LATVIA UNIVERSITY OF LIFE SCIENCES AND TECHNOLOGIES

UNIVERSITY OF WARMIA AND MAZURY IN OLSZTYN (Poland)

VYTAUTAS MAGNUS UNIVERSITY (Lithuania)

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FOREWORD

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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 Eastern Europe and elsewhere. The journal is the first one in the Baltic countries dealing with the mentioned issues.
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CONTENT

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THE CHANGES OF FOREST AREA IN KLAIPEDA COUNTY DURING THE PERIOD BETWEEN 2005-2019

Ivaviciute Giedre [1; 2; 3]

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Abstract
The article presents the analysis of the current situation of the forest area in Klaipeda county.
Comparative, analytical as well as statistical and logical analysis methods were used for the investigation.
The aim of the investigation is to carry out the analysis of the Klaipeda county's forest area during the period between the years 2005 and 2019.
The object of the investigation – forest area of Klaipeda county. Tasks of the investigation: 1. To describe the status quo of forest in Klaipeda county. 2. To analyze and compare the forest area change in Klaipeda county during the period between the years 2005 and 2019.
The study found that forests prevailing in Klaipeda County are of 60-69 years old. It was determined that fire trees prevail in Klaipeda County (25.64 percent) and pine (24.03 percent).
The type of ownership prevailing Klaipeda County is the forests of state significance managed by forest enterprises, national parks and state reserves (51.26 percent).
In the County there are mostly Group IV or commercial forests (62.47 percent).
In Klaipeda County during the period between the years 2005 and 2019 the forest area increased by 8269.85 ha or 6.03 percent.

Key words: forest area, forest coverage, type of ownership, climate change

Introduction

Article relevance. Forests cover nearly a third of all land on Earth, providing vital organic infrastructure for some of the planet's densest, most diverse collections of life. They support countless species. Forests are important both in terms of environmental and socio-economic aspects. From an environmental point of view, forests carry out ecosystem storage functions: contributing to soil conservation, climate regulation, and biodiversity conservation.

Forests play an important role in carbon storage and climate regulation, as well as supporting biodiversity (Benefits..., 2019).

Humans clear millions of acres from natural forests every year, especially in the tropics, letting deforestation threaten some of Earth's most valuable ecosystems.

Forests are a major, requisite front of action in the global fight against catastrophic climate change – thanks to their unparalleled capacity to absorb and store carbon. Forests capture carbon dioxide at a rate equivalent to about one-third the amount released annually by burning fossil fuels. Stopping deforestation and restoring damaged forests, therefore, could provide up to 30 percent of the climate solution (Da Silva et. al., 2018).

Forests represent the largest sink of terrestrial carbon and continued storage, forest growth and removals for long life-span products may help reduce greenhouse gases in the future (Coulston et. al., 2015).

The world's forests influence climate through physical, chemical, and biological processes that affect planetary energetics, the hydrologic cycle, and atmospheric composition (Bonan, 2008).

Changes in patterns of tree growth can have a huge impact on atmospheric cycles, biogeochemical cycles, climate change, and biodiversity (Mc Mahon et. al., 2010).

Changing forest cover is a key driver of local climate change worldwide, as it affects both albedo and evapotranspiration (Prevedello et. al., 2019).

Problem. Effects of climate warming on natural and human systems are becoming increasingly visible across the globe (Harvey, 2016). Forest die-off constitutes a large uncertainty in projections of climate impacts on terrestrial ecosystems, climate–ecosystem interactions, and carbon-cycle feedbacks. Current understanding of the physiological mechanisms mediating climate-induced forest mortality limits the ability to model or project these threshold events (Anderegg et. al., 2012).

Global warming is a well-known natural phenomenon that needs to be controlled for environmental conservation (Khaine, Woo, 2015).
Anthropogenic climate change presents potential risks to forests and future challenges for forest managers. Responding to climate change, through both mitigation and adaptation, may represent a paradigm shift for forest managers and researchers (Keenan, 2015).
Forest management has high potential for mitigating climate change effects, but only with support of insightful policy initiatives that take account of potential climatic changes (Duinker, 1990).
The forest cover in Klaipeda County is 26.25 percent, i.e. lower than in the Republic of Lithuania (33.07 percent). The county's natural framework system includes areas that have lost their natural landscape structure, valuable natural elements and are unable to perform ecological compensation functions. In some sections of regional and regional migration corridors, the diversity of the natural environment is impoverished. Intensive urban development, agriculture and uncontrolled recreation cause the greatest damage to the condition of the natural framework. Taking into account the current situation, it is necessary to carry out the development of the forest area in Klaipeda County.
The object of the investigation – forest area of Klaipeda county.
The aim of the investigation - to carry out the analysis of the Klaipeda county forest area during the period between the years 2005 and 2019 and to submit proposals for the implementation of further development.
Tasks of the investigation:
1. To describe the status quo of forest in Klaipeda county.
2. To analyze and compare the forest area change in Klaipeda county during the period between the years 2005 and 2019.
3. To evaluate the possibilities of forest development in Klaipeda County.

Methodology of research and materials

Comparative, analytical as well as statistical and logical analysis methods were used for the investigation. The article analyses works of Lithuanian and foreign scientists, published in scientific publications.
The land fund statistics of the Republic of Lithuania (Nacionaline zemes..., 2005-2019), graphically depicted in figures, were used for the fulfilment of the research of the forest area change in Klaipeda countyfor the years 2005 - 2019.
The article analyzed and assessed the current state of the forest in the Klaipeda county, i.e. the prevailing tree species and age were determined, the distribution of forests by groups and ownership type was investigated.
The study provides the forest area change analysis in Klaipeda County. The 14 year period, i.e. the period between the years 2005 and 2019, was selected for the determination of the change. Statistics data were systematized, analyzed and expression of the percentage was calculated during the preparation of the research.

Discussion and results

The status quo of forest in Klaipeda county. According to the data of 2019, forests occupy 2158949.68 hectares in the Republic of Lithuania, and the country's forest is 33.07 percent. After analysing the current state of the forests in the Republic of Lithuania, it has been established that the most forested are Alytus (48.28 percent), Vilnius (42.91 percent), Telšiai (35.83 percent), Utena (34.88 percent), and Taurage (33.06 percent).
Klaipėda County is one of ten counties in Lithuania. It lies in the west of the country and is the only county to have a coastline. County occupied the area of 522245.08 ha, i.e. 8 percent of the entire area of the Republic of Lithuania. There are 7 municipalities: Klaipeda City, Klaipeda District, Kretinga District, Neringa, Palanga City, Skuodas District and Silute District.
In the Klaipeda County forests in 2019 occupied the area of 137089.62 ha, i.e. 26.25 percent of the entire area of the county. The largest part of Klaipeda County forests is made up by forests growing in the municipality of Silute district, which in 2019 occupied 37651.49 ha. The smallest forest area was established in Klaipeda city municipality (2023.64 ha).
It has been established that the most forested municipalities are Neringa (51.02 percent), Palanga City (39.21 percent) and Kretinga District (34.50 percent) (Fig.1). In the mentioned counties, the forest coverage is higher than the average of the Republic of Lithuania (33.07 percent).
Age of trees. The largest part of the growing forests consists of forests 60-69 years old, they make up

13.06 percent, 50-59 years old forests make up 12.87 percent, 40-49 years old – 11.48 percent. 90–99 years old forest make up 3.88 percent.

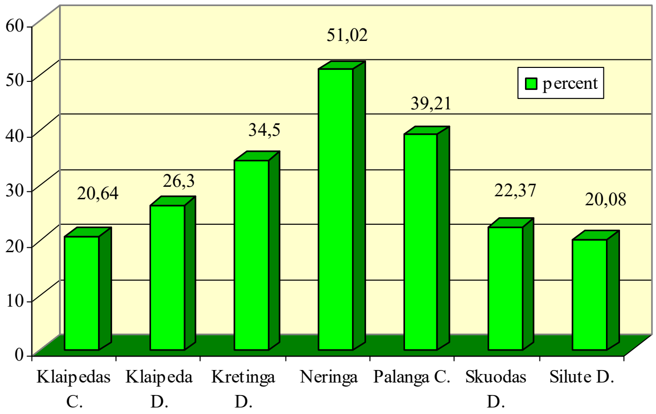

Fig. 1. Forest coverage in municipalities (percent) in 2019
(Consisted by the author of the article)

The prevailing *tree species* in the forest landscape are fir trees, which form 25.64 percent, as well as pine (24.03 percent) and birch trees (21.02 percent).

Coniferous species (56.20 percent) prevail in Lithuania forests, of which pine forests are dominant.

Distribution of forests in Klaipeda County by forest groups. In the County there are mostly Group IV or commercial forests (62.47 percent). Group II special-purpose forests make up 23.34 percent, Group III protective forests – 12.24 percent.

In all of Lithuania's counties there are mostly Group IV commercial forests. These forests make up 71.40 percent, where the main purpose of farming is to form productive stands, to continuously supply wood. The least are Group I forest reserves (1.20 percent) (Ivaviciute, 2018).

According to the *type of ownership*, the forests are divided into the following: forests of state importance owned by forest enterprises, national parks and state reserves make up 51.26 percent, private and other forests – 46.53 percent, state forests belonging to the Ministry of National Defense and the Ministry of the Interior - 0.47 percent. The municipal forests of state significance make up 0.46 percent, forests of state importance managed by the Ministry of Transport and Communications make up 0.10 percent, forests of state significance proposed to be excluded from the areas belonging to the Ministry of the Interior make up 0.06 percent, forests managed by forest enterprises and proposed to be included into the areas belonging to the Ministry of the Interior make up 0.05 percent and etc.

Forest area change in Klaipeda County. During the period under review, forest areas increased in 4 Klaipeda County municipalities: in Klaipeda City the forest area has increased by 231.02 ha or 12.89 percent, in Klaipeda district - 2988.26 ha or 8.59 percent, in Silute district - 3601.28 or 9.56 percent, in Skuodas district - 2871.81 ha or 18.63 percent. Skuodas district municipality has the largest forest development in Klaipeda County.

In Kretinga district forests fell by 823.11 ha or 2.35 percent, in Neringa - 461.13 ha or 6.51 percent, Palanga City - 138.28 ha or 4.45 percent (Fig. 2).

In the Klaipeda County during the period between the years 2005 and 2019 the forest area increased by 8269.85 ha or 6.03 percent and in 2019 occupied 137089.62 ha or 26.25 percent (Fig. 3).

During the period between the years 2005-2019 the forest area of the Republic of Lithuania increased by 120903.13 ha or 5.60 percent.

The area has increased due to the implementation of the forest improvement program, the promotion of plantation forests, the promotion of self-help to forest regeneration, participation in the Rural Development Program, and EU payments for this.

Forest development. In Klaipeda County, intensive forests are classified as economic forests (forest group IV). Forestry activities shall promote efficient multi-purpose use of forests to ensure economic viability and a wide range of environmental and social functions. Economic activities in this group of forests shall aim at preserving biodiversity and related values, water resources, soil, unique and fragile ecosystems and landscapes, and maintaining the ecological functions of the forest and the integrity of forests.

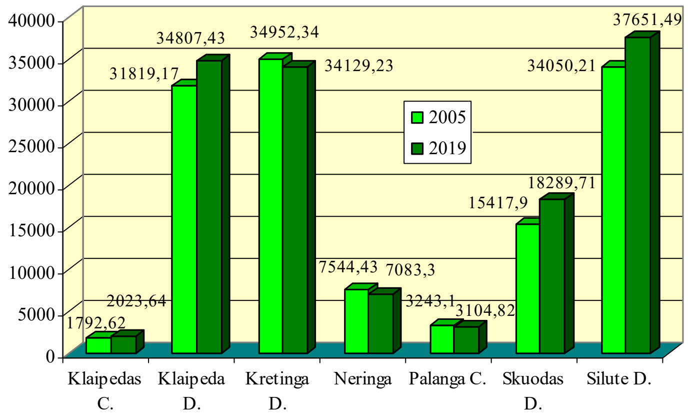

Fig. 2. Forest area change in Klaipeda County municipalities in ha during the years 2005-2019 (Consisted by the author of the article)

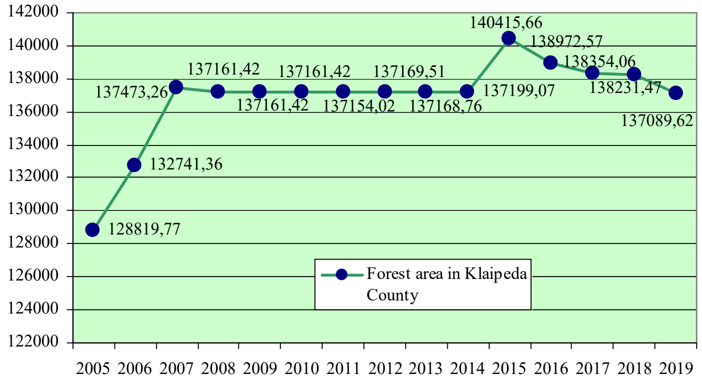

Fig. 3. Forest area change in Klaipeda County in ha during the years 2005-2019 (Consisted by the author of the article)

Sustainable farming zone includes ecosystem protection forests (forest group IIA) - protected forests, habitat and natural resource forests and anti-erosion forests; recreational forests (forest group IIB) include forest park forests and recreational forest areas; protected forests (forest group III) - forests in protected areas, field protective forests, nurseries of forest tree seedlings and forests of protected water bodies. Sustainable, multifunctional use of forests would contribute to the stability of forest ecosystems, the preservation of existing natural and cultural assets, the maintenance of biodiversity, as well as solution of economic issues.

According to the Resolution of the Government of the Republic of Lithuania "On Approval of the Master (General) Plan of the Territory of Klaipeda County " (Lietuvos ..., 2016), reforestation on non-productive land shall be assigned to the zone or group of forests to which adjacent forests are assigned. It is recommended that primary forest planting be planned in pre-erosion forests, field protective forests, and forests of protected water bodies.

It is planned to develop forestry activities in Klaipeda County on forest land as well as in forests located on the land used for agricultural purposes. By increasing the overall forest cover rate of Klaipeda County, it is planned to afforest non-productive land. The afforestation of the territories of the county is planned to be carried out in accordance with the approved land management schemes for forest layout of the municipalities of Skuodas district, Kretinga district, Klaipeda district and Silute district. The forests designed in the schemes have been identified as priority areas where afforestation should be encouraged and their solutions can be implemented to the extent that they do not contradict the solutions of the current Klaipeda County Master plans.

Although the forest area increased in the period of the year 2005-2019, the goals provided for in the Klaipeda County Master Plan were not achieved, i.e. to increase the forest cover in the county to 28.00 percent by 2020. In order to achieve this goal, it is necessary to afforest 9139.00 ha.

According to the data of the National Land Service under the Ministry of Agriculture, in Klaipeda County in 2019 there were 9615.02 ha of land not used for agriculture and unfit for use, of which 5239.86 ha were not used for agriculture and 2543.90 ha were damaged land and 1831.26 ha were

abandoned land. Most of this land is state-owned. After afforestation of all this land, the forest cover of the county would increase by about 7.01 percent and occupy 146704.64 ha as well as will make up 28.09 percent of the county territory.
As almost all areas of Klaipeda, Silute and Kretinga districts are sensitive to wind erosion, poorly insulated depths prevail, therefore in these zones it is necessary to regulate the intensity of land use, increase the amount of greenery, increase the area of forestry land.
After the implementation of the Klaipeda County Master Plan solutions, the forest area will increase in the future. In assessing the relevance of increasing forest cover, the classic aspects of sustainable development - ecological quality, economic development and social development - must be taken into account. Thus, the increase of forest cover is determined by a complex of legal, socio-economic and ecological-environmental factors.
Forest is one of the most important landscape components of biodiversity, sustainable ecosystems and landscaping, so its rational use and protection is essential.

Conclusions

1. After examining the forests according to their age, it was obtained that forests prevailing in Klaipeda County are of 60-69 years old.
2. After analyzing the prevailing species of trees, it was determined that fire trees prevail in Klaipeda County (25.64 percent) and pine (24.03 percent) as well.
3. In Klaipeda County during the period between the years 2005 and 2019 the forest area increased by 8269.85 ha or 6.03 percent.
4. Forest areas increased in 4 municipalities: in Klaipeda City the forest area has increased by 231.02 ha or 12.89 percent, in Klaipeda district - 2988.26 ha or 8.59 percent, in Silute district - 3601.28 or 9.56 percent, in Skuodas district - 2871.81 ha or 18.63 percent.
5. In Kretinga district forests decreased by 823.11 ha or 2.35 percent, in Neringa by 461.13 ha or 6.51 percent, and in Palanga City - 138,28 ha or 4.45 percent.
6. After afforestation of land not used for agriculture and unsuitable for use (9615.02 ha), the forest cover of the county would increase by about 7.01 percent and occupy 146704.64 ha and make up 28.09 percent of the territory of Klaipeda County. It is recommended that forest planting be planned in pre-erosion forests, field protective forests, and forests of protected water bodies as well.

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ESTIMATION OF IONOSPHERIC DELAY INFLUENCE ON THE EFFICIENCY OF PRECISE POSITIONING OF MULTI-GNSS OBSERVATIONS

Alina Khoptar, Stepan Savchuk
Lviv Polytechnic National University

Abstract
Currently, Global Navigation Satellite Systems (GNSS) are developing at a fairly rapid pace. Over the last years US GPS and Russian GLONASS were modernizing, whilst new systems like European Galileo and Chinese BDS are launched. The modernizations of the existing and the deployment of new GNSS made a whole range of new signals available to the users, and create a new concept – multi-GNSS. Ionospheric delay is one of the major error sources in multi-GNSS observations. At present, GNSS users usually eliminate the influence of ionospheric delay of the first order items by dual-frequency ionosphere-free combinations. But there is still residual ionospheric delay error of higher orders. In this paper we present four different processing scenarios to exclude the higher orders ionospheric delay effects on multi-GNSS Precise Point Positioning (PPP) performance, including: "only GPS" and "GPS+GLONASS+Galileo+BDS" – without/with eliminating ionospheric delay error of higher orders. Dataset collected from one GNSS station BOR1 (Borowiec, Poland) over almost two years provided by multi-GNSS experiment (MGEX) were used for dual-frequency PPP tests with one- and quad-constellation signals. For the second pair of scenarios were used a IONosphere map EXchange format (IONEX) that supports the exchange of 2- and 3-dimensional TEC maps given in a geographic grid. Numeric experiments show that, the results of different pairs of scenarios differ at the submillimeter level. The results also show that the multi-GNSS processing are better than those based on "only GPS".
Keywords: Global Navigation Satellite Systems (GNSS), multi-GNSS, Precise Point Positioning (PPP), ionospheric delay.

Introduction

With the fairly rapid pace of Global Navigation Satellite Systems (GNSS) development, its applications in high-precision GNSS geodetic fields, the positioning accuracy has been noticed more and more. With the modernization of US GPS (Global Positioning System) and Russian GLONASS (GLObal NAvigation Satellite System), and newly developed European Galileo and Chinese BDS (BeiDou Navigation Satellite System), users had been able to receive an observations data from different satellite constellations in a whole range of new GNSS signals that formed new term – multi-GNSS.

The ionosphere can be determined as the part of the upper atmosphere, where the density of free electrons and ions is so high that influences the electromagnetic waves propagation (Hargreaves, 1992). The ionosphere can cause a delay in observations, when GNSS signals passing from the satellite to the receiver. As follows, the ionospheric delay is one of the major error sources of GNSS observations, and, accordingly, multi-GNSS. The ionospheric delay estimations with using a prior ionosphere model have the potential to improve positioning productivity for more applications (Gu et al., 2015; Lou et al., 2016).

The first-order of ionospheric effect can be corrected by using linear combinations of GNSS observations that are free from the influence of the ionosphere (Ionosphere-Free, IF) (Odijk, 2003; Seeber, 2008). In recent years, Precise Point Positioning (PPP) method are increasingly being used for high-precision processing of GNSS observations data, including processing data based on multi-GNSS observations (Savchuk, Khoptar, 2019). The concept of PPP is based on single-receiver point positioning using GNSS measurements along with precise orbit and clock information and additional error modeling and dual-frequency code and phase measurement filtering (Zumberge et al., 1997). It mainly associated with the software package GIPSY-OASIS, or rather, its improved version – GipsyX (Official web-site of GIPSY-OASIS software package), that was developed by Jet Propulsion Laboratory (JPL) of California Technical Institute. With this software package observed signals processed using the IF -combination of L1 and L2 signals. But notwithstanding, that the first-order of ionospheric effect corrects with IF -combination, there are residual ionospheric delay errors which are caused by the second- and third-order of ionospheric effect (Marques et al., 2012). Thus, for improving the positioning accuracy, it is necessary to exclude the higher-orders ionospheric effects on multi-GNSS observations.

It was investigated the four different multi-GNSS data processing scenarios in PPP-mode with helping GipsyX software package for GNSS station BOR1 (Borowiec, Poland) to exclude the higher orders ionospheric delay effects, including: "only GPS” and GPS+GLONASS+Galileo+BDS" – without eliminating ionospheric delay error of higher orders; "only GPS” and "GPS+GLONASS+Galileo+BDS" – with eliminating ionospheric delay error of higher orders.

Methodology of research and materials

In multi-GNSS data processing, with considering the higher-order ionospheric delay (Elsobeiey, El-Rabbany, 2012), the IF-combination of each GNSS separately for code (pseudo-distance P) and phase (pseudo-distance L) observations between GNSS station r and corresponding satellite s (conventionally marked as G – GPS, R – GLONASS, E – Galileo and C – BDS), can be formulated as (Savchuk, Khoptar, 2019):

$$\begin{cases} P_r^G = \rho_r^G + c\left(t_r - t^G\right) + c\left(b_r - b^G\right) + T + \dfrac{p}{f_i^2} + \dfrac{q}{f_i^3} + \dfrac{t}{f_i^4} + e_r^G \\ P_r^R = \rho_r^R + c\left(t_r - t^R\right) + c\left(b_r - b^R\right) + T + \dfrac{p}{f_i^2} + \dfrac{q}{f_i^3} + \dfrac{t}{f_i^4} + e_r^R \\ P_r^E = \rho_r^E + c\left(t_r - t^E\right) + c\left(b_r - b^E\right) + T + \dfrac{p}{f_i^2} + \dfrac{q}{f_i^3} + \dfrac{t}{f_i^4} + e_r^E \\ P_r^C = \rho_r^C + c\left(t_r - t^C\right) + c\left(b_r - b^C\right) + T + \dfrac{p}{f_i^2} + \dfrac{q}{f_i^3} + \dfrac{t}{f_i^4} + e_r^C \end{cases} \quad (1)$$

$$\begin{cases} L_r^G = \rho_r^G + c\left(t_r - t^G\right) + \lambda^G\left(N_r^G + B_r - B^G\right) + T + \dfrac{p}{f_i^2} + \dfrac{q}{2f_i^3} + \dfrac{t}{3f_i^4} + e_r^G \\ L_r^R = \rho_r^R + c\left(t_r - t^R\right) + \lambda^R\left(N_r^R + B_r - B^R\right) + T + \dfrac{p}{f_i^2} + \dfrac{q}{f_i^3} + \dfrac{t}{f_i^4} + e_r^R \\ L_r^E = \rho_r^E + c\left(t_r - t^E\right) + \lambda^E\left(N_r^E + B_r - B^E\right) + T + \dfrac{p}{f_i^2} + \dfrac{q}{f_i^3} + \dfrac{t}{f_i^4} + e_r^E \\ L_r^C = \rho_r^C + c\left(t_r - t^C\right) + \lambda^C\left(N_r^C + B_r - B^C\right) + T + \dfrac{p}{f_i^2} + \dfrac{q}{f_i^3} + \dfrac{t}{f_i^4} + e_r^C \end{cases} \quad (2)$$

where P_r^s – code pseudo-distances (unit: m); L_r^s – carrier phase pseudo-distances (unit: m); ρ_r^s – geometric distance between GNSS station and satellite (unit: m); c – speed of light in vacuum (unit: m/s); t_r – receiver clock errors (unit: s); t^s – satellite clock errors (unit: s); λ^s – wavelength of the carrier phase (unit: m); N_r^s – integer carrier-phase ambiguity (unit: cycle); b_r and b^s – delays in equipment for code observations (unit: m); B_r and B^s – delays in equipment for phase observations (unit: m); e_r^s – disregarded effects (noise of receiver, multiply beam, etc.), T – tropospheric delay (unit: m); f_i – frequencies with the dependent terms (unit: Hz); p – total electron content integrated along the line of sight ($STEC$), q – second-order ionospheric effect, t – third-order ionospheric effect.

According to (Bassiri, Hajj, 1993) p, q and t can be given as:

$$p = 40.3\int Nedl = 40.3STEC \quad (3)$$

$$q = 7527c\int NeB\cos\theta dl \approx 2.2566\times10^{12} B\cos\theta STEC \quad (4)$$

$$t = 2437\int Ne^2 dl + 4.74\times10^{22}\int NeB^2\left(1+\cos^2\theta\right)dl \approx 1602.749 Ne_{\max} STEC \quad (5)$$

where Ne – electron density (unit: electrons/m^3), $STEC$ – slant total electron content, B – magnetic field at the at the ionospheric pierce point, θ – angle between the magnetic field and the propagation direction, being the integral performed over the line of sight, $Ne_{\max}$ – maximum electron density at the height of the ionospheric layer.

It is known, that the higher-order ionospheric delay depends on the STEC along the line of sight, magnetic field parameters at the ionospheric pierce point, and the angle between the magnetic field and the direction of signal propagation. STEC values may be obtained from agencies such as the International GNSS Service (IGS), Centre for Orbit Determination in Europe (CODE), Jet Propulsion Laboratory (JPL), European Space Agency (ESA) and others, that use different approaches to compute the global ionospheric model (Feltens, Schaer, 1998). These agencies produce global ionospheric maps (GIMs) in the ionospheric exchange (IONEX) format (Schaer et al., 1998). For example, CODE GIM (CODG) comes from processing double-differenced carrier phase data and TEC parameterization using Spherical Harmonics Expansion "SHE" functions and Bernese software (Schaer, 1999). Thus, for excluding the higher-order ionospheric delay effects on multi-GNSS observations data processing, in this study we had using IONEX files from CODE.

Discussions and results

To investigate the effect of higher-order ionospheric delay on multi-GNSS data processing, GipsyX software package was used. For data processing, we have selected data from multi-GNSS station BOR1 located in Borowiec, Poland. The necessary for observations processing data had been downloaded from the Multi-GNSS-Experiment (MGEX) website for the period from DOY281 of 2017 (October 08, 2017) to DOY161 of 2019 (June10, 2019). This choice was depended on the data presence of multi-GNSS observations in RINEX version 3 and MGEX-products from CODE. Therefore, precise orbit, clock, antenna phase center correction and other products, including IONEX files, were downloaded from the CODE analysis center. Data observations processing occurred at four scenarios that differ between a combination of navigation systems and considering higher-order ionospheric delay corrections. The "only GPS" and "GPS+GLONASS+Galileo+BDS" observations data without/with eliminating ionospheric delay error of higher orders were processed in the static PPP, respectively. Table 1 shows the processing scenarios list. Here, the abbreviation G, R, E and C represent GPS, GLONASS, Galileo and BDS, respectively. The signs "I–" and "I+" represent the without and with eliminating ionospheric delay error of higher-order, respectively.

Table 1

Processing scenarios

Scenario number	GNSS constellations	IONEX
1	G	I–
2	G + R + E + C	I–
3	G	I+
4	G + R + E + C	I+

GipsyX was set to run in PPP mode (Zumberge et.al., 1997), with applied IERS2010 recommendations for the solid Earth tides model (Petit, Luzum, 2010) and FES2004 model for ocean tide loading (Lyard et.al., 2006). Antenna phase corrections and an elevation cut-off 7° were also applied. For tropospheric modeling empirical model of Global Pressure and Temperature GPT2 (Lagler et.al., 2013) and Global Mapping Function GMF (Boehm et.al., 2006) were applied. The wet delay and gradient parameters were modeled as random walk variables with 5 and 0.5 mm/ph, as recommended by GipsyX manual pages. A priori wet delay was fixed to 100 mm. Phase ambiguities were fixed using special res-function, which allows the constraint of double difference integer ambiguities using data from a single receiver, when using clock and orbital data. The products contain a file with wide-lane bias and phase bias information from the global network used to compute the bias fixed orbits and clocks. Detailed description on algorithm can be found in (Bertiger et.al., 2010, Savchuk et.al., 2020). As processing results, we received coordinates for every day of the GNSS station BOR1 for each scenarios. It allowed generalizing the obtained of coordinate changes velocity and their evaluation. Figure 1 shows the graphical representations of the fourth scenario processing results. On the left, we have the plot of observed and modeled position of the station (referenced to the epoch 2019.000), and on the right – residuals plot, that shows the difference between the observed and modeled positions.

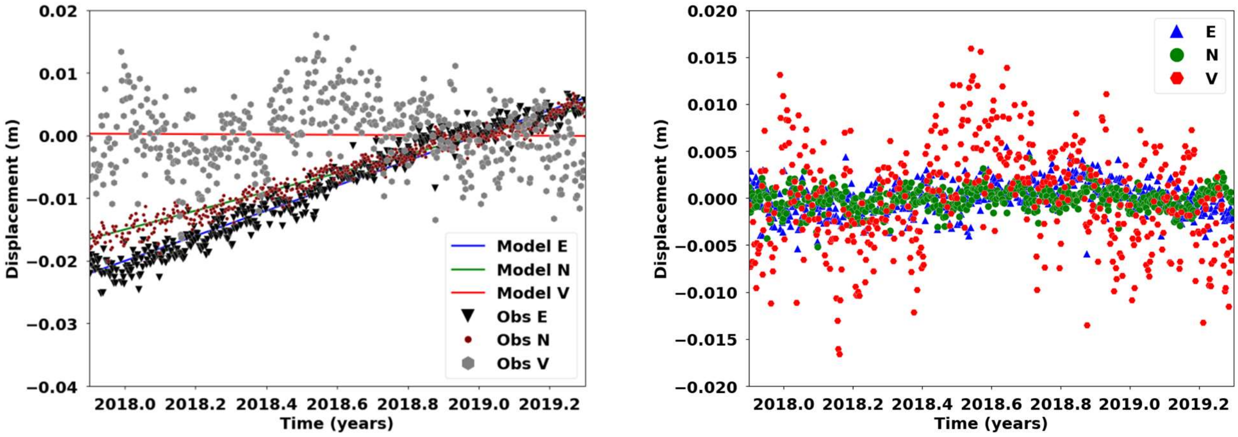

Fig. 1. Results of fourth processing scenario for the station BOR1

As the differences in the results of the processing under the four scenarios are almost not noticeable graphically, we compiled the results obtained into a Table 2, where STA are positions, VEL are velocities, REP – RMS error of coordinate repeatability of GNSS station BOR1 for a time series of observable period.

Table 2

Estimated parameters for the station BOR1

Scenario	Parameter	Values			Accuracy		
		E	N	V	E	N	V
1	STA [mm]	17.0735	52.2770	124.3592	$63\cdot10^{-6}$	$38\cdot10^{-6}$	$106\cdot10^{-6}$
	VEL [mm/year]	20.4056	14.6554	-2.1287	0.089	0.054	0.151
	REP [mm]	*0.002*	*0.001*	*0.005*			
2	STA [mm]	17.0735	52.2770	124.3590	$63\cdot10^{-6}$	$38\cdot10^{-6}$	$106\cdot10^{-6}$
	VEL [mm/year]	20.4136	14.6644	-2.1239	0.089	0.054	0.151
	REP [mm]	*0.002*	*0.001*	*0.005*			
3	STA [mm]	17.0735	52.2770	124.3609	$35\cdot10^{-6}$	$23\cdot10^{-6}$	$66\cdot10^{-6}$
	VEL [mm/year]	20.0022	14.9978	-0.2532	0.051	0.033	0.096
	REP [mm]	*0.002*	*0.001*	*0.005*			
4	STA [mm]	17.0735	52.2770	124.3607	$35\cdot10^{-6}$	$23\cdot10^{-6}$	$66\cdot10^{-6}$
	VEL [mm/year]	20.0160	15.0090	-0.2558	0.051	0.033	0.096
	REP [mm]	*0.002*	*0.001*	*0.005*			

According to this table, in the coordinate velocities domain we could noticed shifts between the two processing variants: a positive eastward and northward shifts (up to 10 mm) and positive vertical shift (up to 2 mm), when coordinate velocities obtained from the solution with I+ and the solution with I–. However, it is well demonstrated the dependence of the obtained results on the number of satellite systems used in the processing. The most significant is this dependence for the vertical component of coordinates. For example, in the situation with stations coordinates the horizontal components are equal for all scenarios, but the vertical components are different in 10 mm with scenarios 1, 2 and 3, 4. The results shown in Table 2, in general, indicate that different pairs of scenarios differ at the submillimeter level, but for high accuracy PPP, higher-order ionospheric delay must be taken into consideration.

Conclusions and proposals

In this paper the observations data from GNSS station BOR1 was processed using GipsyX in PPP-mode software. It has been proven once again that this software package is a very powerful tool for processing GNSS observations data, including multi-GNSS. The higher-order ionospheric delay and its impact on the accuracy of multi-GNSS observations data processing were studied. It was evaluated the ionospheric correction by GIMs provided in IONEX files produced by CODE. The results also show that the multi-GNSS processing are better than those based on “only GPS”. The results indicate that different pairs of scenarios (solution with I+ and the solution with I–) differ at the submillimeter level, and the basic assumption is that the selected observation period was carried out in a more quiet period when no fluctuations in the ionosphere were present. Therefore, further studies of this type are necessary, but a proposed strategy should be applied for dates when ionospheric fluctuations are present.

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CREATION OF MANAGEMENT ZONES FOR THE PURPOSES OF LAND DEVELOPMENT AT THE IMPLEMENTATION OF PRECISION FARMING IN BELARUS

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Abstract
Improving the methodology of on-farm land management in the direction of transition from the formation of work sites to the formation of management zones for the specific requirements of the agricultural producer upon implementation of precision farming is extremely important for the agricultural sector of the Belarusian economy. The article presents the results of applying the methods of geostatistical and multifactor geoinformation analysis for the formation of management zones within the limits of land use of RUE "Uchkhoz BGSHA" (Republic of Belarus, Mogilev region, Gorky district). The total area of the surveyed territory is 83420.1 hectares. The nature of the spatial distribution of data on the content of humus, mobile phosphorus and potassium in the soil as well as pH level was estimated using the tools of the Spatial Statistics module of ArcGIS version 10.5. The presence of reliable clustering of data on soil parameters was established, since the value of the global Moran index I ranged from 0.197827 to 0.360388, and the z-score in all cases exceeded 2.58. The universal kriging method turned out to be the most suitable for modeling the spatial distribution of soil pH data, while the empirical Bayesian kriging method is the most acceptable when modeling the spatial distribution of the content of humus, phosphorus, and potassium in the soil. The method of principal components and the simple summation of rasters using a calculator proved to be suitable for identifying management zones by a set of soil parameters (the discrepancy with the actual area was 16.56 and 16.24 ha, respectively).
Key words: geospatial analysis, soil, management zones, clustering, precision farming.

Introduction

Due to the impact of globalization, agriculture has to face a number of serious problems, in particular, climate change, growing demand for energy resources and their deficit, accelerated urbanization, aging population in rural areas, and increased competition in world markets. With regard to land resources, the primary problem, relevant to the EU countries as well as to Belarus and other neighbouring countries, is the loss of agricultural land area. Decreasing of arable lands in Europe is on average 0.7% per year over the last decade (Daheim at all, 2016), and according to forecast estimates will reach 1.12% by 2030 (EU agricultural outlook, 2018) while in Belarus this indicator reaches 0.1–0.4% (Agriculture of the Republic…, 2019). Given the constant rise in the cost of energy resources and raw materials for the production of mineral fertilizers, as well as shortage of organic fertilizers, the problem of identifying the ways of increasing the economic efficiency of land use is becoming extremely urgent. The introduction of accurate (coordinate) farming as a modern concept of agricultural management using digital methods to monitor and optimize agricultural production processes is one of the methods for its successful solution (Doerge, 1999; GIS for Housing…, 2003). Its ultimate goal is to increase the quantity and quality of agricultural products obtained with less energy consumption and inputs, as well as to reduce the negative impact on the environment. The world market of precision farming technologies averages 2.3 billion euros and is expected to increase by an average of 12% every year (Zarco-Tejada at all, 2014).

Belarus has high potential for the introduction of precision farming systems or their separate elements in agricultural production. Among its main advantages is the existence of over 1380 agricultural enterprises with an average land use of more than 5.3 thousand hectares of agricultural land and over 3.5 thousand hectares of arable land (Agriculture of the Republic…, 2019). Also, a positive factor which should be taken into consideration is the concentration of agricultural land mainly in the state ownership (87.6% of the total area), which opens up the opportunities for agricultural producers to receive government financial support for the implementation of precision farming systems, in particular for the modernization of technological processes and the purchase of high-precision equipment.

However, along with the advantages, there are problems that impede the widespread adoption of precision farming systems in agricultural enterprises. The most important of them is the existing system of on-farm land management, focused on traditional energy and resource-intensive farming and ignoring the existing heterogeneities within a single field or land – the key factors for coordinate farming. In particular, the formation of work sites without taking into account the spatial heterogeneity of both the soil cover and the agrochemical and physicochemical properties of soils excludes the economic benefits of precision farming, such as the reduction of the financial and energy costs of agricultural production without reducing its volume. Accurate determination of the areas of heterogeneity within the field is an essential condition for the effective implementation of coordinate farming. Its successful implementation, in turn, is possible exclusively by using the possibilities of GIS analysis (Bateman at all, 2002; Mitchell, 2005; Myslyva, Bejyavskij, 2019). It is used both for the search of spatial patterns in the distribution of particular soil indicators and the relationships between them, and the development of methods to create relevant maps suitable for use on agricultural machines equipped with global positioning systems.

A number of studies have been undertaken to study the possibilities of geospatial analysis in various fields of the national economy. In particular, works (Barliani, 2016; Kaganovich, 2017; Chymyrov, Bekturov, 2018) are devoted to the use of GIS analysis in territorial planning, researches (Perkins at all, 2009; Kurowska at all, 2018) are dedicated the use of geospatial analysis for housing and urban development, works (Baklanov at all, 2010; Bogodyazh, 2019) – the GIS capabilities applied in the economy of environmental management. Considerable research in recent years has been devoted directly to the delineation of management zones for precision farming (Nawar at all, 2017; Behera at all. 2018; Mohamed at all, 2019; Edge, 2019). However, issues related to the methodology for implementing on-farm land management measures and the application of GIS functionality in the transition to precision farming technologies were not in the focus of attention of Belarussian scientists-economists and land surveyors. Improving the methods of on-farm land management for the transition from the formation of work sites to the formation of management zones according to the specific requirements of the agricultural producer are also underdeveloped.

All of the above indicates that the development of new approaches to on-farm land management in the process of introducing a precision farming system is extremely relevant to the agricultural sector of the Belarusian economy and requires a detailed comprehensive study.

Methodology of research and materials

The purposes of this study were to estimate the spatial distribution of agrochemical and physicochemical properties of soils for the formation of management zones when introducing elements of the precision farming system as well as to identify areas with the most optimal agrochemical indicators by performing multivariate analyzes in the GIS environment.

The studies were carried out on the territory of Gorky district of Mogilev region (Republic of Belarus) within the land use of RUE "Uchkhoz BGSHA" on an area of 8342.1 thousand hectares (Fig. 1).

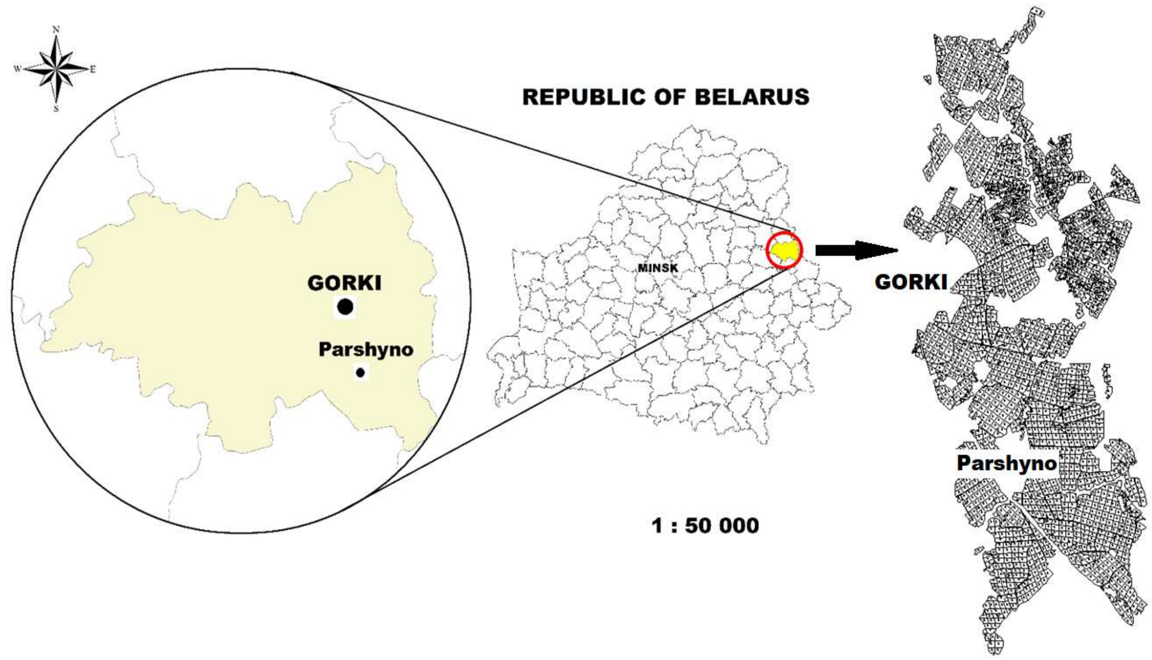

Fig. 1. The location of studied territory

The data obtained from the agrochemical survey of the territory of RUP "Uchkhoz BGSHA", executed in 2018 by the Mogilev Regional Design and Exploration Station of Agrochemicalization were used for the analysis. The soil cover of the study area is represented by Sod-podzolic, Umbric Retisols (WRB, 2016); Eutric Podzoluvisol (FAO, 1988).
The spatial distribution analysis was performed using the functionality of the Spatial Statistics Tools of ArcGIS version 10.5 for the following agrochemical and physicochemical soil properties: soil solution reaction (pH_{KCl}); the content of humus, mobile phosphorus and potassium. Information on the main statistical characteristics of the samples of the source data are presented in Table 1.

Table 1

Statistical characteristics of a sample of data on agrochemical and physicochemical indicators used to perform geostatistical analysis

Indicator name and sample size	**Indicator value**			**Sd**	**Cv, %**	**Med**	**Kurtosis**	**Skewness**
	min	max	mid					
pH_{KCl}, n=1622	4.16	6.90	5.83	0.56	9.6	5.94	2.87	-0.71
Humus, %, n=1636	1.02	4.04	2.14	0.62	28.9	2.0	4.08	1.10
P_2O_5, mg/kg, n=1630	40	426	208	95.7	46.4	192	2.11	0.36
K_2O, mg/kg, n=1634	41	401	217	95.7	44.1	203	2.28	0.45

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

The global Moran (I) index was calculated by the formula (1) (Mitchell, 2005):

$$\mathrm{I} = \frac{n\sum_{i=1}^{n}\sum_{j=i}^{n} w_{ij}(y_i-\bar{y})(y_j-\bar{y})}{[\sum_{i=1}^{n}\sum_{j=i}^{n} w_{ij}][\sum_{i=1}^{n}(y_i-\bar{y})^2]} \quad (1)$$

Where n denotes the number of units in the sample,
w_{ji} denotes the weight of the spatial relationship between the i-th and j-th sampling units,
y_i denotes the attribute value for the i-th sample unit,
$\bar{y}$ denotes the sample mean value of the attribute.
The Getis-OrdGi * index value was counted using the formula (2) (Mitchell, 2005):

$$\text{Getis-OrdGi*} = \frac{\sum_{j=1}^{n} w_{i,j}x_j - \bar{X}\sum_{j=1}^{n} w_{i,j}}{S\sqrt{\frac{[n\sum_{j=1}^{n} w_{i,j}^2 - (\sum_{j=1}^{n} w_{i,j})^2]}{n-1}}} \quad (2)$$

Where x_j denotes the attributive value of the object of observation,
$w_{i,j}$ denotes spatial weight between objects i and j,
n denotes the total number of objects.
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 hypotheses, the semivariogram is expressed as follows (3) (Myslyva at all, 2018):

$$\gamma(h) = \frac{1}{2N(h)}\sum_{i=1}^{N(h)}[Z(x_i) - Z(x_i + h)]^2 \quad (3)$$

Where γ(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):

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

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{N}(O_i - S_i)2}{N}} \quad (5)$$

$$\text{RMSS} = \frac{RMSE}{\Delta} \quad (6)$$

Where 0_i denotes the observed value,

S_i denotes the predicted value,

N denotes the sample size,

Δ denotes the range equal to the difference between the maximum and minimum observable values.

Multivariate data analysis was used for the most accurate determination of land parcels location with low, satisfactory, good and excellent quality.

Discussion and results

Precision farming management zone is defined as "a sub-region of a field that expresses a functionally homogeneous combination of yield-limiting factors for which a single rate of a specific crop input is appropriate" (Doerge, 1999; Edge, 2019). Today, there are mainly two approaches to the definition of management zones:

1) the fields which are divided into control zones in accordance with the values of one or more characteristics of the soil or crop;

2) management zones which are determined by the value of the return on the cost of the yield (Roudier at all, 2008).

It should be noted that since the elements of precision farming technology have just begun to be introduced in Belarus, the application of the approach based on economic characteristics is not possible. However, the definition of management zones based on soil parameters and yield indicators also has a number of limitations. In particular, today there is a small number of combines equipped with devices for accurate crop accounting at the agricultural enterprises of Belarus. Due to this, the soil parameters most often used by the agronomic services of agricultural enterprises were selected as initial indicators for the development of methods to determine management zones in conditions of the Republic of Belarus. Such indicators include the content of humus, mobile phosphorus and potassium, as well as the pH of the soil solution.

At the first stage of research, data were grouped using the k-means algorithm. The purpose of this grouping was to find out natural clusters and to distribute data on soil parameters to a given number of groups in which all indicators are most similar to each other, while the groups themselves are as different as possible (Table 2).

Table 2

R^2 value for identified groups of indicators

Identified group of indicators	Indicator name			
	pH_{KCl}	**P_2O_5, mg/kg**	**K_2O, mg/kg**	**Humus, %**
1	0,5857	0,6634	0,8721	0,5331
2	0,5086	0,8960	0,9514	0,9901
3	0,5257	0,6881	1,0000	0,9901
4	0,6886	0,9282	0,7289	0,6225
Overall value	0,6166	0,5782	0,4573	0,4460

The value of R^2 indicates that the dominant indicator in determining group 1 is the content of mobile potassium (R^2 = 0.87), group 2 – the content of humus (R^2 = 0.99), group 3 – the content of mobile potassium (R^2 = 1.0), group 4 – the content of mobile phosphorus (R^2 = 0.93). Group 3 having a maximum area of the selected clusters is 2703.5 ha; groups 1 and 2 are relatively equal in area size - 2182.9 and 2059.3 hectares correspondingly, and group 4 has a minimum cluster area – 1396.4 hectares.

After clusters had been established, the spatial autocorrelation measure was estimated through the determination of the Moran index. The calculated value of the global Moran I index ranged from 0.197827 to 0.360388; therefore, the data on the agrochemical and physical-chemical properties of the soil in the study area are not randomly distributed and clustered. Since the magnitude of the z-score in

all cases exceeded 2.58, it can be argued with a 99% probability that the clustered type of data distribution is not random.
"Hot Spot Analysis" was performed to establish the reliability of clustering data with high and low values. It was performed by determining the magnitude of the overall Getis-Ord Gi * index, a statistical indicator calculated for each feature in the data set. This information allows to visually identify where, within the study area, the maximum and minimum values of the studied soil properties will be observed, and also approximately indicate the possible localities of the defined management zones.
The analysis of clusters and outliers identifies the concentrations of high values, low values and spatial outliers of data on the agrochemical and physical-chemical properties of the soil. As a result it becomes possible to find out 1) where the clearest boundaries between the contours with a high and low content of a particular element in the soil pass; 2) whether there are abnormally high or abnormally low values of indicators that can be attributed to spatial outliers within the study area. The availability of the maximum amount of outliers with high values was established for the data on the phosphorus content (84 clusters), the data on the content of humus were characterized by the maximum number of outliers with low values (135 clusters), and the data on pH level were characterized by the minimum number of outliers (Table 3).

Table 3

Identified outliers verification results

Indicator name and sample size	**Number of checked outliers, pcs**		**Number of confirmed outliers, pcs**		**Discrepancy of outliers, %**	
	HL	LH	HL	LH	HL	LH
pH_{KCl}, n=1622	57	46	19	17	67	62
Humus, %, n=1636	56	135	12	34	78	75
P_2O_5, mg/kg, n=1630	84	78	52	17	38	78
K_2O, mg/kg, n=1634	59	89	32	22	45	75

Note: HL – cluster with high outliers; LH – cluster with low outliers

Spatial emissions in our case are due to both the imperfection of the soil sampling methodology and the imperfection of the applied methods of mapping the results of agrochemical studies. On the other hand, the presence of emissions may be connected with the objective factors, for example, the use of various doses of mineral fertilizers within certain areas. This, in particular, can explain the variegated spatial distribution of mobile phosphorus and potassium.
In our opinion, it is necessary to carry out an additional examination to clarify the situation when detecting emission sites. The results of such recheck indicated that from 38 to 78% of clusters with high outliers and from 62 to 78% of clusters with low data outliers were not confirmed. Subsequently, the areas with unconfirmed spatial outliers were excluded from the data set during the further modeling of the spatial distribution of the particular indicator by interpolation method.
Kriging interpolation was used to model the spatial distribution of data (Table 4). The universal kriging method turned out to be the most suitable for modeling the spatial distribution of soil pH data, which is consistent with the results obtained in (Mohamed at all, 2019). The empirical Bayesian kriging method turned out to be the most acceptable when modeling the spatial distribution of the content of humus, phosphorus, and potassium in the soil, which also correlates with the results presented in (Samsonova at all, 2017; Durdević at all, 2019).

Table 4

The study area soil properties semivariogram parameters

Variable	**Model**	**Nugget**	**Slope**	**Power**	**ME**	**MSSE**
Humus, %	Power	$3.92 \cdot 10^{-2}$	$1.03 \cdot 10^{-2}$	1.61	0.001	0.929
P_2O_5, mg/kg	Power	$5.26 \cdot 10^{3}$	$5.92 \cdot 10^{3}$	1.54	0.136	0.965
K_2O, mg/kg	Power	$1.71 \cdot 10^{2}$	$4.35 \cdot 10^{3}$	1.52	0,166	0,953
pH_{KCl}	Spherical	0.000	0.318*	0.318**	0.002	1.007

Note: * – partial sill; ** – sill

The next stage of the research was the search for the most acceptable method for determining zones with the best and worst set of studied indicators of soil quality. Multifactor analysis for searching the optimal agrochemical land parcels was carried out in three ways: 1 – analysis using the functionality of the Raster Calculator tool; 2 – analysis using the Principal Components 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. It should be noted that when using the method of principal components, the content of humus in the soil and the pH of the soil solution is 72.3% of the total variability of the data, therefore, if there is insufficient information about the soil parameters, they can be primarily used to identify areas of heterogeneity (Table 5).

Table 5

Principal component analysis of soil properties and loading coefficient for the principal components

Principal component	Eigenvalue		Component loading (%)	Cumulative loading (%)
1	8.573		44.555	44.555
2	5.348		27.799	72.355
3	2.989		15.536	87.891
4	2.329		12.109	100.000
Principal component loading for each variable				
	Humus	**pH_{KCl}**	**P_2O_5**	**K_2O**
1	0.511	0.831	-0.137	-0.169
2	0.289	-0.024	0.957	-0.019
3	0.530	-0.492	-0.186	-0.665
4	0.612	-0.257	-0.176	0.727

The raster images obtained as a result of multivariate analysis were reclassified and converted into vector layers for the subsequent estimation of the area of the identified zones (Figure 2).

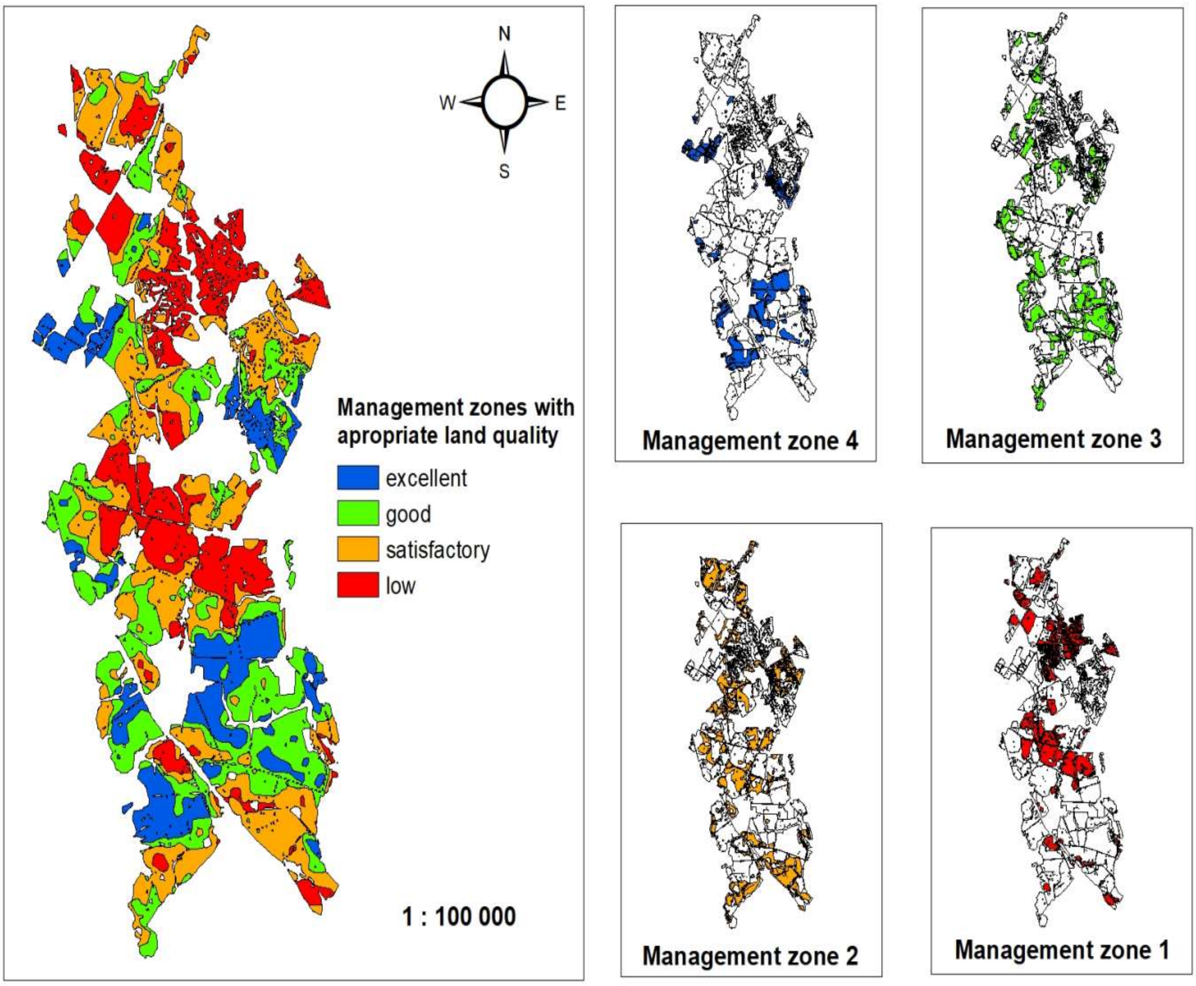

Fig. 2. Identified management zones

When comparing the areas of the identified zones, the analysis using the method of the main components and that of the functionality of the raster calculator turned out to be almost identical, since the differences with the actual area of the study area were only 16.56 and 16.24 ha, respectively (Table 6). Moreover, all identified zones had a significant coincidence with each other in localization and in area; therefore, both of these methods are suitable for identifying management zones within arable land by a complex of agrochemical and physical-chemical indicators.

Table 6

Identified management zones with the relevant land quality

<table>
<tr><th rowspan="3">Management zone</th><th rowspan="3">Land quality</th><th colspan="2">Raster, created by using the functionality of the Raster Calculator</th><th colspan="2">Raster, created by method of Principal Components</th><th colspan="2">Raster, created by method of Maximum Likelihood Classification</th></tr>
<tr><th colspan="6">Zone size</th></tr>
<tr><th>hectares</th><th>% of the total area</th><th>hectares</th><th>% of the total area</th><th>hectares</th><th>% of the total area</th></tr>
<tr><td>1</td><td>Low</td><td>1977.83</td><td>23.66</td><td>1974.35</td><td>23.62</td><td>2927.95</td><td>35.02</td></tr>
<tr><td>2</td><td>Satisfactory</td><td>2784.07</td><td>33.31</td><td>2773.92</td><td>33.19</td><td>2379.04</td><td>28.46</td></tr>
<tr><td>3</td><td>Good</td><td>2278.11</td><td>27.26</td><td>2253.48</td><td>26.96</td><td>1106.81</td><td>13.24</td></tr>
<tr><td>4</td><td>Excellent</td><td>1318.32</td><td>15.77</td><td>1356.91</td><td>16.23</td><td>1946.78</td><td>23.29</td></tr>
<tr><td colspan="2">Total area</td><td>8358.34</td><td>100.0</td><td>8358.66</td><td>100.0</td><td>8360.58</td><td>100.0</td></tr>
<tr><td colspan="2">Difference with the reference value</td><td>+16.24</td><td>+0,19</td><td>+16.56</td><td>+0,20</td><td>+18.48</td><td>+0,22</td></tr>
</table>

However, in case of a wider list of indicators, it is more advisable to use the principal component method to identify areas of heterogeneity. It enables to evaluate more completely the available data and find out those that have the maximum variability, and, accordingly, suitability for the delimitation of management zones, which, in particular, is indicated in a number of other works (Nawar at all, 2017; Behera at all, 2018; Mohamed at all, 2019).

Table 7

The mean values of soil properties within the identified management zones

Management zone	Number of parcels	Humus, %	P_2O_5, mg/kg	K_2O, mg/kg	pH_{KCl}
1	112	2.00	120	132	5.68
2	164	2.04	183	196	5.74
3	136	2.19	251	252	5.98
4	77	2.46	322	332	6.01

Table 7 shows average values of the studied soil properties in each of the four delimited zones, which can be used as input to calculate the rates of fertilizers and chemical reclamants and their differentiated application.

Conclusions and proposals

The results of the studies indicate that the definition of management zones for the conditions of Belarus can be carried out on the basis of data on the agrochemical and physico-chemical properties of the soil. These data are not always reliable because the methodology for obtaining them is outdated and requires fundamental modernization. This is evidenced by the presence of a significant amount of emissions (46–135 pcs) and a low percentage of their validity when re-checking data (from 38 to 78% of clusters with high outliers and from 62 to 78% of clusters with low data outliers were not confirmed). Kriging interpolation (universal for soil pH and empirical Bayesian for humus, phosphorus, and potassium in the soil) turned out to be the most suitable for modeling the spatial distribution of data on soil parameters. Both the principal component method and the simple summation of interpolated rasters are suitable for identifying management zones (the discrepancy with the actual area was 0.19 and 0.20 percentages, respectively); however, if there are more parameters, preference should still be given to the principal component method. The resulting cartographic image with differentiation of management zones can be used for planning differentiated application of mineral fertilizers, which will save resources and improve the chemical, physical and environmental properties of the soil.

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FACTORS AFFECTING COMPULSORY PURCHASE OF LAND FOR PUBLIC NEEDS IN UKRAINE

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Abstract

At the current stage of adapting the goals of the Sustainable Development Concept, compulsory purchase of land to meet public needs may be an effective tool. Public needs may require privately owned land, but it is sometimes only possible to negotiate with the owners through the land compulsory purchase mechanism.

When implementing such projects it is necessary to take into account certain factors that have an impact on this process at each stage of the execution of works. To determine these factors is necessary to make some analysis that will identify primary and secondary factors determine their importance and divide them into certain groups.

To determine the main groups of factors should be used PEST analysis technique that is often used to assess key market trends. The results of PEST analysis can be used to determine the list of threats and opportunities for the implementation of projects for the construction of linear objects of transport infrastructure, it is advisable to supplement the basic elements of PEST analysis, such as Politic (P), Economic (E), Social (S) and Technical (T), with the following indicators: P (Planning) E (Environmental), L (Legal).

Through PEST analysis is necessary to determine each factor and not just describe the current status, and predict its change over the next 3-5 years. The most important and the most difficult are to determine the balance between the factors and to account for their interaction.

Key words: sustainable development, compulsory purchase, public needs, transport infrastructure, PEST.

Introduction

Sustainable development requires the Governments of the countries to establish and maintain in a functional conditions social and engineering infrastructure facilities that provide security, healthy living conditions, well-being, socio-economic development, protection and restoration of the natural environment. One of the first steps in the realization of these tasks is the acquisition of the relevant land. In some cases, there may be several options, for example, the construction of a new pre-school educational establishments, and the Government may purchase a land in a free land market. In other cases, the objects should be located in a certain place - it is about building new infrastructure.

The necessary land plot may not be available for sale at a time when the Government needs it. In order to get the land at the right place and at the right time the Government uses the right to compulsory purchase the land, this right involves forcing the owners to sell their land in order to meet certain public needs.

Compulsory purchase of land for the purpose of their development certainly brings benefits to society. When the government conducts the alienation process in a satisfactory manner, citizens and communities are left in a situation similar to that in which they were before the land alienation and society receives the benefits provided.

The purpose of the article is to analyze the legislation of Ukraine regarding compulsory purchase of land plots to meet the public needs and formulate a list of these needs. Identify groups of factors that may have an impact on the location of infrastructure based on an analysis of the list of public needs and sustainable development trends.

Methodology of research and materials

Ukraine, like other UN member states, has joined the global process of sustainable development. To achieve the Sustainable Development Goals (The Global Goals, 2015), the Ukraine 2020 Sustainable Development Strategy has been developed (Sustainable Development Strategy "Ukraine 2020", 2015). The aim of the Strategy is to introduce European standards of living in Ukraine and Ukraine's leading position in the world.

Compulsory purchase is the transfer of ownership of land and other immovable property located thereon, which are owned by individuals or legal entities for payment, in state or municipal property by means of redemption for the needs of state, local community or society. This procedure is often necessary for the purposes of socio-economic development and environmental protection.

Discussions and results

Compulsory purchase is the transfer of ownership of land and other immovable property located thereon, which are owned by individuals or legal entities for payment, in state or municipal property by means of redemption for the needs of state, local community or society. This procedure is often necessary for the purposes of socio-economic development and environmental protection.

Compulsory purchase of land plots to meet public needs in Ukraine is regulated by the Constitution of Ukraine (Constitution, 1996), the Civil Code of Ukraine (Code, 2003), the Land Code of Ukraine (Code, 2001), and other legal acts.

The realization and effective provision of public land needs are impossible without the existence of a proper legal mechanism for the purchase of land from private owners and the protection of their rights and interests, the use of which enables the state to forcibly alienate private land for use in the public interest.

The rules of the Land Code of Ukraine enshrine the legal foundations of land redemption and their compulsory purchase to meet public needs, but they are of a general nature and do not regulate the grounds and procedure for compulsory purchase.

In this regard, the Law of Ukraine " On compulsory purchase of land plots, other objects of real estate that are located on them, which are in private ownership, for public needs or from the motives of social necessity" (Law of Ukraine, 2009)was adopted by the Verkhovna Rada of Ukraine on November 17, 2009, which clearly defines the concept of compulsory purchase of land and its variety, as well as the grounds, principles and procedure for compulsory purchase. This law defines the legal, organizational and financial principles of regulation of public relations arising in the course of compulsory purchase of land plots, other real estate objects placed on them, owned by natural or legal persons, for public needs, if the needs cannot be secured by use of state or communal property.

Compulsory expropriation of private property shall be applied only as an exception for the common good on the basis of and according to the rules and procedure established by the law, and on condition of prior and full compensation of its value (Kalbro, 2007). The compensation can take form of monetary value or substituting land plot or the combination of these forms. The compensation should cover not only the value of the land, but also damages, including lost profits. The compensation is based on voluntary agreement or, if not agreed, through the court procedure. In the latter case the «expert monetary evaluation standards» are applied. Legislation conserning compensation are The Law of Ukraine «On the evaluation of lands» (Law of Ukraine, 2003) and The Law of Ukraine «On the evaluation of property, property rights and professional valuation activity in Ukraine» (Law of Ukraine, 2001).

Legal aspects of dispossession described in terms of legal capacity of owners of land at the disposal of land for public needs:

- if the owner of land (part), which is dispossessed, is also the owner of the house, other buildings, structures, perennial crops, the requirement on dispossession of land treated with request to terminate the ownership of these objects;
- if the plot of land leased and / or collateral to participate in negotiations involving the owners of these facilities, tenants and / or the mortgagee, but the question of compensation open to them;
- payment of compensation for rights that are not defined legally can be a difficult political task, this issue is very acute now in Ukraine.

Ukrainian legislation tends to exclude the payment of compensation for the value of land to persons who are legally vague right to a house. However, if residents are deemed to deserve special assistance, the government must provide the displacement of other land.

Space-technical aspects of dispossession described in terms of planning capabilities at dispossession of land for public purposes:

- if dispossessed the entire plot of land then the owner refunded the entire cost of land;
- in cases where part of the land and part of the house is dispossessed, and another part may be used inappropriately - these issues are not clear in Ukrainian legislation;
- in the case of part land dispossession, and the rest of the area cannot reasonably be used, at the request of the owner of land dispossession is subject to the entire plot.

Infrastructure is a set of operating structures, buildings, networks, and systems that are not directly related to the production of material goods, but which are necessary for the functioning of the branches of material production and to ensure the conditions of life of society.

The infrastructure of territories, according to its relation to material production, is classified into the following main types:

- a production infrastructure that provides the necessary logistical facilities for the location and operation of public production within a specific territory (roads, ports, bridges, communication systems, etc.);
- social infrastructure that provides the necessary housing, living and socio-cultural conditions for the population of the area, city, region, agglomeration (educational institutions, culture, health care, public services).

In the production infrastructure class, there are separate subclasses:

- transport infrastructure - a system of transport communications, vehicles and equipment providing freight and passenger transportation in a certain territory,
- engineering infrastructure - a system of engineering networks and structures providing water, sewerage, energy supply, communications, lighting, etc. in a specific area.

The social infrastructure of the population includes housing and communal services, retail, household and catering establishments, educational, scientific and cultural institutions, health and sports institutions and more.

The Law of Ukraine " On compulsory purchase of land plots, other objects of real estate that are located on them, which are in private ownership, for public needs or from the motives of social necessity " stipulates that executive bodies and local self-government bodies have the right to buy out land plots owned by natural or legal persons for the following public purposes (Law of Ukraine, 2009):

- ensuring national security and defense;
- construction, repair, reconstruction and maintenance of linear objects and objects of transport and energy infrastructure and facilities necessary for their operation;
- placement of foreign diplomatic missions and consular posts, representations of international organizations in Ukraine in accordance with international treaties of Ukraine;
- placing and maintenance of facilities related to mining;
- construction of protective hydraulic structures;
- creation of city parks, construction of pre-school educational establishments, recreation grounds, stadiums and cemeteries;
- construction and maintenance of oil and gas wells and production facilities required for their operation, facilities for underground storage of oil, gas and other substances and materials;
- location of nature reserve fund objects.

As can be seen from the list of public needs, construction, overhaul, reconstruction and maintenance of linear objects of transport infrastructure and objects necessary for their operation, occupies a separate place and is relevant in the Concept of Sustainable Development of Ukraine (Law of Ukraine, 2009).

When implementing projects for the placement of linear objects of transport infrastructure, it is necessary to take into account certain factors that have an impact on this process at each stage of the work. In order to identify these factors, some analysis is needed to identify the major and additional factors, determine their importance, and divide them into specific groups.

To identify groups of factors when designing any transport infrastructure project, it is advisable to use the PEST analysis technique, which is often used to evaluate key market trends. The results of PEST analysis can be used to determine the list of threats and opportunities for the implementation of these investment projects. In terms of designing transport infrastructure objects, PEST may be an abbreviation of the following indicators: Politic (P), Economic (E), Social (S) and Technical (T). (Fig.1).

P (Politic) - factors of the political and legal environment. In analyzing this indicator, it is recommended to answer questions about key changes in political stability and regulation.

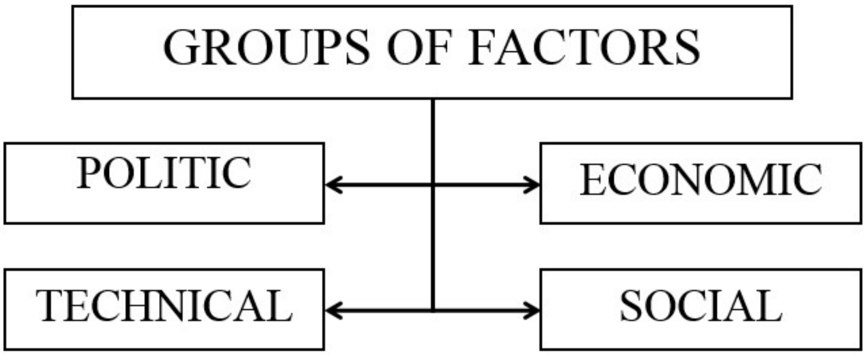

Fig. 1. Groups of factors of PEST analysis

E (Economic) - factors of economic condition. In the analysis of this group of factors, it is necessary to identify not only key parameters characterizing the state of the country's economy, but also the economic indicators of the future project. If we look in more detail form the basis of the principles of sustainable development, we can state that the basic elements of the group of Economic factors are: costs of pre-project research, project development costs, cost of funds involved, the total cost of buying out land plots, compensation costs, the expected net profit from the project implementation, cost-to-earnings ratio of the project, the impact of the infrastructure on the economic situation in the region.

S (Social) – factors of social impact of the project and social attitude towards the project. The main factors in the group of Social factors are: the relevance of the project to the public need and its importance for the development of society and the region, preservation of historical and cultural monuments, public interest in project results and public opinion, population attitudes to the project, employment of the population during the project implementation.

T (Technical) are the factors that characterize the technical process of project development and execution. This group of factors requires detailed analysis, because in the era of technological progress, it is the change in technology that can dramatically change approaches to project implementation. Regarding transport infrastructure projects it is important to consider the need for additional works on strengthening the soil cover and increasing its carrying capacity

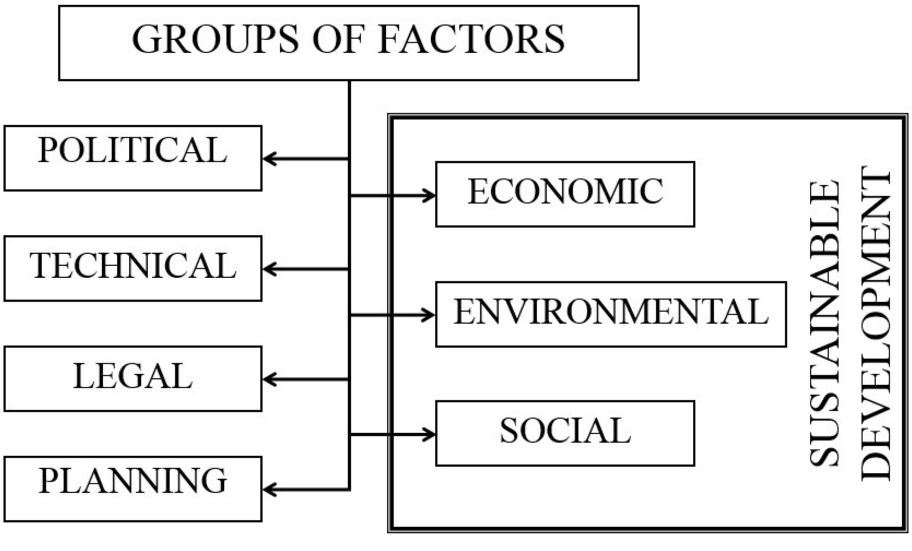

Fig. 2. Groups of factors that affect the placement of transport infrastructure.

PEST analysis is a tool that allows you to assess the impact of external factors and risks in the implementation of transport infrastructure projects. Like any tool, it can change and acquire new variations. In the situation of development of projects of construction, overhaul and reconstruction of objects of transport infrastructure, in the context of ensuring sustainable development (Sustainable Development Strategy "Ukraine 2020", 2015), it is advisable to supplement the basic elements of PEST analysis by Environmental (E), Legal (L) and Planning (P) factors (Fig. 2).

E (Environmental) – environmental factors determine the degree of project impact on the environmental situation in the region, as well as environmental factors that may affect the effectiveness of the project. The main factors in the group of Environmental factors are those that affect (Lizunova, 2019): pollution of land resources, water pollution, air pollution, impact on living organisms and humans.
L (Legal) are the factors that characterize compliance of the project with the norms and rules of the current Ukrainian legislation.
P (Planning) are the factors that characterize compliance of the project: with the approved urban planning documentation, with the economic planning and functional zoning of the territory
The most important and difficult is to determine the balance not only between all groups of factors but also to take into account their interaction

Conclusions and proposals
PEST analysis is a tool that allows you to evaluate the impact of external factors and risks in the process of project implementation, and like any tool, it is easy to change and acquire new variations. In developing projects for the construction of linear transport infrastructure objects and in the context of sustainable development, it is advisable to supplement the groups of political, economic, socioal and technical factors with legal factors, which will determine the compliance of the project with current legislative and regulatory requirements, environmental factors, that determine the degree of impact of the project on the environmental situation in the region, as well as planning factors that can affect the effectiveness of the project.
When implementing investment projects for construction, overhaul and reconstruction of linear objects of transport infrastructure within the framework of the Transport Strategy of Ukraine, it is advisable to use multicriteria optimization methods. However, the effectiveness of the decision-making process depends on the structuring of the factors that serve as the criteria for decision selection.

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STUDY OF THE RELATIONSHIP BETWEEN ABANDONED LAND AND DIFFERENT INDICATORS

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Abstract. One of the most pressing problems in land management is abandoned agricultural land. Abandoned land in Lithuania is unattended and not used for agricultural activities. These areas degrade the country's landscape and over time overgrow with shrubs or low-value plants. The article analyzes the change of abandoned agricultural land in 2015-2019. State control to reduce abandoned land is discussed. Relations with selected indicators are analyzed. Data visualization was performed with ArcGIS software.
However from 2015 to 2019, a constant decrease of abandoned land has occurred. The analysis showed that the majority of abandoned land is found in Vilnius, Utena and Alytus counties. The results of the correlation analysis showed the highest dependence of abandoned lands on the average performance score in counties.
Key words: abandoned land, average performance score, population rate, statistical analysis

Introduction

All the land in the territory of the Republic of Lithuania is a state asset, therefore, it is particularly important to ensure a proper and rational land use. As a result, provisions, methodological instructions, laws and Government-issued resolutions have been enshrined in law on the basis of which the land protection is carried out. In accordance with the resolution No. 1244 “On the Approval of the Provisions of the State Control of Land Use” issued by the Government of the Republic of Lithuania on 1994-12-12, the state is obliged to ensure a proper and rational use of land (as a resource). The National Land Service under the Ministry of Agriculture organizes and performs the state control of land use (Resolution of the Government of the Republic of Lithuania..., 1994).
According to the newest data from the Centre of Registers, currently, there are almost 60.6 thousand recorded abandoned agricultural land plots (hereinafter referred to as AL) in the entire country, that cover 34.8 thousand hectares (ha) or 0.6 percent of the country’s entire territory (www.delfi.lt, 2019).
In accordance with Article 2 of the Law on Land Tax of the Republic of Lithuania, “the Abandoned Agricultural Land shall mean the areas of agricultural land in a land parcel or any part thereof covered with woody plants (except for plantations) identified by remote cartographic methods in accordance with the procedure established by the Government of the Republic of Lithuania or an authority authorised thereby” (Law of the Republic of Lithuania..., 2011). V. Daugalienė states that “during the last thirty years, the area of cultivated land has decreased in many EU countries, and the reason for it is the abandoned agricultural land. The land abandonment is only a consequence of social and economic issues in rural areas. A short abandonment period for intensively cultivated land is useful due to the decrease in the pollution caused by agricultural activities. However, the abandonment of former often botanically rich meadows causes a great harm to biodiversity. Due to these reasons, the land abandonment causes a growing concern among people who make the decisions on both national and EU levels” (Daugalienė, 2019). Abandoned land plots distort the landscape, negatively affect the development of the national agriculture, complicate the resource management (Kuliešis, Šalengaitė, 2010).
The state control of land use aims at ensuring the land management and use in compliance with the requirements of the Law on Land of the Republic of Lithuania and other laws regulating the supervision of the land use. The National Land Service (NLS) is planning to carry out 12 thousand state land control checks this year. 60 percent of checks are anticipated to be scheduled, and the remaining ones – unscheduled: on the basis of received complaints and requests, or follow-up checks aimed at checking whether previously identified violations have been eliminated (National Land Service under the Ministry of Agriculture[a], 2019). In 2019, the following objectives were set: to tighten the state control of the land use over territories with the most recorded abandoned (state and private) land; to tighten the state control of the land use over the leased state land, whose purpose is “for other uses”, use and the control of the use of land plots transferred free of charge to municipalities for use managed by the right of use. A particular attention will be allocated to the use of land plots

located in the state border protection zone (National Land Service under the Ministry of Agriculture[a], 2019).

The NLS director Laimonas Čiakas stressed that "the analysis of the 2018 data provided by the state control of land use revealed that the majority of violations are identified when land plots are abandoned, unmanaged and uncultivated. Still, a significant share of owners and users of a land do not properly manage and use their land. Laimonas Čiakas noted that the amount of state control checks of the land use performed in 2018 exceeded the planned amount and constituted 105.79 percent of the checks scheduled in the NLS plan of land management works" (National Land Service under the Ministry of Agriculture[a], 2019).

In order to decrease the amount of abandoned agricultural land areas, an order of the Minister of Agriculture of the Republic of Lithuania (on the approval of the Abandoned Land Program) was approved (2011 years Decemberer for agricultural or other activity to be performed there. Tasks of the program: to include the abandoned land into the state land accounting; to accelerate agricultural land market processes; to create preconditions for more rational land use; to create preconditions for alternative land use; to create better conditions for the development of animal husbandry on abandoned land; to initiate studies of changes in the land condition in accordance with the extent and period of abandonment (Order of the Minister of Agriculture of the Republic of Lithuania..., 2011).

The aim of the paper: to analyse the change in abandoned agricultural land of the Republic of Lithuania and its dependency on various factors.

The tasks of the study:

1. To analyse the distribution of abandoned agricultural land areas on the territory of Lithuania and to assess its change during the 2015-2019 period.
2. To analyse the dependency of the abandoned land on various parameters.

The subject of the research is abandoned agricultural land areas.

Methodology of research and materials.

In order to determine and assess the change in abandoned agricultural land using the 2017–2018 satellite photos and taking into account notes provided by landowners and other persons, the collection of the spatial data AŽ_DRLT of abandoned land of the Republic of Lithuania was updated in 2018. The data (AŽ_DRLT) is used for calculating the land tax for abandoned agricultural land. The critical tolerance of the graphic accuracy of AŽ_DRLT objects is no more than 8 m. This dataset was used for research.

On the basis of the analysis of the 2015-2019 data of the NLS land fund under the Ministry of Agriculture of the Republic of Lithuania and the data from the Land Information System (LIS), a distribution map of abandoned agricultural land was compiled (Figure 1).

Fig. 1. Distribution map of abandoned land in the Republic of Lithuania

A study of links between the selected criteria is conducted using a correlation analysis. The correlation analysis has been conducted between these parameters (1):

1. percentage of AL area to the county area (2019 year) (r_1),
2. average performance score in counties (r_2),
3. population rate in counties (r_3).

Coeficient of correlation:

$$r = \frac{\overline{xy} - \bar{x} \cdot \bar{y}}{\sqrt{\overline{x^2} - (\bar{x}^2)}\sqrt{\overline{y^2} - (\bar{y}^2)}} \quad (1)$$

x,y – variable.

Discussions and results

1.1 Change in Abandoned Agricultural Land in 2015-2019

As of 1 July 2018, there were 57.1 thousand ha of abandoned agricultural land, which is about 1.7 percent of the total agricultural land area. For comparison, as of 1 July 2017, there were 63.2 thousand ha of abandoned agricultural land, which is about 1.9 percent of the total agricultural land area (National Land Service under the Ministry of Agriculture[b], 2019).

Figure 1 reveals that the main spread of abandoned land is in Utena, Vilnius and Alytus counties. Furthermore, Telsiai county and a part of Tauragė and Siauliai counties stand out in the Western Lithuania. In accordance with the available data, the analysis of AL areas was conducted.

The analysis of the change in AL areas in counties during different periods reveals that the tendencies remain the same as can be seen in the map provided in Figure 1 (Figure 2).

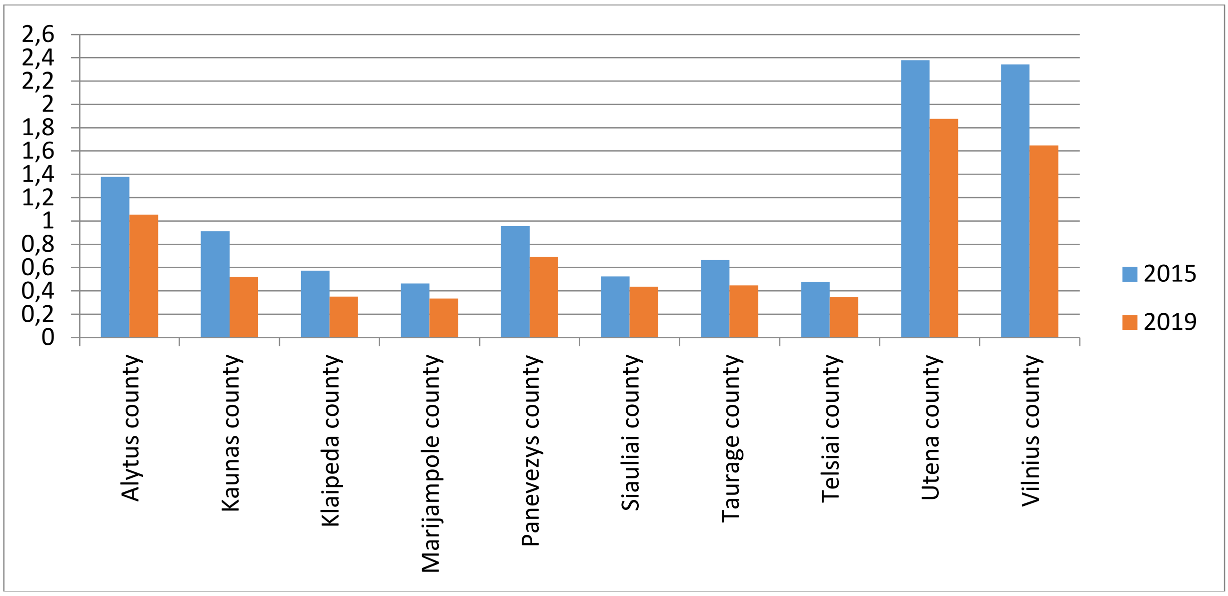


Fig. 2. Percentage of the abandoned land area to the total area of counties

In Figure 2, the share of abandoned land in percent to the total area in counties in 2015 and 2019 is depicted. The highest percentage is found in Vilnius, Utena and Alytus counties – from 2.4 to 1.4 percent in 2015 and from 1.9 to 1.1 percent in 2019. It is not a low percentage, because it was estimated on the basis of the total area, without subtracting forest and other land areas. The lowest percentage is in Telsiai, Marijampole, Klaipeda and Siauliai counties. As can be seen from Figure 1, some districts have larger abandoned land areas than are found in the rest of the districts constituting the same county.

The comparison of diagrams provided in Figure 2 reveals that there is a change in AL areas during 2015-2019; there is a visually observed decrease, especially in Vilnius and Panevezys counties. The change in abandoned land (in hectares) in counties during the period of 2015-2019 was performed as well, which is demonstrated in Figure 3. Moreover, the AL area decrease rate, i.e. by how many ha did AL areas in the counties decreased per year.

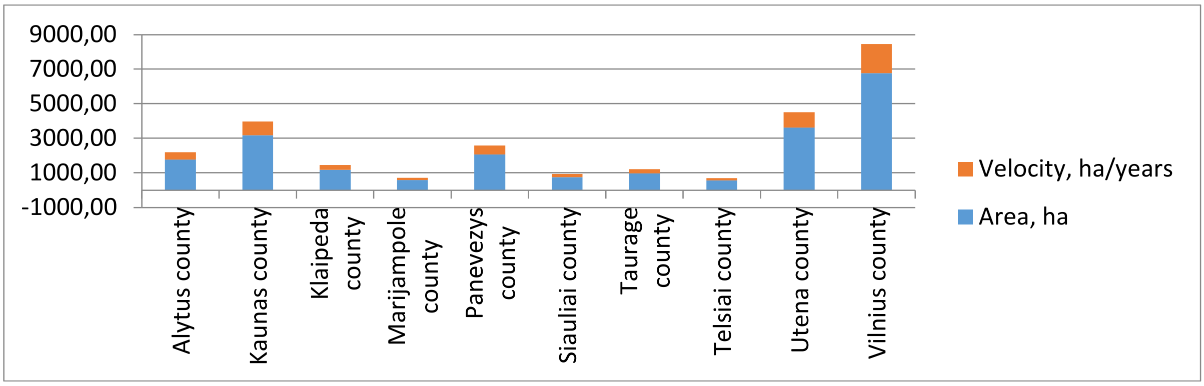


Fig. 3. Decrease of abandoned land in counties, ha

As can be seen from Figure 3, the largest decrease in abandoned land area during the studied period occurred in Vilnius (6769 ha), Utena (3611 ha), Kaunas (3176 ha) and Panevezys (2070 ha) counties. Correspondingly, the decrease rate of the areas was: 1,692, 902, 794, 517 ha/year. The results of the study (Figures 2, 3) show that the greatest decrease in abandoned land is not necessarily related to the largest abandoned land area in the county. Kaunas and Panevezys counties did not have so many AL areas as Alytus county, but these counties outperformed the latter in terms of AL decrease rate.

1.2 Links Between Abandoned Land and Selected Parameters

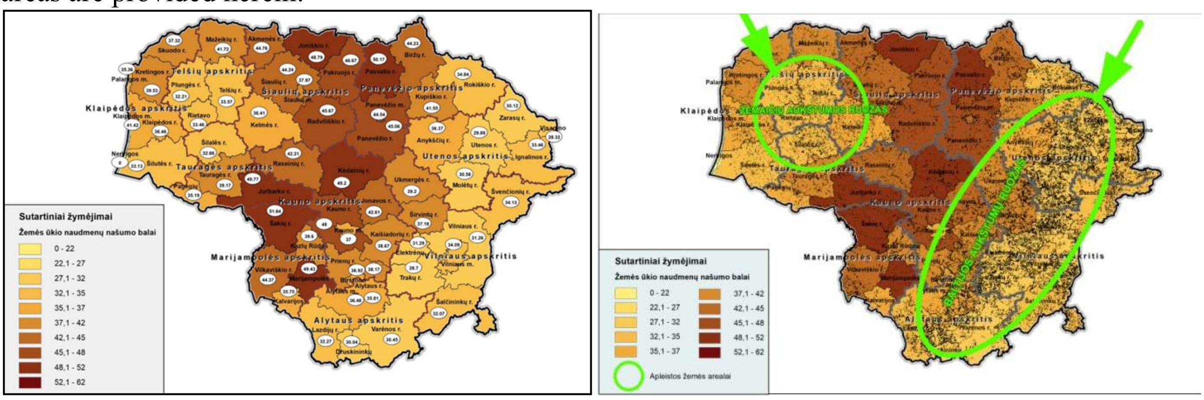
The density of abandoned land is affected by the performance score of the agricultural land (Kuliešis, Šalengaitė, 2010, Aleknavičius, 2007). The performance score is determined by the soil typology of agricultural land, its granulometric composition, the land reclamation state, moisture, the soil cover diversity, stoniness, agrochemical properties, climatic conditions and a basic score.

In accordance with the soil productivity results (Order of the Minister of Agriculture of the Republic of Lithuania..., 2007), the soil is divided into 5 groups (types). I soil group – dominated by the soil of a very good economic value (47.1-52.0 points). II soil group – dominated by the soil of a good economic value (42.1-47.0 points), III soil group – dominated by the soil of a medium economic value (37.0-42.0 points); IV soil group – mostly dominated by the soil of a relatively poor economic value (32.1-37,1 points). V soil group – dominated by the soil of a poor economic value (27.1-32.0 points) (Mažvila, Lukšienė, Staugaitis, Mockevičius, 2015).

The relation between the population rate and the abandoned land was analysed by XX (Rybokas, 2011; Kuliešis and Šalengaitė, 2010).

The application of statistical methods allows determining links between studied parameters. A statement that the abandoned land area depends on the performance score and the population rate is encountered in works of many authors. During the study conducted hereby, the links between these criteria considered in the works by other authors as well and AL area counties.

While using the aforementioned studies conducted by other authors, no statistical analysis methods were employed. Therefore, the results of the correlation analysis between the selected criteria and AL areas are provided herein.



a) b)

Fig. 4. Maps: a) The point assessment of agricultural land, b) The distribution of abandoned land areas in counties

Firstly, by using maps compiled by the authors, a visual assessment of the distribution of AL areas has been conducted, and it has been compared to the performance score map (Figure 4).
The visual comparison of maps reveals the correspondence of the distribution of AL areas with the distribution of the land performance score in Lithuania. It is evident, that, in the Zemaitija Upland dominated by land areas with a poorer performance, AL areas are correspondingly larger. The same could be said regarding a stretch of land in the eastern Lithuania with a low performance: the distribution of a stretch of abandoned land areas is similar.
A study of links between the selected criteria is conducted using a correlation analysis. The obtained result is provided in Table 1.

Table 1.

The results of the correlation analysis

Correlation coeficients	r_1	r_2	r_3
r_1	1	-	-
r_2	-0,68	1	-
r_3	0,41	-0,07	1

As can be seen from the results in Table 1, the correlation link between the performance score and the population rate is insignificant; therefore, these criteria may be considered unrelated. A rather significant negative correlation link is obtained between AL areas and the performance score (-0,68). Therefore, due to it, it can be stated that while the performance score increases, the abandoned land area decreases. Meanwhile, the population rate and the AL area in counties are linked by a significantly weaker correlation when compared to the AL and the performance score. This correlation coefficient does not reach 0.5, therefore, the causal relationship between these parameters is relatively doubtful.

Conclusions

Largest abandoned land areas in 2015-2019 in the Republic of Lithuania were distributed on the basis of the same tendencies. The majority of abandoned land is found in Vilnius, Utena and Alytus counties – from 2.4 to 1.4 percent (2015 year) and from 1.9 to 1.1 percent (2019 year) to the total area of counties.
From 2015 to 2019, a constant decrease of abandoned land had occurred. The most significant decrease is observed in Vilnius (6769 ha), Utena (3611 ha), Kaunas (3176 ha) and Panevezys (2070 ha) counties. The decrease rate of these areas reached correspondingly 1,692, 902, 794 and 517 ha per year. The highest and lowest change in these land areas during the selected period partially corresponds to the amount of these areas in counties. However, some counties stand out – in Kaunas and Panevezys counties, a more significant decrease in AL areas than their relative amount in comparison to other counties is observed.
The correlation analysis revealed a relatively high negative dependency (-0.68) between the point assessment abandoned and agricultural land areas. And the dependency between the population rate in counties and AL areas is doubtful: a coefficient less than 0.5 was obtained during a correlation analysis, therefore, a statement that there is a link between these parameters would be inexpedient.
It is planned to carry out further investigations. Need to identify more factors that determine the existence of the abandoned land.

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PRECISE POINT POSITIONING TECHNIQUE VERSUS RELATIVE POSITIONING

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Abstract
Precise point positioning is a GNSS based positioning method that is known to regaining more precise information about major systematical errors in its functional model. This method is seen as an advanced version of the conventional absolute positioning method that is able to offer higher accuracy of the estimate parameter. Contrarily, the relative positioning method is able to achieve high precise of the estimated parameters by using two or more receiver. Nowadays because of this development, the PPP technique it started to grow on the detriment of the relative GNSS positioning. PPP, it is able to offer point determination by processing undifferenced dual frequency receiver, combine with precise orbit and clock corrections offered by JPL to obtain centimeter/millimeter accuracy. The aim of this paper is to make a comparative study between Precise Point Positioning (PPP) versus relative positioning under different conditions.
Keywords: GNSS, JPL, Precise Point Positioning, relative positioning, GipsyX, accuracy.

Introduction

Two approaches are possible to achieve a high level of accuracy in coordinate provision with the help of Global Navigation Satellite System (GNSS). In the presence of a permanent reference GNSS stations network that spans a specific region territorially, the relative method of positioning is most common (Hofmann-Wellenhof et.al., 2008). This method allows determining the accurate coordinates of the rover receiver using observations from reference stations, position of which is known. At the same time using either continued static GNSS observations with their further processing (post-processing) or GNSS observations in real time mode (RTK technology). The main feature of the relative method is that the communication "reference station - rover receiver" is affected by common disturbing effects in the form of systematic errors, to eliminate or mitigate most of them is using the principle of double difference of observations (DD-double-differencing). Since the creation of the global positioning system in the late 1970s, the relative method of observation and processing has prevailed in the field of the use of satellite technologies in geodetic projects. Even more recently, it would be true to say that the relative method had a monopoly on high-precision positioning. While this approach is relatively simple, it also has some significant disadvantages. Thus, due to the limitation of distances between the reference and rover receivers, a dense network of permanent GNSS stations is required, which significantly complicates (organizationally and financially) the process of their installation and operation.

All this changed in the late 1990s, when some competition to the relative positioning method entered the market in the form of accurate positioning of the point (PPP - Precise Point Positioning) (Zumberge et.al., 1997). Precision Point Positioning (PPP), based on non-difference two / multi-frequency phase observations, almost immediately became an alternative to relative positioning. From the early 2000s to the present, the PPP approach has evolved in precision from decimeters to millimeters, using observations from a single GNSS receiver. This was made possible by the use of high-precision ephemeris-temporal information (orbital parameters and satellite clock corrections) in the framework of the processing and modeling of systematic effects that influence on the determination of pseudoranges between satellites and receivers (Chen et.al., 2009). With PPP technology, using the ephemeris-temporal information, the obtained coordinates of the observation point are automatically "tied" to the highly accurate International Terrestrial Reference Frame (ITRF). This approach was originally used almost exclusively for scientific tasks such as studying the state of the ionosphere, studying the movement of continental plates, determining the parameters of the troposphere. Recently, the PPP method has become popular in topographic surveying, accurate positioning, and even in high-precision agriculture (El-Mowafy A., 2009). This is mainly due to the simplification of processing with the help of numerous PPP software packages or automatic PPP-online-services of observation point coordinate calculation.

In this way, technological advancements and constant modernisation of GNSS make it possible to increase the final positioning accuracy. An important step in improving the accuracy, accessibility and

operationality of using the PPP method is the free provision of actual ephemeris-temporal information in real, or close to it, time by international research centers via the Internet (Kouba, 2009).
In this study, using the comparative accuracy characteristics of the PPP method and the relative positioning method, it is analysing the possibility of using the absolute method in tasks requiring the highest accuracy. The PPP method was implemented by GipsyX software, and the relative method - GAMIT / GLOBK, using constellations relating to Multi-GNSS (GPS + GLONASS + Galileo + BeiDou).

Methodology of research and materials
The vast majority of scientific or commercially available programs of GNSS observations processing have used the principles of relative positioning. With the reliability increasing of the PPP method, as well as the quality and availability of softwares, significant changes have taken place in the area of high-precision satellite positioning and related fields. The PPP method, in the case of achieving comparable in accuracy parameters with the relative method, which is traditionally considered as more reliable, will increasingly be chosen as the main because of its convenience and low cost.
In the case of GNSS measurements at only one point, the phase ambiguities cannot be corrected, so a significant disadvantage in the PPP method was the long period of accurate convergence, which is determined by the time from cold start to reaching the decimeter level. Conducted studies show that a typical convergence time lasts about 30 minutes under standard conditions and will be significantly longer for weak satellite geometry (Collins et.al., 2010). To overcome this inconvenience, it is using the Integer PPP method (PPP-AR). It allows to solve the ambiguities of phase measurements for high-precision absolute coordinates. The essence of this method is that a decoupled clock model is used at the output frequencies of the correction information generated by the GNSS measurements results on a IGS permanent stations network. Thus, in PPP-AR mode, separated satellite clock corrections are considered known from the network solution. Besides, for code and phase measurements must be compensated in advance the systematic offsets, which are related to relativistic and gravitational effect, antenna phase center variations, tidal effects, windup effect, atmospheric delays, etc.
The PPP method is implemented using various algorithms and models in online services and software packages. As late as the 1990s, the Jet Propulsion Laboratory NASA (JPL) introduced a new processing technology that did not require formation the differences to obtain accurate positions. It was named Precise Point Positioning (PPP), and JPL implemented it in its software for processing, at that time, GPS data - GIPSY / OASIS II (Official web-site of GIPSY-OASIS software package). This software has undergone nearly 30-years period of formation and improvement. During this time took place its evolution from processing only GPS to multi-GNSS observations. Ephemeris-temporal information was improving in the form of JPL products. It should be noted that JPL products (orbital parameters and clock corrections) are for scientific and educational purposes only. In 2019, an updated version of GIPSY / OASIS, called GipsyX, was released.
This study presents a accuracy comparative assessment of the PPP method implemented by the GNSS observations at 10 stations in Eastern Europe with the GipsyX software package, version 1.0 of 2019. The control values were the processing results of these observations with GAMIT / GLOBK (GG) software, version 10.70 of 2018 (Herring et.al, 2018), which implemented the relative positioning method, as well as the processing results from the EPN Analysis Center conducted by Bernese software (B).

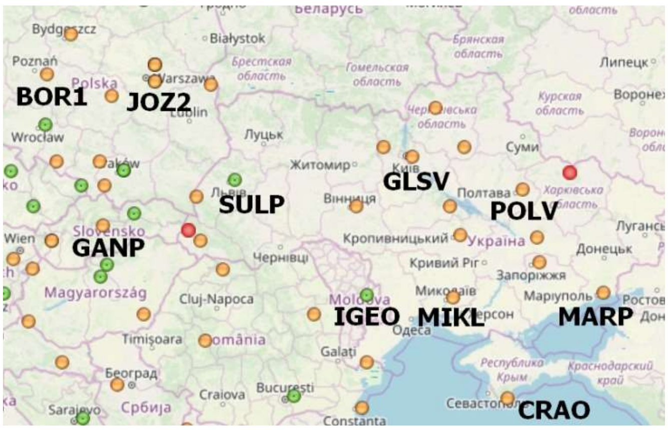

Fig.1. Location scheme of permanent GNSS-stations

To determine the coordinates we used stations of global and regional GNSS networks located closest to the territory of Ukraine. The GNSS observations data of 10 permanent stations of IGS / EPN network from April to June 2019 were selected. A total of 20 days were selected from the specified period, which was related to the availability of data from all stations at the same time (Official EPN server). Figure 1 shows the location of the GNSS stations selected for research.
It should be noted that fully multi-GNSS observations were conducted only at stations GANP, GLSV and, partly, IGEO, MARP (GPS + GLONASS + Galileo). At the other stations, these observations concerned only constellations GPS + GLONASS. Table 1 lists the main parameters, models, and processing strategy used to estimate the coordinates of GNSS observation stations.

Table 1

Parameters, models and strategy of experiments

Processing Strategy		
Software	GipsyX, 1.0	GAMIT/GLOBK, 10.70
Strategy	PPP-AR	DD-double-differencing
Orbit, Clocks and Satellites Biases		
Orbits and clocks	JPL's Precise Orbit and Clock in GipsyX Forma	IGS final
Satellite biases	MGEX wide-lane satellite biases	MGEX wide-lane satellite biases
Elevation cut-off	7º	7º
Models for Processing		
Antenna phase center corrections	ANTEX14	ANTEX14
Troposphere model	Saastamoinen/GPT2/VMF1	Saastamoinen/GMF
Ionosphere model	Ionosphere-free combination and second ordercorrections	Ionosphere-free combination
Ocean loading effects	FES2012	FES2004
Earth orientation modelling	IERS Conventions 2010	IERS Conventions 2010
Earth orientation parameters	EOP C04	EOP C04
Estimated Parameters		
Troposphere	ZTD/30 min	ZTD/2 h
Station coordinates	X, Y, Z transformed to East, North, Up	X, Y, Z transformed to East, North, Up

The PPP strategy underlying GipsyX software involves pre-processing GNSS observations, followed by actual processing and parameters estimation by by least squares method. During pre-processing, after selection of adequate data, each observation is being inspected for "outliers" and "cycle slips" detection using linear combinations (LC) and statistical tests. The ionospheric-free combination applied in processing uses dual-frequency GNSS pseudorange and carrier-phase observations. When the JPL orbit and clock products are applied (JPL's Satellite orbits and clocks), satellite clocks can be considered as known. The zenith tropospheric delay (ZTD) can be divided into an easily-predictable, thus easy-to-eliminate a priori, hydrostatic delay - ZHD, and an estimated in processing wet troposphere delay – ZWD. In GipsyX, the zenith tropospheric delay (ZHD) is computed using the Saastamoinen model with pressure and temperature from the Global Pressure Temperature (GPT2) model. The resulting ZTD is subsequently mapped using the dry Vienna Mapping Function (VMF1). Other corrections used in this study are: tidal displacement related to solid Earth, pole, ocean and atmospheric tides compliant with the International Earth Rotation and Reference Systems Service (IERS2010) standards, phase wind-up and relativistic effects.

Discussions and results

Table 2 presents statistics on the differences between the results of PPP solutions using JPL final products and control coordinates with EPN (B) in the measurement epoch, as well as the average differences in PPP coordinates with our solution by relative method (GG).

Table 2

Global RMS for PPP-B and PPP-GG for the entire stations examined

GNSS-station	North (mm)		East (mm)		Up (mm)	
	PPP-B	PPP-GG	PPP-B	PPP-GG	PPP-B	PPP-GG
BOR1	1.4	1.2	4.4	2.4	5.2	6.1
CRAO	-2.5	-1.2	6.2	3.3	-4.6	-9.6
GANP	-1.8	2.0	2.1	3.0	4.2	-0.2
GLSV	-4.1	3.2	2.6	2.3	4.0	3.2
IGEO	-0.5	2.7	2.8	3.1	-6.2	-8.0
JOZ2	2.0	-3.1	3.5	4.3	4.9	5.3
MARP	3.4	3.6	3.4	4.3	-5.1	-10.3
MIKL	-2.3	1.4	2.7	2.1	-3.1	-5.2
POLV	-0.7	2.1	2.5	2.3	-6.1	-7.2
SULP	2.9	1.1	3.8	3.2	5.8	5.1

Both approaches are characterized by the high precision of differences of horizontal coordinates: from 0.5 mm to 6.2 mm for Bernise and from 1.1 mm to 4.3 mm for Gamit / Globk. According to the well-known fact about PPP processing, the northern component (N) is determined somewhat more accurately than the eastern component (E). However, this principle is not so obvious for the solutions using JPL products (see Table 2). According to the statistics of determining the height component U, the comparison results are less satisfactory than the results of the horizontal components: the differences between the two approaches were approximately 5-8 mm, and in some cases slightly higher than 10 mm.

Conclusions and proposals

In the present study, PPP and DD positioning methods were used to determine high accuracy coordinates. During 2019, 20 days of simultaneous GNSS observations at 10 IGS / EPN stations were selected and processed using GipsyX, 1.0, and GAMIT / GLOBK, 10.70 software packages. The results of PPP and DD multi-station solutions have shown that the current accuracy of the absolute positioning method is practically similar to that of the relative method. Based on the results obtained from the combined EPN network solution using Bernese software, horizontal coordinates accuracy on the level of 3-5 mm for all stations and solutions can be characterized, and vertical component accuracy is changing depending on the specific station and varies by about 5-10 mm. In the analysis of daily values, the vast majority of mean differences in horizontal coordinates did not exceed ± 10 mm during the whole year. As for the vertical component, there are some fluctuations from -2 cm to 2 cm, which may be associated with seasonal atmospheric processes. This seems most likely because it applies to all stations at appropriate times. However, for the area covered by the selected observation stations, the results of the PPP solutions will satisfy the requirements of many surveying and engineering applications where the position is to be gotten in an ITRS reference system with an accuracy of 1 cm or less.

The benefits of combining signals from different GNSS when processing daily observation files are debatable, since this does not significantly improve positioning accuracy (up to 10%). The results obtained show that the improvement of accuracy from the use of combined GNSS observations can only take place in cases of weak satellite geometry and short observation sessions.

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IMPROVEMENTS IN THE CIVIL ENGINEERING FOCUSED ON THE REAL ESTATE APPRAISAL WITH THE USE OF ARTIFICIAL INTELLIGENCE AND FUZZY LOGIC

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Abstract
In the field of civil engineering, there are some traditional methods of property evaluation that deal with these techniques. However, there is controversy about what would bring the best performance, a greater degree of ease and clarity without presenting multicollinearity. This controversy is due to the difficulty of finding appropriate predictive variables in real estate valuation since they often do not fit the binary model, involving human subjectivity. From this, the research aims to propose improvements in the property evaluation process with the use of artificial intelligence without presenting the effects of multicollinearity and autocorrelation, to predict the value of the real estate market. The object of study is a standard 2-bedroom residential apartment with $48m^{-2}$ located in the central area of Jelgava, Latvia, in October 2019. Therefore, the methodology uses statistical inference as an initial analysis parameter and the fuzzy logic incorporates the best association rules which are originated from artificial intelligence extracted from the *apriori* algorithm. Finally, the results obtained by regression and fuzzy were compared with the value in euros m^{-2}, according to the official publication of the government of Latvia, referring to the market value of a 2-bedroom residential apartment in the city of Jelgava, Latvia, in October 2019, this government publication is the reference for this study. The statistical hypotheses that allowed its validation were accepted. In the Fuzzy model, the results indicated an excellent equivalence to market prices in relation to the traditional valuation process.

Keywords: artificial intelligence, civil engineering, fuzzy logic, rules, real estate valuation.

Introduction

Fuzzy set theory contemplates the subjectivities of the variables involved, imprecision, and uncertainty of human expression (Bustince, Herrera & Montero, 2008). Although there is a limited number of studies on diffuse logic for real estate (Kusan, Aytekin & Özdemir, 2010), there is a strong tendency for improvements related to imprecise knowledge representation process through Fuzzy Logic, with the support of computational modeling (Marro, Pells, 2010). Due to these subjectivities involved in the process of real estate evaluation, many of them involve the need for knowledge of the areas of civil engineering or architecture passing for decision theory. The decision theory is an interdisciplinary area of study, with definitions that relate philosophy, mathematics, and statistics, applicable to almost all branches of science, engineering, and mainly to consumer psychology.

Plous (1993) conceptualizes heuristics as general rules of influence used to arrive at their judgments in uncertainty decision-making tasks, with the advantage of using them, the reduction of time and efforts made so that reasonably good judgments are made. Heuristics reduce the complexity of the tasks of accessing probabilities and predicting values to simple judgment operations. However, according to Ferreira (2000) when using the concept of subjectivity, it is the same as working with the complex, and one must be open to understanding that subjectivity is also something changeable. And in this direction, the fuzzy theory is a good estimator. (Del Giudice, De Paola & Cantisani, 2017) presented a study on the fuzzy logic system to evaluate some properties involving inaccurate and vague data through fuzzy logic. The study also revealed that in the value of a property, there is a difficulty in working with linear approximation. On the other hand, one of the observed factors, which may be influencing this implementation is the fact of the number of fuzzy rules, established by the generated model, grow in a geometric way, directly proportional to the number of attributes selected for evaluation of the real estate. However, this does not seem to be a problem, but there is a possible intelligent solution because the proposal follows with the help of the decision tree allied to the algorithms of artificial learning. In the order hand, the non-linear behavior of the market, this range of values needs to be flexible. In this way, it will be more appropriate to obtain fuzzy inference in the Mamdani structure. The Mamdani model proved to be a reliable method for modeling property valuation considering the variability originated in man. The Mamdani approach structured in the study can be applied in government or private applications, wherever the value of the property is needed

(Bustince, Herrera & Montero, 2008). Thus, this way won´t be losing the scientific character as the traditional evaluation. These algorithms belong to the machine learning field.

The creation of scenarios, as well as the definition of classification rules, are indexed to the software Weka data mining systems (Eibe, Hall & Witten, 2016). Weka is a machine learning software for data mining tasks, written in Java and developed at Waikato University, New Zealand. In this context, accordingly (Posselt, Frozza & Molz, 2015).

Although, this market value is explained by the International Valuation Standards as an estimated value at which something must be negotiated between buyer and seller in a market transaction after prudent and non-compulsory negotiation. On this basis, the powerful linear regression method is used to assess according to the objective and availability of the information so that the hedonic method is the most used according to Pinto & Fernandes (2018). Nevertheless, there are cases where the regression method is not very suitable due to multicollinearity situations. Thus, fuzzy logic is an appropriate tool for dealing with uncertain variables and can contribute considerably to the techniques currently used in property evaluations.

The value to be estimated is usually based on several factors in the area of study. According to Fiker (2019) there are four methods for identifying the value of properties, a) Market direct comparative data method; b) Involutive method is generally employed when there is no similar sample data; c) An evolutionary method is used when there is no similar sample data to the evaluation; d) Income method. In this context, the scientific treatment to determine the value of a property deduces from a regression equation, where the market data surveyed are analyzed by inferential statistics (Nunes, Neto & Freitas, 2019). In research involving the engineering of valuations, the model variables are chosen, which are numerical representations of the intrinsic and extrinsic characteristics of real estate (Dantas, 2012). It is important to note the relationship between the selected variables to verify the dependencies or not between them (Darlington et al., 2012).

In that context, the fuzzy methodology has been advancing since its discovery. These advances encompass different applications in engineering, management, etc. According Hajnal (2014) a study was made in Budapest on how to link project management using fuzzy logic. As a result, it provided decision support to better estimate the project's true market value. Another example of an application of fuzzy logic whose rule associations were based on specialized knowledge, and criterion analysis by Mandami, with use of the MatLab computational tool. The authors measured the absolute mean error. This revealed a high accuracy of the obtained results and indicated the possibility of using the fuzzy model in property valuations in Turkey (Yalpir, Ozkan, 2018).

From this, the first method used to evaluate was the comparative method of market data using statistical inferences and the second method is fuzzy logic. Accordingly, Borodiņecs A. et al. (2013) affirm the existing building stock in most of the European countries is relatively old and on average 70% of buildings are built before the year 1980. Despite that Jelgava is a small, calm, and beautiful city of Latvia located near to the Lielupe river. That city suffered and was destroyed by war, but rebuilt during the years under Russian rule, and nowadays became an important city of independent Latvia with a polite people. Given this, 31 samples of residential apartments are employed. The analysis of a model in the Mamdani structure is built by Infuzzy software from the Universidade de Santa Cruz do Sul in Brazil. That tool is a free software designated for showing fuzzy systems (Posselt, Frozza & Molz, 2015).

Based on the above, the research aims to propose improvements in the property evaluation process using artificial intelligence without presenting the effects of multicollinearity and autocorrelation to predict the value of the property market. The object of study is standard 2-room residential apartment with $48m^{-2}$ located in the center area of Jelgava, Latvia, in October 2019. For this purpose, the methodology uses statistical inference as the initial analysis parameter and Fuzzy logic incorporates the best association rules originated from artificial intelligence extracted from the *apriori* algorithm. Finally, the results obtained by regression and fuzzy were compared with the value in euros m^{-2}, according to the official publication of the Latvian government regarding the market value of a 2-room residential apartment in the city of Jelgava, Latvia, in October 2019. From that to propose a new vision of artificial intelligence, fuzzy logic, and practical application for property. These Latvian government figures will be our reference available at http://liaa.gov.lv/en/business-latvia/real-estate-market-research. The research took place in September and October 2019. The basic tasks are knowledge of the region under study; inspection of the asset being valued; collected data; choice of methodology for the evaluation; data processing has an important point which is to use artificial intelligence and data mining to simplify the number of rules and, based on them, predict the market value established by the

model, moreover this technical artifact will do the hard work using binary logic computational. The civil engineering inspection was carried out with a real estate agent, and sometimes with the presence of the owner.
This article is part of an ongoing thesis in Latvia.

Materials and Methods

The first method used to evaluate was the comparative method of market data, using statistical inferences in the hedonic model. The second method is fuzzy logic combined with the formulation of rules of the artificial learning algorithm. The object of this study is one of the standard 2-bedroom residential apartment with 48 m^{-2}, located in the center area of Jelgava, Latvia, the research took place in the months of September and October 2019. Jelgava city is a small and beautiful city of Latvia located near to the Lielupe river. The city suffered and was destroyed by war, but rebuilt during the years under Russian rule, and nowadays became an important city of independent Latvia. In view of this, 31 samples of standard residential apartments are employed and both available on the world wide web. The inference statistic model was chosen with the best adjustment of the observed data and without presenting multicollinearity. The direct comparative method of market data consists in obtaining a representative sample of real estate market data with characteristics, as much as possible, similar to those of the good evaluating, using all the possible evidence and based on existing theories, acquired knowledge, common sense and other attributes and self-expertise. Initially, scientific treatment by regression analysis was used with 31 samples of 1, 2, and 3 bedroom apartments, similar and located close to the evaluation apartment, in the center area of Jelgava, Latvia, in 2019, September, and both available on the network world of computers.
The second way utilized by fuzzy logic. In this context, the Fuzzy set (Zadeh, 1999) can be established by a membership function that maps the elements of a space X to a real number in the range [0; 1] or formally, A: X →[0;1]. In this way, a membership function assigns each element a degree, varying between 0 and 1, that is, the function returns a value between 0 and 1 if the value of the X attribute is between a lower threshold and an upper threshold. Some classes of pertinence functions are most used, for example: linear by parts (triangular and trapezoidal), Gaussian and Sigmoidal.
So, the choice of these samples is formed by similar reference properties and belonging to the regions surrounding the property evaluated. In the methodology used as an initial parameter of analysis the hedonic model, and in the second analysis, the Fuzzy method combined the incorporation of the best association rules originated from artificial intelligence by the *apriori* algorithm. Used the computational tool Weka Software from the University of Waikato located in New Zealand (Eibe, Hall & Witten, 2016), by the way, basically in little words Weka is a free software for data mining.
A model in the Mamdani structure will be built in Fuzzy Software with Fuzzy Inference. Because of the non-linear behavior of the market, this range of values needs to be flexible. In this way, it will be more appropriate to obtain fuzzy inference in the Mamdani structure. Because the Mamdani model proved to be a reliable method for modeling property valuation considering the variability originated in man. The Mamdani approach structured in the study can be applied in government or private applications, wherever the value of the property is needed (Bustince, Herrera & Montero, 2008).
In relation to the quality of the data surveyed, this study opted for: Latvian Government Office, http://liaa.gov.lv/en/business-latvia/real-estate-market-research; and experience of own researcher in the formation of value.

Step one:

The generic model of the study follows the traditional expression (1).

$$Y_i = \beta_o + \beta_1 \times x_{1i} + \beta_2 \times x_{2i} + \cdots + \beta_k \times x_{ki} + \varepsilon_i \rightarrow = 1,2,\ldots,n \qquad (1)$$

Where the β coefficients are unknown parameters, and the ε_i are random error terms.
The verification and validation of the regression model used. It follows the statistical analysis criteria:

1) Multiple linear correlation coefficient (r): 10% and coefficient of determination(r^2).
2) Regression existence test: The test is affected by the distribution of FischerSnedecor. Analysis of variance, test F, model significance: 5%. The basic hypothesis is accepted, i.e., that there is a regression of y in X_1, X_2, X_3, ..., X_k, . The significance level α=5%, if Fc > F.
3) Test of the significance of the regressors: The Student's T-distribution (Tailed) was used in this case, with the basic hypothesis that the regressors are different from zero to the level of significanceα=10% e 30%. t-Test, Regressors, two-tailed: 30%; Sequences z-Test: 10%.

4) Kolmogorov-Smirnov Test: 10%. Thus, the hypothesis that the residues are distributed normally if $d_{max}<d_{crítico}$. The value of $d_{crítico}$ is obtained from the table, With a significance level of 5% e n=31 (sample size).
5) Durbin-Watson test: 5%. Cook Distance Test F: 0.10%.
7) Graphical analysis of residues. Checked the trusted the: 80%. A confidence interval of the estimated value: 80%.
8) Variables involved in modeling:
- The dependent variable *Y* is apartment price (EUR m^{-2}); The independent variables were chosen: area (m^2), consv_ap = apartment conservation (new (1), renew (2), old (3)), consv_build = building conservation (new (1), renew (2), old (3)), number of rooms (1), (2) or (3).

9) Criteria: sanitation with medium limit ± 2,00 × Standard Deviation; Minimum number of samples: 3× number of independents variables +3. Extrapolations not admitted.

Step two by Fuzzy logic:

Basically, this study by fuzzy logic consists of four steps (Fig. 1). Step 1: Collect real estate market data from offers for sale of standard residential apartments and analyze the characteristics and properties of one with civil engineering inspection tecniques. Estimate the price of the square meter by comparative method with the use of statistics tools; Step 2: Simplify the number of rules established by the model, using a tree of decision; and an association´s rules by artificial intelligence by Weka Software and Create the Fuzzy model for real estate evaluation; Step 3: Compare the created model in fuzzy logic results to those obtained directly in the real estate market by binary logic accordingly step 1; Step 4: analyze both results obtained in the study comparing those results with the data from the published by Latvia Government.

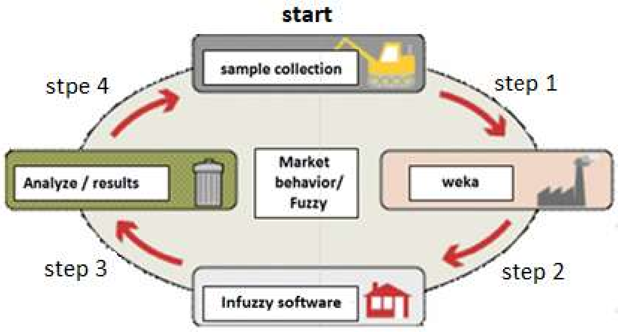
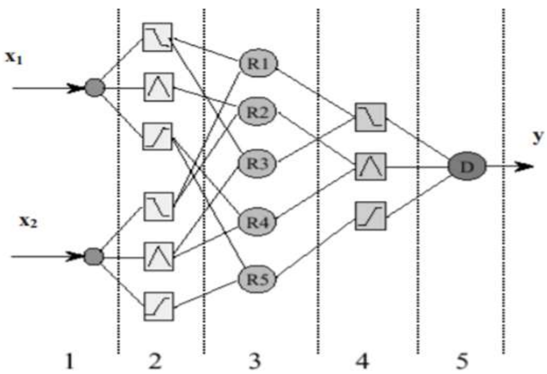


Fig. 1. The methodology used as a support tool for creating scenarios with open source software, such as Weka, Infuzzy Software, or similar.

The samples are based on offers of real estate for sale published on the worldwide network of computers. Thus, according to Fig. 2 are shown to the following steps 1 until 5.



1- Inputs (variables)
2- Fuzzification of inputs (fuzzy weights)
3- Rules (from algorithm *apriori* by Weka)
4- Consequences of the rules (hidden layer).
5- Defuzzification (sets the numerical value of the output

Fig. 2. Fuzzy methodology of the proposal for improvements in the real estate valuation

The functions chosen are illustrated in table 1 related to variable involved in fuzzy modeling based on the computational tool with technical InFuzzy software. Thus, the relationship between the terms and values is established by a fuzzy set, in which pertinence functions model this relationship. The next step consisted in determining the rules of inference, the rules were set based on binary logical reasoning, based on scattered data from samples of properties for sale advertised on the worldwide computer network in the city of Jelgava. For this, we used the algorithm apriori to establish the best rules of the association. At this stage of the research, WEKA software was used to maintain the scientific seal of the analysis. In a utopian representation of reality, it would require a model with 81 rules. The mother-file computational was successfully built being aided by a text editor computational tool. That mother-file was used in the WEKA software to obtain better association rules.

Moreover, human behavior is governed by the direct influence of the environmental variables, and these are in most cases of subjective value. In our case, the real estate appraisal there is a need to consider subjective aspects, ambiguous, inaccurate, difficult to measure the value of a property.

Table 1

Classifiers – The variables involved in fuzzy modelling

	Variables	Range	Classification	Degree of relevance	Pertinence function
Input	area	[0, 150]	small	0, 30	left ramp
			normal	20, 30, 50, 60	trapezoidal
			big	50, 100	right ramp
	consv_ap	[1, 3]	new	1	discrete
			renew	2	discrete
			old	3	discrete
	consv_build	[1, 3]	new	1	discrete
			renew	2	discrete
			old	3	discrete
	rooms	[1, 3]	1	1	discrete
			2	2	discrete
			3	3	discrete
output	price	[0, 1200]	low	150, 300	left ramp
			average	250, 350, 450, 600	trapezoidal
			expensive	550, 600	right ramp

The defuzzification method chosen was the geometric center of the final set. In other word clouds, it is the media of centroid points weighted by the areas; and an average of the maxims, where the final value is the result of the average value of the central values activated by the rules. The discrete data were transformed into linguistic variables, that is, for each variable were attributed linguistic terms representing the numerical values of the same. The thesis is underway at Latvia University of Life Sciences and Technologies. Then, once the rules were set, we defined the methods of implication, aggregation and "defuzzification" as shown in Fig.2 completing the fuzzy system and making it fit for the inference of values.

Results and Discussion

1) At the 1st stage:

By the analysis of the traditional statistical process, the hypotheses formulated were accepted. The estimated values x observed values show the adequacy of the points to the line which means a good fit of the model. The model for the dependent variable:

$$[\text{price}] = 1/(1.9501 \times 10^{-3} - 1.5774 \times 10^{-2}/[Area] + 1.2747 \times 10^{-4} \times \text{Ln}([Consv_{ap}] - 5.368 \times 10^{-4} \times Ln([Room])) \quad (2)$$

The coefficient of determination (r^2) was 0.4748, i.e., 47.48% the market value of the properties is being explained by the model, and the adjusted coefficient of determination was (r^2_{aj}) was 0.4165. The multiple linear correlation coefficient was 0.6891 indicating a STRONG correlation and between the explanatory variables and the explained. By Table 1, the analysis of variance presents the coefficient F calculated 8.137 > F tabulated 2.960 for the significance level of 5.000%, and the significance of the model equal to 0.05%. Therefore, it is accepted the hypothesis of the existence of regression. No sampling was found outside the range, there are no outliers. The results of the Kolmogorov-Smirnov

test sample elements revealed that the greatest difference obtained: 0.0603, with a critical value: 0.2220 for the level of significance of 10%. According to the Kolmogorov-Smirnov test, at a significance level of 10%, the alternative hypothesis that there is normality is accepted. Note: The Kolmogorov-Smirnov test has an approximate value when it is performed on a population whose distribution is unknown, as is the case of real estate assessments by the comparative method.
By the sequence test, the hypothesis of the randomness of the residue signs is accepted. The result of the test with deviations around the average presents lower Limit: 1.4689, Upper Limit: 1.1031, Within the normality interval [-1.2817, 1.2817] for the level of significance of 10%. Value z (Calculated): 0,1796, Value z (Critical): 1,2817 (for the level of significance of 10%), Thus by the signal test, the null hypothesis is accepted, and it can be affirmed that the distribution of the deviations around the mean follows the normal curve (Gaussian Curve). Processed elements: n number of positive elements: 15; N number of negative elements: 16; Number of sequences: 20; Average signal distribution: 15.5; Standard Deviation: 2.784. Durbin-Watson Test: The Durbin-Watson test proved inconclusive for the hypothesis of the existence of autocorrelation between the residues. The calculated statistic (D) was equal to 2.4698, located between the values of 4-du e 4-di, being *du* and *di*, for *k* explanatory variables and N samples to 5% of significance, equal to 1.34 and 2.66, respectively. However, the graphic analysis showed that there is no autocorrelation between residues. The result of the Cook distance F test presents the following effect of each observation in the F-tabulated regression: 6,326 (for the level of significance of 0,10%). Therefore, all the elements of the sampling passed through the consistency test. Multi-collinearity graphical verification test. The graphic result showed too that there is no multicollinearity between residues and explanatory variables. The results obtained are the following for the apartment of 2 rooms with 48 m^{-2} by statistical inference: Average price 747.50 EUR m^{-2}, minimal 728.04 EUR m^{-2}, maximum 768.03 EUR m^{-2}. Comparing the results obtained in the study with the data of the government, we can see the existence of a similarity between these numbers. Thus, it is suggested that the result is in accordance with the prices estimated at 2019, according to the Latvian government, in this case, the region of Jelgava is 550-700 EUR m^{-2}.

2) At the 2nd stage:

The Fuzzy inference process is fuzzification, rule evaluation, defuzzification as output. The variables involved in fuzzy modelling are the same used in the linear regression model Fig.5, a) the dependent variable *Y* is apartment price (EUR m^{-2}); b) the independent variables were chosen: area (m^2), apartment conservation = consv_ap (new (1), renew (2), old (3)), building conservation = build_consv (new (1), renew (2), old (3)), number of rooms = rooms (1), (2) or (3).

1) Fuzzification / **Fuzzy sets**: by using pertinence functions accordingly table 1.

1.1) From the same set of samples used in linear regression, the file was successfully built by the text editor computational tool. The file format is used as the default for structuring the databases manipulated by Weka. Thus, by the software WEKA, 49 association rules were generated by the algorithm for learning/data mining. After analysed the purpose of price prediction was chosen the 7 best rules with accordance 60% (confidence).

2) **Rule Evaluation** are shown in an IF / THEN rule set.

1	IF	(consv_build = renew)	THEN	(Price = expensive)
2	IF	(room = 3)	THEN	(Price = expensive)
3	IF	(consv_ap = renew) AND (consv_build = renew)	THEN	(Price = expensive)
4	IF	(consv_build = old) AND (room = 2)	THEN	(Price = average)
5	IF	(consv_ap = old) AND (consv_buid = old) AND (room = 2)	THEN	(Price = average)
6	IF	(consv_ap = renew)	THEN	(Price = expensive)
7	IF	(consv_ap = old)	THEN	(Price = average)

3) Defuzzification: The method of defuzzification used was the center of gravity or mass Fig.5.

Price [0, 1200]

low average expensive

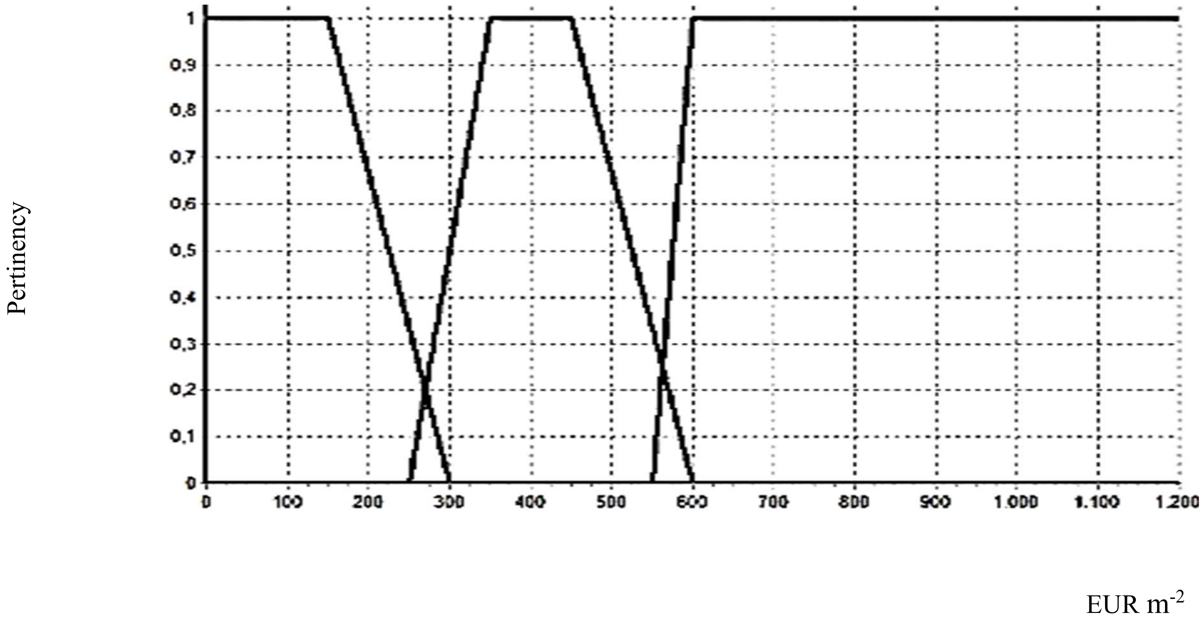


Fig.5. Overview obtained - defuzzification method by the center of mass criteria

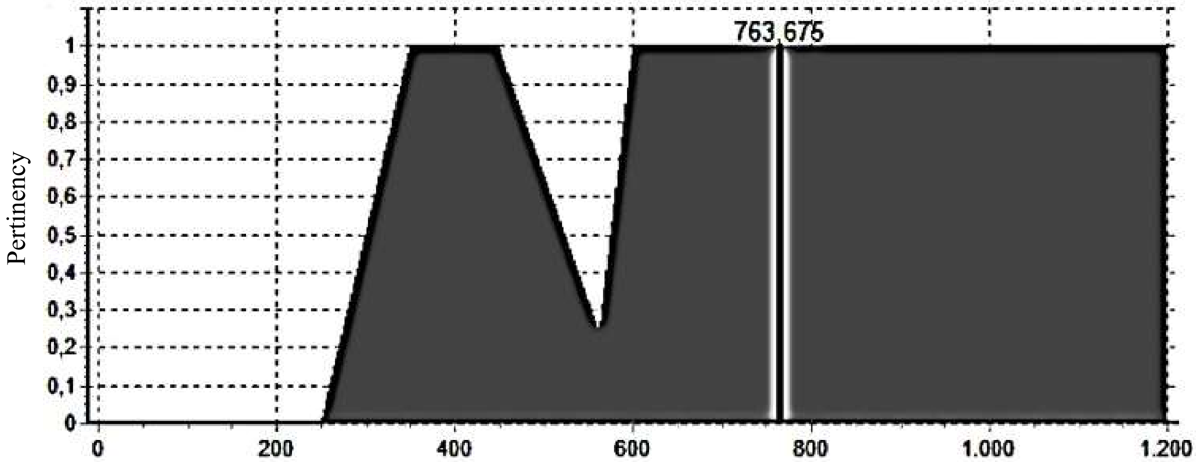


Fig.6. The result obtained: Price in EUR m^{-2} by the center of mass criteria (defuzzification method)

The simulations in the fuzzy model used the same variables with the same area in square meters of the property evaluating by statistics inference. In other words, consv_ap = 2 (renew); consv_build = 3 (old); room = 2; area = 48.00 m^{-2}. The value obtained in the fuzzy logic appears between the maximum and minimum intervals from binary logic, the results from the Fuzzy model will be qualified as ideal for this case. The Fig.6 shows the evaluation of the apartment by the fuzzy method resulted in values (output) = 763 Eur m^{-2}. In fact, an important point of view is the source factor or trade factor (Fa) it makes the correction of the elasticity of the information because usually the properties are offered in higher value than what is effectively transacted. Thus, the usual value is 0.9 for offered properties. On the other hand, depending on market conditions, this rate may reach 0.8 in some cases. Especially in the city of Jelgava, in some cases, this transaction factor was 0.7, as was said by the realtors. This fact was personally verified by this researcher at the time of the surveys of the buildings used as samples. Thus, the results obtained by the regression model and by the fuzzy model have similar values, from this, Table 2 shows the comparison between the official values of the Latvian Government 2019 and the results obtained by the conventional statistical inference and the Fuzzy method composed of the best association rules derived from binary logic (*apriori* algorithm).

Table 2

Results with values by the conventional statistic and fuzzy model
Jelgava city in October 2019 (applied the transaction factor = 0,90) / Value reference (EUR m^{-2})

Government of Latvia	Fuzzy model	Regression/ Statistical Inference
550 (minimum)	500 (minimum)	655 (minimum)
xxx---xxx	687 (average)	672 (average)
700 (maximum)	697 (maximum)	691 (maximum)

From the traditional statistical hypotheses by the hedonic model the market value was accepted and without the effect of multicollinearity. An added comparison shows too that the Fuzzy methodology used in this study incorporated with the best association rules originated from the apriori algorithm produces great results in predicting the values market in EUR m^{-2}. These results in the possibility of using fuzzy Logic in the real estate market as an alternative. Furthermore, this is a feasible proposal for improvement in the process of valuation of real estate. Because it encompasses the human subjectivity present in the process of evaluation of real estate, and with the advantage of not causing the problem of multicollinearity or autocorrelation, both experienced largely in the traditional assessments performed by traditional hedonic models. Therefore, the results allowed us to affirm that the scattered data is useless. But aggregated data can generate rules. Rules can generate forecasts and forecasts generate knowledge. Finally, that knowledge generates income and increases aggregate the values for the economic and civil engineering sectors.

Conclusions and proposals

The study compared the use of fuzzy logic with statistical inference and data declared by the Latvian government on the market value of a standard residential apartment, both with the same characteristics involved in the variables. And so, based on the results obtained, it is concluded that there are compatibility and scientific equivalence between these market values. From this, it is possible to consider that the proposed improvements are incredibly good for real estate appraisal.

Thus, it is possible to affirm that this new heuristic vision of artificial intelligence, fuzzy logic, and practical application in the property reaches the objectives of evaluating urban properties based on requirements that involve imprecision, uncertainty, and human subjectivity. expression, ambiguous variables added to the basic criteria of civil engineering inspection. These variables were transformed into a plausible solution to determine the value of the property and without presenting the problem of autocorrelation or multicollinearity, as in many cases in the statistical inference generating results with unrealistic values.

Finally, as future proposals are advised to carry out additional research to extend the method to other property valuation markets, p. agricultural properties.

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EVALUATION OF THE EFFICIENT LEVEL OF USEFUL AGRICULTURAL SOILS

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Abstract
The article describes overall useful agricultural soil in Azerbaijan, as well as the level use in crop production and animal husbandry, as well as the quality and evaluation of variety of crops in accordance with a system of 100 points under the land cadastre.
To determine the efficient level of useful agricultural soils, first of all, the main types and subtypes of soil and their cultivated area used in agricultural production were identified. Data was calculated on the overall soil fund of the republic, the agricultural region and its composition (structure), the level of use of each type and subtype of soil in agriculture, as well as in crop production and animal husbandry. Calculations show that the total utilization rate in agriculture varies between 0.52 and 0.98.
To assess the quality of the type and subtype of soil used in agricultural production, to assess the quality of various plants, a system of 100 points was used, and it was proposed to combine the soil in 10 agricultural production groups instead of 5 There are ways to calculate the "Comparative soil value" (TMDƏ) for a specific territory to simplify and facilitate the practical use of materials from agricultural soil groups.
Using the data obtained from the survey, any farm manager can plan to obtain higher yields per unit area with minimal and less labor, and can also determine the need of plants for fertilizers depending on soil quality.
Key words: soil, agriculture, useful soil, quality of soil, productivity, evaluation.

Introduction

Despite its small territory, Azerbaijan has diverse and complex natural and economic conditions. In terms of agricultural suitability, Azerbaijan is one of the smallest countries in the world. This forces to be more careful and make the right decisions both in the use of soil resources as a natural, and in the organization of agricultural production.
Soil is the main production tool in agriculture, which is the basis of its economic development. The economic condition of agriculture depends on how much of its soil is used to be efficiently and effectively. The efficient use of soil resources, protection and improvement of their fertility have always been considered actual issues.
Conducting a quantitative and qualitative land inventory to ensure the efficient use of agricultural soil, determine the directions of agricultural production, study the quality of soil cover, find out how good (bad) or bad (less productive) is. It is important to determine the extent of soil use in agriculture. All this can be achieved through land cadastral work, which includes reliable, necessary and reasonable information about the natural quality of the soil, its economic and legal status.

It is known that in a concrete area, not only one but also several varieties of soil are found, and their quality is also different. This makes it difficult to use cadastral data for this soil in agriculture, and to overcome this difficulty, the soil is grouped according to quality indicators. This grouping is called agro-production grouping of soil. In Azerbaijan, the soils are grouped into 5 agro-production groups according to a 100-point system, and the difference between the soils of each group is equal to 20 points. Research shows that the difference in this limit does not allow us to correctly assess productivity depending on the quality of the soil. Taking this into account, we considered it appropriate to carry out improvements in the agro-production grouping of soil.

Therefore, the main purpose of the article was to determine the level of use of soils suitable for agriculture, to assess the quality of the soils in accordance with the demand of different plants and to improve the grouping in terms of agro-production.

Methodology of research and materials

At first glance, determining the extent to which useful agricultural soil can be used is simple and easy, but it is a very complicated process. Usually, researchers, especially economists, pay more attention to the soil use and to what extent the culture is used under the agricultural crop, that is, the structure of the soil fund. Of course, knowledge of the structure of the soil fund is one of the key, but it is important to remember that not every plant is able to grow and produce high yields in any soil. There are certain soils that include the qualitative characteristics of each plant, and it is important to consider this factor when using these soils. Because the qualitative and economic valuation of soil, as well as the calculation of the standard price (monetary value) of soil should be determined based on the qualitative and productive characteristics of each land.

For 2019, according to the State Committee on Property Issues of the Republic of Azerbaijan, 4779.5 thousand hectares with a total area of 8655.5 thousand hectares are useful for agriculture. Of these, 1895.0 thousand ha (21.9 %) are used for planting various crops, 186.9 thousand ha (2.1 %) - for perennial cultivation, 2317.8 thousand ha (26.8 %) - for pasture, and the rest - for other crops, 1040.4 thousand ha (12.0 %) of the rest of the republic are forest fund soils, 984.8 thousand ha (11.4 %) of other categories, 1850.8 thousand ha (21.4 %) of other purposes (Table 1).

Table 1

Composition of the General Soil Fund of the Republic of Azerbaijan (data of 2019)

Places of use of soils	**General Soil Fund**	
	area, thousand ha	**%**
Total area of the Republic	8655.5	100.0
Total of suitable areas for agriculture, including:	4779.5	55.2
sown area	1895.0	21.9
perennial plantations	186.9	2.1
pasture areas	2317.8	26.8
other agro plants	379.8	4.4
Forest Fund soils	1040.4	12.0
Soils belonging to other categories	984.8	11.4
Different fixing of soils	1850.8	21.4

To find out the degree of soil use, it is necessary to determine the main types and subtypes of the soil that are considered useful for agriculture, both their total and actual area used for crops. For this purpose, you are able to use the available data for a specific area, statistics, research materials and funds.

Soil scientists of the republic found that the diversity of natural conditions and the influence of the ancient agricultural culture led to the formation of a complex and diverse soil cover in Azerbaijan. They are most widely used in agricultural production: mountain gray-brown (mountain chestnut)-(371.4 thousand ha), brown (262.0 thousand ha), meadow-brown (332.2 thousand ha), dag-gara (mountain black)-(75.8 thousand ha), podzoll yellow (28.2 thousand ha), podzoll-yellow clayey (57.4 thousand ha), brown-grey (chestnut) -1028.7 thousand ha), gray (166.5 thousand ha), gray (915.5 thousand ha), gray-meadow (1311.2 thousand ha), meadow (458.4 thousand ha), sub-alluvial meadow (647.3 thousand ha) and etc., soil types and subtypes (Babayev M., Hasanov V.,2001, Mamedov Q., 2000, Valiyev A., 2011).

It is important to calculate coefficient of soil use ($T_ə$) based on the comments of N.N. Rozov in order to determine the degree of agricultural soil use (Розов Н. 1962). Thus, it is possible to determine the degree of soil use for any crop with concrete numerous. It is proposed to calculate the soil use coefficient according to the following formula (1):

$$T_ə = S_i : S_ü, (1)$$

where: Tə - coefficient of soil use; Si – actually used soil area;
Sü - total area of that soil.

After determining the degree of use of soils suitable for agriculture, their quality scores were calculated on the basis of bonitirovka. In accordance with the quality score, the soils were combined in agro-production groups. To simplify and facilitate the practical use of materials of agricultural soil groups, you are able to calculate the “Comparative soil value” (TMDƏ) in a particular area. To do this, you can use the following formula (2):

$$Tmdə = Tb : Tob, (2)$$

where: Tmdə – coefficient of the comparative value of soils,
Tb bonitet (quality) of the soil,
Tob the average bonitet (quality) score of the soil area.

Using this formula, we are able to calculate any agro-production (comparative value coefficient of soils belonging to quality group).

It is necessary to calculate the comparative cost of soils of the III group of agricultural production, and in this group the index of bonitet of dark mountain-gray brown soils under crops is 78, typical mountain-gray-brown soils - 73, chestnut – 80, light chestnut soils - 77, gray-meadow soils - 75 and gray - 71. In this case, the average soil value estimate for the quality group was found (78 + 73 + 80 + 77 + 75 + 71: 6 = 76). Then, using the proposed formula, we are able to calculate the relative cost of soil for each soil, or agro-production group, or any territorial unit. The comparative soil value belonging to the III group of agricultural production, as a result will be 1.03; 0.96; 1.05; 1.01; 0.99; 0.93. If the comparative value soils is equal (TMDƏ = 1) or higher than one (TMDƏ>1), then there is no need for additional resources to increase or improve the fertility of these soils or agro-industrial groups. Conversely, if the relative value of land is lower than unit (TMDƏ<1), then additional costs should be increased to improve land quality.

Discussions and results

Thus, using proposed procedure, the degree of useful soil in the country as a whole for agriculture, including crop production and animal husbandry, was determined (Rozov H., 1962). According to the calculations, the utilization of all soil in agriculture as a whole range between 0.52 and 0.98. The coefficient use of mountain gray-brown (mountain-chestnut) soils in crop production 0.21 and 0.31 in animal husbandry. It also means that these soils are mainly used for animal husbandry, as they are mainly pastures. The reasons for the scarcity of these soils are different, but one of the main reasons is that they spread along the slopes and undergo intensive erosion. Nevertheless, there are extra opportunities for the use of these soils in agriculture.

The relatively used meadow brown (Tə - 0.61) and mountain black soils (Tə - 0.68) are among the best in soil in terms of fertility. Since they have a rich vegetation cover, the erosion process here is also relatively weak. Therefore, the use of these soils at a low level is regrettable.

The most commonly used soils in agriculture are gray (Tə - 0.98), gray-brown (chestnut) (Tə - 0.97), podzoll-yellow (Tə - 0.94) and gray-meadow (Tə - 0.90) types and subtypes of soil (Valiyev A., 2011). This is also natural, since this group of soils is mainly used in the irrigated territories of the republic, in the lowlands and foothills and is widely used under the various crops. The yellow soil group is distributed over a small area in the foothill plains of the Lankaran economic region and is mainly used for tea, subtropical vegetation and partially for vegetable growing. Low soil and population density also contribute to the intensive use of these soils. Since they do not have a large area and are useful for use, it is advisable to use them only for the growth of tea and subtropical plants, since these plants are able to grow only on these soils.

Although meadows and meadow-wetland soils are widely used in agriculture, and at a very low level. Of these soils, Tə - 0.68 in general agriculture, 0.13-0.15 in crop production and 0.53-0.55 in animal husbandry. Favorable conditions have been created here for the broad development of breeding, fodder and vegetable growing.

Thus, it was determined that the part of the main type and semi-sub-type soils spread in the territory of the Republic injured to agriculture is equal to 5610.9 thousand hectares, the coefficient of its use in agriculture is equal to 0.84 (4779.5 thousand ha). It was calculated that about 831,4 thousand hectares of these soils remained unused, and most of them (more than 60%) are quality soils.

These soils can be defined, mapped and used in agricultural production in the order of their structure.

In addition to agricultural soil throughout the country, exception forest fund soil can be directly involved in agricultural use, and some areas can be used directly in agriculture with appropriate measures (areas listed above with hectares). However, for this purpose, the cadastre and land management should be invented, mapped, and quantitative and qualitative records should be reviewed.

Thus, using the proposed rule, it is possible to determine the degree of soil use in any district, farm or district. It should also be noted that the accuracy of determining accuracy is higher when determining soil use in small areas.

After determining the extent of quantitative soil use as an integral part of the cadastre, it is necessary to assess its quality, that is, the level of agricultural production. These datum are very important not only for the efficient use of soil, but also for the construction of a profitable farming system, the determination and purchase of normative prices (value by money) of soil. Also, they are widely used in the implementation of other land-related deals, planning and forecasting of agricultural production, management and specialization of farms, as well as in the solution of many issues that ensure the development of agricultural production.

It is known that the quality and productivity of soil as a means of production is determined by its fertility. Soil fertility is formed as a result of a natural process and forms of its value. Various methods are used to determine how fertile one soil is from another. The method we use is called soil "assessment (bonitirovka)".

Soil quality assessment in Azerbaijan, i.e. "Bonitirovka", was carried out on the basis of the 100-point system proposed by F. Gavrilyuk (Гаврилюк Ф. 1974). However, in our study, we did not have the highest quality indicators in accordance with this method. In this case, it is possible to more accurately determine the actual quality of the soil, as well as the plant's need for soil. This is clearly seen by assessing the diversity of the main types and semi-arable land used in agriculture.

Thus, although the overall quality index of brown-grey (chestnut) soils used in agriculture was 72, the demand for crops was 76, vegetables were 86, grapes were 88, and 90 for fruits. Or gray soils have a total quality score of 66, for grain 54, for cotton 76, for vegetables72, for fruits 66 and 64 for grapes. The overall quality index of podzoll yellow soils was 78, for tea plants - 89 points, vegetables - 80 points and grain - 73 points. Thus, such calculations (other types and subtypes of soils) can be made to determine which soil is most useful for the plant and which plant is most useful for other species. For example, gray soils are considered more useful for cotton and vegetable crops.

Thus, based on the valuation, you can determine how much the quality of the soil is different. It should be noted that due to geographical conditions in one area you can meet more than one species. This greatly complicates the use of the results of the land cadastre in agriculture. To overcome such problems, land classification by quality indicators is necessary.

Since soil is the main production facility in agriculture, this grouping is called the agro-industrial (soil) classification of soil. Agro-industrial classification of soils is a grouping of soils that have the same properties due to their genesis and agronomic quality.

Agro-industrial classification of soils solves many common problems of agricultural production: specialization of farms, the right choice of soil, determining which plant to grow, forecasting productivity, evaluating the production activity of farms and determining potential soil productivity. is of paramount importance.

In the 60-70s of the last century in Azerbaijan there were two types of soil: special and general agricultural production. In a special group - the main diagnostic indicators and qualitative characteristics of the soil (chemical and physical indicators, salinity, salty (salinity), erosion, etc.) are based on the general group - the need for specific agricultural plants in the soil. Subsequently, agro-industrial classification of land on the basis of accrued points was given more space. According to this 100-point system, soils were grouped into the following 5 agricultural production groups based on bonuses, each of which included 20 points:

I group – high quality soils (100-81 score);
II group – good quality soils (80-61 score);
III group – medium quality soils (60-41 score);
IV group – low quality soils (40-21 score);
V group – conditionally unsuitable soils (20-1 score).

We believe that each approach to the classification of agricultural soils has its advantages and disadvantages. Given the complexity and difficulty of the problem, these shortcomings should be naturally accepted. However, we must not forget that the main goal of a qualitative assessment of soils, as well as the agro-industrial group, is the efficient use of soil and its fertility, as well as an increase in agricultural production. If the quality of the soil (bonitet scores) or the agro-industrial grouping does not serve the purpose, it does not matter.

As you can see, the difference between the soil quality indicators of each agro-industrial group is 20. If we consider the soil as a natural product and not as the main production object, then the fact that the difference of 20 scores between agro-industrial groups and intra-group soils cannot be a real indicator of its quality and economic indicators. That's an example. For example, in the Barda region, Farida's business produces 50 centners of grain per hectare, and the soil quality indicator is 67. This means that

the price of each piece of soil will be 0.7 cents / ha. Then the price of one ton of soil quality is more than 8.0 EUR with current exchange rate, if we calculate the sale price of each centner of grain. If we assume that the quality of the soil in the same agro-production group is 20 score, then it is 161.5 EUR (8.0 EUR x 20 score = 161.5 EUR), which does not fully reflect reality.
In our opinion, agricultural soil classification should be based on the nearest points obtained by the quality of toxic soil units and the needs of a particular plant. The genetic and production characteristics of soils with this classification, their relationship with the main agrotechnical and reclamation measures, the level of use of material and technical resources, such as fertility, economic indicators, labor costs, potential land productivity, etc., issues are also taken into account.
Based on the foregoing, it is more expedient to combine the republic's lands in the following 10 agro-industrial groups in accordance with the bonitet classes:
I group – the highest quality soils (100-91 score);
II group – high quality soils (90-81 score);
III group – the best quality soils (80-71 score);
IV group – good quality soils (70-61 score);
V group – medium quality (60-51 score);
VI group – relative medium quality soils (50-41 score);
VII group – low quality soils (40-31 score);
VIII group – the lowest quality soils (30-21 score);
IX group – conditionally unsuitable soils (20-11 score);
X group – Incomplete soils (areas) (10-1 score).
Since this group reflects reality, it is also a group of agri-food groups, in addition to being accessible from the point of view of maintaining and improving soil fertility, efficient use, productivity and organizing proper management and development of implementation measures of the farm, simultaneously also facilitates the practical application of materials and datas.
Using the "Comparative Value Coefficient of Soil" (TMDƏ), it is possible to calculate the coefficient of comparative value of soil in any territorial unit and determine the amount of funds needed to increase the productivity of soil in that territory, thereby preventing excess costs incurred in the farm.
Using this data, any farm manager is able to plan their production in such a way that higher productivity per unit area can be achieved with minimal cost and labor. For example, data on soil quality (fertility) is of great practical importance for the development and implementation of measures to reduce the cost and productivity of crops, the effective and proper use of fertilizers and the implementation of relevant agricultural measures. It is important to know how much and what plants need for fertilizers, as well as the size and quality of the soil so that they can be used correctly and in a timely manner. To determine the duration and speed of irrigation, it is necessary to obtain cadastral data on the water-physical and chemical characteristics of the soil.

Conclusions and proposals

Based on the research, it can be concluded that in order to increase the economic efficiency use of agricultural soil in the republic, it is necessary to conduct an accurate inventory of soil and its natural resources (agricultural areas).
It is established that agricultural soil is not fully utilized. Unused soil, land cadastre and land management should be identified and mapped on the spot and involved in agricultural production.
In order to correctly assess the quality and productivity of the soil, cadastral work should be carried out on the basis of new indicators and the use of modern methods.
Based on the study, we consider it expedient to combine agricultural soil in the republic into 10 agro production groups, and not into 5 agro production groups.
"Comparative soil value" for a particular territorial unit was developed to simplify and facilitate the practical use of materials from groups of agricultural soils, as well as to determine the financial costs necessary to improve the quality of soil.

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