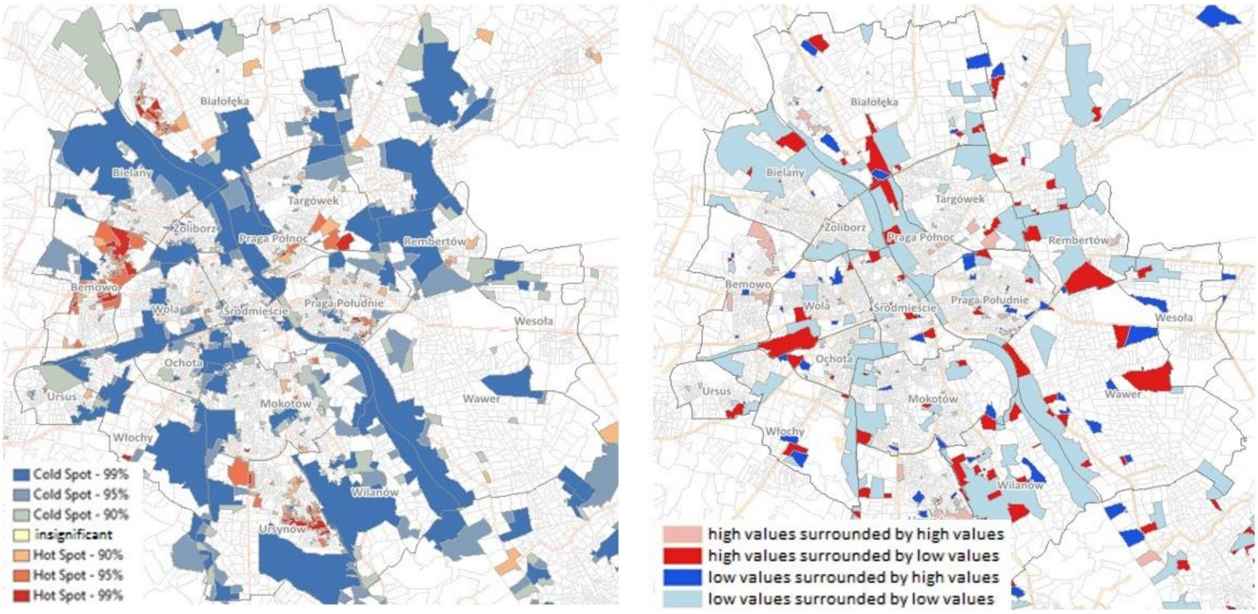



**Fig. 4.** Spatial distribution of the working-age population: a) global correlation coefficients, b) local correlation coefficients (own elaboration).

An analysis of global and local correlation coefficients relating to the working-age population in districts produced similar observations. A cohesive and homogeneous cluster of high values was identified in the district of Wilanów in the global analysis, but the presence of outliers where the values of the investigated variables were clearly lower than in the neighbouring districts was noted only in the local analysis.

Local statistics not only support the identification of significant clusters with similar values in the vicinity of the analysed unit, but they also provide valuable information about the spatial distribution and homogeneity of the analysed variable in a given area. Local statistics are also helpful in identifying atypical observations and clusters of high and low values.

However, the analysed phenomena are not always easy to describe with the use of two independent statistics. Districts with a predominance of the working-age population and single-family homes may be difficult to validate in this approach. In analyses that involve a higher number of variables, all attributes should be analysed jointly to select districts where the investigated variables reach maximum values.

Cluster analysis involves the search for natural clusters in datasets and data classification. Objects are grouped based on user-defined variables to minimise the differences between objects belonging to the same group and maximise the differences between objects belonging to different groups. Similarities are determined in the groups specified by the user or estimated by the tool.

The coefficient $R^2$ was calculated for every variable to determine the extent to which the variability of the original dataset was preserved during the grouping process. The accuracy of clustering increases with a rise in the value of $R^2$. The minimum, maximum and median values, standard deviation and the spread of the variables in the dataset and in groups are presented in Table 3.

**Table 3**

Statistics for the entire dataset and datasets generated by clustering

| | **Mean** | **SD** | **Min** | **Max** | **R2** |
|---|---|---|---|---|---|
| single-family homes | 0.3084 | 0.4095 | 0 | 1 | 0.9059 |
| working-age population | 0.6025 | 0.1606 | 0 | 1 | 0.7927 |
| | **Mean** | **SD** | **Min** | **Max** | **Share** |
| single-family homes | 0.0305 | 0.0845 | 0 | 0.449 | 0.449 |
| working-age population | 0.6363 | 0.0808 | 0.3333 | 1 | 0.6667 |
| single-family homes | 0.8671 | 0.1443 | 0.45 | 1 | 0.55 |
| working-age population | 0.6372 | 0.0625 | 0.25 | 1 | 0.75 |
| single-family homes | 0.1119 | 0.2916 | 0 | 1 | 1 |
| working-age population | 0.0022 | 0.0221 | 0 | 0.2778 | 0.2778 |

The most interesting results were obtained when the observations were divided into three independent groups (Table 3 and Fig. 5):

- blue – predominance of single-family homes and an above-average proportion of the working-age population;
- red – negligible proportion of single-family homes and an above-average proportion of the working-age population;
- green – negligible proportion of single-family homes and the working-age population.

Despite the fact that mutual spatial relations were not taken into account in the process of defining clustering parameters, clusters of objects belonging to different groups can be clearly identified in the map. This observation confirms the spatial dependence of the analysed variables.

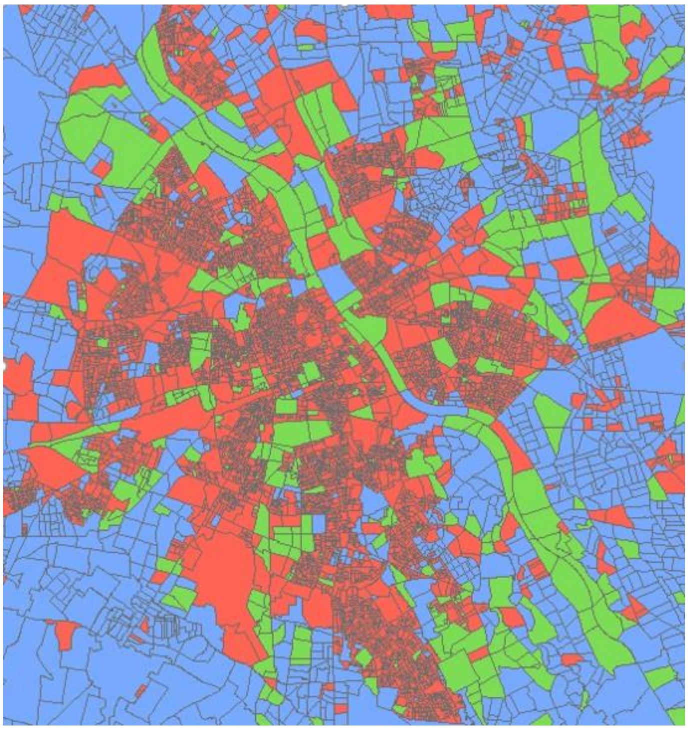


**Fig. 5.** Division of the urban space into groups based on the proportion of the working-age population and the proportion of single-family homes

The greatest benefits stemming from the implementation of local and global spatial statistics in traditional analytical processes include the identification of statistically significant clusters of high and low values, detailed analyses of the spatial distribution of the examined variable in a given area and the identification of outliers and atypical values.
In practice, the discussed solutions are applied by businesses and institutions to investigate the heterogeneity of a variable in the studied area. The visualisation of local statistics supports a quick identification of areas with low variable values, which cannot be achieved with the use of traditional analytical tools.

**Conclusions**

1. Cities play a key role in human settlement systems and they are the main hubs of economic activity. Depending on their rank in the settlement systems, cities are local, regional or national growth centres whose development influences the surrounding areas. The economic status of cities and the demographic processes that take place in urban areas are of vital significance for the national economy.
2. The growing applicability of software tools supports the broad use of methods and models exploring the location of spatial objects. The unique features of spatial data have to be taken into account in every stage of the process, beginning from the selection of data and the appropriate analytical methods to data visualisation. The user is responsible for the selection of the methods and tools that are best suited for analysing specific types of data.
3. mining requires methods that support detailed analyses of the examined variables and the identification of the type and degree of spatial autocorrelation, heterogeneity and interdependence. The choice of the appropriate visualisation techniques facilitates analyses of the spatial distribution of variables, determination of atypical locations and observations, and the identification of data patterns, clusters and special objects.
4. The choice of visualisation technique is determined by the scale of measurement, the number of dimensions and the user’s preferences. Data transformations and calculations produce valuable spatial information for decision making.
5. Geographic information systems are valuable tools for mining demographic data. They can be used for simple visualisations of data as well as for planning, forecasting and modelling demographic processes. Detailed information about the location of spatial objects not only improves analytical accuracy but is an essential component of spatial research. It facilitates parameter prediction in any time interval, effective analyses of current data, demographic forecasts and evaluations of the influence of spatial correlations on strategic decision-making in a wide range of industrial applications.
6. The cross-sectional studies and reports generated with the involvement of GIS tools support comprehensive assessments of the observed phenomena and contribute to optimal decision making.

**References**


1. Anselin L. (1995) Local Indicators of Spatial Association. *Geographical Analysis*, 27, No. 2. p. 93-115.
2. Cigno A. (1991) *Economics of the family.* Oxford University Press, New York.
3. Cliquet R.L. (1991) *The second demographic transition: fact or fiction?* Council of Europe, Strasbourg.
4. Esri, (2010) ArcGIS Desktop 10 Help.
5. Gawryszewski A. (2010) Demographic and social development of Warsaw in the twentieth century. Mazovia Province. *Regional Studies*, 5, p. 11-28.
6. Gaździcki J. (2001) *Leksykon geomatyczny. [Lexicon of geomatics]*, Polskie Towarzystwo Informacji Przestrzennej, Warszawa.
7. Geary R.C. (1954) *The contiguity ratio and statistical mapping*. Incorporated Statistician, p. 115–145.
8. Kajdanek K. (2011) *Pomiędzy miastem a wsią. Suburbanizacja na przykładzie osiedli podmiejskich Wrocławia*. Nomos, Kraków.
9. Kasanko, M., Barredo, J. I., Lavalle, C., McCormick, N., Demicheli, L., Sagris, V., Brezger, A. (2006) Are European cities becoming dispersed?: A comparative analysis of 15 European urban areas. *Landscape and urban planning*, 77(1-2), p. 111-130.

10. Kotowska I.E. red. (1999) *Przemiany demograficzne w Polsce w latach 90. w świetle koncepcji drugiego przejścia demograficznego.* Wydawnictwo SGH, Warszawa.
11. Kowalczyk C. (2015) Dynamics of urban space. *Journal of Economics and Management* 19(1), p. 5-15.
12. Kurowska K., Kietlińska E. (2017) The applicability of accessibility analyses in spatial planning. *Baltic Surveying*, 49, p. 47-56.
13. Lee A.C.D., Rinner C. (2015) Visualizing urban social change with self-organizing maps: Toronto neighbourhoods, 1996–2006. *Habitat International*, 45, p. 92-98.
14. Ord J.K., Getis A. (1995) Local spatial autocorrelation statistics: distributional issues and an application. *Geographical Analysis*, 27, p. 286-305.
15. Ord J.K., Getis A. (2011) Testing for Local Spatial Autocorrelation in the Presence of Global Autocorrelation. *Journal of Regional Science*, 41, p. 411-432.
16. Pardo-García S., Mérida-Rodríguez M. (2018) Physical location factors of metropolitan and rural sprawl: Geostatistical analysis of three Mediterranean areas in Southern Spain. *Cities*, 79, p. 178-186.
17. Piatetsky-Shapiro G. (1995) Knowledge discovery in personal data vs. privacy: A mini-symposium. IEEE Expert: Intelligent Systems and Their Applications, 10(2), p. 46-47.
18. Piatetsky-Shapiro G. (1996) From Data Mining to Knowledge Discovery: an Overview. U. Fayyad, G. Piatetsky-Shapiro, P. Smyth, in *Advances in Knowledge Discovery and Data Mining*, AAAI/MIT Press.
19. Piatetsky-Shapiro G. (2007) Data Mining and Knowledge Discovery – 1996 to 2005: Overcoming the Hype and moving from "University" to "Business" and "Analytics", Gregory Piatetsky-Shapiro, *Data Mining and Knowledge Discovery Journal*.
20. Ramirez M.T. , Loboguerrero A.M. (2002) *Spatial dependence and economic growth: Evidence from a panel of countries.*
21. Salamon J. (2008) Studies on spatial autocorrelation of technical rural infrastructure development in the Świętokrzyskie province using Moran's I statistics. *Infrastructure and Ecology of Rural Areas*, 8, p. 207-214.
22. Siano R. De., D'Uva M. (2011) Italian regional specialisation: a spatial analysis. *Università degli Studi di Napoli-Parthenope, Discussion Paper*, 07.
23. Słodczyk J. (2001) *Przestrzeń miasta i jej przeobrażenia*. Wydaw. Uniwersytetu Opolskiego, Opole.
24. Sroka W., Mikolajczyk J., Wojewodzic T., Kwoczynska B. (2018) Agricultural Land vs. Urbanisation in Chosen Polish Metropolitan Areas: A Spatial Analysis Based on Regression Trees. Sustainability, 10(3), 837p.
25. Suchecka J. (2014) *Statystyka przestrzenna. Metody analizy struktur przestrzennych*. *[Spatial statistics. Methods of spatial structures analysis]* C.H.Beck, 2014.
26. Sunmin L., Saro L., Moung-Jin L., Hyung-Sup J. (2018). Spatial Assessment of Urban Flood Susceptibility Using Data Mining and Geographic Information System (GIS) Tools. Sustainability 10 (648); doi:10.3390/su10030648
27. Tobler W.R. (1970) A computer model simulating urban growth in the Detroit region. *Economic geography*, 46(2).

**Information about authors**

**Krystyna Kurowska, PhD.**, Faculty of Geodesy, Geospatial and Civil Engineering, University of Warmia and Mazury in Olsztyn. Prawocheńskiego 15, 10-720 Olsztyn, phone: +48 895 234281, krystyna.kurowska@uwm.edu.pl Fields of interest: spatial planning, rural development, GIS.

**Ewa Kietlińska, M.Sc.**, Faculty of Geodesy, SGN Sp. z o.o. Wyspiańskiego 14, 39-400 Tarnobrzeg, phone: +48 600 287 133, evakietlinska@gmail.com . Fields of interest: GIS, geostatistics, geoinformatics.

**Hubert Kryszk, PhD.**, Faculty of Geodesy, Geospatial and Civil Engineering, University of Warman and Mazury in Olsztyn. Prawocheńskiego 15, 10-720 Olsztyn, phone: +48 895 234209, hubert.kryszk@uwm.edu.pl Fields of interest: real estate market, rural development, geoinformatics.

DOI: 10.22616/j.balticsurveying.2018.019

# USE OF GEOSPATIAL ANALYSIS METHODS IN LAND MANAGEMENT AND CADASTRE

**Tamara Myslyva, Bronislava Sheluto, Olesya Kutsaeva, Svetlana Naskova**
Belarussian State Agricultural Academy

**Abstract**
The possibilities of using the geospatial analysis methods for visualizing land monitoring data and modelling the spatial distribution of the main agrochemical soil indicators are discussed in the article. The research was conducted within the limits of land use of RUP "Uchkhoz BGSHA" (Republic of Belarus, Mogilev region, Goretsky district). The total area of the surveyed territory was 3187.0 hectares. The geospatial analysis of the spatial distribution of humus, mobile phosphorus, mobile potassium and $pH_{KCl}$ was carried out using the Geostatistical Analyst module of the ArcGIS software. Semivariograms were used as the main tool for studying the structure of the spatial distribution of agrochemical indicators. The exponential function was identified as the best variogram model, the type of the circle was standard, the type and the number of sectors was 4 with a displacement of 450, and the lag was 200 metres. The interpolation accuracy was determined from the mean error (ME), mean square error (RMSE) and standard error (RMSS). The universal kriging method was used to perform the forecast and visualize the spatial distribution of agrochemical indicators. The multivariate analysis was performed using the functionality of the Raster Calculator tool, Principal Component analysis and Maximum Likelihood Classification. The search and determination of areas of sites with the most optimal agrochemical indicators were carried out by the multifactor analysis in the GIS environment. Calculation of the area of each circuit within the limits of working parcels was carried out using the utility "Zone Statistics".
Key words: geospatial analysis, interpolation, universal kriging.

## Introduction

One of the main strategic national interests declared in the National Security Concept of the Republic of Belarus is sustainable economic development and high competitiveness of the Belarusian economy, as well as the achievement of a high level and quality of life of citizens (Ob utverzhdenii…, 2010; Myslyva et al., 2016). An effective tool for ensuring the economic well-being and food security of the country is its powerful and modern agro-industrial industry. The productive potential of the agricultural sector, especially husbandry, is determined by the quantitative and qualitative characteristics of agricultural land, the quality of which, in turn, is determined by the fertility of the soil cover (Kurakpaev, 2016; Myslyva, 2018). The economic efficiency of land use and the efficiency of agriculture generally largely depend on the quality of land resources.
Rational use of land resources is one of the most important factors in the development of the Republic of Belarus. Monitoring of the state of land becomes a reference point for public authorities for developing regulatory legal acts regarding their use, conducting territorial planning, implementing measures to protect land and reproduce soil fertility. It is necessary to use innovative means for processing and analyzing spatial information about the state of land, to master methods of appropriate solution of management problems, assessing and monitoring the dynamics of land use to solve these problems.

## Methodology of research and materials

The purpose of the research was to establish the possibility of using methods of geospatial analysis to estimate the spatial distribution of humus, mobile phosphorus, mobile potassium and $pH_{KCl}$ within the land use of RUP "Uchkhoz BGSHA" (Fig. 1), and to identify areas with the most optimal agrochemical indicators by performing multivariate analyses in the GIS environment.
The geospatial analysis of data was carried out using the Geostatistical Analyst module of the ArcGIS software version 10.2. The data obtained from the materials of the agrochemical survey of the territory of RUP "Uchkhoz BGSHA" (Republic of Belarus, Mogilev region, Goretsky district), executed in 2014 by the Mogilev Regional Design and Exploration Station of Agrochemicalization were used for the analysis. The total area of the surveyed territory is 3187.0 hectares. The soil cover

of the study area is represented mainly by sod-podzolic sandy loam on water-glacial sandy loam soils and sod-podzolic loamy on loess-like loam soils.

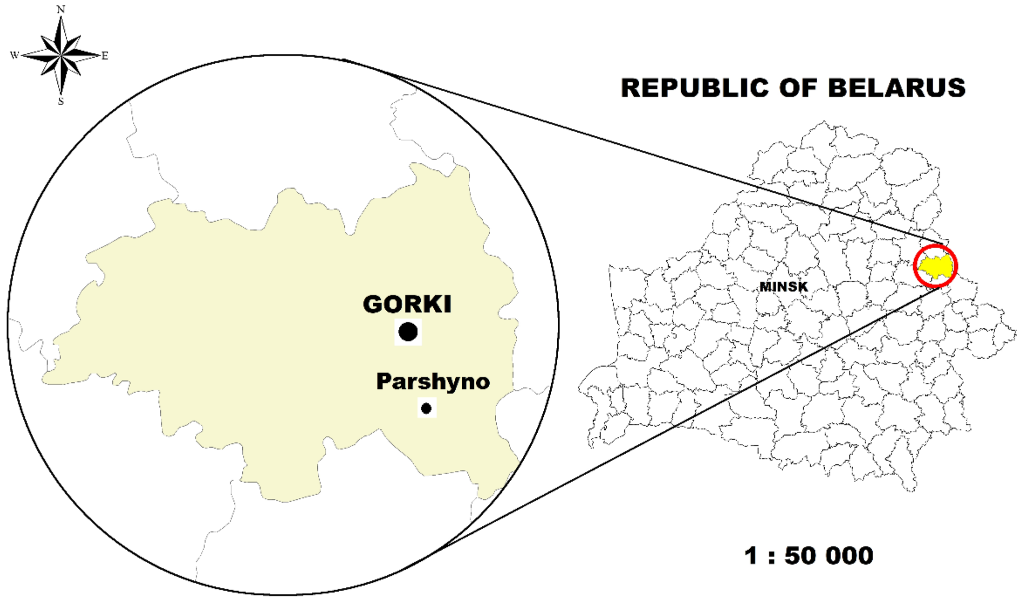



**Fig. 1.** The location of the studied territory

The universal kriging (Universal Kriging, UK), a geostatistical method of interpolation using the statistical properties of measured points to construct the surface, was used to perform the forecast and visualize the spatial distribution of agrochemical indicators. The universal kriging (UK) method is used when it is assumed that there is some dominant trend in the data that can be modelled using a deterministic polynomial function. It can use either variograms or covariances (mathematical forms used to express autocorrelation), apply transformations, and take into account the measurement error. The advantage of kriging is that it gives not only interpolated values, but also estimation of a possible error of these values (Myslyva et al., 2017). The interpolated value when applying universal kriging is determined by the formula (1):

$$Z(s) = \mu(s) + \varepsilon(s) \qquad (1)$$

Where $\mu(s)$ denotes a deterministic function described by a polynomial of the second order,

$\varepsilon(s)$ denotes a random error that is calculated by subtracting a second-order polynomial from the original data.

Semivariograms were used as the main tool for studying the structure of the spatial distribution of agrochemical indicators. Based on the regional theory of variations and internal hypothesis (Gouri et al., 2016), the semivariogram is expressed as follows (2) (Wang, Shao, 2013):

$$\gamma(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [Z(x_i) - Z(x_i + h)]^2 \qquad (2)$$

Where $\gamma(h)$ denotes semi-variant,

$h$ denotes the lag interval,

$Z$ denotes soil property parameter,

$N(h)$ denotes the number of pairs of places separated by the distance lag $h$,

$z(x_i)$ and $z(x_i+h)$ denotes the values of $Z$ at the positions $x_i$ and $x_i + h$.

The interpolation accuracy was determined from the mean error (ME), mean square error (RMSE) and standard error RMSS (3), (4), (5):

$$ME = \frac{\sum_{i=1}^{N}(O_i - S_i)}{N} \qquad (3)$$

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{N}(O_i - S_i)2}{N}} \quad (4)$$

$$\text{RMSS} = \frac{RMSE}{\Delta} \quad (5)$$

Where $0_i$ denotes the observed value,

$S_i$ denotes the predicted value,

$N$ denotes the sample size,

$\Delta$ denotes the range equal to the difference between the maximum and minimum observable values.

**Discussions and results**

The application of the module "Geostatistical Analyst" for spatial modelling of distribution in soil humus, exchangeable phosphorus and potassium, as well as $pH_{KCl}$ of soil solution provided a preliminary assessment of the initial data for their suitability for modelling purposes. As a result of the use of tools for an exploratory analysis of spatial data, a histogram of the distribution of initial data was created and the form of their distribution was investigated, and the basic statistical characteristics of the sample were calculated (Table 1).

**Table 1**

Statistical characteristics of a sample of data on agrochemical indicators used to construct interpolation models, n = 92

| Indicator | Indicator value | | | Sd | Cv, % | Med | Kurtosis | Skewness |
|---|---|---|---|---|---|---|---|---|
| | min | max | mid | | | | | |
| Humus, % | 1.25 | 3.35 | 1.93 | 0.44 | 22.8 | 1.92 | 4.01 | 0.75 |
| $P_2O_5$, mg/kg | 94.0 | 401.0 | 263.2 | 90.0 | 34.2 | 278.0 | 2.26 | -0.29 |
| $K_2O$, mg/kg | 186.0 | 516.0 | 230.9 | 104.5 | 45.3 | 216.0 | 2.02 | 0.27 |
| $pH_{KCl}$ | 5.2 | 7.0 | 6.07 | 0.4 | 7.76 | 6.05 | 0.34 | 0.04 |

Note: Sd is the standard deviation; Cv is the coefficient of variation; Med is the median.

Preliminary evaluation of the data makes it possible to establish the necessity of carrying out their transformation with the subsequent modelling of the distribution surface. If the data distribution differs significantly from the normal one, you need to convert the data. In particular, if the data distribution has several peaks (extremums), that is, the data are asymmetrically distributed; the logarithmic transformation that approximates the distribution to normal is applied to such data. In our case, the conversion is suitable, since the distribution of the sample data in all cases was unimodal and close to normal, but the mean values and the median are relatively close in value.

The Trend Analysis tool of the Geostatistical Analysis module allows to display data in a three-dimensional perspective. The locations of the reference points, which in our case are the locations of the selection of soil samples for agrochemical analysis, are plotted on the x, y plane. A unique feature of this tool is that the values are projected onto the perpendicular planes x-z and y-z in the shape of dispersion diagrams. Then, polynomials are fitted with using scattering diagrams on the projected planes. The line of the best fit (polynomial), drawn through the projected points, shows the trends of data changes in certain directions. In our case, a certain trend for all the investigated agrochemical indicators is observed both in the direction of the west-east and in the direction of the north-south. Since the trend is U-shaped, it is advisable to use a second-order polynomial as a global trend model for performing interpolating as well as apply the trend removal option for constructing models using the universal kriging method.

The experimental anisotropic variograms were calculated to determine the possible spatial structure of humus content, mobile phosphorus and potassium, and the pH of the soil solution. The exponential function was identified as the best variograms model, the type of the circle was standard, the type and the number of sectors was 4 with a displacement of 450, and the lag was 200 meters. The results of estimating the predictive models generated by the universal kriging method are presented in Table. 2.

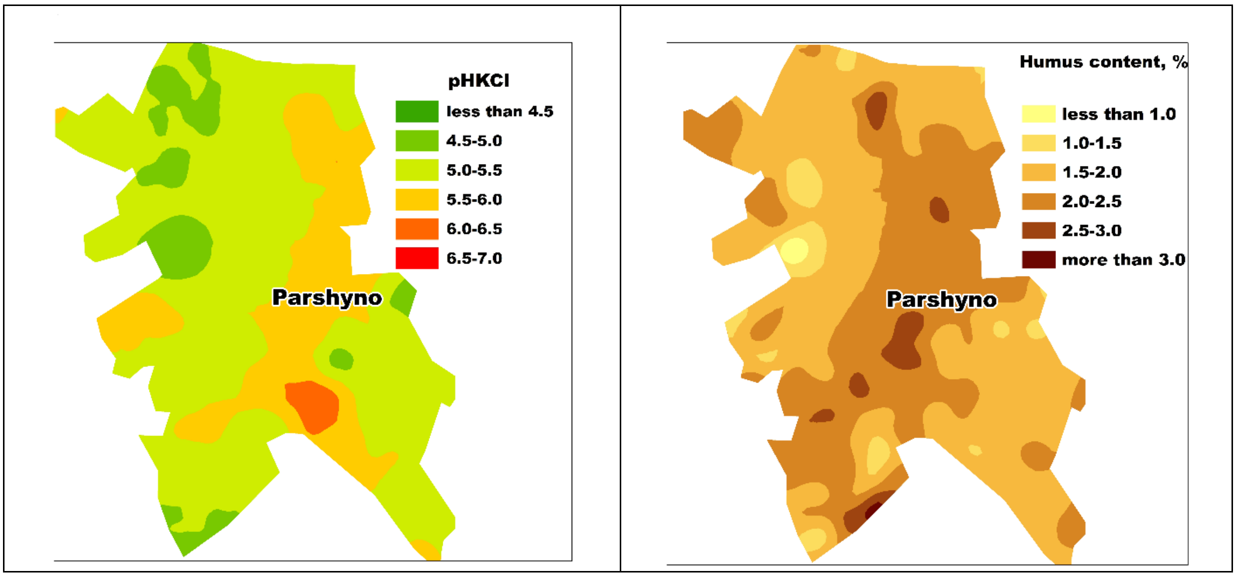
**Table 2**

Results of interpolation accuracy estimation

| Semivariogram model | ME | RMSE | RMSS |
|---|---|---|---|
| Humus content, % | 0.0015 | 0.38 | 1.03 |
| Mobile phosphorus content, mg/kg | 0.25 | 71.09 | 1.01 |
| Mobile potassium content, mg/kg | 0.85 | 84.20 | 1.03 |
| $pH_{KCl}$ of the soil solution | 0.0049 | 0.81 | 1.08 |

By the accuracy of the interpolation, the predicted models of the spatial distribution of agrochemical indicators created using geospatial analysis methods are located in the following descending series: humus > phosphorus> potassium > $pH_{KCl}$. This is explained by the fact that there is a close correlation (r = 0.97) between the content of humus and phosphorus in the soil, but the pH of the soil solution, unlike other indices, does not undergo any dramatic changes within the study area (Cv = 7.76). In the case of sharp changes in the index, interpolation by the kriging method gives results that are more accurate.

Fig. 2 presents the results of visualization of the spatial distribution of the studied data (the classification was performed by the method of manual intervals).



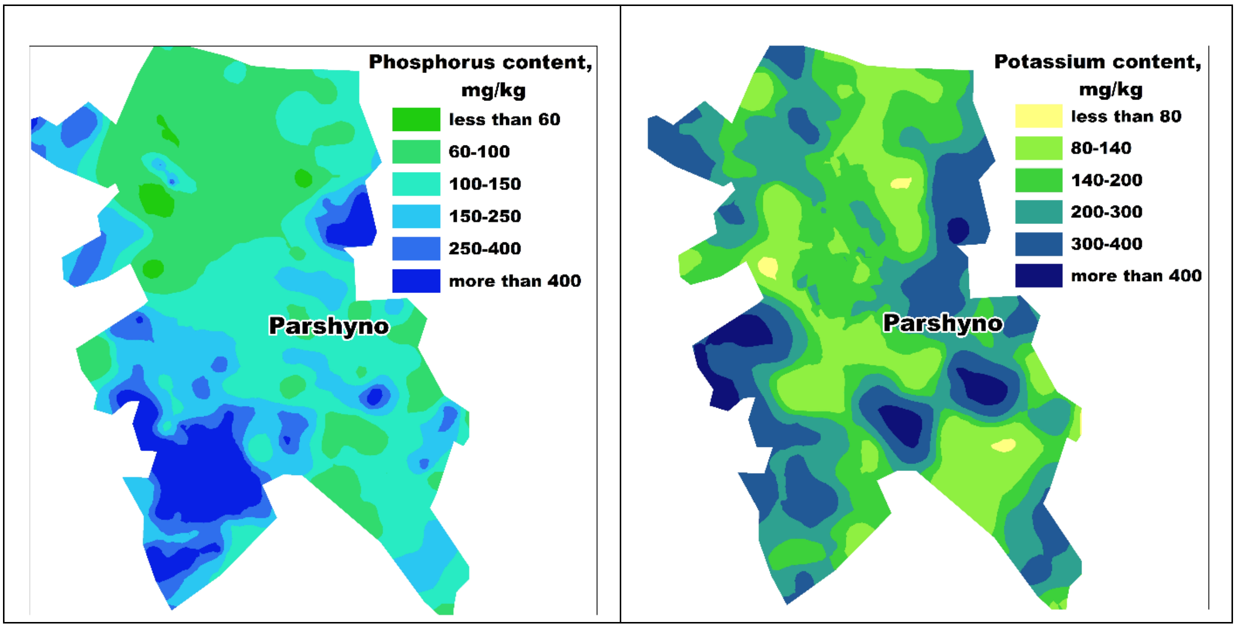



**Fig. 2.** The spatial distribution of agrochemical indicators in a 0-20 cm layer of soil, modelled by the method of universal kriging

It is necessary to note that the implementation of multifactor analysis, when based on the analysis of several interpolated rasters simultaneously drawing conclusions about the qualitative state of the territory and its suitability for various purposes of use, is quite frequent in solving problems through spatial analysis. The main task of our studies was to analyze the interpolated surfaces in order to find the sites the most favorable for the complex of basic agrochemical indicators. To perform this kind of analysis, the toolkit of the ArcToolbox module was used. Before starting the analysis, you need to reclassify the interpolated surfaces using the Reclassification utility from the Spatial Analyst toolbox. This tool changes the values of the raster to the corresponding values of the class specified by the user.

Multifactor analysis for searching the optimal agrochemical land parcels was carried out in three ways:

- Method 1: analysis using the functionality of the Raster Calculator tool of the “Map Algebra” utility;
- Method 2: analysis using the tool “Principal Components” of the utility “Multidimensionality”, in the application of which one resulting multichannel raster is created from several rasters;
- Method 3 - Maximum Likelihood Classification, using classification with training.

As a result of multifactor analysis, three resulting images were obtained by the methods described above. If we compare the maps obtained by different classification methods, we can see that the most qualitative sites have the same spatial localization. This indicates the possibility of using the proposed approaches for the search (localization) of the most valuable areas (Fig. 3).

The next step was to use the functionality of the raster calculator and create the resulting raster surface based on the rasters obtained in three different ways, where localization of the sites with low, satisfactory, good and excellent quality was noted.

Due to the advantages of visualizing the results of spatial analysis, more valuable from the practical point of view is to determine the areas of parcels or land masses belonging to a particular quality group. This option is especially important for an introduction of precision farming systems based on the concept of the existence of heterogeneities of factors that determine the fertility of the soil within a single field.

This feature is also provided in the functionality of the ArcToolbox module. Calculation of the area of each circuit within the limits of each working area was performed using the tools of the “Zonal Statistics As Table” tool of the utility “Zonal Statistics”. Zonal operations allow to perform analysis, the output data of which is the result of calculations performed on all cells belonging to each input zone. A zone can be defined as one area of the specific value, but it can also consist of several detached elements, or regions, all of which have a single value. Zones can be specified by raster or sets of object classes.

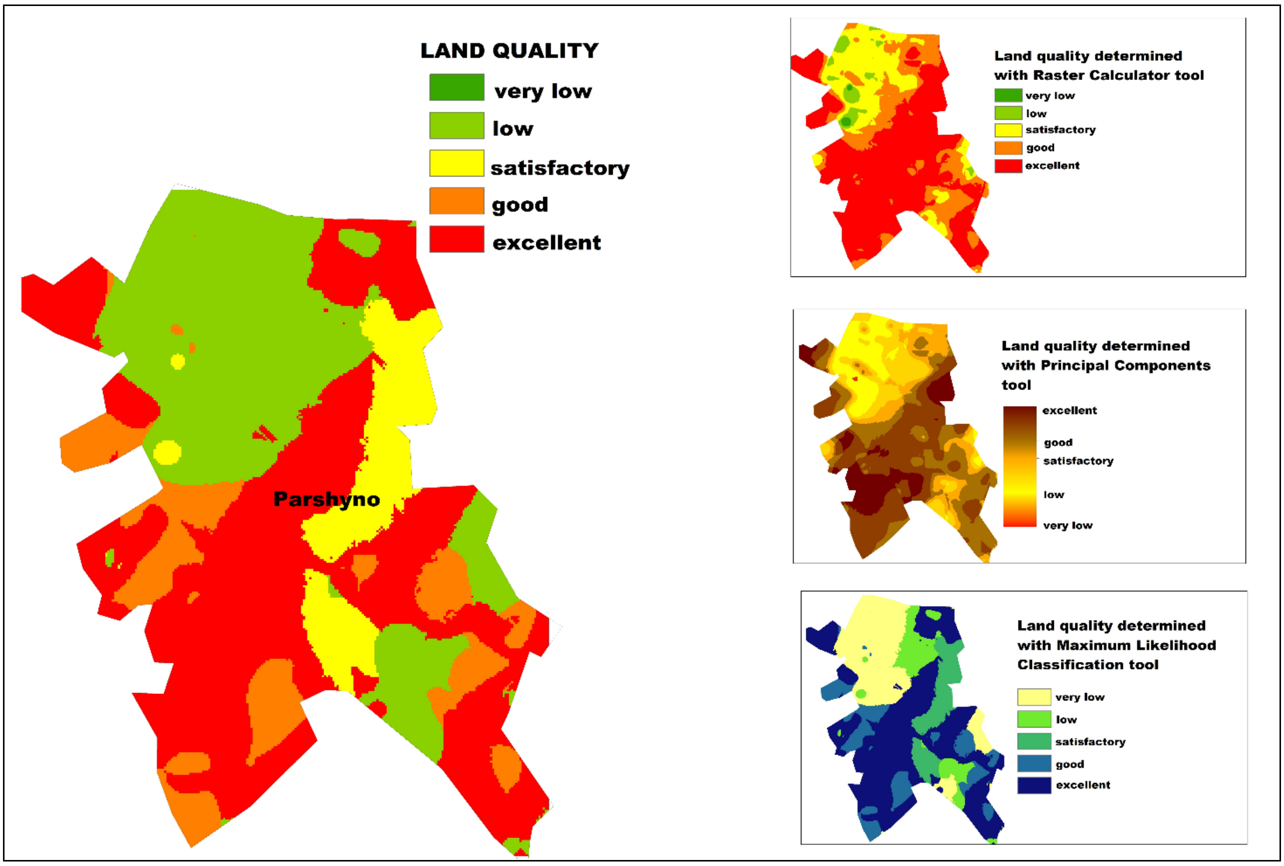



**Fig. 3.** The spatial distribution of agrochemical indicators in a 0-20 cm layer of soil, modelled by the method of universal kriging

As a result of the performed actions, a table is created in which the fields FID 0, FID 1 .... FID N – have ordinal numbers of working areas. The values in each field are the area of the contour of land within the limits of each specific plot, corresponding to one or another class of quality. The contents of this table can be exported to an Excel spreadsheet as well as analyzed with calculating the descriptive statistics of the resulting raster. As a result of the performed calculations, it was established that out of 3187.0 ha of the surveyed land area of RUP “Uchkhoz BGSHA”, the quality of 1469.3 ha is excellent, the quality of 430.2 ha is good, the quality of 390.1 ha is satisfactory and the quality of 897.4 ha is low.

**Conclusions and proposals**

The functional advantages of geospatial analysis provide visualization of monitoring data of the qualitative state of land, as well as ensure the search for individual land parcels according to the specified optimal parameters. It is the most expedient to use the universal kriging method to perform forecast and visualization of the spatial distribution of agrochemical indicators, the data having some dominant trend, which can be modelled using a deterministic polynomial function. An exponential function with the standard type of a circle and a lag size of 200 m is proposed as the best semivariogram model for determining the possible spatial structure of agrochemical soil indices. It is advisable to use the resultant raster surface based on the rasters obtained by three different multifactor analysis methods to have the most accurate establishment of localization of land parcels with low, satisfactory, good and excellent quality.

**References**

1. Gouri S.B., Shit P.K., Maiti R. (2016) Comparison of GIS-based interpolation methods for spatial distribution of soil organic carbon (SOC). *Journal of the Saudi Society of Agricultural Sciences*, Vol. 2, p. 1–13.
2. Kurakpaev O.T. (2016) Vozmozhnosti ispolzovznia GIS-tehnologij v zemleustrojstve i zemelnom kadastre. *Vestnik KRSU*, T 16, Volume 5, c. 154–156 (in Russian).
3. Myslyva T.N. (2018) Ekologiya pochvy. PP ”A.A. Evenok”, Zhytomyr. 516 c. (in Russian).
4. Myslyva T.N., Kalmykov A.V., Drugakov P.V. (2016) Proizvodstvennyj potencial selskohozyajstvennyh zemel selskohozyajstvennyh organizatsij Mogilevskoj oblasti i ego ratsionalnoe ispolzovanie. *Vestnik BGSHA*, Volume 4, c. 81–88 (in Russian).
5. Myslyva T.N., Kutsaeva O.A., Podlesnyj A.A. (2017) Sravnenie effektivnosti metodov interpolacii yna osnove GIS dlya otsenki prostranstvennogo raspredeleniya gumusa v pochve. *Vestnik BGSHA*, Volume 4, c. 146–152 (in Russian).
6. Ob utverzhdenii Koncepcii natsionalnoj bezopasnosti Respubliki Belarus: Ukaz Prezidenta Respubliki Belarus №575 (2010). Natsionalnyj tsentr pravovoj informacii Respubliki Belarus. Minsk, 8 c. (in Russian).
7. Wang Y.Q., Shao M.A. (2013) Spatial variability of soil physical properties in a region of the Loess Plateau of PR China subject to wind and water erosion. *Land Degrad. Dev*., Vol. 24 (3), p. 296–304.

**Information about authors**

**Tamara Myslyva** is a Doctor of Agricultural Sciences, Professor, Head of the Department of Geodesy and Photogrammetry of Belarusian State Agricultural Academy. Her current area of study surrounds the topics of GIS-analysis, GIS-modelling and forecasting the yield of grain and forage crops using GIS technologies and remote sensing data. Contact details: Faculty of Land Management, Belarusian State Agricultural Academy, Michurina 5, Gorki, Mogilev region 213407, Republic of Belarus, e-mail: byrty41@yahoo.com , tel: +375 2992 16839.

**Bronislava Sheluto** is a Doctor of Agricultural Sciences, Professor of the Department of Fodder Production and Storage of Plant Growing Products of Belarusian State Agricultural Academy. Her current area of study surrounds the topic of forecasting the yield of forage crops using GIS technologies and remote sensing data. Contact details: Faculty of Agronomy, Belarusian State Agricultural Academy, Michurina 5, Gorki, Mogilev region 213407, Republic of Belarus, e-mail: a.sheliuta@mail.ru , tel: +375 4470 12382.

**Olesya Kutsaeva** is a Senior lecturer of the Department of Geodesy and Photogrammetry of Belarusian State Agricultural Academy. Her current area of study surrounds the topics of GIS-analysis, photogrammetry and remote sensing. Contact details: Faculty of Land Management, Belarusian State Agricultural Academy, Michurina 5, Gorki, Mogilev region 213407, Republic of Belarus, e-mail: alexa-1982@bk.ru , tel: +375 2933 21631.

**Svetlana Naskova** is a PhD, Assistant professor, Head of the Department for International Cooperation of Belarusian State Agricultural Academy. Contact details: Faculty of International Relations and Pre-University Training, Belarusian State Agricultural Academy, Michurina 5, Gorki, Mogilev region 213407, Republic of Belarus, e-mail: naskova@mail.ru , tel: +375 2233 79664.

DOI: 10.22616/j.balticsurveying.2018.020

# RESEARCH OF COMPATIBILITY AND SYSTEMITY OF LAND MANAGEMENT TERMINOLOGY

**Ihor Trevoho[1], Valery Riabchii[2], Vladyslav Riabchii[2]**
[1] Lviv Polytechnic National University, Ukraine
[2] Dnipro Polytechnic National Technical University, Ukraine

**Abstract**
The analysis results of common terms in land management and their interpretations in normative-legal acts of Ukraine are presented. It have been established collisions and significant differences in the wording of even such common terms as a land parcel, a boundary of land parcel, a size of land parcel, etc. The purpose of the study is to identify collisions and contradictions of some key terms used in land surveying and geodetic works, as well as development of concrete proposals for improving and perfection the relevant terms. For this purpose, the following tasks were set and solved: analysis of regulatory legal acts of Ukraine concerning the conceptual apparatus of land management, systematization and generalization of substantiation results of the relevant terms correction need, development of proposals taking into account works content on land management and geodetic works for information provision of the State Land Cadastre. In the course of the study, the comparative method of analysis and the systematization of inconsistencies in the current normative legal acts of Ukraine regarding the terms and their interpretation are used. During the proposals development, known approaches "from general to partial" and vice versa were used. The established disadvantages do not allow unambiguously interpreting and performing such important work as geodetic setting or restoration of the land parcels boundaries, resolution of land disputes between adjacent users of land parcels. Completed summaries of content and wording of the relevant terms justify a need for correction of the terms and additions to their definitions. It was set the features of each term. As a result of integrated approach to solution of the existing problem and systematization of established differences, the general wording and detailed specification of the analyzed terms interpretations are proposed. Knowledge of technological stages for geodetic and land management works provided an opportunity to improve the geodetic information support of the State Land Cadastre. The proposals for correction of the studied terms eliminate existing contradictions, provide an unambiguous interpretation of land management terminology, which leads to the exact execution of geodetic and land management works, and, accordingly, obtaining reliable information for the State Land Cadastre.
Key words: land management, land parcel, boundary of land parcel, size of land parcel.

## Introduction

In the society, development of land resources always plays a leading role. Therefore, one of the decisive factors that determines the paces and efficiency of land management and cadastre developments in Ukraine is the specification and improvement of the land legislation terminology of Ukraine and methodological and technological procedures. It’s specification and improvement remains important and relevant.

The basis for correct and unambiguous understanding in science, technology and production are terms. Each science and specialty has their own peculiarities in the terminology that characterizes the professionalism and qualification of its specialists. One of high level indicators of professionalism in any industry is unambiguous interpretation of terms and concepts.

Since various definitions of the same term, ambiguous interpretation or no explanation exists in the normative legal acts of Ukraine, this leads to an unsatisfactory state of land management terminology. Some existing contradictions in terms of land management are found even by curious students. Therefore, solving the problem of correction and specification terminology in the normative legal acts of Ukraine is relevant and important for land management and improvement of the educational process.

The purpose of the study is to identify collisions and contradictions of some key terms used in land surveying and geodetic works, as well as development of concrete proposals for improving and perfection the relevant terms.

**Methodology of research and materials**

Below an analysis of some the most common terms that are used not only in land law, but also in everyday life of almost every citizen of Ukraine is given.

Determination of such a widespread term as a land parcel, even in the Land Code of Ukraine dated 25.10.2001 No. 2768-III with changes introduced by the law of Ukraine from 05.09.2017 No. 2145-VIII and the Tax Code of Ukraine dated 02.12.2010 No. 2755-VI with changes introduced by the law of Ukraine from 07.09.2017 № 2146-VIII are different. Thus, in accordance with Article 79 of the Land Code of Ukraine, a land parcel is a part of the earth's surface with established boundaries, a specific location, with the rights assigned to it. Ownership of the land parcel extends within its boundaries to the surface (ground) layer, as well as water objects, forests and perennial plantations, that are located on it, unless otherwise provided by law and do not violate the rights of other persons. Ownership of the land parcel extends over the space above and below the surface of the land parcel to the height and depth necessary for the construction of residential, industrial and other buildings and structures.

In subparagraph 14.1.74 of the Tax Code of Ukraine, "the land parcel is a part of the earth's surface with established boundaries, a specific location, intended (economic) purpose and the rights determined in relation to it".

The definition of the term land parcel provided in the Land Code of Ukraine is duplicated: Article 1 of the Law of Ukraine "On Land Valuation" dated 11.12.2003 No. 1378-IV with changes introduced by the law of Ukraine from 02.03.2015 No. 222-VIII, paragraph 2 of the National Standard No. 2 "Real estate valuation" dated 28.10.2004 No. 1442 with changes introduced by the decision of the Cabinet of Ministers of Ukraine from 31.03.2015 No. 168, paragraph 1.2 of the Regulation on the organization of apartment maintenance of the Armed Forces of Ukraine, approved by the order of the Ministry of Defence of Ukraine dated 03.07.2013 No. 448 with changes introduced by the order of the Ministry of Defence of Ukraine from 04.08.2015 No. 383, and paragraph 3 of the Classifier of State property dated 15.03.2006 No. 461 448 with changes introduced by the order of the State Property Fund of Ukraine from 14.07.2013 No. 840.

There are other options for defining this term different from the previous ones. In paragraph 1.5 of the Technical instructions on determination of boundaries of land parcels of joint and common partial ownership of individuals and legal persons in the built-up territory in settlements approved by the order of the State Committee of Ukraine for Land Resources dated 18.05.1998, it is stated that "The land parcel is a plot of land , that is subject to homogeneous property rights and that is a single property, has fixed boundaries and is characterized by a certain location, natural properties, physical parameters, legal and economic status and other characteristics that are its essential components".

In accordance with paragraph 1 of the Provisional methodical instructions on the assignment of cadastral numbers to land plots for the maintenance of the state land cadastre (with amendments) dated 26.01.1998 No. 1 "The land parcel – part of the earth's surface, that has fixed geometric and legal boundaries and is the base unit of the land registry cadastre".

In accordance with paragraph 1.3 of the Order on the organization of the objects protection and premises in which drug-containing plants are cultivated, used, stored and destroyed, as well as final products received from them or waste from such plants are used, stored and destroyed, approved by the order of the Ministry of Internal Affairs of Ukraine dated 27.10.2010 No. 507, "The land parcel is a field where drug-containing plants are cultivated, used, stored and destroyed, as well as final products obtained from them or waste of such plants are used, stored and destroyed".

According to the Geodesic encyclopedic dictionary (Geodetic encyclopedic dictionary, 2001), "Land parcel – a part of the earth's surface that is spatially limited by a closed external boundary and is the object of possession or use and is registered as a unit of account in a land registry system".

In the Glossary of Terms in the Field of Land Relations and Land Use (Glossary of Terms in Land Relations and Land Use, 2008), in general, seven definitions of the term land parcel are given.

According to Article 1 of the Forest Code of Ukraine dated 21.01.1994 No. 3852-XII with changes introduced by the law of Ukraine from 23.05.2017 No. 2063-VIII, "The forest land parcel is a land plot of a forest fund of Ukraine with specified boundaries, that is provided or withdrawn from the land user or the owner of a land plot for forest management or other public needs in accordance with the land legislation".

According to paragraph 3 of general part of the Collection of aggregate indicators of the cost of reproduction of functional analogues for the evaluation of low-rise buildings, buildings and structures dated 23.12.2004 No. 2929, " smallholding land parcel – a land plot (boundaried, provided with exit to the street, lane, etc.), on that are located a residential building, household buildings, a garden, a croft, etc."
In accordance with Article 1 of the Law of Ukraine "About sea ports" dated 17.05.2012 No. 4709-VI with changes introduced by the law of Ukraine from 04.07.2013 No. 406-VII, "artificially created land parcel is a land plot established (washed out, poured, created with the use of other technologies) within the water area of the seaport".

## Discussion and results

### *Polysemy of term land parcel*

Interpretations of the land parcel term are summarized in the table 1 (Riabchii V.A., Riabchii V.V., Khomiak Yu.Ye., 2012, Riabchii V.A., Riabchii V.V., Khomiak Yu.Ye., 2013, Riabchii V.V., Khomiak Yu.Ye., 2013).

**Table 1**

The generalization of comparing results of land parcel term definition in the normative legal acts of Ukraine

| Definition of land parcel term | References to normative legal acts of Ukraine |
|---|---|
| It is a part of the earth's surface with established boundaries, a specific location, with defined rights to it | - Article 79 of the Land Code of Ukraine;<br>- Article 1 of the Law of Ukraine "On Land Valuation";<br>- paragraph 2 of the National Standard No. 2 "Estimation of Real Estate"<br>- paragraph 1.2 of the Regulation on the organization of apartment maintenance of the Armed Forces of Ukraine;<br>- paragraph 3 of the Classifier of State Property"; |
| It is a part of the earth's surface with established boundaries, a specific location, intended (economic) purpose and determined in relation to it | sub-paragraph 14.1.74 of the Tax Code of Ukraine |
| It is a plot of land, that is subject to homogeneous property rights and that is a single property, has fixed boundaries and is characterized by a certain location, natural properties, physical parameters, legal and economic status and other characteristics that are its essential components | paragraph 1.5 of the Technical instructions on determination of boundaries of land parcels of joint and common partial ownership of individuals and legal persons in the built-up territory in settlements |
| It is part of the earth's surface, that has fixed geometric and legal boundaries and is the base unit of the land registry cadastre | paragraph 1 of the Provisional methodical instructions on the assignment of cadastral numbers to land plots for the maintenance of the state land cadastre |
| It is a part of the earth's surface that is spatially limited by a closed external boundary and is the object of possession or use and is registered as a unit of account in a land registry system | Geodetic encyclopedic dictionary |

In addition to the interpretations in the normative legal acts of Ukraine, the term "land parcel" are cases where the authors of some publications (Andreitsev V.I., 2007, Kalynichenko Yu., Sai V., 2014, Miroshnychenko A.M., 2011, Nosik V.V., 2006, Trehub M., 2012, Shulha M.V., 1998) give their interpretation and explanation of this term. Each of these formulations has its own content, and each of them has its own specific features, but there is no unambiguousness, and all these definitions reflect the more legal side of this term. For example, the spatial, individually determined and legally separate surface part of the corresponding category of land, the boundaries of which are established on the ground and fixed in the land legal documents that certify its belonging to the corresponding legal title to owners or users for the purposeful use as a means, conditions and sources of life and satisfaction of material, social, ecological, spiritual, other needs and interests of the person (Andreitsev V.I., 2007) or located above the subsoil of the earth's surface, that is the basis of the landscape, immovable in the location, individually determined in a particular area by size, boundary, function purpose, as well as by the law, administrative act or contract, the rights and obligations of citizens and legal entities and other subjects of the land rights (Nosik V.V., 2006), or part of the earth's surface, that is the basis of the landscape, has a fixed area, boundary and location, and is characterized by a certain qualitative state and its legal status (Shulha M.V., 1998), etc.

In the practice of land management, in accordance with the Land Code of Ukraine, there are also terms with the following phrases: land for farming, for the maintenance of a private peasant farm, for gardening, for the construction and maintenance of a dwelling house, household buildings and structures (private parcel), for an individual cottage construction or for the construction of individual garages, etc., but this is more than the intended purpose of the land parcel.

Based on logical and hierarchical considerations, it is necessary to choose the standard term given in the Land Code of Ukraine, but it is also not perfect, since it does not reflect all the features of existing land parcels. So in the Land Code of Ukraine there are four main features of the land parcel:

- part of the earth's surface;
- has set boundaries;
- there is a specific location;
- rights determined in relation to it.

However, two last signs are contradictory, since a land parcel cannot be without a specific location and not always in the course of the existence of the land parcel there are certain rights. For example, it is obvious that a land parcel exists until the registration of rights to it.

In wording this term, the Land Code of Ukraine and other normative legal acts of Ukraine do not take into account those facts that the land may be subject to restrictions and encumbrances, land improvements (real estate, perennial plantings, natural vegetation, etc.) may be included there in. There is no interpretation of the right of lease of the land parcel, its prevalence in vast that located on and below the surface of the land parcel, etc.

### *Polysemy of term boundary of the land parcel*

In the normative legal acts of Ukraine there are such formulations of the term "boundary of the land parcel".

In Article 1 of the Law of Ukraine "On state control over the use and protection of land" dated 19.06.2003 No. 963-IV with changes introduced by the law of Ukraine from 23.12.2015 No. 901-VIII, is the definition that "the boundary of the land parcel is a conditional closed polygon that separates land parcels".

According to paragraph 1.3 of the Instruction on the establishment (restoration) of the boundaries of land parcel in nature (on the ground) and their affixing by boundary marks, approved by the order of the State Committee of Ukraine for Land Resources dated 18.05.2010 No. 376 with changes introduced by the order of the Ministry of Agrarian Policy and Food of Ukraine from 03.07.2013 No. 405, "the boundary of the land parcel – a set of lines forming a closed loop and separating land parcels ".

According to the Technical instructions on determination of boundaries of land parcels of joint and common partial ownership of individuals and legal persons in the built-up territory in settlements, given the following wording: "the boundary of land parcel – ground material turning point, indicating the boundaries of the land parcel, or the conditional line on the surface, that divides two invented parcels".

According to paragraph 3 of general part of the Collection of aggregate indicators of the cost of reproduction of functional analogues for the evaluation of low-rise buildings, buildings and structures, "the boundary is the minimum width of the land strip that separates one land parcel from another (from the street, the passage, etc.)".

In the Geodetic encyclopedic dictionary (2001), this notion is interpreted as "the legally defined line, depicted on maps or set in a digital model of terrain and fixed on the ground by natural or physical contours or corresponding turning point."

In addition, normative legal acts of Ukraine have such notions as:

- the boundary of a district, village, town, city, city district– is a conditional closed line on the surface of the land, which separates the territory of the district, village, town, city, city district from other territories (in accordance with Article 173 of the Land Code of Ukraine);
- the boundary of the city – the outer boundary of the city lands, which separates them from land of other purpose and determined by the city planning and development project or the feasibility study of the city development (in accordance with the Land Code of the Ukrainian Soviet Socialist Republic);
- the common boundary of the land parcels – the boundary at which the exact line separating the land parcels is not established (according to paragraph 1.5 of the Technical instructions on determination of boundaries of land parcels of joint and common partial ownership of individuals and legal persons in the built-up territory in settlements);
- legal boundary – an airspace that determines where the ownership of one land parcel is conditionally terminated and the property of another begins. It is not locally established (in accordance with clause 5.6 of the Technical instructions on determination of boundaries of land parcels of joint and common partial ownership of individuals and legal persons in the built-up territory in settlements).

Analysing the above concepts of boundaries of the land parcel, one can see that there are differences between them and not all the peculiarities of using the notion of boundary are taken into account. Any of these concepts of the land parcel boundaries do not fully disclose its contents.

***Uncertainty of concepts metric data and size of the land parcel***

The term metric data (information, low-down) of the land parcel is used in some normative legal acts of Ukraine (paragraphs 21, 27, 28, 37, 44, 45 and 67 of Annex 1 to the Procedure for the State Land Cadastre dated 17.10.2012 No. 1051, paragraph 1.2 of the Instruction on the establishment (restoration) of the boundaries of land parcel in nature (on the ground) and their affixing by boundary marks, etc.) These three concepts (data, information and low-down) are similar in content, but are different things. In land management and cadastre, the use of term "metric data of the land parcel" is more correct.

Let's analyze the concept of "size of the land parcel". In the Land Code of Ukraine, this term is set out in many articles, in particular 25, 31, 32, 41, 42, 63, 64, 66, 88, 89, 118-121, 123, 137, 139, 151 and 211. In the Civil Code Ukraine dated 16.01.2003 No. 435-IV with changes introduced by the law of Ukraine from 03.10.2017 No. 2147-VIII, it was fixed in Articles 325, 377 and 796. In Articles 35 and 47 of the Law of Ukraine "On Land Management" dated 22.05.2003 No. 858-IV with changes introduced by the law of Ukraine from 17.01.2017 No. 1817-VIII, and Article 15 of the Law of Ukraine "On Land Leasing" dated 06.10.1998 No. 161-XIV with changes introduced by the law of Ukraine from 23.03.2017 No. 1983-VIII, also term "the size of the land parcel" is given. That is, this term is actually approved, but its specific wording or interpretation in these normative legal acts of Ukraine is not given.

According to paragraph 2.3 of the Technical instructions on determination of boundaries of land parcels of joint and common partial ownership of individuals and legal persons in the built-up territory in settlements, "the size of the land parcel is characterized by physical and analytical areas". But, what is the size of the land parcel, there is no specific wording or interpretation in this normative legal act of Ukraine. If under the size of the land parcel to understand only its area, it is also not quite correct, because there are other indicators without which the characteristics of the land will be incomplete.

In addition, according to part 2 of Article 128 of the Land Code of Ukraine "... the application indicates the location of the land parcel, its intended purpose, size and area, as well as agreement to conclude a contract about advance payment for the land parcel price". From this it turns out that the size of the land parcel is not its area.

**Conclusions and recommendations**

As a result of analysis and comparison of land management terms in the normative legal acts of Ukraine, significant differences are found in their wording and interpretations. Some commonly used terms, such as the land parcel, the boundary of land parcel, metric data of land parcel, etc., are not commonly formulated and detailed.

**References**

1. Andreitsev V.I. (2007) *Zemelne pravo i zakonodavstvo suverennoi Ukrainy* (*Land law and legislation of sovereign Ukraine*). Kyiv, Znannia. 445 p. (in Ukrainian).
2. *Heodezychnyi entsyklopedychnyi slovnyk* (*Geodetic encyclopedic dictionary*) (2001). Lviv, Yevro svit. 668 p. (in Ukrainian)
3. Kalynichenko Yu., Sai V. (2014) *Kontseptualni zasady pravovoho rehuliuvannia zemelnykh vidnosyn* (*Conceptual principles of legal regulation of land relations*) Suchasni dosiahnennia heodezychnoi nauky ta vyrobnytstva (Modern achievements in geodetic science and production). Vyp. 1 (27), p. 62-66 (in Ukrainian).
4. Miroshnychenko A.M. (2011) *Zemelne pravo Ukrainy* (*Land law of Ukraine*). Kyiv, Alerta: Tsentr uchbovoi lit. 680 p. (in Ukrainian).
5. Nosik V.V. (2006) *Pravo vlasnosti na zemliu Ukrainskoho narodu* (*Ownership of the land for the Ukrainian people*). Kyiv, Khrinkom Inter. 544 p. (in Ukrainian).
6. Riabchii V.A., Riabchii V.V., Khomiak Yu.Ye. (2012) *Analiz zmistu ta tlumachennia deiakykh terminiv u zemelnomu zakonodavstvi* (*Analysis of the content and interpretation of some terms in land legislation*). Zbirnyk prats III Vseukrainskoi naukovo-tekhnichnoi konferentsii studentiv, aspirantiv i molodykh vchenykh «Naukova vesna 2012» (Collected Works of the 3rd All-Ukrainian Scientific and Technical Conference of Students, Postgraduates and Young Scientists «Scientific Spring 2012»), Dnipropetrovsk, 29 bereznia 2012 r. Dnipropetrovsk, p. 143-144 (in Ukrainian).
7. Riabchii V.A., Riabchii V.V., Khomiak Yu.Ye. (2013) *Tlumachennia terminiv zemelnoho zakonodavstva u normatyvno-pravovykh aktakh Ukrainy* (*Interpretation of the terms of the land legislation in the normative legal acts of Ukraine*). Naukovyi visnyk Uzhhorodskoho universytetu. Seriia Heohrafiia. Zemleustrii. Pryrodokorystuvannia (Scientific herald of Uzhgorod University. Series Geography. Land management. Nature use), Vyp. 1, p. 93-97 (in Ukrainian).
8. Riabchii V.V., Khomiak Yu.Ye. (2013) *Analiz zmistu normatyvno-pravovykh aktiv Ukrainy stosovno deiakykh terminiv ta yikh tlumachennia* (*Analysis of the content of Ukrainian legal acts on certain terms and their interpretation*). Inzhenerna heodeziia (Engineering geodesy), Vyp. 59, p. 61-70 (in Ukrainian).
9. *Slovnyk terminiv u sferi zemelnykh vidnosyn ta zemlekorystuvannia* (*Glossary of Terms in Land Relations and Land Use*) (2008). Derzh. kom. Ukrainy iz zemelnykh resursiv. Kyiv, Avhust Treid. 240 p. (in Ukrainian).
10. Trehub M. (2012) *Propozytsii shchodo udoskonalennia terminiv u derzhavnomu zemelnomu kadastri Ukrainy* (*Proposals for improving the terms in the state land cadastre of Ukraine*). Inzhenerna heodeziia (Engineering geodesy), Vyp. 58, p. 78-87 (in Ukrainian).
11. Shulha M.V. (1998) *Aktualnye pravovye problemy zemelnykh otnoshenyi v sovremennykh uslovyiakh* (*Actual legal problems of land relations in modern conditions*). Kharkov, Konsum. 224 p. (in Ukrainian).

**Information about authors**

**Ihor Trevoho**, Doctor of Technical Sciences, Professor, President of Public Union “Ukrainian Society of Geodesy and Cartography”, Dean of Institute of Geodesy, Professor of Department of Geodesy of Lviv Polytechnic National University, 12 Bandery St., Lviv, Ukraine, 79013, e-mail: itrevoho@gmail.com
**Valeri Riabchii,** Associated Professor of Department of Geodesy of Dnipro Polytechnic National Technical University, 19 Dmytra Yavornitskogo Av., Dnipro, Ukraine, 49005, e-mail: ryabchyv@nmu.org.ua
**Vladislav Riabchii**, Associated Professor, Head of Department of Geodesy of Dnipro Polytechnic National Technical University, 19 Dmytra Yavornitskogo Av., Dnipro, Ukraine, 49005, e-mail: ryabchyv@nmu.org.ua

DOI: 10.22616/j.balticsurveying.2018.021

# ACCURACY ESTIMATION ANALYSIS OF LAND PARCEL AREA DETERMINATION BASED ON AEROSURVEYING MATERIALS IN COMPARISON WITH RESULTS OF GROUND GEODETIC MEASUREMENTS

**Anatoliy Tserklevich[1], Vasyl Khoptar[1]**
[1]Lviv Polytechnic National University, Lviv, Ukraine

**Abstract**
The presence of a large number of territorial units with a high price of land determines the appropriate accuracy of their area determination in the short term. The widespread use of unmanned aerial vehicles (UAVs) is a modern geospatial mapping technology. Using an UAV equipped with appropriate devices for aerosurveying – such as, for example, the Trimble UX5 – is economically feasible in comparison with ground geodetic measurements, since the latter requires a lot of costs. Therefore, the main purpose of this study is to analyze accuracy estimation of land parcel area determination based on aero surveying materials using an unmanned aerial vehicle (UAV) in comparison with results of ground geodetic measurements using a total station. As a result, a comparison of detailed plan and an existing base of land parcel measurements with accuracy estimations have been made. Based on our analysis and experimental studies, we can state that the UAV allows more efficient data collection within the requirements of land management in comparison with ground geodetic measurements. The use of aero surveying materials for determination of land parcel areas has been proposed. The results of the study provide an opportunity to improve the reliability of land parcel data in the normative and methodological framework.
Key words: accuracy; area; land parcel; unmanned aerial vehicle; orthophotomaps.

## Introduction

Innovation development in geodesy focused largely on obtaining a more voluminous set of data with high accuracy. It is especially acute problem of creating an actual normative-methodical base for land inventory both within and outside settlements. Therefore, it is very important to carry out continuous monitoring of land use and making changes to data for formation of cadastral situation of territories [Opalinskiy, 2010].

Geodetic works remain the main means of obtaining relevant and reliable information for land management and cadastre. The use of unmanned aerial vehicles (UAVs) for geodetic measurements is currently widespread and they are used for many tasks, including land-use projects. Heretofore, it is unclear whether it is possible to apply UAVs for individual land parcel and land inventory.

Appropriate issue in the geodetic works is the timing of their implementation. There is a lot of equipment on the market, such as total stations, GPS receivers, laser scanners, as well as software for processing of received data. All this simplifies and accelerates production of geodetic works, but sometimes this is not enough.

Aerosurveying − photographing process of terrestrial surface from an aircraft − one of technologies that allows, partially, to solve the problems described above. The use of data obtained from UAVs surveying − orthophotomaps − shortens timing, increases productivity of works and allows, in many cases, to refuse to carry out the surveying by ground method [Petrie, 2013].

The main information obtained from surveying works for ensuring of inventory is area of land parcel. Therefore, improving methods and instruments of land inventory is an actual topic of scientific research.

Land inventory is a set of works, for example [Inventaryzatsiya zemel …, 1993; Polozhennya pro zemelno-kadastrovu inventaryzatsiyu …, 1997], which includes collection and analysis of bulk archive documentation on land management, a large number of legal documents; creation and decipherment of orthophotomaps; performing field geodetic works, etc. The paper [Opalinskiy, 2010] describes in detail the methodology of data work, in which the author claims that the technology of land inventory implies that all materials are firstly integrated into geographic information systems (GIS). In GIS-

environments, land parcel area calculations are also performed, summary tabular and graphic materials are formed. The author of this work is convinced that a significant economic effect can be achieved precisely with the use of UAVs.
For example, in works [Tserklevych, 1999; Tserklevich, Protsik, 1997; Tserklevich, Siglyak, 1999] the technology of conducting geodetic measurements in the inventory of settlements is proposed. As stated in [Tserklevich A., Kalinich I., 2015], the question about substantiation of necessary accuracy of land parcel area determination during cadastral surveying becomes very important in recent times. Accordingly, a large number of native and foreign scientists engaged in study of accuracy of land parcel area determination.
The paper [Tserklevych, 1999] analyzes accuracy of determining land parcel boundaries and land parcel areas for purpose of land inventorying of settlements. The obtained results of these studies confirmed the necessity of adding a marginal error of land parcel areas into the instructional materials, within which the area could be compared with their repeated measurements.
In paper [Tserklevich A., Chernyagha P., 2002] a method is proposed for assessing the accuracy of land parcel area determination by contours of theodolite measurements. Based on analysis of this study, the authors asserted that, depending on a value of mean square error of the coordinates of turning points of land parcel boundaries proportional to change in the mean square error of its area.
Based on [Tserklevich, Siglyak, 1999], we can conclude that the values of mean square error of land parcel areas $m_p$ and relative errors $\frac{m_p}{P}$ in a certain approximation are consistent regardless of method of their calculation.
Another important aspect of impact on the accuracy of land parcel areas is economic factor. This problem is discussed in details in [Volosetskyy, 1999], as a result of which the value of error in land parcel area determination was obtained by the method of monetary valuation.
The state of this problem was considered in details in paper [Shendyapina, 2004], where the formulas for calculating the accuracy of land parcel areas determination were analyzed, and it was found that the use of aerosurveying materials can provide land parcel area determination not only in rural settlements, but also in small towns and settlements.
The aim of this work is to investigate the possibility of land parcel area determination based on aerosurveying materials, as well as the analysis of accuracy of data obtained using UAVs compared with the results of surveying by ground method.

**Methodology of research and materials**

Ground-based methods of cadastral surveying are currently the most commonly used methods to obtain high-precision terrain information. Using GNSS station networks in real time kinematic (RTK), or tacheometry method, surveyor can perform hundreds of points per day.
On the other hand, surveying using of UAVs allows operatively, at low cost level, to carry out aerosurveying of lands in order to build an orthophotomaps for various engineering and economic tasks. Aerosurveying consists of two main stages: image getting and processing.
Aerial images are taken using an UAV that is equipped with a high-resolution digital camera installed on UAV board. An example of such technology may be Trimble UX5 UAV with the following characteristics [Vovk, Hlotov, Hunina, Malitskyy, Tretyak, Tserklevych, 2015]:

- Range of flight heights: 75-750 m, cruising height: 150 m.
- Cruising speed: 80 km / h.
- Maximum flight time: 50 min.
- Remote control range: up to 5 km.
- Image quality (pixel size): up to 5 cm.
- Accuracy of surface modeling in plan: ± 5 cm, in height: ± 10 cm.
- Calibrated digital camera: SONY NEX 5R.

This UAV is designed to produce high-quality orthophotomaps and digital terrain model.
The flight is performed completely in automatic mode – from take-off to landing. The ground control station is used for launch, flight control and surveying. At the stage of image processing using special

software, aerosurveying material – orthophotomaps are produced. In determining land parcel areas based on orthophotomaps a geometric method is used, which consists of measuring linear elements of the land parcel. The smaller is a land parcel, the greater is a relative error of determining its area [Shendyapina, 2004].
In order to determine land parcel areas, we used the materials of aerosurveying on the territory of Grabovets village, Stryi district, Lviv region. With the help of software Digitals [http://www.vinmap.net/], on the base of received orthophotomaps, we collected the contours of land parcels (only sections with clearly defined contours were taken into account), as shown in Figure 1. From our experience, the boundaries of land parcels are not properly secured. Often, it is an obsolete fence or hedge, where it is difficult to determine unambiguously the geometric center of turning angle. When comparing the data obtained on orthophotomaps and results of land-based extraction using a total station, differences in contours of land parcels is observed, which characterizes accuracy of works.

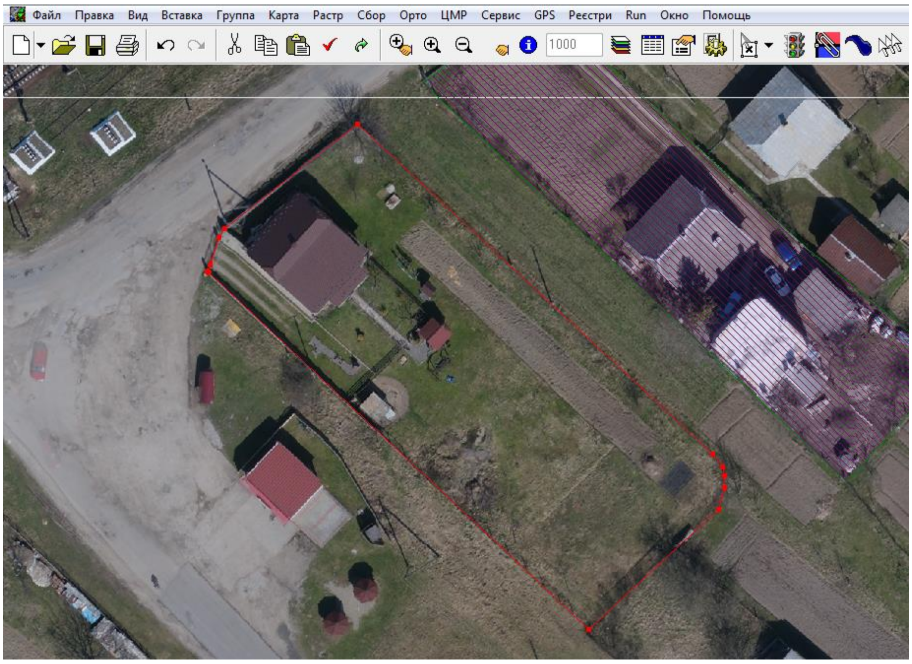



**Fig. 1.** Land parcel contour on the orthophotomap

According to normative and technical documents [Opalinskiy, 2010; Tserklevych, 1999] the permissible relative error of area determination should not exceed the value of 1: 1000 (which is 0.1% of land parcel price), and error of position in plane of measurement base points and boundary marks is 0.10 m. Accuracy calculation of land parcel areas determination is obtained by following formula:

$$m_p = m_t \sqrt{P} \tag{1}$$

where $m_t$ – average square error of boundary mark position; $P$ – land parcel area.
During measurements in order to determine land parcel area, their accuracy depends on accuracy of linear and angular measurements, so double calculations of area by different measurements due to their errors leads to two values of area [Tserklevich, Siglyak, 1999]. Therefore, it is reasonable to assume that difference between these two values of area cannot exceed the margin of error. Marginal error ( $\Delta p$ ) of land parcel area is determined by the following formula:

$$\Delta p = 2,5 \cdot m_p \tag{2}$$

And the permissible difference ( $\Delta p_{diff}$ ) of land parcel area obtained by different methods, – by the formula:

$$\Delta p_{diff} = \Delta p \cdot \sqrt{2} \tag{3}$$

As an example, by the formulas (1-3), in Table 1 calculations of above estimates for land of small towns and villages are performed. The average square error of boundary mark $m_t = 0,10$ m is fixed for this gradation of land.

**Table 1**

Estimation for land parcels of small towns and villages

| **Gradation of land** | **Average square error of boundary mark position,** $m_t$ **, m** | **Land parcel area,** $P$**, ha** | **Average square error of area,** $m_p = m_t\sqrt{P}$ **, ha** | **Marginal error of area,** $\Delta p = 2,5 \cdot m_p$ **, ha** | **Permissible difference of area,** $\Delta p_{diff} = \Delta p \cdot \sqrt{2}$ , ha |
|---|---|---|---|---|---|
| Land of towns and villages | 0,10 | 0,010<br>0,100<br>0,250 | 0,0001<br>0,0003<br>0,0005 | 0,00025<br>0,00075<br>0,00125 | 0,0004<br>0,0011<br>0,0017 |

In reality, there are also other sizes of land parcels, with corresponding errors of boundary marks position and measurements of sides.

## Discussions and results

Based on gotten aerosurveying materials and data set of results of ground methods surveying on the territory of Hrabovets village, the accuracy of determination of land parcel areas was evaluated. Below, in Table 2, the data obtained as results of studies are given, and on picture 2 the differences and marginal errors between the land parcel areas are shown, that is taken from aerosurveying and by ground-based surveying using a total station.

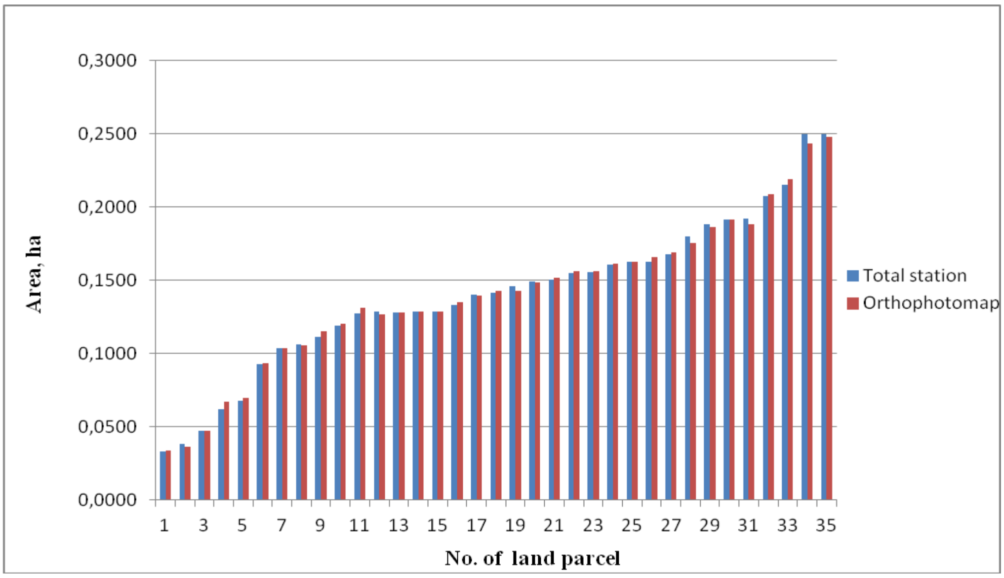



**Fig. 2.** Diagram of differences between areas determination by aerosurveying and based on ground method

**Table 2**

Differences in land parcel areas determination

| No. | Cadastral number | Land parcel area (ground method), ha | Land parcel area (aerosurveying), ha | Difference, $m^2$ | Marginal error, $m^2$ |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 4625380600:01:004:0019 | 0,0335 | 0,0337 | 2 | 1,84 |
| 2 | 4625380600:01:005:0149 | 0,0384 | 0,0366 | 18 | 1,91 |
| 3 | 4625380600:01:004:0018 | 0,0476 | 0,0472 | 4 | 2,17 |
| 4 | 4625380600:01:012:0167 | 0,0620 | 0,0671 | 51 | 2,59 |
| 5 | 4625380600:01:005:0024 | 0,0682 | 0,0696 | 14 | 2,64 |
| 6 | 4625380600:01:005:0027 | 0,0932 | 0,0933 | 1 | 3,05 |
| 7 | 4625380600:01:012:0099 | 0,1039 | 0,1036 | 3 | 3,22 |
| 8 | 4625380600:01:012:0158 | 0,1061 | 0,1056 | 5 | 3,25 |
| 9 | 4625380600:01:012:0013 | 0,1115 | 0,1152 | 37 | 3,39 |
| 10 | 4625380600:01:012:0181 | 0,1190 | 0,1204 | 14 | 3,47 |
| 11 | 4625380600:01:012:0007 | 0,1276 | 0,1311 | 35 | 3,62 |
| 12 | 4625380600:01:005:0026 | 0,1288 | 0,1270 | 18 | 3,56 |
| 13 | 4625380600:01:012:0005 | 0,1283 | 0,1284 | 1 | 3,58 |
| 14 | 4625380600:01:012:0182 | 0,1285 | 0,1286 | 1 | 3,59 |
| 15 | 4625380600:01:012:0182 | 0,1285 | 0,1286 | 1 | 3,59 |
| 16 | 4625380600:01:012:0018 | 0,1335 | 0,1351 | 16 | 3,68 |
| 17 | 4625380600:01:012:0149 | 0,1403 | 0,1396 | 7 | 3,74 |
| 18 | 4625380600:01:012:0134 | 0,1414 | 0,1429 | 15 | 3,78 |
| 19 | 4625380600:01:012:0078 | 0,1463 | 0,1431 | 32 | 3,78 |
| 20 | 4625380600:01:012:0064 | 0,1491 | 0,1485 | 6 | 3,85 |
| 21 | 4625380600:01:013:0002 | 0,1503 | 0,1519 | 16 | 3,90 |
| 22 | 4625380600:01:012:0055 | 0,1550 | 0,1565 | 15 | 3,96 |
| 23 | 4625380600:01:012:0121 | 0,1560 | 0,1561 | 1 | 3,95 |
| 24 | 4625380600:01:005:0025 | 0,1610 | 0,1614 | 4 | 4,02 |
| 25 | 4625380600:01:012:0097 | 0,1628 | 0,1628 | 0 | 4,03 |
| 26 | 4625380600:01:012:0103 | 0,1628 | 0,1661 | 33 | 4,08 |
| 27 | 4625380600:01:012:0054 | 0,1680 | 0,1695 | 15 | 4,12 |
| 28 | 4625380600:01:012:0069 | 0,1798 | 0,1757 | 41 | 4,19 |
| 29 | 4625380600:01:003:0006 | 0,1883 | 0,1863 | 20 | 4,32 |
| 30 | 4625380600:01:012:0156 | 0,1918 | 0,1918 | 0 | 4,38 |
| 31 | 4625380600:01:012:0073 | 0,1921 | 0,1886 | 35 | 4,34 |
| 32 | 4625380600:01:013:0007 | 0,2078 | 0,2089 | 11 | 4,57 |
| 33 | 4625380600:01:004:0003 | 0,2154 | 0,2192 | 38 | 4,68 |
| 34 | 4625380600:01:013:0004 | 0,2500 | 0,2434 | 66 | 4,93 |
| 35 | 4625380600:01:012:0022 | 0,2500 | 0,2478 | 22 | 4,98 |

Analyzing values of difference between areas and marginal errors of land parcels in Table 2, we can see that all measurements are at the required level of accuracy, which allows us to assert that aerosurveying with the help of UAV can be used to determine the land parcel areas to ensure the requirements of land inventory.

## Conclusions and proposals

In this article, it was proposed to use surveying results from UAV to determine land parcel areas. Unlike ground-based geodetic methods, using UAV allows quickly and cost-effectively perform aerosurveying of territories.

The conducted theoretical research and practical recommendations make it possible to improve the reliability of the data on accuracy of the land parcel area determination based on aerosurveying materials compared to results of measurement by ground method, which will promote the development of territories and improve the investment climate.

When comparing the results of this study, we can say that obtained values of the land parcel areas on the territory of Grabovets village are within the required precision. In many cases, the results of our research give grounds to assert that high-resolution orthophotomaps can be used for land parcel areas determination, as well as for land inventory of settlement.

## References


1. Vovk A., Hlotov V., Hunina A., Malitskyy A., Tretyak K., Tserklevych A. (2015) Analiz rezultativ dlya stvorennya ortofotoplaniv ta tsyfrovykh modeley relyefu iz zastosuvannyam BPLA TRIMBLE UX-5. Heodeziya, kartohrafiya i aerofotoznimannya: mizhvidomchyy naukovo-tekhnichnyy zbirnyk. Vypusk 81. Lviv, s. 90–103 (in Ukrainian).
2. Volosetskyy B. (1999) Analiz tochnosti vyznachennya parametriv zemelnykh dilyanok v naselenykh punktakh z vrakhuvannyam ekonomichnykh chynnykiv. Suchasni dosyahnennya heodezychnoyi nauky ta vyrobnytstva. Lviv. s. 119–121 (in Ukrainian).
3. Inventaryzatsiya zemel naselenykh punktiv (nazemni metody) (1993) *Kerivnyy tekhnichnyy material*. 15 s. (in Ukrainian).
4. Opalinskiy A. (2010) Inventarizatsiya zemel' v naselennykh punktakh i za ikh predelami. Elektronnyy nauchno-tekhnicheskiy zhurnal «Geoprofil». No. 1, s. 9-16, (in Russian).
5. The official site of Digitals. Viewed 28 February, 2018, (http://www.vinmap.net/).
6. Polozhennya pro zemelno-kadastrovu inventaryzatsiyu zemel naselenykh punktiv (1997) *Zakonodavstvo Ukrayiny*, No. 522/2326, 12 s., (in Ukrainian).
7. Tserklevych A. (1999) Vykorystannya novykh tekhnolohiy i aktualni zadachi zemelnoho kadastru. Suchasni dosyahnennya heodezychnoyi nauky ta vyrobnytstva. Lviv, s. 121–124 (in Ukrainian).
8. Tserklevich A., Protsik M. (1997) Pro tochnist vyznachennya polozhen hranychnykh znakiv i rozrakhunku ploshchi zemli. Suchasni dosyahnennya heodezychnoyi nauky ta vyrobnytstva. Lviv. s. 185–188 (in Ukrainian).
9. Tserklevich A., Siglyak M. (1999) Pro tochnist vyznachennya mezh ta ploshch zemelnykh dilyanok pry vykonanni inventaryzatsiyi zemel naselenykh punktiv. Suchasni dosyahnennya heodezychnoyi nauky ta vyrobnytstva. Lviv. s. 124–130 (in Ukrainian).
10. Tserklevich A., Chernyagha P. (2002) Koordynuvannya mezh zemelnykh dilyanok i tochnist vyznachennya yikhnikh ploshch. Zemlevporyadnyy visnyk. - No. 2., p. 24-28 (in Ukrainian).
11. Tserklevich A., Kalinich I. (2015) Yakist heoprostorovykh danykh natsionalnoyi kadastrovoyi cystemy i problemni pytannya vstanovlennya (vidnovlennya) vezh zemelnykh dilyanok. Visnyk heodeziyi ta kartohrafiyi. No. 3., s. 32-40 (in Ukrainian).
12. Shendyapina S. (2004) Sovershenstvovaniye tekhnologii mezhevaniya zemel na baze primeneniya elektronnoy izmeritelnoy tekhniki i materialov aerofotosyemki: dis. kand. tekhn. nauk. Moskva, 92 s., (in Russian).
13. Petrie, G. (2013) Commercial operation of lightweight UAVs for aerial imaging and mapping. GEOInformatics, vol. 16, No. 1, p. 28–39.


## Information about authors


**Anatoliy Tserklevich**, Doctor of Science, Professor, Dean of Engineering Geodesy Department, Institute of Geodesy, Lviv Polytechnic National University, S. Bandera str., 12, Lviv, Ukraine, 79013

**Vasyl Khoptar**, Master of Science, Ph.D.-student, Department of Engineering Geodesy, Institute of Geodesy, Lviv Polytechnic National University, S. Bandera str., 12, Lviv, Ukraine, 79013, e-mail: vasyl.khoptar@gmail.com

DOI: 10.22616/j.balticsurveying.2018.022

# UTILIZATION OF AGRICULTURAL LAND IN THE RUSSIAN FEDERATION

**Sergey Volkov, Vladimir Kosinsky**
The State University of Land Use Planning

**Abstract**
This article reviews the initiatives for setting up rational use and protection of agricultural lands in order to ensure accelerated growth of the agricultural sector of the Russian Federation, enhancing its sustainability, efficiency, competitiveness, and environmental safety. It is hereby proposed to complete the differentiation of public lands into federal property, property of the subjects of the Russian Federation, property of municipal settlements; as well as to conduct topographic survey of lands in the Russian Federation (to establish and locally document the boundaries of territories of the subjects of the Russian Federation; municipal settlements; communities; special-purpose lands; areas with special land use conditions; and to systematically (once every 5 years) perform agricultural land inventory in order to identify unused, irrationally used or non-purposely used lands, as well as land use in violation of the relevant permitted use of land plots; to relaunch land survey works relating with the performance of pedologic, geobotanical and other studies and research.
Key words: land management, agricultural land, land utilization, land protection.

## Introduction

Ensuring food security in the Russian Federation is one of the priorities of socio-economic development of the Russian Federation. The degree of success of this strategy largely depends on the level of efficiency of using agricultural lands, both currently and in foreseeable future.

Russia's agricultural sector has lately demonstrated sustainable growth in terms of manufacture of agricultural products. However, the sector's land potential allows for higher growth rates, provided there is objective evaluation of the condition and well-grounded determination of the trends and contents of activities of the land administration of land resources and setting up rational land ownership and land utilization.

The existing land- and resource potential of our country and, primarily, its agricultural lands is currently estimated at being around 30% lower than the level of 1990. One can assuredly state that the land reforms of 1990-2017 yielded much more negative outputs than the positive ones when it comes to the issue of land utilization.

On the one hand, successful farming and agricultural entities, due to efficient land organization involving environmental protection activities, are able to ensure sustainable yields, even during years with clearly unfavorable weather conditions. On the other hand, there are substantial reserves in terms of involvement of lands in agriculture.

According to the relevant statistical records, as of January 1, 2017 in the Russian Federation there were 383.6 million hectares of agricultural lands including 197.7 million hectares of arable lands, of which 122.8 million hectares of tillable lands (Table 1) (Волков, 2017).

Entities and persons engaged in agricultural production used 521.4 million hectares of lands, of which agricultural lands accounted for more than 349.2 million hectares (65.2 %). This is the area composed of 60 million land plots and it is the subject of land relations, while more than 40 million land owners, agricultural tenants, and land users engaged in farming or those affiliated with any cadastral issues acted in the capacity of subjects of land relations (Table 2) (Волков, Липски, 2016).

**Table 1**

Allocation of the land fund of the Russian Federation by land category

| | Land Category | As of 01.01.2006 | As of 01.01.2011 | As of 01.01.2017 | 2017 vs. 2006 | |
|---|---|---|---|---|---|---|
| | | | | | Million hectares | % |
| 1 | Agricultural lands | 401.6 | 393.4 | 383.6 | - 16.0 | - 4.0 |
| 2 | Urban lands | 19.1 | 19.6 | 20.4 | + 1.3 | + 4.8 |
| 3 | Industrial lands and special-purpose lands | 16.7 | 16.8 | 17.4 | + 0.5 | + 2.9 |
| 4 | Lands of specially protected areas | 34.2 | 34.9 | 47.3 | + 13.1 | + 37.5 |
| 5 | Forest reserve lands | 1,104.9 | 1,115.8 | 1,126.3 | + 17.7 | + 1.6 |
| 6 | Water fund lands | 27.9 | 28.0 | 28.1 | + 0.1 | + 0.4 |
| 7 | Undistributed lands | 105.4 | 101.3 | 89.5 | - 15.9 | - 15.1 |
| | **Total lands** | **1,709.8** | **1,709.8** | **1,712.5** | **+ 0.1** | **-** |

**Table 2**

Trends of allocation of agricultural lands by business pattern

| | Business pattern | 2006 | | 2016 | | 2016 vs. 2006 % vs. % |
|---|---|---|---|---|---|---|
| | | Million hectares | % | Million hectares | % | |
| 1 | Agricultural organizations | 410.3 | 91.0 | 291.6 | 83.5 | - 8.2 |
| 2 | Farms | 26.0 | 5.8 | 37.9 | 10.8 | + .0 |
| 3 | Sole proprietors | 3.4 | 0.8 | 5.4 | 1.5 | + 0.7 |
| 4 | Private subsidiary farm and other private farms | 9.7 | 2.2 | 13.1 | 3.8 | + 1.6 |
| 5 | Nonprofit private entities | 1.2 | 0.3 | 1.2 | 0.3 | 0 |
| | **Total** | **450.6** | **100** | **349.2** | **100** | **-** |

Thus, hundreds of millions of hectares of land used in the agricultural sector of the Russian Federation, tens of millions of land owners, agricultural tenants, and land users who are engaged in land relations of various forms require specific organization and management, which is impossible without the corresponding institutions, infrastructure, and mechanisms, the lack of which spawns multiple issues and thus require the appropriate science-based and practical resolution.

**Methodology of research and materials**

What is required to meet the above targets?

- Analysis of the condition and organization of agricultural land utilization in 1990-2018, identification of the key trends for the establishment and development of agricultural tenure, and determination of the main areas for setting up rational utilization and protection of agricultural lands in the near-term and for the period ending in 2030 (Хлыстун, 2018);
- Analysis of the land laws and the practice of legal enforcement in the area of setting up the use and protection of agricultural lands, and development of proposals for their further improvement (Волков, Липски, 2018);
- Determination of the trends in the development of land- and property relations in the area of the agricultural sector, evaluation of the status of government-induced registration, cadastral accounting, and cadastral valuation of agricultural lands, and drafting of proposals for the improvement of the state regulation of their circulation;

- Definition of the condition, scope, and qualitative characteristics of unused farmlands, and develop recommendations for their engagement in agricultural circulation, melioration, and reclamation;
- Determination of losses of the national agricultural sector due to withdrawal of agricultural lands for use in industrial, transport, energy, and residential construction, as well as lands used for any other non-agricultural purposes, and establish measures for their protection and reimbursement of damages and losses of the agricultural sector;
- Substantiation of the need for comprehensive land survey- and cadastral works in rural areas and drafting of design and estimate documentation for land tenure documentation in case of any changes in production and territory;
- Evaluation of the areas of high-value agricultural lands, evaluation of the degree of their degradation, desertification, water erosion, deflation, and any other adverse effects based on the materials of studies and monitoring of agricultural lands and their zoning in terms of their fitness for use in agriculture;
- Calculate economic efficiency of the proposed activities in terms of using lands for the nation's agricultural sector until 2030 (Волков, Липски, 2018). Methodology of research and materials should explain the data source (if any) and the empirical methodologies used in the manuscript. Proper reference should be maintained, if the paper is produced by following any published methods. It should describe what was actually done including description of the techniques used so someone could figure out what experiments were actually done.

**Discussions and results**

Therefore regulatory framework in the area of land relations pertaining to agricultural lands should include (Волков, Липски, 2016):

– Inventory of the norms of the federal and regional legislation which regulate utilization and protection of agricultural lands;
– Determination of trends and measures for the improvement of the said legislation, as well as evaluation of the system of government supervision and municipal control over compliance with the same;
– Development of the concept of improvement of the legislation in the part of harmonization of issues of management of land plots, ensuring rational utilization of lands and protection thereof. Introduction of prohibition of withdrawal of high-value farmlands;
– Introduction of restrictions for withdrawal of agricultural lands by way of regulation (establishment of the types of permitted use and restriction of the relevant development density);
– Introduction of amendments and addenda into legislative enactments of the Russian Federation pertaining to the development of real property cadaster for the formation and informing about the properties of real estate items by way of land tenure, as well as in order to exclude land survey work from cadastral activities and appropriation of their independent status;
– Introduction of amendments into the legislation which provide for conduction of specialized auctions for provision of land plots exclusively to SMEs (Small and Medium-sized Enterprises), as well as one-time provision of agricultural land plots without a tender to novice farms (farmers);
– Establishment of a single, maximum size of a land plot for the subjects of the Russian Federation as located in the territory of one municipal district and which may be owned by one person and/or one legal entity or a group of persons and inclusion of this size in the Federal Law dated 24.07.2002 No. 101-FZ On Agricultural Land Transactions;
- Formalization of liability of persons and entities for any degradation and wasteful utilization of land plots (Волков, Липски, 2018)

Improvement of the legal and regulatory issues in the area of land utilization should be aimed at:

– Segregation of functions, authority, and setting up interaction of the federal executive authorities between their own branches and agencies and executive authorities of the subjects of the Russian Federation in the area of legal relations and management of land resources and land tenure;
– Harmonization of the land laws and regulatory enactments with the international law in the area of managing land resources and land tenure, as well as harmonization with the urban planning laws, forestry laws, water resource laws, and other bodies of law;

– Legislative recognition of the forms and methods of participation of self-regulating entities and persons in land tenure activities.
– Further development of the new draft and introduction of amendments and addenda into the Federal Law dated 18.06.2001 No. 78-FZ On Land Utilization in the section of differentiation of land utilization as government-sponsored and self-motivated, stiffening of requirements to the compulsory nature of land tenure and compliance by titleholders of land plots with the approved land tenure documentation.
Specification of regulatory enactments for the procedure of withdrawal of land plots for government- and municipal needs; the procedure of changing and delimiting (restoration) borders of the subjects of the Russian Federation, municipal and other administrative and territorial units, and settlement of disputes arising between them with regards to border delimitation;
– Preparation of regulatory enactments aimed to improve the procedure of execution of land title for the construction of linear-type production facilities (power distribution lines, communications lines, pipelines, transportation lines, etc.), agricultural (land utilization) zoning and determination of the legal regime for using lands outside of settlements, especially in urbanized rural settlements, locations with intensive exploration of mineral resources, allotment of land plots as limited interest in joint property to a land plot;
– Specification of the existing regulatory enactments in the part of regulation of land relations and land tenure in the areas of traditional residence of small-numbered indigenous peoples of the North, Siberia, and the Far East of the Russian Federation (Волков, Липски, 2016).
Due to the above, ensuring rational land utilization and protection of agricultural lands should include:
– Completion of differentiation of public lands into federal property, property of the subjects of the Russian Federation, property of municipal settlements;
– Conduction of topographic survey of lands in the Russian Federation (to establish and locally document the boundaries of territories of the subjects of the Russian Federation; municipal settlements (municipal districts, urban settlements, urban districts, rural districts, rural settlements, closed administrative territorial units); communities; special-purpose lands; areas with special land use conditions; territorial cones, as well as parts of the said territories and areas) (Волков, Косинский, 2013);
– Systematic (once every 5 years) performance of agricultural land inventory in order to identify unused, irrationally used or non-purposely used lands, as well as land use in violation of the relevant permitted use of land plots.
– Relaunch of land survey works relating with the performance of pedologic - geobotanical,- and agricultural land surveys, evaluation of their qualitative characteristics, updating of the data of the state cadastral valuation of lands, as well as assessment of the quality of lands relating with the original ecosystem of the indigenous minority peoples of the North, Siberia, and the Far East of the Russian Federation;
– Targeted land utilization activities in order to research and identify the condition and utilization of slough, arid glazing lands, and reclaimed lands;
– Sustainable development, for purposes of comprehensive planning, of rural areas and territories, enhancement of efficiency of the regional and municipal agricultural sector in terms of land management of area owned by the subjects of the Russian Federation, as well as schemes for land management of municipalities;
– Experimental land utilization activities aimed at zoning of agricultural lands and determination of the relevant regulations for land plot usage;
– Zoning of rural (inter-settlement) territories of the subjects of the Russian Federation and municipal settlements in terms of their fitness of use in agriculture; and based on the above development of the land use regulations and regulations for the development of agricultural lands, development of agricultural (land use) regulations, limiting dimensions (maximum and minimum) of land plots (Волков, 2015);
– Development of projects aimed at redistribution of lands and land plot surveys in order to engage 17.2 million hectares of unused land lots in agricultural and economic circulation;

– Reorganization of territories of defunct farming entities in the area of 15.9 million hectares, the lands of which were accounted in the relevant cadastral documents as lands used by agricultural manufacturers, while the titleholders to such lands had been excluded from the corresponding registers of legal entities and persons;
– Consolidation of land plots from redistribution in the area of 43.7 million hectares including 11.9 million hectares of farmlands, of which 3.5 million hectares are plough lands, within the borders of municipal districts for purposes of ensuring their efficient use, by way of renting them out or sale on competitive terms;
– Identification, delimitation of borders, location, and area of 24.4 million hectares of farmlands allocated to other land categories (excluding agricultural lands) and taking measures for their subsequent utilization in order to manufacture agricultural products or in order to exclude them from agriculture and to draft programs for the development of new lands instead of the lands withdrawn from such agricultural circulation;
– Temporary closing of inefficient and industrially-contaminated farmlands by way of developing the corresponding land use projects and setting up their implementation mechanisms;
– Ensuring intra-farm land tenure for purposes of setting up rational utilization of agricultural lands and their protection, as well as utilization and protection of the lands used by communities of small-numbered indigenous peoples of the North, Siberia, and the Far East of the Russian Federation in order to guarantee their traditional lifestyle;
– Ensuring the following types of works in case of intra-farm land tenure activities (Волков, Косинский, 2013):
a) Setting up rational utilization by persons and legal entities of land plots designed for agricultural production, as well as setting up territories used by communities of small-numbered indigenous peoples of the North, Siberia, and the Far East of the Russian Federation, in order to guarantee their traditional lifestyle;
b) Development of activities aimed at the improvement of farmlands, development of new lands, reclamation and preservation of lands, cultivation of disturbed lands, protection of lands from erosion, mudflows, saturation, mire formation, resalting, drying out, compaction, pollution with industrial waste and household waste, contamination with radioactive and chemical substances, poisoning, and other adverse effects;
– Ensuring substantiation of land utilization and improvement of soil quality, afforestation amelioration, hydrotechnical construction, infrastructure development of agricultural lands;
– Land utilization-related assistance to farming entities included in the government programs for agricultural development, development of the raw materials- and food markets; improvement of soil quality; melioration and land reclamation; as well as implementation of priority national projects aimed at the agricultural sector development (Волков, Косинский, 2013).

## Conclusions

Thus, the development and implementation of the recommendations for the use of agricultural lands in the short-term – (until 2020) and long-term perspective (until 2030) will allow for substantial changes in the existing approaches to setting up the utilization and protection of the country's land potential, as well as to engage agriculturally-fit unused lands and to rationally organize inter-settlement territories, ensure protection of lands from any embezzlement and degradation, and increase the yield of each and every hectare based on the application of advanced technologies.

### References

1. Волков С. Н., Липски С. А. (2018) Особенности правового регулирования земельных отношений в АПК в современных условиях и первоочередные землеустроительные меры по реализации соответствующих законодательных норм (Features of the legal regulation of land relations in the agricultural sector under current conditions and priority land surveying measures aimed at implementing the corresponding legislative regulation) // Землеустройство, кадастр и мониторинг земель. – 2018. - №4, с.5-10 (in Russian).
2. Волков С.Н.(2017) Современное состояние земельных отношений, землепользования и землеустройства в Российской Федерации и научное обоснование основных направлений их регулирования в АПК (Current condition of land relations, land utilization, and land use planning in the

Russian Federation and scientific substantiation of the main areas of their regulation of the same in the agricultural sector) / ГУЗ. – М. 72 с. (in Russian).
3. Волков С.Н., Липски С.А. (2016) Проблемы действующего правового механизма выявления неиспользуемых земель принудительного прекращения прав на них и их последующего вовлечения в хозяйственный оборот (The problems of the current legal framework for the identification of unused land and forced termination of rights to them and their subsequent drawing into economic circulation) // О совершенствовании законодательного регулирования оборота земель сельскохозяйственного назначения. Аналитический вестник №24 (623). – М.: Совет Федерации Федерального Собрания Российской Федерации, с. 14-18 (in Russian).
4. Волков С.Н. (2015) О критериях и порядке отнесения земельных участков к особо ценным сельскохозяйственным землям (On the criteria and procedure of allocation of land plots to high-value agricultural lands) // Землеустройство, кадастр и мониторинг земель. – 2015. - №1. – с. 6-13 (in Russian).
5. Волков С.Н. (2015) Землеустроительное обеспечение перехода от категорий земель к территориальному зонированию: [текст выступления на парламентских слушаниях] (Ensuring land use transfer from the categories of land to land zoning: [Transcript of the speaking engagement at parliamentary hearings]) // Землеустройство, кадастр и мониторинг земель. – 2015. - №8, – с.6-9 (in Russian).
6. Волков С.Н., Косинский В.В. (2013) Концепция землеустройства в Российской Федерации на современном этапе (The concept of land utilization in the Russian Federation at the current stage) // Baltic Surveying, 2013: Proceedings of the International Scientific Methodical Conference. – Kaunas: Akademija, – с. 157-163 (in Russian).
7. Хлыстун В. Н. (2018) Структурные изменения в земельном фонде России (Structural changes in the Russian land reserves) // Землеустройство, кадастр и мониторинг земель. – 2018. - №4, с.11-18 (in Russian).
8. Хлыстун В.Н., Волков С.Н., Комов Н.В. (2014) Управление земельными ресурсами в России (Management of the land resources in the Russian Federation) // Экономика сельскохозяйственных и перерабатывающих предприятий. – 2014. – №2. – С.41-43 (in Russian).
9. State University of Land Use Planning (SULUP). Volkov S.N. (2014) Land policy of Russia. Millennium experience. Academic and scientific edition. / Volkov S.N., Shirokorad I.I. M.: SULUP. 520 p.

**Information About the Authors**

**Sergey Nikolaevich Volkov,** Rector of the State University of Land Use Planning, Academician of the Russian Academy of Sciences, Meritorious Scientist of the Russian Federation, Head of the Land Utilization Department, Doctor of Economics, Professor. The State University of Land Use Planning (SULUP). Address: 15 Kazakova St., Moscow 105064 Russian Federation. Phone: +7 (499) 261-31-46; Email: info@guz.ru. The area of scientific interests: The economics of land utilization, land use planning and cadasters; the theory and methods of modern-day land use planning, and the systems of automated design of land utilization.

**Vladimir Vasilyevich Kosinsky**, Doctor of Economics, Professor of the Land Utilization Department, Meritorious Culture Professional of the Russian Federation, Academician of the Russian Academy of Natural Sciences. The State University of Land Use Planning (SULUP). Address: 15 Kazakova St., Moscow 105064 Russian Federation. Phone: +7 (915) 339-35-45; Email: kosinskij1@mail.ru. The area of scientific interests: The history of land utilization; methods of the design and substantiation of intra-farm land use and taking into account the land use systems and agriculture systems, and environmental management activities.