LATVIA UNIVERSITY OF LIFE SCIENCES AND TECHNOLOGIES

UNIVERSITY OF WARMIA AND MAZURY IN OLSZTYN (Poland)

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FOREWORD

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- Institute of Land Management and Geomatics of Vytautas Magnus University, Lithuania

The journal includes original articles on land administration, land management, real property cadastre, land use, rural development, geodesy and cartography, remote sensing, geoinformatics, other related fields, as well as education in land management and geodesy throughout the Baltic countries, Western and Eastern Europe and elsewhere. The journal is the first one in the Baltic countries dealing with the mentioned issues.
Journal disseminates the latest scientific findings, theoretical and experimental research and is extremely useful for young scientists.

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CONTENT

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COMPARATIVE ANALYSIS OF THE SELECTED LAND CONSOLIDATION PROJECTS

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Abstract
Land consolidation is an important stage for agriculture and rural development. During the land reform, parcels of irrational size and shape were formed, which became difficult to cultivate efficiently. In essence, land consolidation projects must primarily be developed in areas with large, viable farms, and land parcels forming land holdings are not compact, distant from each other and from centers. Land consolidation projects have been under development for many years, but it is appropriate to pay attention to the expediency of implemented projects. Land consolidation goals and procedures vary from country to country, as the development of this procedure in each country is determined by historical trends, culture, traditions and land consolidation legislation. Many of those who have analyzed this topic emphasize the need for consolidation, but it is very important that landowners understand the importance of this process and make sure of its opportunities and benefits. Land consolidation must be designed so that the benefits of the project are higher than the results of the conversion works before the project. The purpose of this article is to compare land consolidation projects which were prepared in different areas of Lithuania. Two objects of the research in which land consolidation projects had been carried out and implemented in 2013 were selected, where the number of sites in units decreased: 41.8% in one project and 28% in the other. Changes in parcel configuration were also noticeable, when in one of the projects analyzed even 92 percent of land parcels have become regular - close to rectangular - shapes. The average size of land parcels in this project increased from 5.32 ha to 9.14 ha.
Key words: land parcel, consolidation, land users, private and state land.

Introduction

During the land reform in Lithuania, where the ownership rights were restored, the focus was on returning land rather than forming farms, so landowners or land users now have to cultivate land in several irregularly shaped and distant lands.

In order to improve the conditions for agricultural land use and cultivation, in many European countries, land consolidation has been underway for almost 100 years, with the aim of completing complex land reparcelling, changing land parcels' boundaries and location according to a land consolidation project for a particular area.

From land consolidation processes in Lithuania, it is expected that they will help to solve the problems of abandoned lands, as well as increase the productivity, efficiency and competitiveness of the agricultural sector, and at the same time will ensure the balanced development of rural areas as well as promote the creation of jobs in rural areas, will contribute to environmental protection and management of natural resources (Dapkus, 2008).

In 2008, the Government of the Republic of Lithuania approved the National Land Consolidation Strategy, the main objective of which is to ensure rational use of land and infrastructure development, increase the competitiveness of farms, protect the environment, foster cultural heritage and landscape and develop alternative activities (Lietuvos, 2018).

In order for farmers to compete successfully on the European Union market, it is necessary to provide for new land management measures that help to transform small and scattered plots of land into rational, more efficient land use. For this purpose, land consolidation is needed (Gaudėšius, 2010).

Rural development, consolidation projects are mainly carried out in Germany, the Netherlands, France, Belgium, Luxembourg, Austria and Switzerland, as well as in Finland, Norway and Sweden (Vitikainen, 2004).

In Denmark, land consolidation is carried out on a voluntary basis by landowners and a democratic approach to land parcel conversion. In Germany, this process is more regulated by the relevant public authorities. However, in many other countries in central and eastern Europe, especially where land consolidation has only recently begun, there are more areas than a simple land conversion. Other land-related issues related to environmental protection, infrastructure and the improvement of living conditions in rural areas are also addressed concerning land management issues (Dapkus, 2008).

After conducting the research of land consolidation projects in Central and Eastern Europe, P.Aleknavičius (2009) presents four different levels of land consolidation projects:

Comprehensive land consolidation. This consolidation includes key works such as rural renewal, improvement of road infrastructure, reconstruction and construction of land reclamation systems, improvements in environmental and natural resource use, development of social infrastructure.
Ordinary land consolidation. The main optimization works of land parcels in such projects are the redevelopment of land parcels, improvement of form, development while purchasing land from state or land owners. These works can be combined with the restoration of infrastructure and drainage.
Voluntary group consolidation. These projects are similar to simplified land consolidation, but landowners participate in these projects only on a voluntary basis.
Individual land consolidation. It is a random and individual spread of land parcels initiated by private farmers.
The most effective tool for consolidating agricultural development is comprehensive land consolidation, although other ways can also bring benefits (Martinkus, 2010).
In order to form rational land holdings and improve their structure, pilot land consolidation projects have been started in Lithuania since 2000, and the first legal actions were implemented only in 2004 when the Seimas of the Republic of Lithuania adopted amendments to the Land Law (Selmonė et al., 2016).
The primary objective of the first pilot project was to develop the most convenient use of arable land for 392 ha. The consolidation project has improved the value of the land parcels by changing their configuration and designing new access roads. It has been proven that land consolidation improves local agricultural structures and increases the economic stability of family farms within the design area. In 2002, a second Danish-Lithuanian pilot project was launched: "Land consolidation – an instrument for sustainable rural development". This project also sought to achieve more goals, including the promotion of local initiatives and the establishment of a related rural development strategy (Daugalienė, 2003).
These pilot land consolidation projects have shown that land consolidation can be a tool for achieving sustainable rural development, when through spatial planning processes agricultural structure and infrastructure are being improved, combining and meeting public interests, contributing to the environment and the countryside, cultural heritage, conservation and upholding of values (Naujokaitytė, 2017).
The National Land Service under the Ministry of Agriculture has confirmed that the land consolidation project will give landowners and the local community priority to receive external funding from other European Union Structural Funds to achieve the anticipated improvements, such as renovation of drainage systems, the local road network. Currently, the critical situation is with local (outdoor) roads. Farmers drive beyond the boundaries of their neighbors, although the road network is planned in the land reform plans (Pasakarnis and Maliene, 2010).
In general, 14 land consolidation projects were implemented in Lithuania from 2005 to 2007. The projects were organized in four Lithuanian counties: Marijampolė, Panevėžys, Tauragė and Telšiai (Čepkauskaitė, 2016). In 2007-2013, 39 land consolidation projects were completed in 18 municipalities (Naujokaitytė, 2017).
After this period, following an overview of these projects, it was considered most convenient to develop land consolidation projects in larger areas where more land users would be involved, thus creating preconditions for better land parcel design. Unfortunately, it was not possible to achieve optimal results in almost all land consolidation projects, as these projects could not include state land plots due to legislative changes (Aleknavičius et al., 2016).
Currently, i.e. during the period 2014-2020, 8 land consolidation projects are being prepared.

Methodology of research and materials

The aim of the article is to compare land consolidation projects carried out in Lauksargiai cadastral area of Tauragė district and Upyna cadastral area of Telšiai district.
The following tasks are aimed at achieving the goal:

1. To perform an analysis of the prepared two consolidation projects.
2. To identify and evaluate the expediency of land consolidation project preparation.

The article was prepared by the method of analysis of legal acts and scientific literature. The results of the statistics are presented on the basis of methods of collection, systematization, processing, logical analysis and generalization.
The object of the work - two land consolidation projects carried out and implemented in 2013 in Lauksargiai cadastral area of Tauragė district and Upyna cadastral area of Telšiai district, the purpose

of which is to find out the expediency of preparation of these projects. Research data - statistics of State Land Fund.

Discussions and results

1.1 Solutions for land consolidation project in Tauragė district Lauksargiai cadastral area

The main mission and goal of the consolidation project of the Lauksargiai cadastral area of Tauragė district is to re-plan land holdings by changing land parcels and using free state land in order to make them comfortable for farming (Figure 1).

The selected area is 16 km from the town of Tauragė. The area consists of three arrays - a mythological object, which covers a part of a private parcel, is enclosed in the project area. The largest part of the project area includes intensive agricultural activity with a priority of cattle-breeding - crop production in land of good economic activity, and in the south-eastern part of the territory existing group IV forests, among which are not used agricultural land, which is suitable for planting forests.

Agricultural land in the project area is 408.08 ha, of which arable land - 400.20 ha, gardens - 0.37 ha, meadows and natural pastures - 7.50 ha, forests 54.56 ha, waters - 2.07 ha and the other land - 59.17 ha.

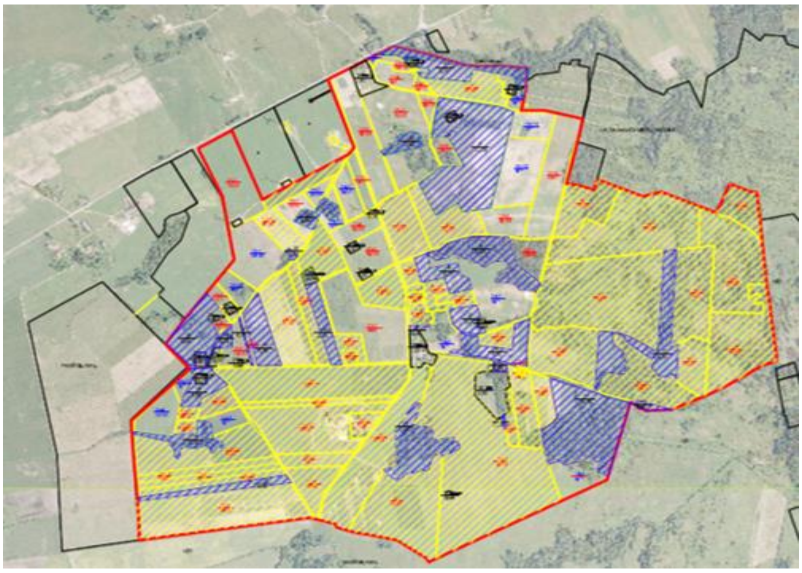

Figure 1. Tauragė district Lauksargiai cadastral area before the project (Tauragės, 2013)

31 person participated in the preparation of the consolidation project. The total area of the territory is – 521.02 ha, in which 98 plots of land have been formed and legalized, including 26 state land parcels, which occupy 86.3495 ha. The other 72 parcels (434.6705 ha) are owned by the citizens of the Republic of Lithuania. State land parcels are located throughout the project area between private land parcels. Some of them are of irrational and irregular configurations. The average parcel area is 3.32 ha. In order to form a land of rational size and form for agricultural and forestry land, this area was restructured without prejudice to the boundaries of the area selected for the project. The area selected for the project was complexly reconfigured by joining, dividing, separating and redistributing land parcels, anticipating their location and boundaries. The solutions for the consolidation project are presented in Figure 2.

Figure 2. Taurage district Lauksargiai cadastral area after the project (Taurages, 2013).

The results of the analyzed land consolidation project are presented in Table 1.

Table 1.

Indicators of land consolidation project in Taurage district Lauksargiai cadastral area (Author's, Source, Taurage, 2013)

Situation	The area of LC project territory	Number of private land owners	Number of land parcels	of these – state land parcels	Average parcel size	The shape of the parcel is close to a rectangle		The form of the parcel is different, irregular	
						number in units	%	number in units	%
Before the reparcelling	521.02	31	98	26	5.32	33	34	65	66
After the reparcelling	521.02	31	57	19	9.14	9	16	48	84

After the land consolidation project, the number of landowners remained unchanged (31). The number of land parcels decreased by 41.8 percent (from 98 plots to 57). Of the 26 state land parcels, 19 remained, 27.8% of them fell. Average land parcel size increased by more than 41 percent (from 5.32 to 9.14 ha). Regular forms of land parcels fell to 16 percent and irregular parcels increased to 84 percent.

1.2 Solutions for land consolidation project in Upyna cadastral area of Telšiai district

The preparation of the land consolidation project in Upyna cadastral area of Telšiai district was expected to have a positive long-term impact on agricultural activity and faster economic development of competitive farms. Provision was made for a positive impact on the soil of consolidated and designed parcels of land of regular shape, as the quality of the parcels would be improved by adapting crop rotations. Intensive agricultural activity is foreseen in the project area (Figure 3).

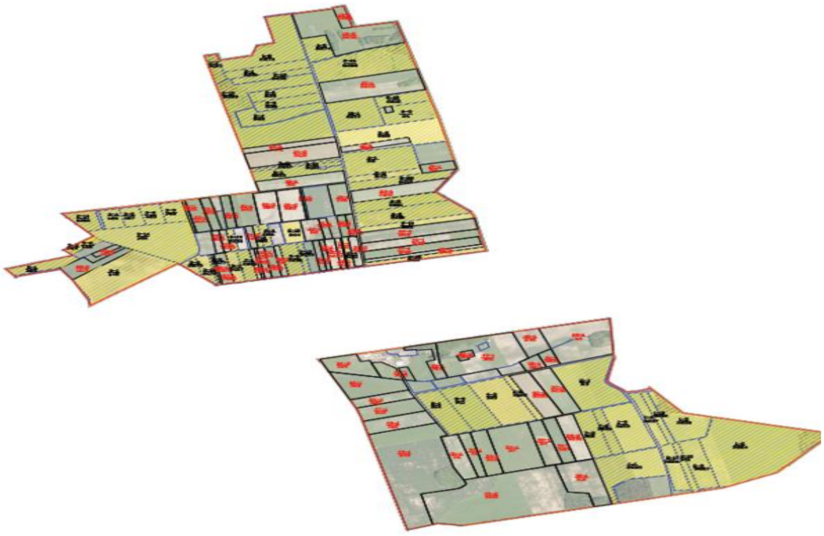

Figure 3. Territory of the planned land consolidation project in Upyna cadastral area of Telšiai district (Telšiai, 2013)

75 people participated in the project. The area occupied 695.19 ha, of which 11 land parcels belonged to the state. The area of state land is 10.65 ha. The area selected for the project was complexly reconstructed by joining, dividing, separating and redistributing land plots, anticipating their location and boundaries (Figure 4).

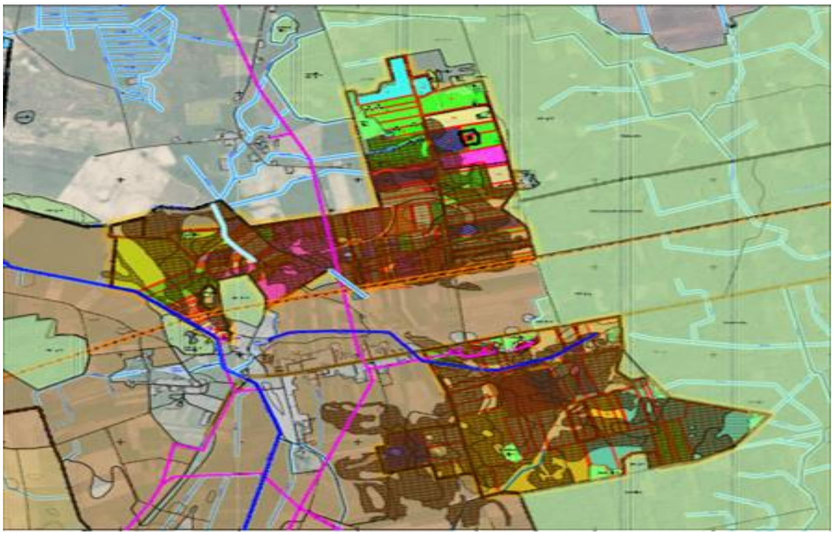

Figure 4. The Upyna cadastral area of Telšiai district after the consolidation project (Telšiai, 2013)

The land consolidation project did not change the number of landowners. The number of land parcels fell from 161 to 116 parcels, i.e. 28 percent. State land fell by only 1 parcel (10 percent). The average size of the land parcel before the land consolidation project was 4.32 ha and after the project increased to 6.00 ha. Before the conversion 63% of parcels were classified as close to the rectangle, and 37 percent were of another irregular shape. After the transformation – most of the parcels were enlarged and their form was close to the rectangle, such parcels constituted 92 percent. Only 8 percent of the irregular land parcels remained. Changes in parcel configuration are presented in Table 2.

Table 2

Indicators of the land consolidation project in Upyna cadastral area of Telšiai district (Author, source, Telšiai, 2013)

Situation	The area of LC project territory	Number of private land owners	Number of land parcels	of these – state land parcels	Average parcel size	The shape of the parcel is close to a rectangle		The form of the parcel is different, irregular	
						Number in units	%	Number in units	%
Before the reparcelling	695.19	75	161	11	4.32	101	63	60	37
After the reparcelling	695.19	75	116	10	6.00	103	92	9	8

1.3 Summary of the results of land consolidation projects

Following the analysis of two land consolidation projects, the following evaluations of the expediency indicators of the preparation of these projects were identified, assessing the indicative project development objectives (indicators) (Table 3).

Table 3

Evaluation of expediency indicators of completed land consolidation projects (compiled by authors).

Indicators	Cadastral area Lauksargiai	Cadastral area Upyna
1. To form parcels of rational size and form for agricultural and forestry land.	There were 98 land parcels before the project, 26 of which belonged to the state. In the course of the consolidation project, 57 private parcels of land were formed. State ownership remained – 19 parcels. But irregular land parcels increased by 18 percent.	Before the consolidation project there were 161 private parcels of land, including 11 state land parcels. After the project 116 land parcels were formed. 10 land parcels have remained in state ownership. During this project, the regular parcels of land increased by 29 percent.
2. To enlarge land holdings and improve their brevity.	These requirements are met by two farmers' farms. There were 33 parcels of land in the area of 201.45 ha before the conversion, and after the conversion – 11 parcels in the area of 201.45 ha. By restructuring 26 land parcels with an area of 86,349 hectares were converted into 19 land parcels with a total area of 86.28 ha.	One owner owned 9 parcels of land, of which 5 parcels were combined with two other parcels of land owned by both farmers. Compact land parcel of 28.07 ha and 43.22 ha were designed. Two landowners owned 11 land parcels with a total of 88.81 hectares of land before design. 5 land parcels with an area of 89.63 ha were designed for them. 6 land parcels were owned by two spouses prior to design, with an area of 22.13 ha. One of the spouses owned 22 more parcels with an area of even 102.30 ha. After the project, 4 land parcels of 63.59 ha of common ownership have been designed and 8 parcels of land of 63.07 ha were designed for one of the spouses.
3. To reduce distances between parcels of land on farm land.	3 land parcels belonging to farmers were formed around a farm center, which contains the main farmer's buildings, machinery and equipment. Another 5 owners have achieved the best distance reduction.	In the land consolidation project, the key solutions were not foreseen in terms of the reduction of distances between land parcels on the farm land.

Continuation of Table 3

Indicators	Cadastral area Lauksargiai	Cadastral area Upyna
4. To create the right rural infrastructure.	The road network was analyzed during the design. The road was rebuilt to the extent necessary to consolidate land parcels and provide access roads to each formed parcel and cemetery.	A number of roads have been redesigned to improve the road network, making them more convenient for passing agricultural machinery, and instead of the 4-meter-wide field road, a 10-meter-wide road with a length of 709 meters was designed. More convenient passes to land parcels were designed, 81 meters long and 6 meters wide. To make it easy to get to the parcel, a road of 81 meters long and 6 meters wide was designed for another farmer.
5. To identify regulatory restrictions on land use.	The area is classified as a component of the natural framework – geo-geological divisions of regional importance. 3 servitude roads were designed for land parcels.	Formed servitudes: road servitude – right to drive (dominant object); road servitude – the right to drive vehicles (serving object); servitude, right to build underground, ground communications (serving object). It is planned to build a gas pipeline, for which a servitude (serving object) to construct a trunk gas pipeline and its facilities was established, as well as a servitude (serving object) the right to serve underground, ground communications. Specific land use conditions are defined: road protection zone, protection zone of power lines, territory of immovable cultural property and protection zones, land parcels with state-owned land reclamation systems and equipment, protection zones of main gas pipelines and pipelines and their facilities, protection zones of surface water bodies and coastal protection belts, forest use restrictions, soil protection and pipeline protection zones.
6. To improve the territory's recreational, rural tourism and aesthetic resources.	The area selected for the project is used for intensive agriculture, so there are no recreational areas.	The land consolidation project did not foresee solutions for territorial recreation, rural tourism.
7. To implement other objectives of agriculture, rural development and environment policy.	Two owners of one parcel of land on forest parcels (situated between forests) wanted to plant a forest. An area of 81.33 hectares is planned to be planted with forest (from the formed area of 125.60 hectares). The other two owners of the same parcel wished to expand the area of the farmstead, as farmers anticipate the development of their farm.	The overall physical state of land reclamation in the land consolidation project is good, therefore no reconstruction of land reclamation systems and equipment is foreseen. No new power lines will be provided while reconstructing land parcels.

Summarizing the expediency of the 2 land consolidation projects analyzed, it can be stated that the land consolidation projects in Tauragė district Lauksargiai and in Telšiai district Upyna cadastral areas were aimed at implementing territorial planning solutions. Implementing the solutions of these projects, the basic economic benefits of improving the configurations of the sites, their conciseness and tightness are obtained by transport costs. Significant economic benefits will also be felt by the owners of the parcel intended to be planted with forest, since instead of several forest planting projects, only one will be required. Agricultural activity will reduce environmental pollution by reducing the number of kilometers traveled and forest planting.

Conclusions and proposals

1. According to formed land parcels of rational size and form, it can be stated that the average size of the parcel of land in Lauksargiai cadastral area increased from 5.32 to 9.14 ha. But in this area, after the consolidation project, land parcels of irregular shape (18 percent) increased. The area of the land parcel before the land consolidation project was 4.32 ha in the area of the Upyna cadastral area, and after the project increased to 6.00 ha. In this area, the number of land parcels of regular shape has increased (29%).
2. In the Tauragė district Lauksargiai cadastral area, the number of parcels of land was 98 before the land consolidation project. After the land consolidation project, the number of parcels decreased to 57 plots (41.8%). The number of land parcels in the Upyna cadastral area of Telšiai district was 161, and after the project implementation decreased to 116 parcels (28%).
3. The land consolidation project in Lauksargiai cadastral area has achieved the best result of distance reduction for 8 landowners. And in the area of Upyna cadastre, the issue of distance reduction between land parcels on the holding was not decided.
4. Better results had been achieved in the road network management of Upyna cadastral area consolidation project. Analysis of both projects showed that land use restrictions were taken into account and land easements were established. The cadastral areas examined are not included in recreational areas.
5. For the implementation of other objectives of agriculture, rural development and environment policy, the land consolidation project in Lauksargiai has formed the area of land for the establishment of the forest and it is planned to expand the place of the homestead, anticipating the development of the farm. These issues were not solved in the Upyna land consolidation project.
6. Based on the results of the analysis carried out, it can be stated that in order to compete successfully in agriculture, the consolidation and enlargement of parcels as well as the purposeful complex restructuring of the territory are of great importance, not only to form land of rational size and form, but also to develop agricultural, rural development land management projects together ensuring the rational use of farm land, taking into account farm activities and environmental protection requirements, as well as creating the necessary rural infrastructure and improving recreational and rural tourism resources. All this would increase the attractiveness of rural areas.

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THE FINANCIAL IMPACT OF URBANIZATION COSTS IN POLAND AT MUNICIPALITY LEVEL – THE CASE OF WROCŁAW CITY

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Abstract

The study discusses the problem of financial impact on Wrocław Municipality exerted by the costs of implementing decisions resulting from the selected local spatial development plans. Currently in Poland, at the stage of local spatial development plan establishment, a forecast of financial consequences is prepared. The expected own revenues and the costs of financial impact exerted on the municipal budget are presented in this document. The study facilitates making decisions about the final version of the local development plan. Taking into account the planned spatial development in the area of Wrocław city, the urbanization costs exerting financial impact on the municipal budget were identified. The study analyses only the cost of implementing investments within the scope of the municipality own tasks, including the cost of constructing municipal roads, sanitary sewerage system, water supply system, public greenery facilities and land purchase for public investments. The analyses covered two selected areas of the city, located in its different parts. These are largely uninvested areas, predominantly constituting agricultural land, and such land development requires the construction of technical and social infrastructure facilities. The anticipated costs of implementing local development plans in force in various parts of Wrocław indicate significant expenses to be covered by Wrocław Municipality in order to build sewage systems and municipal roads. Taking up new development sites is also correlated with taking over the real properties by Wrocław city, on which the implementation of public goals is planned.
Key words: financial effects, urbanization, local development, plan, implementation

Introduction

Currently, in Poland, space development is based on the local spatial development plan, and in the case of its absence – pursuant to the decision on land development conditions. The spatial policy defined in the document of municipal conditions and directions for spatial development provides the basis for determining functions in the local development plan, and next for the implementation of investments (Hełdak and Raszka, 2013; Hełdak et al., 2016).

When such local spatial development plan becomes binding, it results in economic implications. In Poland, these consequences are specified in the forecast of the financial impact. It estimates own revenues as well as the costs incurred by the municipal budget with respect to the implementation of municipal tasks. In turn, the access to technological infrastructure facilities, in particular to cultural, educational and sports services influences the quality of life of local residents (Przybyła et al., 2014; Hełdak and Płuciennik 2017).

The identification of municipal financial impact results from the provisions of the Local Government Act (The Act dated March 8, 1990, on Municipal Self-Government), in which the legislator provides the catalogue of tasks to be implemented by the municipal authorities. It allows verifying the economic rationality of the local development plan draft and adjusting the adopted planning solutions before the plan is approved, thus reducing municipal expenses, which result from the adoption of the plan. Pursuant to the Act, the municipality own tasks include satisfying collective needs of the community, covering e.g. the most frequently estimated, in the financial impact forecast, own tasks including: real property management, municipal roads, streets, bridges, squares and road traffic organization, waterworks and water supply issues, sewerage system, municipal wastewater removal and treatment, maintenance of cleanliness and order as well as sanitation facilities, landfills and municipal waste disposal, local public transport, physical culture and tourism also including recreational areas and sport facilities, municipal greenery, tree stands, and municipal cemeteries.

The document of financial impact forecast provides the expected own revenues and the costs charged to the municipal budget in terms of the municipal tasks implementation. Therefore, the forecast is an important strategic document prepared for the local development plan draft, it should be done well in

advance and in cooperation with town planners and property appraisers as the persons responsible for estimating economic effects (Cymerman et al., 2008).
The problem of new residential areas excessive planning is widely discussed in Poland. Local development plans, in their current form, have a flawed functional structure, because they allocate excessively large areas for housing development, frequently exceeding by far the economic needs and possibilities of municipalities. In the entire country, as at the end of 2012, they allowed for the settlement of 62 million people (Report…, 2013). The question arises as to whether it can also apply to the area of Wrocław city.
The main purpose of the study is to analyse the economic effects resulting from the local development plans in force in several selected parts of Wrocław city, located within the geodesic precincts of Marszowice and Widawa. The research covers the costs of implementing local development plans, which exert financial impact on the budget of Wrocław Municipality as a result of the ongoing investment in these parts of the city.

Methodology of of research and materials
The realisation of the adopted research purpose required collecting information using the direct observation method. The information about the area covered by the study were collected from the available planning documents, i.e. local spatial development plans, the area base map and also maps from the Wrocław Spatial Information System. The identification of costs charged to the municipal budget was prepared based on the entries in local development plans. The study specifies costs of implementing local development plans taking into account the division, commonly found in the subject literature, into the following groups (Hełdak, 2013; Cymerman et al., 2008; Hełdak and Płuciennik, 2017):
– financial charges for negative consequences affecting real properties (compensations specified in Art. 36, item 1, point 1 and item 3 of the Spatial Planning and Management Act),
– financial charges connected with purchasing real property for the realisation of public goals,
– financial charges connected with the costs of infrastructure construction,
– financial charges connected with handling the investment process.
The analysis of costs charged to the municipality for the implementation of its own tasks related to purchasing real properties for the implementation of public goals required specifying the average transaction prices using the data from the Property Price and Value Register obtained from the Board of Geodesy, Cartography and Municipal Cadastre in Wrocław. The information about the existing transport connections and utilities network, resulting from the analysis of the area base map, allowed identifying the necessary infrastructure investments to be implemented. The cost of implementing planned construction works and infrastructure facilities (road construction, utilities network, greenery facilities and the construction of education establishments) was obtained from price registers of construction objects. The areas of the study are located within the city of Wrocław. They are as follows:
– Local spatial development plan in the area of western part of Marszowice Malownicze III development area in Wrocław, the Resolution by the City Council of Wrocław dated November 20, 2003 (Official Journal of Lower Silesia Voivodship dated April 20, 2004, No. 71, item 1337);
– Local spatial development plan in the area of Kominiarska, Jubilerska and Sułowska Streets as well as the Wrocław motorway ring road in Wrocław, the Resolution by the City Council of Wrocław No. LXI/1566/14 dated October 7, 2014 (Official Journal of Lower Silesia Voivodship from 2014, item 3223) (Fig. 1).

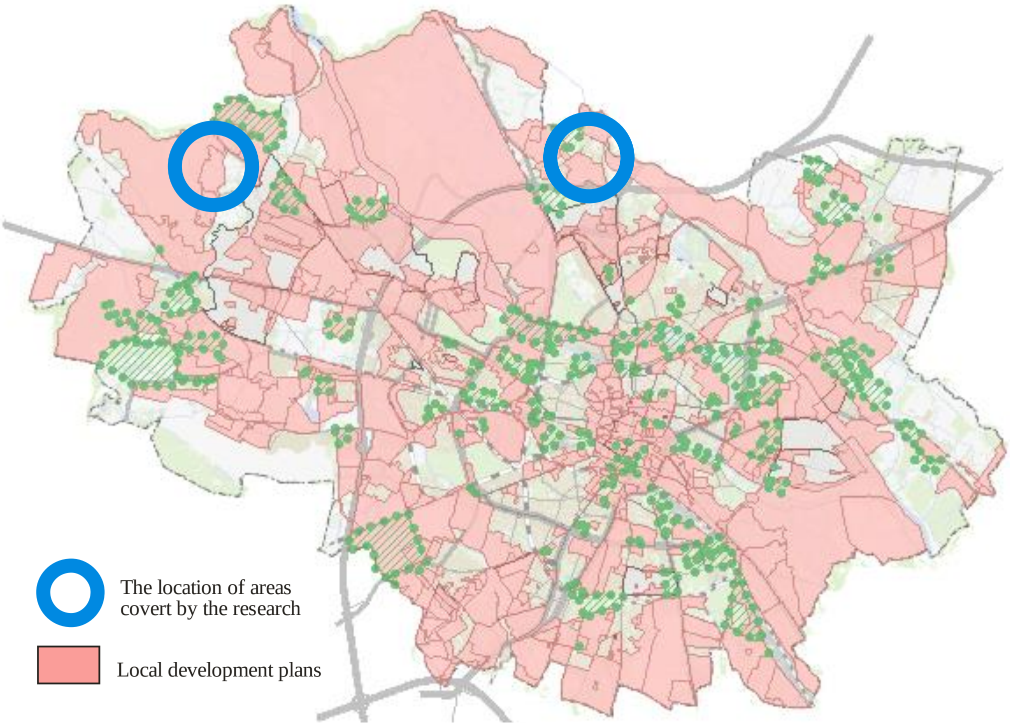

Fig. 1. The location of areas covered by the research regarding costs of local development plans implementation.

Identification of the municipality own tasks

Pursuant to the provisions of the local spatial development plan in the area of western part of Marszowice Malownicze III development area in Wrocław the areas designated for the implementation of public goals are defined. These are the communication areas (L (local) class roads), marked on the plan with the following numbers and symbols: KL 1, KL 2, KL 3, KL 4. The identification of Wrocław Municipality obligations is preceded by the analysis of ownership status of the studied area. The areas of local roads are owned by Wrocław Municipality, therefore their buyout is not anticipated. Other areas of communication are the internal roads, i.e. the roads for which the owners of adjacent real properties (road co-owners) are responsible. Such solution reduces municipal costs, however, impedes the construction and maintenance of roads as the communication between the large number of the adjacent plots' co-owners regarding the construction and maintenance of the road is difficult.

Pursuant to the provisions of the local development plan in the area of the following streets: Kominiarska, Jubilerska and Sułowska as well as the Wrocław motorway ring road in Wrocław, the following areas are designated for the implementation of public goals: 1KDZ, 2KDD/1, 2KDD/2, 2KDD/3, 2KDD/4, 2KDD/5, 2KDD/6, 2KDD/7, 2KDD/8, 2KDD/9, 2KDD/10, 2KDD/11, 2KDD/12, 2KDD/13, 2KDD/14, 2KDD/15, 2KDD/16. Within the area covered by the local spatial development plans, the majority of real properties are owned by natural persons. Two of the plots located in the area covered by the plan to be developed for Widawa area are owned by the municipality. Road construction is planned on one of these plots (marked as 2KDD/3 in the local development plan), the other is intended for the service area (9U), the access street area (2KDD/14) and the green area (11Z/1). The construction of other public roads has to be preceded by the buyout to the municipal resources. A prerequisite for the construction of a public road is either the State Treasury or the local government unit ownership status of the land on which the discussed investment is to be carried out (Hełdak, 2013; Hełdak and Płuciennik, 2018). Similarly, the implementation of other municipal tasks requires, first of all, taking the land over to the municipal resources. The identification of the real properties area to be bought by Wrocław Municipality is presented in the table below (Table 1).

Table 1

The area of land designated for roads to be bought out by Wrocław Municipality in the area of the following streets: Kominiarska, Jubilerska and Sułowska as well as the Wrocław motorway ring road.

Symbol in the local development plan	**Buyout purpose**	**Buyout area [m2]**
2KDD/2	road widening	340
2KDD/3	new road construction	770
2KDD/4	intersection extension	10
2KDD/5	road widening	1385
2KDD/6	road widening	260
2KDD/7	intersection extension	10
2KDD/9	road widening	1110
2KDD/10	intersection extension	5
2KDD/11	new road construction	5070
2KDD/12	new road construction	2570
2KDD/13	road widening	2735
2KDD/15	new road construction	2605
2KDD/16	new road construction	1915
Total:		**18785**

Source: authors' compilation

The conducted analyses also concerned the need for buying out land designated for public green areas. It was established that the obligation to buy out park greenery refers to 18425 m^2 of land in the plan located within the area of Widawa (Tab. 2).

Table 2

The area of land designated for park greenery to be bought out by Wrocław Municipality in the area of the following streets: Kominiarska, Jubilerska and Sułowska as well as the Wrocław motorway ring road.

Symbol in the local development plan	**Buyout purpose**	**Buyout area [m^2]**
10ZP	park greenery	14350
11Z/2	park greenery	2215
11Z/3	park greenery	1030
11Z/4	park greenery	830
Total:		18425

Source: authors' compilation

Financial impact related to the buyout of land for the implementation of public tasks

A municipality is obliged to buy out land designated for carrying out public goal investments according to the plan within Widawa geodetic area. As a result of implementing the provisions of the analysed plan, Wrocław Municipality will have to buy out land designated for public green areas, the areas intended for new access class communication routes and the land aimed at extending the existing communication routes indicated above.

To estimate the costs of buying out land designated for access roads in the local development plan, the average price of 1 m^2 was adopted and calculated based on the real properties market analysis, referring to roads or intended for roads, in the amount of 180 PLN (42 EUR). The size of the area necessary to buy out is 18785 m^2. The cost of buying out land designated in the local development plan for public roads was estimated at approx. 788970 EUR.

To estimate the cost of buying out land designated for public green areas in the local development plan, the average price of agricultural property in the amount of 120 PLN (28 EUR) for 1 m^2 was adopted. The total buyout area of the land designated for public green areas is 18425 m^2. The cost of buying out land designated for green areas and park greenery in the local development plan was estimated at the amount of approx. 515 900 EUR.

The construction costs of technical infrastructure facilities within the scope of municipality own tasks

Water supply system

The construction cost of water supply system was estimated based on the data from the Newsletter of Prices in the Construction Industry "SEKOCENBUD" part II Engineering objects published in the fourth quarter of 2018, issue number 70/2018 (1840). Projected technology: from PE-HD pipes Ø 160 m, cast iron gate valves, underground fire hydrants, disinfection of pipelines, substrate for pipelines made of sand, layer thickness 10 cm (object number 5566 C). The network unit price (1 linear meter), taking into account the regional coefficient (for Lower Silesian Voivodship, the coefficient equals 0,952) is 360 PLN (84 EUR). According to the plan drawing in the local development plan, the length of water supply system is planned for 2500 m in the analysed area of Marszowice and 1550 m in Widawa region. The cost of water supply system construction was estimated at approx. 210 000 EUR in Marszowice and 130 200 EUR in Widawa area.

Sanitary sewage system

The construction cost of sanitary sewage system was estimated based on the data from the Newsletter of Prices in the Construction Industry "SEKOCENBUD". Projected technology: PVC pipes Ø 250 mm, inspection chambers made of concrete coils Ø 120 mm, bedding material made of sand, layer thickness 15 cm, tightness test (object number 5575). The network unit price (1 linear meter), taking into account the regional coefficient is 1 200 PLN (280 EUR). According to the plan drawing in the local development plan, the length of sanitary sewage system is planned for 2500 m in the analysed area of Marszowice and 1550 m in Widawa region. The total cost of sanitary sewerage system construction will amount to approx. 700 000 EUR within the scope of local development plan for Marszowice and 434 000 EUR within the scope of the plan covering the part located in Widawa geodetic area.

Access roads, passageways and paths for pedestrians and cyclists

The cost of constructing municipal access roads was estimated based on the "Consolidated standards for the valuation of buildings and constructions" Issue No. 109. The investment implementation was estimated based on the object No. 72 (local roads and squares with cast asphalt surface) featuring the following parameters: mechanical trenching, 15 cm thick sand drainage layer, foundation of gravel concrete B-7.5 18 cm thick, concrete curbs 44,72 m/100 m^2, asphalt concrete base 3 cm thick. The construction cost of 100 m^2 of this surface type, taking into account the conversion factor for the region (the conversion coefficient range for Lower Silesia Voivodship (0,77 - 0,88) was adopted as 0,80 equals PLN 18 830 (4 390 EUR). The size of the surface was calculated based on the measurement of the length of roads from the plan drawing (length of roads – 1550 m) and the adopted road width. In accordance with the provisions of the Regulation on technical conditions to be met by public roads and their location[1], the width of access road lane in built-up areas should range between 2,25 m and 2,5 m. The adopted width of the road lane is 2,5 m, therefore the road width will be 5 m. The surface of 3500 m^2 (Marszowice) and 7750 m^2 (Widawa) was intended for hardening. The total construction cost of municipal access roads was estimated at 493 875 EUR.

The construction costs of passageways and paths for pedestrians and cyclists were estimated based on the data from the Newsletter of Prices in the Construction Industry "SEKOCENBUD". In the forecast, the price of 1 m^2 surface construction was adopted as 1 m^2 pavement surface (passageway) of the path for pedestrians and cyclists "D" class in the urban area (object No. 5335), which taking into account the regional coefficient is PLN 185 (43 EUR). The size of the surface was calculated based on the plan drawings (length of passageways – 1000 m and 1675 m) and the adopted passageway width, that according to legal provisions (Regulation) should not be less than 2,5 m regarding bike paths which can also be used by pedestrians and not less than 2 m in the case of pavements by the roads. It was adopted that a path for pedestrians and cyclists will be 3 m wide and the width of a pavement – 2 m,

[1] §15 Regulation of the Minister of Transport and Maritime Economy of March 2, 1999 on technical conditions to be met by public roads and their location (Official Journal from 1999, No. 43, item 430).

thus the surface of passageways was established at 2000 m^2 (Marszowice) and 3870 m^2 (Widawa). The total construction cost of passageways and paths for pedestrians and cyclists was estimated at approx. 86 000 EUR i 166 410 EUR

Financial impact related to setting up public green areas

The municipality is also responsible for setting up areas designated in the local spatial development plan for the purposes of public greenery. The analysed local development plan in the area of Kominiarska, Jubilerska and Sułowska Streets as well as the Wrocław motorway ring road in Wrocław allocates four areas for greenery purposes (marked in the plan with the following symbols: 11Z/1, 11Z/2, 11Z/3, 11Z/4) and one area aimed at park greenery (10ZP). In the case of green areas, it was adopted that trees will be planted along the planned rows of trees and a lawn will be set up. The average tender price in Wrocław of PLN 900 (210 EUR) was adopted as the cost of planting one tree. The price includes the cost of purchase, planting and three-year care used for planting rows of tree saplings approx. 2,5 m high with trunk circumference of 16-18 cm. The number of trees was determined based on the planned length of the rows of trees and the assumption that they will be planted 8 meters apart. Therefore, as a result of implementing the plan provisions, it will be necessary to plant 63 trees. The cost of planting was estimated at 63 x 210 = 13230 EUR.

The cost of planting a lawn was estimated based on the data from the Newsletter of Prices in the Construction Industry "SEKOCENBUD". The price of 1 m^2 of lawn surface in flat area (object No. 8392, taking into account the regional coefficient, is PLN 20 (4,70 EUR). The above price covers preparing the ground for the lawn and unfolding the lawn from a roll. The estimated costs of setting up a lawn amount to PLN 39 442 EUR. The total cost of arranging public greenery marked in the plan with the following symbols: 11Z/1, 11Z/2, 11Z/3, 11Z/4 was estimated at approx. 52 672 EUR.

In the area designated for park greenery, marked in the local development plan with the symbol 10ZP, the construction of a rectangular playground was adopted, presenting the following dimensions 20x25 m and covering the area of 500 m^2. It was assumed that the playground will be situated along the path for pedestrians and cyclists. The cost of the playground construction was estimated based on the data from the Newsletter of Prices in the Construction Industry "SEKOCENBUD" – object No. 8393 children playground. The price of 1 m^2 of the playground surface, including the regional coefficient, is PLN 185 (EUR 43). The price covers the play equipment available at the playground such as e.g. a swing, a slide, etc. The total cost of arranging park greenery area, marked in the local development plan with the symbol 10ZP, was estimated at approx. 21 500 EUR.

Discussion

The research estimates budget expenditure of Wrocław Municipality related to the implementation of decisions resulting from the analysed local spatial development plans. The costs were not broken down into particular years of the forecast due to the difficulty in determining the duration of the investment implementation. The selected construction materials used in the implementation of infrastructure and communication networks have impact on the forecasted costs. The local development plan provisions lack the specification of investment parameters, therefore for the needs of the study the data included in the "Consolidated standards for the valuation of buildings and constructions" were adopted. The list of expenditure is presented in Table 3.

Table 3

The list of costs of the analysed local development plans implementation

Specification	Marszowice [EUR]	Widawa [EUR]
Buyout of real properties intended for the implementation of public goals	none	788 970
Construction of municipal roads	153 650	340 225
Construction of paths for pedestrians and cyclists	86 000	166 410
Construction of sanitary sewage system	700 000	434 000
Construction of water supply system	210 000	130 200
Construction of a street lighting network	not estimated	not estimated
Financial impact related to setting up public green areas	none	74 172
TOTAL:	**1 149 650**	**1933977**

Source: authors' compilation

The analysis showed that the construction of communication passageways has a large financial impact on the municipal budget and these costs were estimated at EUR 153 650 and EUR 340 225

respectively (approx. 17% of the total expenditure in Widawa). The total cost of technical infrastructure network construction was estimated as: 910 000 EUR (Marszowice) and 564 200 EUR (Widawa), whereas the cost of sanitary sewerage system construction definitely exceeds that of water supply system implementation.
Recently, the regulations regarding co-financing costs, associated with infrastructure development, resulting from the adoption of the local spatial development plan for revitalization were introduced in Poland. This fee is a completely new solution and, so far, has been rarely used. Investors, including developers, often do not incur any costs of expanding technical infrastructure facilities and they never cover the costs of social infrastructure facilities. The construction of education, culture, sport and recreation establishments at the local level is charged to the municipal budget (Hełdak, Płuciennik 2017).

Conclusions

The presentation of legal and theoretical determinants for preparing the financial impact forecast associated with the adoption of the local development plan, as well as the prepared cost analysis having impact on the municipal budget and related to the implementation of the selected local spatial development plans, allowed formulating the following conclusions:

1. The estimated costs of preparing construction sites constitute a major challenge for the municipal budget. New construction sites require significant financial outlays to allow their development and subsequently to organize services for the local population.
2. The ownership situation of real properties covered by the local development plan is of significant importance in the context of the need to buy out land for the implementation of the municipality own tasks.
3. Another component of municipal policy included in the local development plan provisions is to avoid public roads planning (the plan in the area of Marszowice estate). Instead of offering public communication, the communication accessibility is planned through internal roads, the implementation of which does not have financial impact on the municipality and the owners of adjacent land.
4. Based on the example of selected local development plans it is noticeable that the level of costs to be invested in the local development plan implementation depends not only on the area covered by the plan, but also on the level of investment and development of this area. For this reason, e.g. in Germany, spatial development of a given location is possible only within the capacity of existing infrastructure network or provided it is properly expanded (Czaja-Hliniak, 2010).

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SPATIAL HETEROGENEITY OF LAND TAXATION IN UKRAINE: THE IMPACT OF DECENTRALIZATION

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Abstract
Starting in 2016, the process of financial decentralization began in Ukraine, in which local governments of lower levels (rural, urban, city councils and united territorial communities) were entitled to independently establish on their territory the rates of many local taxes and fees credited to community budgets. In particular, tax legislation of Ukraine allows local governments to vary land tax rates in the range from 0.1 to 3% of the normative monetary valuation of land, as well as to differentiate tax rates depending on the type of intended use of land plots. The study created a database and analyzed the spatial heterogeneity of land tax rates in more than 9.6 thousand communities. It is shown how the level of tax burden on land owners and land users, established by local self-government bodies, correlates with the economic development of the regions, as well as the normative monetary valuation of land, which is used in Ukraine as a tax base. The problems of taxation of real estate, which arise at the separate collection of land tax and tax for real property other than land, are considered, as well as suggestions on the necessity of introduction of tax zoning of territories in Ukraine, which will allow to further differentiate the rates of taxes on the property and provide more flexible and adaptive taxation of real estate.
Key words: decentralization, land-use, land tax, normative monetary, valuation of land, taxation.

Introduction

The world economic experience shows that the economic, social, political state of local development is better understood and can be reformed by local authorities. Successful top-ranked authorities have diverged from various resources and should be open to scrutinizing government functions that occur throughout the year (Khotenko, at al, 2017). It is the authorities that form the tax system, thereby determining the economic relations between the entities and the state (Vdovichenko, at al, 2019). Local authorities can create favourable conditions for economic growth on the ground, use all levers for the development of entrepreneurship, small and medium-sized businesses, help create new jobs and increase self-employment of the population. The process of transferring powers to places, increasing the capacity of local self-government and expanding its powers, transferred from the "centre to the grassroots level of territorial communities" on the principles of subsidiary, is an objective basis of decentralization, and at the same time, it is an integral part of the processes of reforming the territorial organization of power (Bila, 2015).

Land resources are an important factor in strengthening the financial self-sufficiency of territorial communities, especially in the context of decentralization of power. The unification of territorial communities creates favourable conditions for the growth of local budget revenues by improving the administration of land fees. Decentralization in the field of land relations will allow territorial communities to determine the land tax rate themselves. Communities should pay special attention to land fees. The land was, is and will be, and it should take appropriate fee. The tax legislation of Ukraine allows local governments to change land tax rates in the range from 0.1 to 3% of the normative monetary valuation of land, as well as to differentiate tax rates depending on the type of land use.

The normative monetary valuation of settlements' land, methodological provisions of which was developed by domestic scientists and teams of research institutions and design organizations, and gave the opportunity to establish the principles, directions, mechanisms of formation of land taxation, plays an important role in the regulatory policy of the state.

Issues of land taxation are investigated in the writings of such domestic scientists as: D.S. Dobriak, A.G. Martyn, L.Y. Novakovsky, A.M. Tretyak, M.A. Khvesyk and others. However, the present requires the continuation of research in this direction, taking into account the changes that have taken place under the influence of decentralization, which is especially important in the formation of local budgets.

That is why the article analyzes the spatial heterogeneity of land tax rates and the level of tax burden on landowners and land users.

Methodology of research and materials

The methodology of studying the problem of land taxation determines that the subject of the study is to determine the influence of local governments on land tax rates. It analyzes the changes in land tax rates in the context of financial decentralization, when local governments of lower levels have the right to independently establish on their territory the rates of many local taxes and fees charged to community budgets. The study of the level of tax burden on landowners and land users, established by local authorities, allowed to reveal the spatial heterogeneity of land tax rates. The tasks were solved using general scientific and special methods, namely: statistical - when generalizing statistical data, analyzing land tax rates; economic analysis - to determine the level of tax burden on landowners and land users; abstract-logical - to substantiate the purpose, objectives and conclusions of the study. The information base of the study was made by the current legislative and regulatory acts, statistical and analytical materials of the State Service of Ukraine for Geodesy, Cartography and Cadastre, Ministry of Finance of Ukraine and State Treasury Service of Ukraine.

Discussion and results

One of the main economic principles in the land policy of the state is the payment for the use of land. Land fee is an important source of local budgets, since it is fully counted towards the budgets of village, town, city councils and councils of united territorial communities at the location of land. In 2007, the share of land payments in the structure of tax revenues in local budgets was 8.7%, in 2015 - 15.1%, and in 2017 - 13.1% (see Figure 1). Land tax and land rent have been and are one of the main components of local tax revenues (Reserves of filling…, 2018).

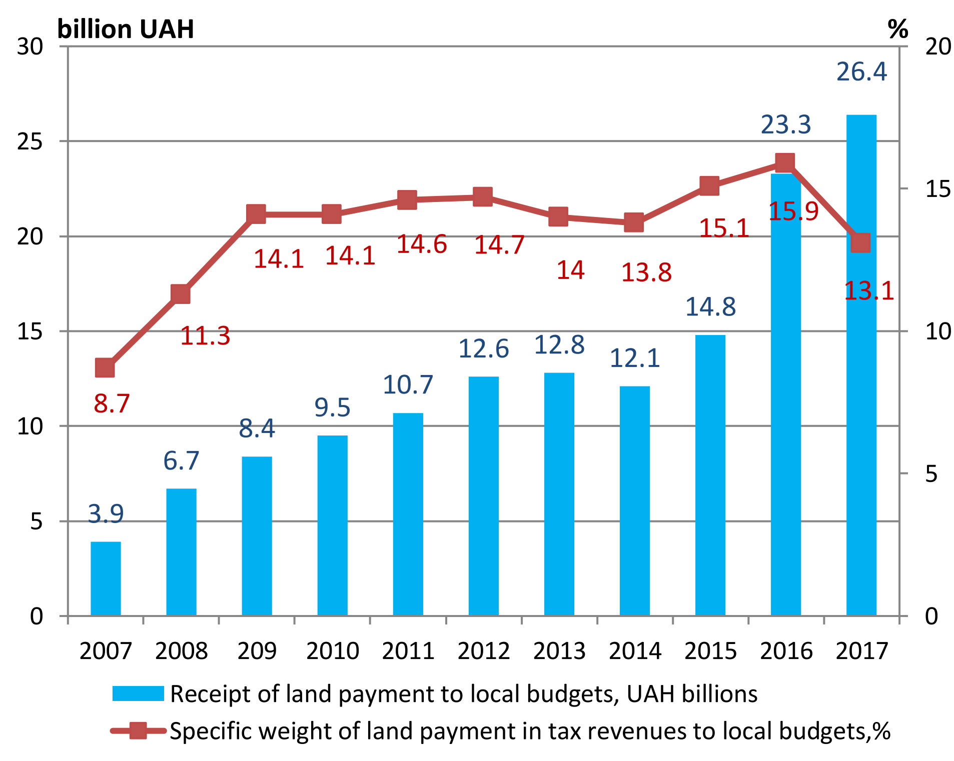

Fig. 1. Revenues from land payment and its share in tax revenues to local budgets *

* Calculated according to the data of the Ministry of Finance of Ukraine and the State Treasury Service of Ukraine.

Fig. 1. Land tax and land rent as one of the main components of local tax revenues

Significant growth in revenues from land payment to local budgets in 2016 and 2017 compared with previous periods is due to the termination of the Law of Ukraine "On Land Fee", which reduced the list of privileges, and the elimination of a fixed agricultural tax, expanded the base of collection land payments. Also, the allocation of payment for land in the category of "local taxes" played a positive role, which in some way influenced the efficiency of the administration of land tax and rent (Golyan, 2018).

Consequently, an important component of effective land relations is a well-balanced fiscal policy in the field of land use. Sustainable development of territorial communities can be ensured by improving the payment of agricultural land use, in particular, from payments for land (Martyn, Lisetskii, 2012).

The completeness of the receipt of funds from the payment for land depends on the powers of the controlling bodies that administer this fee and ensure the completeness and timeliness of payment to the corresponding local budgets of land tax and rent for land plots of state and communal property, as well as the powers of the same local councils, the competence of which is to decide on the establishment of payment for land in the respective territories, the completeness of the registration of all the land parcels actually used, which should ensure Ghana Derzhheokadastru and, of course, the proper exchange of information between all these bodies on subjects and objects of taxation of the land matched the result can ensure the proper collection of the fee.

Every year changes are made to the Tax Code of Ukraine, which change the procedure of taxation of individual taxes and fees. Thus, from January 1, 2019, the Law of Ukraine dated November 23, 2018 No. 2628-VIII "On Amendments to the Tax Code of Ukraine and certain other legislative acts of Ukraine regarding the improvement of the administration and revision of the rates of certain taxes and duties" came into force (Law of Ukraine On Amendments…, 2018). The changes and issues related to land payments, in particular, regarding the powers of local councils and the size of land tax rates, did not go away.

In accordance with clause 8.3 of Art. 8 of the Tax Code of Ukraine to local taxes and fees that are established in accordance with the list and within the limits of the maximum rates determined by this Code, decisions of village, town, city councils and councils of the joint territorial communities, established in accordance with the law and the prospective plan the formation of community territories within their authority and are obligatory for payment in the territory of the respective territorial communities (Tax Code of Ukraine, 2010).

Consequently, land tax, which is a part of the local taxes in the property tax, is implemented on the territory by the decisions of the village, settlement, city councils and councils of the united territorial communities. Therefore, when taxing land plots for land for payers is important is the correct application of relevant decisions of local councils. In turn, local councils in making such decisions should not exceed the powers granted to them, which are specified in Article 12 of the Tax Code of Ukraine. Thus, according to clause 12.3 of Art. 12 of the Tax Code of Ukraine, village, settlement, city councils and councils of united territorial communities established in accordance with the law and the prospective plan for the formation of community territories, within the limits of their authority, make decisions on the establishment of local taxes and fees. Establishment of local taxes and fees shall be carried out in accordance with the procedure established by this Code (Tax Code of Ukraine, 2010).

Having analyzed the level of tax in more than 9.6 thousand territorial communities, it was found that the tax rates for landowners and land users established by the local self-government bodies depend on the economic development of the regions and on the size of the normative monetary valuation of land that is used in Ukraine as a tax base (Figures 2-7).

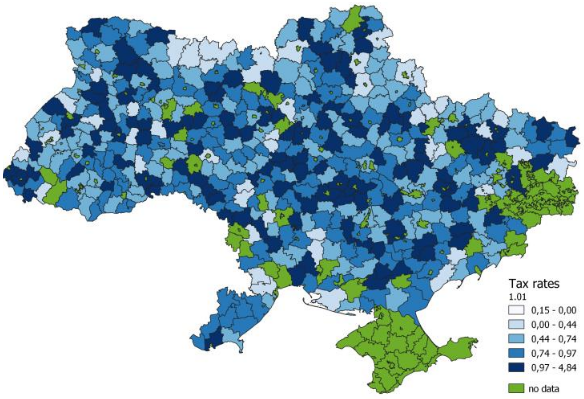

Fig. 2. Tax rates for commercial agricultural production, as of 01.01.2019

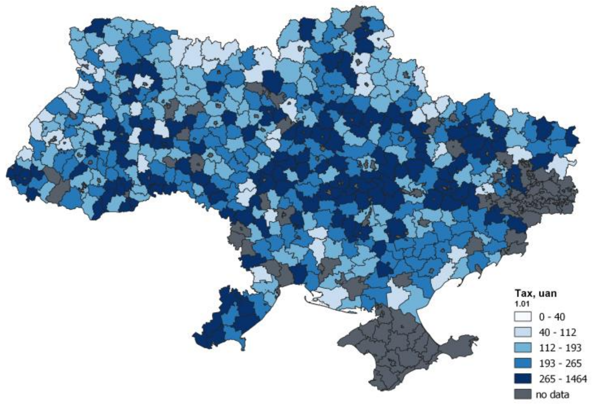

Fig. 3. The size of payment for land for commercial agricultural production on the basis of normative monetary valuation of arable land, as of 01.01.2019

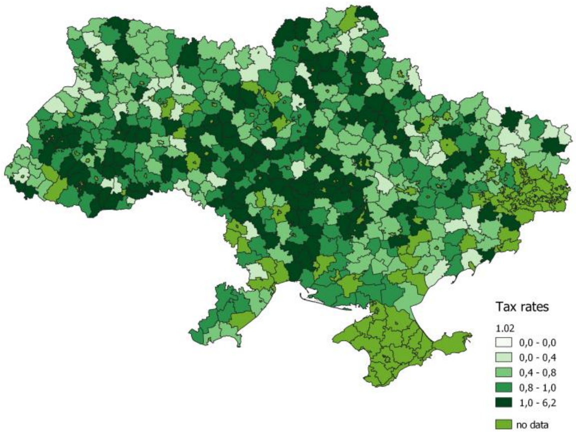

Fig. 4. Tax rates for farming, as of 01.01.2019.

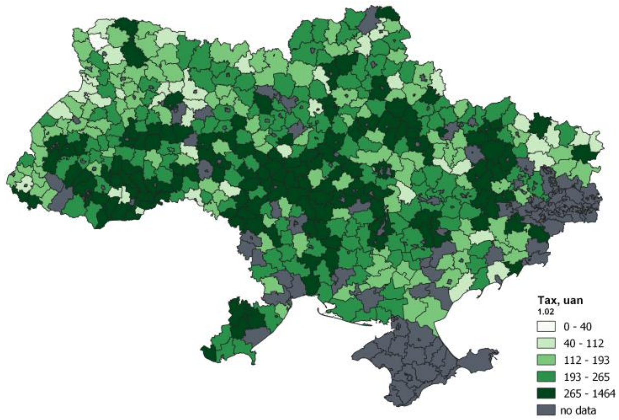

Fig. 5. The size of the payment for the land for farming on the basis of the normative monetary valuation of arable land, as of 01.01.2019

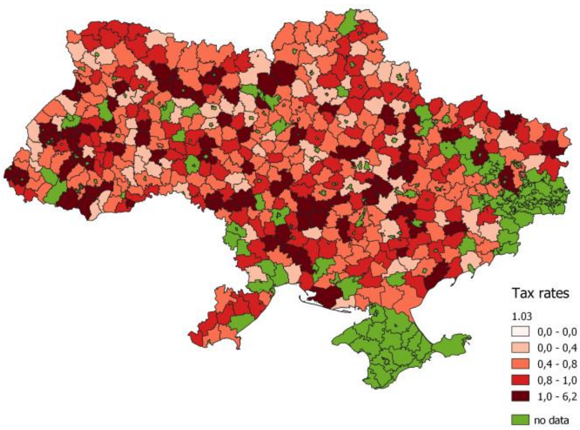

Fig. 6. Tax rates for conducting a private farm, as of 01.01.2019

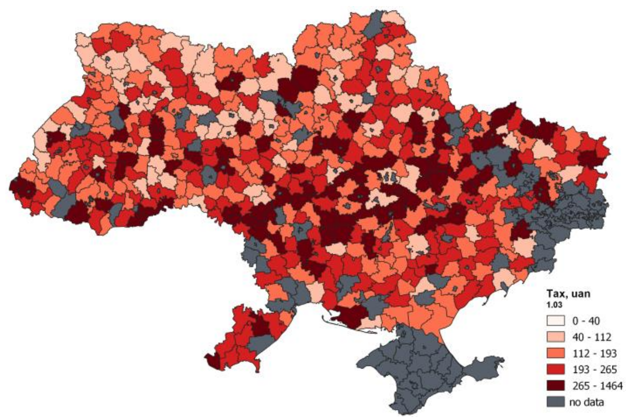

Fig. 7. The size of the payment for conducting a private farm on the basis of normative monetary valuation of arable land, as of 01.01.2019

As we see, there is no clear territorial dependence of land tax rates on normative monetary valuation. In addition, even within the same area, land tax rates can vary by almost 6 times. For example, let's consider the differentiation of the land tax of agricultural land by type of intended use in the Vinnytsia region, the vast majority of whose land is used for agricultural purposes and is a well-known agricultural region (Table 1).

Table 1.

Differentiation of the land tax for agricultural land in the Vinnytsia region, as of 01.01.2019

№	The name of the area	Normative monetary valuation 1 ha of arable land, UAH	Types of purpose land use		
			for the conduct of commodity agricultural production	for farming	for conducting a private farm
1	Barsky	21727.32	1.15	1.04	0.63
2	Bershadsky	32506.31	1.08	2.55	0.72
3	Vinnitsa	23469.82	1.39	1.44	1.26
4	Haysinsky	27794.18	0.45	2.30	0.34
5	Illinetsky	26035.72	1.03	1.00	1.00
6	Koziatynsky	30484.02	1.38	1.34	0.60
7	Kalinovsky	29250.77	0.53	0.49	0.63
8	Kryzhopolsky	30106.07	0.80	0.85	0.80
9	Lipovetsky	30919.64	0.82	0.88	0.82
10	Litinsky	21122.35	1.15	1.07	1,14
11	Mohyliv-Podilsky	25472.48	0.50	0.34	0.92
12	Murovani Kurylivtsi	21754.31	0.76	0.88	0.90
13	Nemirovsky	23933.67	0.94	0.96	0.86
14	Orativsky	28072.73	0.82	0.82	0.73
15	Sandstone	29159.96	1.84	1.67	1.56
16	Pogrebishchensky	26768.31	1.00	1.00	1.00
17	Teplicki	32890.39	0.93	0.,93	0,84
18	Tomashpilsky	26148.62	0.53	0.52	0.47
19	Trostyanetsky	27032.14	0.56	2.08	0.34
20	Tulchinsky	24546.00	0.33	0.33	0.32
21	Tyvrivsky	21982.56	0.90	1.59	1.02
22	Khmelnytsky	29961.27	0.86	1.35	0.61
23	Chernivtsi	28986.94	0.77	0.84	0.83
24	Chethelnitsky	29513.37	0.97	0.98	0.65
25	Shargorodsky	22645.20	0.56	0.53	0.40

The table shows how the level of tax burden on landowners and land users, established by local authorities, correlates with the economic development of the regions, as well as the normative monetary valuation of land used in Ukraine as a tax base. As you can see, the mechanism of payment for land for today does not work perfectly. So, the highest normative monetary valuation in Teplitskiy (32890.39 UAH / ha) and Bershadsky (32506.31 UAH / ha), and the tax rates in these areas differ considerably: in Teplitsky for commercial agricultural production for - 0.93, for the management of the farm – 0.93, for the personal farm management – 0.84, and in Bershadsky respectively – 1.08, 2.55, 0.72. Since land payments are an important source of budget revenues, the land-use payment system needs to be improved.

However, one can not unequivocally attribute the payment of land to property taxes. In addition to the payment for land, the property tax includes a tax on immovable property, different from the land plot. The tax rates for residential and / or non-residential real estate owned by individuals and legal entities are established by the decision of a village, settlement, city council or council of united territorial communities established in accordance with the law and a prospective plan for the formation of community territories , depending on the location (zoning) and types of such real estate at a rate not exceeding 1.5 per cent of the minimum wage, established by law on January 1 of the reporting (tax) year, per 1 square This is the tax base meter.

Today we used methods of calculating tax liabilities are imperfect and do not provide nor justice nor protection from corrupt abuse as requiring improvement. Land should be subject to taxation, taking into account the way of use, and not measured inside real estate objects. The tax rate should be the same for all countries, in particular. Neither individual civil servants or public authorities and local governments will have no impact on the amount of tax liabilities of taxpayers.

The approach in Ukraine to the taxation of real estate, different from the land plot, does not take into account the valuation of property, but defines the tax base, based simply on the area. This, of course,

simplifies administration. However, this method is unfair, because it does not take into account the differences in location and does not allow to reveal the positive potential of the property tax.
Excluding the tax on real property other than land, with land tax system will get the same rate of land tax throughout.

Conclusions and proposals

The fee for land has been and is one of the main components of tax revenues to local budgets. Land tax in a well-developed economy, especially at the local level, is a constant source of public expenditure on education, health care, infrastructure support for settlements, and the reproduction of land resources. Consequently, he must not only cope annually but also be an effective tool for the development of the territory.
As a result of our research, we found that local governments in Ukraine set the land tax in the range from 0.03 to 6.15%, which in absolute terms ranges from 6.54. Up to 1961.11 UAH per hectare. The highest tax rates are concentrated in the Kyiv and Vinnytsia regions, due to the fact that there are the highest rates of agriculture. At the same time, it should be noted that in Ukraine as a base for taxation of land, a normative monetary valuation of land is used, which is not based on the market value of land. This requires further improvement of taxation mechanisms, and tax rates in the present conditions can be used as an instrument that allows modelling the actual amount of tax payments in a situation where the tax base does not give an objective picture of the value of taxed areas.

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ROLE OF BROWNFIELDS REGENERATION IN SUSTAINABLE USE OF NATURAL RESOURCES

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Abstract
With growing importance of the global economy, one of the basic natural resources - intensity of land use - is also increasing, which often is the cause of land degradation processes. The causes and manifestations of brownfields are diverse, and their elimination is the first prerequisite for the sustainable use of land resources and development of each region. Improvement, maximal and efficient engagement in economic activity of brownfields is one of the key challenges for sustainable resource use that makes significant contribution to regional development. The reuse of brownfields has significant impact on sustainable development as it meets all three of its objectives: improving the economy, improving social cohesion and the environment. The aim of the article is on the basis of special literature examples to examine issues of sustainable development, evaluation and restoration of brownfields, transformation of brownfields into recreational areas, as well as further use of brownfields in cities and rural areas.
Key words: degraded territory, brownfield, land resources, regeneration, sustainable development.

Introduction

The land is non-renewable resource with limited accessibility, so it is very important to ensure conservation and sustainable use of beneficial properties of the land. With the growing importance of the global economy, intensity of land - one of the basic natural resources, also is increasing, which often is the cause of land degradation processes. Sustainable land management is a key factor in the rational use of land resources, including the reduction of land degradation and putting in order of degraded territories. At the end of 2014, Land Management law in Latvia was adopted, the main aim of which is to promote the protection and sustainable land use. Great attention in this law is paid to land and soil degradation issues. Two terms has been differentiated separately: soil degradation and land degradation. An explanation of the degraded area has been provided. Soil degradation is defined as changes occurring or on-going under the influence of natural processes and human activities, due to which the possibility to use the soil in the implementation of economic, environmental protection and cultural functions is reduced. Land degradation is defined as the reduction or disappearance of the economic or ecological value of land and associated resources as a result of natural processes or human activity or inaction. On the other hand, degraded area is explained as an area with damaged surface of the earth, or abandoned build-up, mining, economic or military activity territory (Land Management Act, 2014). This study explores the brownfields that have arisen as a result of land degradation processes.

Arrangement of brownfields, maximal and efficient its engagement in economic activity is one of the key challenges for sustainable resource use, which makes significant contribution to development of the regions. In recent years have been accepted a number of high-level decisions in regard to land and soil degradation and its prevention. In 2015 the General Assembly of United Nations adopted the resolution “Transforming our World: the Program 2030 for Sustainable Development”. This resolution sets 17 goals for sustainable development that includes an economic, social and environmental dimension.

One of objectives of environmental dimension (Objective 15) is - to renew degraded land and to try to achieve a world which is neutral to land degradation. In mentioned resolution has been stated an aim - to combat desertification by 2030, to renew degraded land and soil, including land affected by desertification, dryness and floods (United Nations …, 2015). Desertification has not been observed in Latvia however risk of land degradation exists. The process of formation of brownfields in Latvia has been similar to other Eastern European countries and partly to Western Europe. Most of the brownfields occurred after collapse of the Soviet Union. Their development was influenced by transition to market economy and changes in industry. Most typical brownfields are industrial sites and their infrastructure, abandoned military bases and sites where construction started many years ago but still is not completed. Compared to some Eastern European countries, such as the Czech Republic and Romania, total area of brownfields is considerably small in Latvia. According to the information given by Ministry of Environmental Protection and Regional Development, 5826 ha of municipal and private land is degraded (Gerhards, 2018).

The Land Management law emphasizes that objective of land degradation prevention measures is to eliminate the causes and consequences of degradation in order to promote sustainable land use. The causes and manifestations of brownfields are diverse, and their elimination is the first prerequisite for sustainable use of land resources and development of regions. The general objective of brownfields revitalization is to promote the sustainable development of urban and rural area: maximal elimination of brownfields thus contributing to environmental regeneration. This includes solving of environmental problems and increasing the economic efficiency of territory use, improving visual and structural functional quality of environment, as well as humanization elements of the social environment. Specific circumstances in each region determine which aspects should be more observed in the context of real situation. Also important factor is that providing arrangement of brownfields not only landscaping and functionally suitable areas which promote attractiveness and sustainability of the cities and towns are created, but also existing engineering networks and other communications have been economically used in these areas.

Several foreign and Latvian scientists dealing with spatial planning and sustainable development issues in their scientific publications have shared an experience in evaluation and restoration of various brownfields. Systematic approach to land degradation issues has been demonstrated in investigations of Western European scientists (Ferber, 2006), also significant contribution to this problem has been made by Central and Eastern European scientists (Barta, Beluszky, et al., 2006; Kunc et al., 2014; 2016; Frantal, Greer- Wootten et al., 2015; Martinát et al., 2014; 2016; Simion, 2016). Russian scientists have given an overview on transformation of brownfields into recreational areas (Быкова, Косточкина et al., 2018). Authors of this article during the planned study trip have familiarized themselves with nature in various types of former industrial objects and examples of brownfield regeneration in Germany and Poland (Industrial Lodz ..., 2018; Natur-Park Schöneberger ..., 2018; Park am Gleisdreieck, 2018).

Methodology of research and materials

The **purpose** of the article is to evaluate Latvian and foreign experience in brownfield regeneration on the basis of scientific literature and other information, as well as analyse its benefits.

To achieve this goal tasks were performed as follows:

- information on brownfields and their regeneration in foreign and Latvian scientific literature has been gathered and analysed;
- an overview on possible solutions in regeneration of brownfields and benefits of brownfield regeneration for development and sustainable use of resources has been made.

The **object** of research is degraded build-up area. As it can be seen from the explanation of degraded territory provided by the Land Management law, processes of land degradation can express in different ways. So far there were no criteria in Latvia for determining the existence of degradation, as well as classification of brownfields. According to the Land Management law, in 2019 the Cabinet of Ministers has developed draft of classification of types of land and soil degradation and rules for its evaluation, public discussion has been opened (Table 1).

Table 1 shows that degraded build-up territories are one of the types of land degradation and they can be divided into three sub-types: degraded residential or public build-up, industrial and military territories. In all cases there are located abandoned buildings, constructions or other objects that are not managed and endanger human health or life due to their physical wear and tear or harm the environment.

In the research scientific publications of Latvian and foreign scientists, knowledge and impressions obtained during planned study trip in Poland and Germany on regeneration of brownfields have been used. There general scientific methods of theoretical research: analysis and synthesis, induction and deduction, as well as monographic method have been used.

Table 1

Classification of types of land and soil degradation and order for its evaluation (draft, developed by Cabinet of Ministers of Latvia)

Type of land degradation	Sub-type of land degradation	Feature
Degraded build-up area	Degraded residential or public build-up area	Territory on which are located abandoned or incompletely used residential buildings or public buildings which do not fulfil their intended function, or which are not managed, or endanger human health or life due to their physical wear and tear, or harm the environment
	Degraded industrial area	Territory on which are located abandoned or incompletely used production facilities where economic activity has been suspended, or they do not fulfil its intended function, or they are no longer managed, or endanger human health or life due to their physical wear and tear, or harm the environment
	Degraded military territory	Territory on which is located abandoned military object, which do not fulfil its intended function, or is no longer managed and endanger human health or life due to physical wear and tear, or harm the environment
Degraded mineral extraction site	Non-recultivated mineral extraction site	Territory greater than 0.5 ha, where is located abandoned and non-recultivated mineral extraction site
Waste disposal at non-designated for this purpose sites	Waste disposal, preservation and storage in non-designated for this purpose sites	Territory on which is located waste deposit area or dumping-ground, which has not been recultivated after its closure and is not subject to monitoring and proper management. Territory where waste disposal, preservation and storage takes place in non-designated for this purpose sites
Land pollution	Pollution of the territory by hazardous substances	Territory in which local or diffuse contamination by pollutants has been detected to such extent as to pose a significant risk to normal functioning of the ecosystem and appropriate actions should be taken to mitigate this undesirable effect on the basis of the criteria laid down in regulatory enactments regarding soil and ground quality standards and regulatory enactments regarding surface and groundwater quality, as well as taking into account the regulatory framework for the identification and registration of polluted and potentially polluted sites
Spread of invasive plants	Territory infested with invasive plants	Unmanaged area where grows at least one invasive plant

Discussions and results

Studying scientific publications on land degradation problems it can be concluded that in the world, especially in Europe, there already has been developed some theory and experience of brownfields regeneration. Also it can be concluded that brownfields are developing in process of social and economic changes. Abandoned territories, visual collapse, symptoms of chronic unemployment and social stratification of society always have very negative economic and physical impact on the territory, and it shows the lack of social administration. Brownfields also are closely linked to the transformation of industrial society in post-industrial period. This means that strong changes not only in economy but also in spatial standards, land use, property governance and in people's lifestyles have happened. In post-industrial society much less space is needed for production, but much more for services, consumption and entertainment (Brownfields ..., 2010). In other countries the issue of brownfield regeneration began to play a prominent role in political programs in the 1970s. This means that the search for solutions with international approach has taken place for almost 50 years. Now they are closely linked to a wider range of issues of sustainable urban and regional development. The regeneration of brownfields not only strengthens the vitality and efficiency of urban area, but also helps to remove the developmental pressures of greenfields located on the outskirts of cities.

Reuse of brownfields has significant impact on sustainable development because it meets all three of its objectives: improvement of economy, social cohesion and environment. It helps to return unused land and improves land use economy. When economic activities return to degraded areas, firstly, these areas have been significantly improved and, secondly, areas of greenfields are preserved. New activities taking place on former brownfields create new opportunities for public, increase employment, income, etc. Remediation of brownfields can also improve social cohesion, prevent risks to the environment, protect cultural and historical values and improve quality of life. Development of brownfields has the added benefit strongly influencing the surrounding urban environment. Importantly, renovation of brownfields has positive impact on real estate prices in the territory. Further savings are achieved through the opportunities offered by existing resources and infrastructure (buildings, energy, sewerage networks, etc.) and transport options.

Customized planning suggestions that take into account public needs can maximize investment in brownfield redevelopment not only for the general public but also for builders and landowners. As a result, the sustainability of specific brownfields and the wider area is promoted.

One of the main drivers of brownfield regeneration is the economic revitalization of the urban area and potential profits. Assessing the impact of economic globalization and increasing difficulties on the current European real estate market, it can be concluded that the role of brownfields in supporting economic development and competitiveness in Europe has become increasingly important. This is most often case in traditional former industrial areas, where economic opportunities are increasingly becoming evident as a result of change of development of brownfields. Revitalization of brownfields is an incentive for economic development and it affects different market areas: land market, real estate market, labour market, capital market, financial market, resources market; infrastructure market; innovation market. The link between land market and real estate market with revitalization of brownfields has been identified as the most influential factor in the revitalization process (Brownfields. Handbook, 2010). Analysing foreign experience, it can be concluded that, irrespective of the end use of brownfields, aim is to develop sustainable localities with higher quality of life. In the past too little attention was paid to the areas where people live, work and spends their free time. One of the key elements of high-quality urban development is accessibility and good connection with open space. Essential importance for design of these public spaces has good quality of pedestrian and bicycle roads and public transport, as well as a great sense of space. Many of regenerated sites once have been an “engines” that fuelled the industrial revolution - coal mines, quarries and edges of channels. With the decline of heavy industry, often these vast territories became abandoned. Many of them were unofficially used as playgrounds and recreation areas, but mostly they fall by the wayside and become abandoned, sometimes dangerous.

There are many examples in the world with a long history and relevant experience, where public and commercial centres, museums and exhibition galleries, relax and recreation areas, amusement parks, sports centres etc. cultural objects for local public and visitors have been created. Often they change the habits of the city and people. The development of urban areas takes place on the basis of more efficient use of existing built-up land and with infrastructure for new construction and thus preventing new investments in the construction and maintenance of transport and other infrastructure (Barta, Beluszky, et al., 2006).

Getting acquainted with activities of several Eastern European countries (Czech Republic, Hungary, East Germany, Romania, Poland) in the regeneration of brownfields can be recognized several similar features. Major cities are undergoing major changes in functions. New activities take place in the premises of former industrial companies and in areas where military objects and railway lines were predominant. These spontaneous changes in post-socialist countries occurred in a shorter period of time than in Western Europe. As a result, rehabilitation of brownfields became one of the first issues of territorial development along with changes in property rights after cessation of industrial activity and real estate market reorganization after 1990. Functional changes are characteristic in industrial zones close to the city center and having other priority features to replace industry with other functions. More exposed to reconstruction are former production sites in industrial areas with good location, where it was easier and cheaper to reconstruct or completely demolish the buildings. Functional changes are also characteristic for less favoured areas of industry, where typical phenomenon is continuous preservation of previous buildings, simply replacing their earlier functions with commercial, warehouse and logistics functions. However, the growing importance in many abandoned industrial and infrastructure territories has feature of preserving industrial buildings and structures as monuments of the era and their use for cultural, educational and tourism purposes (Barta, Beluszky, et al., 2006; Frantal, Greer-Wootten, et al., 2015).

Summarizing and analysing scientific publications on regeneration of brownfield sites and evaluating benefits from it, several regularities and variants of brownfield regeneration can be distinguished.

Arrangement and construction of shopping centers is one of widely used forms of abandoned brownfields in Eastern Europe. The changed economic environment also created changes in consumer habits and retail activity. In 1990s on abandoned production sites having good location (proximity to underground railways, traffic junctions, good access) started construction of a new type of shopping centres. For example, in Budapest at the end of the 1990s already were 33 such shopping centres (Barta, Beluszky, et al., 2006), several shopping centers in Lodz (Poland), of which the multifunctional shopping and entertainment center "Manufaktura" which was created on the site of former textile factory particularly should be mentioned (Industrial Łodź ..., 2018).
Arrangement of science and technology parks plays an important role in the development of brownfield sites in several countries. Former industrial and military territories were transformed to parks, and if such parks were located near universities, there were created research and technology-oriented companies. An example of this can be mentioned Budapest (Hungary), where park "Infopark" and "Graphisoft Park" was arranged. "Infopark", established in 1996 was the first park of information and technological innovations in Central and Eastern Europe, first as an area for World Expo, but after closing of the exhibition in collaboration with two neighbouring universities there was established state-owned joint stock company "Infopark". It promotes innovations, research and development, and supports start-ups. Thanks to proximity of universities, as tenants mostly are IT and software development companies, providers of telecommunications and Internet service (IBM, Hewlett-Packard, Magyar Telekom, Panasonic, Maxell, etc.). It is planned that around 4500 people will be employed there. In the long run "Infopark" could become a regional high-tech center (Barta, Beluszky, et al., 2006).
Preservation of industrial heritage is the problem how to develop post-industrial space. It has been affected many countries around the world - from the United States, France, England and Germany to Eastern Europe. Everywhere rural municipalities are looking for ways to preserve and redesign former factory buildings. Often they are monuments - valuable examples of 19th and 20th century architecture and important relics of the past. Protection of historic buildings and monuments is deliberate interference in the historical process of over a hundred years, characterized by the transformation and replacement of architecture heritage. The existence of an industrial culture was very important in Europe, it has been the driving force of the economy since the Industrial Revolution. As a result of restructuring of global economy significant production capacity no longer exists. This process ended after political and economic changes in the 1990s. Emphasis now is placed on reorganization of the physical environment, closure of factories and renovation programs. Buildings are the majority of industrial heritage, but equipment and technological devices can also play an important role. Reconstruction of industrial architectural monuments started in the 1960s, to preserve industrial heritage in Western Europe an extensive research was carried out. Industrial heritage can be protected by the state as industry museums and open-air museums with technologically significant monuments, as well as industrial buildings and complexes as industrial and cultural monuments of their time. By preserving these monuments as museums and using modern technology, double effects can be achieved – combination of industrial heritage with cultural tourism. The increasing number of technical and scientific museums points to this effect. For example, several military, transport and industrial museums - metalwork's museum, a collection of electrical engineering, a museum of lifts, a museum of mills, a museum of fire fighting, etc. have been set up in Hungary. Successful example is the Millenaries Park, constructed in Budapest (Hungary), which is designed as comprehensive industrial rehabilitation project (Barta, G., Beluszky, et al., 2006). There are other examples of industrial heritage conservation in other countries, we can mention the old brewery in Poznan (Poland) (Stary Browar ..., 2019), the Zollverein Coal Mine Industrial Complex in Essen, Germany (Zollverein Park Essen, 2018) and others.
Development of cultural, educational and business centres is a part of national industrial heritage with its aesthetic values and individual look, suitable for cultural purposes. However, reconstruction costs are often very high, especially in case of monuments, and these costs are difficult to cover due to low profitability and non-profit character of cultural institutions. Use of industrial buildings for culture began in Europe in the 1960s and 70s as result of social and economic transformation, together with support for urban policy and at the same time with prestige large-scale publicly funded architectural and cultural investments, e.g. Pompidou Center, Musée d 'Orsay in Paris, Tate Modern, Millennium Dome in London. Qualitative cultural life strengthened individual character of cities in tough competition between them. There was an increasing role of rural cultural policy which promoted projects for creation of cultural institutions. Most of these projects were related to reconstruction of

former industrial buildings thus creating many symbolic values - protection of historic buildings, environmental protection, etc. Creation of cultural projects has added value to the economic and tourist attraction of cities and the value of urban land has also increased (Barta, Beluszky, et al., 2006).
The Art Factory (Fabryka Sztuki) in Lodz (Poland) is a complex of three buildings provided for representatives of creative industry. The Center for Culture and Entrepreneurship "Art Incubator" was opened in 2014 and there are located art studios, conference rooms, art production rooms, halls and galleries, coffee-bar and club. Other former post-industrial buildings also have been modernized and expanded to include 3D cinema, science center, planetarium, studio, workshops and laboratories, gallery, sound theatre, seminar and conference rooms. It should be noted that several former factories have been transformed into museum of the history of industry sector concerned, e.g. in former Geyer Biała Fabryka for more than half a century is acting the Museum of Textile History (Industrial Łodź ..., 2018). An important art center in Poland is the old brewery "Stary Browar" in Poznan. Now it is not only modern shopping center, but also cultural and educational center (Stary Browar ..., 2019).
There are also some excellent examples of transforming post-industrial objects into cultural and artistic objects in Germany. The best known is "Zollverein Coal Mine Industrial Complex" in Essen, which was granted the name of UNESCO's World Heritage Site in 2001 and is one of the most impressive industrial monuments on the planet. Since coal mining and industrial complex Zollverein has been closed in 1986, it has become as main object of art, culture and creative industries, attracting more than two million visitors a year. This building symbolizes structural changes in the metropolis of Ruhr more than any other (Zollverein Park Essen, 2018; Ferber, et al., 2006).
Arrangement of residential and office spaces can be the challenge of architecture, how to transform old abandoned industrial buildings into residential and office spaces. Former factories can be located in centers of cities and towns, they are more suited to both offices and apartments as the cities are growing. For example, one of the largest spinning factory of Lodz (Poland) founded the in 1825 now has been transformed into modern post-industrial living space. Monumental buildings were thoroughly renovated to emphasize the architectural features, while the creation of residential spaces is linked to the location of offices (Industrial Łodź ..., 2018). Examples of post-industrial transformations can be found in Latvia, too. Extraordinary residential complex "Gypsum Factory" in Riga is located on the bank of Daugava river and has wonderful panorama to Old Riga (Gypsum Factory, 2019).
Arrangement of parks for recreation and entertainment, amusement and sports activities is the problem how parks can be created in areas which are not intended for these purposes (shipyards, swamps, former factories or railway tracks) and on land that must first be cleared of harmful substances. In the some time heir historical memory should be preserved. Foreign experience shows that it is possible. Since 1980s, two to six new recultivated post-industrial parks have been created in European countries every decade.
There are many examples of parks that have developed instead of former industrial or other economic sites, mainly from the 80s to 90s of the last century. However, as one of the first landscape architecture objects can be mentioned Tilerie Park in Paris (France) established in 1564 on the place of former tile manufacturing factory. Whereas in 1985 instead of former slaughterhouse and livestock market of Paris was established park "La Villette", in 1987 - Cloth Park in Barcelona (Spain) instead of a former factory and railway track, in 1995 - amusement park "Wunderland Kalkar" in Germany in the former nuclear reactor area and others. Development of such parks in post-industrial areas has evolved in the 21st century, and their national spectrum is very diverse, for example, in 2000 - park "Promenad Plante" in Paris (France) instead of former railway viaduct, in 2001 - park in Chiang Mai city (China) instead of shipyard, in 2002 - MFO in Zurich (Switzerland) at the site of former engine production plant, in 2003 - "Parque da Juventude" in San Paulo (Brazil), former investigative isolator, in 2006 - Diagonal-Mar Park in Barcelona (Spain), in 2007 - Cliché-Batihniola park in Paris (France) instead of the former railway station, in 2011 - Dora park in Turin (Italy), etc. (Быкова, Косточкина, 2018).
The most recent examples should be mentioned several parks in Germany, which have been developed on place of former industrial sites, maintaining historical evidence of these places. The most outstanding of them are Gleisdreieck park in Berlin (Germany) established in 2011 on the area of former railway, and the natur-park Schöneberger Südgelände in Berlin which after 50 years of desolation was arranged around closed Tempelhof railway station. Both of these parks have become real oases of natural diversity and historical experience in the city.

Conclusions and proposals

In large cities of Europe are undergoing major functional changes. In post-socialist countries these changes have taken place in shorter period of time than in Western Europe. For reconstruction more exposed have been former manufacturing sites with good location.

Reuse of brownfields has the significant impact on sustainable development – improvement of economy, social cohesion and environment.

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RECLAMATION OF DAMAGED AGRICULTURAL LAND: AN EXAMPLE OF THE SAMARA REGION

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Abstract
The issues of environmental protection, prevention of degradation and reclamation of damaged land are currently very significant and relevant. As damaged land has been observed the land where low productivity and low economic potential have arisen and natural productivity of ecosystems is changed due to human-caused activities. The nature and extent of the violation depends on the type, depth and duration of anthropogenic impact, on adopted system of work organization and the conditions of the environment.
Black soil dominates in the soil cover in Samara region, therefore there has been developed agricultural production. However there are located large oilfields and gas fields, which are under active exploitation and reduction of vegetation, dumping technological sites, laying trenches for pipelines, etc. have been noticed, which leads to formation of technogenic soils, damaged land cover, loss of soil fertility and land use type change. There special restoration measure - reclamation should be putted into practice on the territory of all categories of land, but especially on agricultural land.
The aim of the article is to study the situation with damaged agricultural land in Samara region of Russia and to develop scientifically based proposals for regeneration of its fertility after reclamation measures. The problems of pollution of agricultural land in the region have been investigated, main sources and types of pollution have been analysed, as well as legal, methodological and environmental protection documents on land reclamation have been studied. The peculiarities of reclamation of land on federal, municipal and property level have been considered. The article presents measures for reclamation of the land on the example of natural monopolies in the territory of the Samara region
Key words: agricultural land, damaged land, land degradation, prevention of degradation, reclamation.

Introduction

The issues of environmental protection, prevention of land degradation, as well as recultivation of disturbed land currently are very significant and relevant. The term “disturbed land” includes land on which productivity of natural ecosystems has been changed as a result of economic activity. The nature and extent of the violation depends on the type, depth and duration of anthropogenic impact, on adopted system of work organization and the general situation of environment. On the territory of Russian Federation, as result of long-term intense anthropogenic impact of industrial enterprises of different profiles, there are large areas of disturbed land with various environmental changes (Ponomarev, Kaplunov et al., 2014; Smetanin, 2004).

Land use should be based on the following principles: preservation of fertile soils as a non-renewable natural resource used for agriculture and forestry; preservation of agricultural land areas as limited resources of exceptional value, improvement of their quality and productivity; etc. (Aleknavičius P., Aleknavičius M., 2016). Non-compliance with these principles inevitably leads to land degradation, which is a pressing issue for many countries (Pomelov A., 2014).

The purpose of the article is to study disturbed agricultural land and possibility of restoring their fertility after reclamation.

In order to achieve this goal, the following tasks were set:

- according to the analysis of statistical reports of the ministries of Samara region, Rosprirodnadzor, Rosresstra, etc., to study the dynamics of the agricultural land in the region and the development of reclamation;
- on an example of the project on rehabilitation of the disturbed lands at unapproved working out of building minerals, to consider works which are spent at recultivation of the earths in the Samara region;
- to study the modern system of land resources management at the federal and regional levels, to identify the shortcomings of this system and to propose ways of solving the problem.

In the Samara region, which is located in the southeast of the European territory of Russia in the Middle Volga region, black soil dominates in the soil cover, therefore the region has developed agricultural production. The area of agricultural land in Samara region is 4067 thousand hectares (on

01.01.18.) or 76% of total area of region. Arable land occupies 2.8 thousand hectares or 70% of total area of agricultural land (State report…, 2018).
On territory of region there are large gas and oil fields, which are being actively investigated and developed, as well as repair and restoration works, leading to oil spill. Large number of oil and gas pipelines on various levels passes through the territory of the region. In addition, solid mineral deposits (sand, limestone, chalk, marl, sandstone, shale, etc.) are being utilized. Mining is accompanied by the reduction of vegetation, arrangement of dumping sites, trenches for pipelines, etc., which leads to formation of man-made (technogenic) soils, to disturbed land cover, loss of soil fertility and land use change (Voronin, Vlasov et.al., 2013).
To prevent and correct negative effects of technogenic activities, it is necessary to carry out reclamation of the land (GOST 17.5.3.04-83, 1983). Reclamation is a complex of works on the restoration of disturbed land, fertility of which was lost as a result of economic or other activities (GOST 17.4.3.04-85, 1985; Recommendations…, 1983). It takes place on the territory of all categories of land, but it is very important on agricultural land (Collection…, 1987; The main provisions… 1995; On land reclamation…, 1994).

Methodology of research and materials
The statistical data of annual reports of Ministry of Forestry, Environmental Protection and Nature Management, of Federal Service for State Registration Office, Cadastre and Cartography (*Rosreestra*) regarding Samara Region on the state of the environment and natural resources and on the status and use of land have been reviewed.
Simple methods of mathematical calculations based on statistical reports were used to study the changes in the area of damaged lands by years, and methods of scientific analysis of literary sources were used.

Discussions and results
Area of agricultural land in recent years has been reduced annually due to its transfer to other categories of land, usually as a result of urbanization and development, as well as due to arrangement of linear objects. At the same time, agricultural land should be subject to special protection, because it has been used systematically for production of agricultural products. In recent years the area occupied by agricultural land in the Samara Region has not changed significantly (Table 1).

Table 1

Characteristic of agricultural land in Samara region

Type of land use	**Area**			
	2010	**2013**	**2016**	**2017**
Agricultural land, thousand hectares	4089.4	4070.1	4067.4	4067.2
Agricultural land of total area of Samara region, %	74.7	74.7	74.6	74.6
Arable land of total area of agricultural land, %	73.7	73.4	73.4	73.5
Fallow land of total area of agricultural land, %	2.4	2.6	2.6	2.6
Arable land, transformed from previously unused land, thousand hectares	X	X	7	3

Source: own elaboration, using statistical data of annual reports

On the territory of region orchards occupy an area of 42 thousand hectares, meadows - 67 thousand hectares, pastures - 847 thousand hectares, irrigated land - 141 thousand hectares. Area of mentioned types of land use also practically did not change over the last 10 years.
Land users in Russia are obligated to submit annually statistical reports, which contain information on recultivation of the land, removal and use of layer of fertile soil. This report should be submitted by land users or organizations engaged in construction, amelioration, forest exploitation, survey, as well as producing industrial, construction and solid household waste.
According to the statistical reports on reclamation of the land, on 01.01.2018 area of damaged land in Samara region was 1.8 thousand hectares. Volume of removed fertile layer of soil was about 4 million m^3. Table 2 shows the dynamics of changes in the area of damaged land in the Samara region over past three years (Table 2). Official statistical data about removed soil used for land reclamation purposes was not available.

Table 2

Area of damaged agricultural land in Samara region

	Year		
	2015	**2016**	**2017**
Area of damaged land, ha	1970	2329	1421
Land involved in turnover of agricultural land after recultivation, ha	X	529	1020
Removed fertile layer of soil, ha	1970	2254	1374
Removed soil used for land reclamation, thousand m^3	7058	5590	25690
Fertility of soil of unproductive land improved using removed soil, ha	X	X	6

Source: own elaboration, using statistical data of annual reports

The data show that in the Samara region over the past three years the area of damaged land changed. As positive measure should be noted that area involved in the turnover after the reclamation of agricultural land is growing. In 2017 started use of fertile upper humus-accumulative soil horizon to improve the properties of low-productive land, which was not observed in previous years. There was a rapid increase (about 4.5 times) of use of fertile soil for land reclamation (Report …, 2018; State report …, 2018).

On territory of Samara region there is an acute need for land reclamation (Voronin, Vlasov, Vasilieva, 2013). Development of land reclamation projects is an obligatory stage in the preparation of project documentation for construction of roads, power lines, oil pipelines, gas pipelines, railway lines and other facilities, as well as for the transformation of agricultural land to another category.

The cases of frequent occurrence of non-observance of environmental legislation, is illegal, unauthorized utilization of mineral resources (sand, gravel, etc.) for economic needs on agricultural land (Fig. 1).

Fig.1. Appearance of damaged land in case of illegal utilization of mineral resources

As a rule, in this case reclamation project should to provide environmental aspect of remediation. Chosen direction of reclamation is governed by the fact that such project is developed not for the entire land plot, but only for utilised territory, where shape of this territory is obtained by topographic vertical surveying.

At the site of utilization of mineral resources is going on formation of disturbed land, overgrown with weeds, often swamped, with reed-sedge vegetation or filled with water in case of close occurrence of groundwater.

Reclamation is carried out gradually in two stages: technical and biological (GOST 17.5.3.04-83, 1983). For technical stage the master plan for restoration of disturbed land should be developed. The technical stage includes formation of technogenic landscape on worked-out areas in order to create the relief that smoothly goes down with adjacent territory of optimal geometric parameters and favourable conditions for using the site for its intended purpose by flattening the pit walls (slopes), partially raising the bottom of the pit, carrying out levelling of territory, strewing fertile layer of soil, etc. Carrying out the technical stage of recultivation the layer of fertile soil should be removed depending on soil fertility level and main soil property indicators. The depth of the fertile black soil layer is usually determined to the depth of the humus horizon (A + AB). At the technical stage it is necessary to cut the upper soil horizon about 0.5 m deep, dump the grooves and make rough surface levelling. After completion of the work the fertile soil layer should be dispersed on formed relief for seeding of perennial grasses (Ponomarev, Kaplunov et al., 2014).

The biological stage includes complex of agrotechnical and phytomeliory measures in order to restore agrophysical, agro-chemical, biochemical, and other soil properties. Biological reclamation is subject to land used in agricultural production. On such disturbed land an accelerated seeding of perennial grasses should be carried out, which is the most effective method of improvement of the sites with strewed soil. The minimum term of a biological stage of recultivation (ameliorative period) is 1 year. In case of restoration of land for pasture the ameliorative period of restoration of fertility of the applied fertile layer is 3 years. Recultivation is carried out using conventional agrotechnical measures, including pre-sowing tillage, application of organic and mineral fertilizers, sowing of perennial grass seeds, etc. During this period measures to preserve strewed soil layer from erosion, to maintain its biological activity, soil structure and air-water regime, as well as the accumulation of organic matter and nitrogen in the soil should be used.

The reclamation project should provide creation of sustainable grass stand. Grass mixtures sown on the reclaimed land protect the soil from erosion and give high yields. Very important is selection of proper species of leguminous plants and perennial cereal grasses and their mixtures. It has been accepted - if mixed crops of perennial grasses belong to different families and biological groups, moisture and nutrients are more fully used, because their root systems are distributed in different layers of soil. In addition, grass mixtures of several types of perennial grasses are more sustainable than pure crops. As a rule, the presence of strewed soils increases the feasibility of erosion processes, so it is necessary to carefully select certain types of perennial grasses and their mixtures. Sown grass mixture should create a closed slam and strong turf. Sowing should be done in well prepared and moist soil. Compulsory agrotechnical method should be rolling up with ragged rollers before and after sowing. It helps to level the soil surface and improve work into the ground of seeds.

To restore damaged fertile soil layer and soil biota, it is necessary to apply increased doses of organic and mineral fertilizers. Especially effective is the application of organic fertilizers in addition to plant leftovers. Fertilizers improve the water-physical properties of soil, enrich the soil with organic matter, improve water and air permeability of surface horizons and contribute to enhanced release of carbon dioxide during decomposition of dead organic matter and plant respiration. Grazing on restored pasture (up to 4 years), also hay mowing (2 - 3 years) before strong turf has been formed is not recommended.

Another type of technogenic impacts on the territory of the Samara region is construction of infrastructure objects for operation of oil producing wells. It also requires preparation of project and reclamation of disturbed land. Often the technology of biological reclamation of disturbed land for fodder land has been applied. In case of construction of oil wells appears necessity of land acquisition in short-term lease for period of construction and land reclamation (temporary allotment) and long - term lease for period of operation of facilities (permanent allotment).

Control over implementation of measures for the preservation and reproduction of fertility of agricultural land is delegated to Federal Service for Veterinary and Phytosanitary Supervision (*Rosselkhoznadzor*) and the Federal Service for Supervision of Natural Resources (*Rosprirodnadzor*).
Rosselkhoznadzor on agricultural land carry out the control over:

- conservation and restoration of fertility of agricultural land, including reclaimed land;
- prevention of unauthorized removal, displacement and destruction of topsoil and damage of the land as result of mismanagement of pesticides, agricultural chemicals or other hazardous to human health and the environment substances and wastes of production and consumption.

Rosprirodnadzor carry out the monitoring of:

- land reclamation after exploitation of mineral deposits, construction, amelioration, logging, etc.;
- improvement of land properties and soil protection from wind and water erosion;
- prevention of other processes worsening qualitative properties of the land.

Rosprirodnadzor in the Samara region in 2018 as land control conducted 39 inspections. The main violations identified during inspections was unauthorized removal or movement of the fertile soil layer; destruction of a fertile layer of soil, as well as damage to land as a result of violation of the rules for handling pesticides and agrochemicals or other substances hazardous to human health and the environment, production and consumption waste.

After reclamation damaged land by the Permanent Commission on land reclamation, appointed by the municipal district administration should be transferred to land users, restoration of soil fertility should be confirmed. After completion of land reclamation, land should be classified to the relevant types of land use. In practice, the complex of land reclamation works often has been not fully implemented, while environmental deteriorates have been accumulated.

Thus, on the studied example of disturbed lands reclamation at unauthorized development of construction minerals in Samara region the progress of reclamation works was given. In the region the volume of these works is gradually increasing, after which the areas of agricultural lands are involved in circulation. The main way to solve the problem of reducing the area of disturbed lands is to improve the legal framework for land resources management, and in particular, to improve the mechanisms of land control. As in the Russian Federation at the federal level there is no single body for land resources management, these functions are divided into different ministries and federal agencies.

Conclusions and proposals

Summarizing the received information it is possible to draw a conclusion that the problem of recultivation of the disturbed lands is actual for regions with the developed industry and high density of the population to which the Samara region belongs. The difficulty in solving this problem is primarily due to shortcomings in environmental and land legislation at both the federal and regional levels.

Over past three years in Samara region the area of disturbed land was 1.4 – 2.3 thousand hectares. At the same time, after recultivation yearly 500 - 100 hectares of agricultural land were involved in production. In 2017 started use of fertile soil layer for improvement of unproductive land, which was not observed in previous years. Use of fertile soil for land reclamation increased very fast, from 5.5 thousand m^3 in 2016 to 25.7 thousand m^3 in 2017.

An important issue is development of regulatory framework in order to improve control over land reclamation, as well as creation of a single authority in land management sphere in Russian Federation.

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DIFFERENTIATION OF REQUIREMENTS FOR THE ACCURACY OF CADASTRAL SURVEYS: THE VALUE OF REAL ESTATE AS A DETERMINING FACTOR

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Abstract
For millennia, the geodesic industry has improved methods and technologies for obtaining information on the location of objects on the Earth's surface, whose key task has been to improve the accuracy and reliability of measurements. At the same time, in recent decades, the rapid development of positioning technologies based on satellite radio navigation systems has created prerequisites for a situation where the acceptable accuracy of determining the geodetic characteristics of real estate becomes quite affordable even when using non-specialized geodetic equipment, including personal mobile devices. The article shows that the error in determining the area of land for registration of rights to real estate has its own "cost", which depends on the value of real estate in the area of survey. By the example of model sites, it is shown that further improvement of the accuracy of engineering surveying to determine the spatial characteristics of real estate objects would be economically feasible only if the cost of geodetic surveys (including the cost of purchasing new geodetic equipment, payment for labor of specially trained engineers, additional technical services and etc.) will not exceed the "cost of error" to determine the area of the site. Using the example of Ukraine, it is shown that the most accurate geodetic surveys (determining turning points of land borders with an accuracy of more than 0.02 m) are economically feasible only when the market value of a land plot exceeds USD 208 per square meter.
Key words: accuracy, geodetic surveys, value of land, cadastral registration.

Introduction

At the current pace of development of satellite and network technologies, the role of man in performing topographic and geodetic surveys in the field of land management is decreasing. In particular, today the use of GNSS-technologies has practically replaced the basic methods of creating geodetic networks for various geodetic works (triangulation, trilateration, polygonometry), including the determination of the coordinates of the turning points of the land plot during cadastral surveys and land inventories, the establishment of boundaries of the land plot on the ground.
Existing differentiation of accuracy and cost of topographic and geodetic surveys, in particular, for the purpose of inventory of land, creates preconditions for further research in the field of engineering economics, namely:

- definition of the dependence of the cost of topographic and geodetic works in the field of land management on the accuracy of these works;
- estimation of the efficiency of using modern satellite technologies for the purpose of the real estate cadastre (especially when installing (fixing) the turning points of the land plot within the permissible error of 0.5 meters), and determining the prospects for using these mobile gadgets (smartphones, tablets, etc.) for these purposes;
- the establishment of acceptable accuracy of topographic and geodetic surveys in the real estate cadastre depending on the market value of the land plot.

Problems of establishing the requirements for the accuracy of land cadastral papers were undertaken by various scientists, in particular, Zhilinsky (2013) tried to investigate the influence of economic factors on the accuracy of geodetic measurements during cadastral works, and established, in the conditions of the city of Lviv, the size of the error of determining the area of land in cash equivalent (Жилінський, 2013).
Petrov and Tserklevich (2011), found that the change in the mean square error (MSE) of determining the coordinates of the points of land plots boundary proportionally affects the change in the MSE of their area.
Kristin M. Stock (1998) carried out a sociological study, in which she insisted on the accuracy of establishing the boundaries of the land in the countryside. It is determined that the overwhelming majority of surveyed landowners, including local authorities and relevant municipal organizations in the study area, require the maximum accuracy of establishing the boundaries of the land plot in the range of +/- 0.2 and +/- 0.5 m.

An analysis of the historical stages of the development of technologies in geodesy and their impact on the accuracy of land cadastral surveys is presented in the scientific publication Belle A. Craig and Jerry L. Wahl (2003).
At the same time Tim Burch (2017) in his article draws attention to the fact that the development of modern GNSS technologies reduces the relevance of the classical study of geodetic surveying methods and minimizes the role of a certified geodesist specialist in the implementation of various types of land cadastral work (Tim Burch, 2017).

Methodology of research and materials
The current state of the development of GNSS technologies allows you to get the coordinates of the points with the maximum possible accuracy of 1 meter (raw data by satellite observations) even under favorable observation conditions (PDOP, GDOP, etc.).
It is clear that for the purpose of land management, the accuracy of positioning in 1 m is not permissible, such circumstances directly influenced the development of appropriate positioning methods for achieving higher accuracy in determining the planned height position of the reference points: the static method; fast static; RTK – Real Time Kinematics.
However, the use of RTK mode involves receiving amendments from the base station, that is, from the receiver which is set at a point with a known (true) coordinate, points of the state geodetic network. To date, such base stations have permanent stations.
In Ukraine, the main organizations that hold national networks of GNSS permanent stations are private companies, as described in table 1.

Table 1

Analysis of Private Permanent Networks to Provide GNSS Surveillance Data Adjustment in Ukraine

Name	System Solutions	TNT TPI GNSS Network	Zak Pos
1	2	3	4
GNSS brand equipment offered by the company	Leica Geosystems	TOPCON	Trimble
The cost of services:			
Real-time positioning (RTK)			
1 hour	-	12 UAH	-
1 minute	4 UAH RINEX & Virtual RINEX – 1.20 UAH	0.70 UAH	1.75 UAH
1 month subscription	-	600 UAH	1 160 UAH
Subscription 3 months	5820 UAH	1600 UAH	-
Annual subscription	16080 UAH	5700 UAH	11 600 UAH
Post processing raw file in RINEX format	50 UAH	-	-
Equipment rental	1 day – 1000 UAH / day; 2-6 days – 800 UAH / day; 7-13 – days 760 UAH / day; 2 weeks – 8745 UAH; month – 17000 UAH	Do not provide such services (only the sale of equipment)	Do not provide such services
Precision farming	from 7000 UAH	from 900 UAH	-

The above information was taken into account when further development of the estimate of the cost of geodetic works in establishing the boundaries of the land plot (table 2).

Table 2

Calculation of the cost of geodetic works in relation to fixing the boundaries of the land plot

The level of acceptable accuracy for the purpose of inventory of land			GNSS technology		Estimate of the cost of geodetic works in relation to the establishment of the boundaries of the land plot ***				Number of employees	Cost of determining the boundaries of the land plot
			The type of the most effective method for achieving the correct accuracy	Geodetic binding	Cost of data on the coordinates of the item of the state geodetic network (reference points) *	Rent for the required geodetic equipment **	Cost of receiving RTK corrections **	Total		
I	a	up to 2 cm	Static	State geodetic network (reference points)	3×150 UAH = 450 UAH	Base + Rover (GNSS Leica GS08Plus (GS12) + CS10) – 2000 UAH/day; Tacheometer (Leica TS09plus R500 (5″)) – 1000 UAH/day;	-	3450 UAH	2	300 UAH / point (at the same time the minimum cost of departure of a surveyor is 1500 UAH)
I	b	2-10 cm	Real Time Kinematic (RTK)	Permanent stations + SGN point for calibration	150 UAH	Rover (GNSS Leica GS08Plus (GS12) + CS10) – 1000 UAH/day;	5820 UAH/3 month →1 day=65 UAH	1215 UAH	1	300 UAH / point (at the same time the minimum cost of departure of a surveyor is 1500 UAH)
II		10-20 cm	RTK	Permanent stations + SGN point for calibration	150 UAH	Ровер (GNSS Leica GS08Plus (GS12) + CS10) – 1000 UAH/day;	65 UAH/day	1215 UAH	1	300 UAH / point (at the same time the minimum cost of departure of a surveyor is 1500 UAH)
III		20-50 cm	RTK	Permanent stations	-	Ровер (GNSS Leica GS08Plus (GS12) + CS10) – 1000 UAH/day;	65 UAH/day	1065 UAH	1	300 UAH / point (at the same time the minimum cost of departure of a surveyor is 1500 UAH)

*- according to the Research Institute of Geodesy and Cartography [2];
**- according to System Solutions (Table 1);
***- in the indicated estimate there are no calculations for logistics costs, since these data are individual for each object.

In Ukraine, in accordance with the Resolution of the Cabinet of Ministers of Ukraine dated May 23, 2012, No. 513 "On Approval of the Procedure for Land Inventory Management", the error of determining the turning points of land plots relative to the nearest points of the state geodetic network should not exceed (Resolution of the Cabinet …, 2012):

- in Kyiv, Sevastopol and cities of regional subordination – 0.1 meters;
- in other cities and towns – 0.2 meters;
- in villages – 0.3 meters;
- outside of settlements – 0.5 meters.

The stated allowable accuracy of determining the position of the turning points of the land plot on the ground, we have been based on the analysis of the cost of topographic and geodetic works, namely:

- when choosing effective methods of creating a reference geodetic network – the most accurate differential method in the application of GNSS technologies is the "Static" method, which allows to determine the position of points (sampling ground) to 1 mm, and then, with the help of the geometry, fix the boundaries of the land plot to within 10-20 mm; At the same time, the application of the polygonometric method, in modern technologies, is inappropriate, except for the presence of dense building, densely planted areas – forest arrays, etc.
- in determining the required geodetic equipment and the number of performers. According to the above methods, for the purpose of achieving the appropriate precision, we have identified the kits of the required equipment and presented their market lease payment (System Solutions. Rental…),

determined on the basis of (Table 2) the amount of payment for receiving RTK corrections, and the cost of coordinates of the outgoing points of the State Geodetic Network (Official website. State…).

It is important to note that at the time of drafting the estimate of the cost of land cadastral works for fixing the boundaries of the land, the rate of USD – 28.12 UAH / $ (official data of the National Bank of Ukraine as of 18.09.2018), and the average wage in Ukraine – 7621 UAH / month ($ 271) (Official website. Pension …).

Thus, from the above calculations in Table 3, we have the cost of geodetic works for fixing the boundaries of the land plot with an accuracy of I-a of 45.27% of the average monthly salary in Ukraine and requires two executors, and II – 15.94% (one performer), III – 13.97% (one performer).

In fact, we have established a direct correlation between the accuracy and cost of topographic and geodetic works in relation to fixing the boundaries of the land plot on the ground, that is, what is "higher precision" so "higher price".

Discussions and results

According to the results of our analysis, we can further speak about the dubious necessity of conducting high-precision geodetic surveys (in view of their high cost) for the purpose of land cadastre, in particular, inventory of land and the establishment of boundaries of land in the area. We believe that achieving high accuracy in conducting geodetic works in the field of land cadastre is an indirect necessity, which should be determined based on the market value of the surveyed land plot.

Subsequently, our studies concerned the definition of acceptable accuracy of land cadastral work, which in our opinion, should be determined on the basis of economic factors. That is, in order to find out the expediency of implementing high-precision topographic and geodetic works in the field of land cadastre, it is necessary to compare the error of the definition of the area and market value of the corresponding land with the cost of geodetic works.

Conditionally, if a plot of land has the shape of a rectangle whose sides a and b are defined with average square errors m_a and m_b accordingly, then the error of determining the area of the land S, according to the theory of errors, will be determined by the formula:

$$m_S^2 = (\frac{\partial S}{\partial a})^2 \times m_a^2 + (\frac{\partial S}{\partial b})^2 \times m_b^2 \quad (1)$$

We find partial derivatives:

$$\frac{\partial S}{\partial a} = b; \frac{\partial S}{\partial b} = a \quad (2)$$

Having defined partial derivatives we have the general formula for determining the error of the area of the land plot of a rectangular shape, with certain errors in measuring the length (m_a) and width (m_b):

$$m_S^2 = b^2 \times m_a^2 + a^2 \times m_b^2 \quad (3)$$

Thus, mathematically proved and quite understandable is the fact that the error in the area of the land will be directly affected by the error of determining the linear elements (boundaries) of the land.

Consequently, in general, if the value of f is expressed in terms of independently measured values x_i (i = $\overline{1, n}$) – the coefficients, then the mean square error m_f of the value of f will be

$$m_f = \pm\sqrt{\sum_{i=1}^{n} a_i^2 \times m_i^2} = \pm\sqrt{[a^2 \times m^2]} \quad (4)$$

If the measurements x_i (i = $\overline{1, n}$) are equivalent and $m_1 = m_2 = \ ... \ = m_n = m$, then:

$$m_f = \pm m\sqrt{[a^2]} \quad (5)$$

The resulting formula for the mean square error is obtained from the relation::

$$m_F^2 = (F_x')_0^2 \times m_x^2 + (F_y')_0^2 \times m_y^2 + \ ... + (F_u')_0^2 \times m_u^2, \quad (6)$$

and expressions for partial derivatives of f for arguments x_i:

$$\frac{\partial f}{\partial x_i} = a_i, (i = \overline{1,n}). \quad (7)$$

At the same time, the function to determine the area of the land plot with known coordinates of the turning points, will have the following form:

$$S = \frac{1}{2}\sum_i^n X_i(Y_{i+1} - Y_{i-1}) \quad (8)$$

In this case, the margin of error in determining the area of the land will be determined by the following formula:

$$m_s = \sqrt{1/4\sum_{i=1}^n\{(X_{i+1} - X_{i-1})^2 \times m_y^2 + (Y_{i+1} - Y_{i-1})^2 \times m_x^2\}} \quad (9)$$

where m_x, m_y – mean square error of the coordinates of the turning points of the land plot.

In the course of our study, we determined the margin of permissible error in determining the area of land. To do this, simulation of the size of the land plot, which in shape corresponded to the figure of the rectangle, with different perimeters (lengths) of the parties in the range from 0.01 ha to 5 hectares. The average quadratic error in determining the position of turning points was determined in accordance with the Resolution of the Cabinet of Ministers of Ukraine dated May 23, 2012 No. 513 (Resolution of the Cabinet …, 2012) (Table 3).

Table 3

Calculation of the error of the area of land

№	Placement of land [1]	The average square error of determining the position of the turning points of the land (m) [1]	Calculation of the error of the area of land, m²					
			Land area, ha					
			5	1	0.5	0.25	0.10	0.01
			Perimeter, m					
			895	400	283	200	128	40
1	Kiev, Sevastopol city and cities of regional subordination	to 0.02 (high precision)	17.9	8	5.66	4	2.56	0.8
		0.1	89.5	40	28.3	20	12.8	4
2	in other cities and towns	0.2	179	80	56.6	40	25.6	8
3	in villages	0.3	268.5	120	84.9	60	38.4	12
4	outside of the settlement	0.5	447.5	200	141.5	100	64	20

Thus, we have calculated the errors in determining the area of land ($S_1 = 0.01\ ha$; $S_2 = 0.10\ ha$; $S_3 = 0.25\ ha$; $S_4 = 0.50\ ha$; $S_5 = 1.00\ ha$; $S_6 = 5.00\ ha$), taking into account the errors of the position of the turning points ($m_1 = 0.02\ m$; $m_2 = 0.1\ m$; $m_3 = 0.2$ м; $m_4 = 0.3\ m$; $m_5 = 0.5\ m$) (table 3).

The next stage of our study was to determine the acceptable accuracy of establishing the boundaries of the land due to its market value. Taking into account the data of Table 2 (cost of topographic and geodetic works) and table 3 (size of errors in land parcels) and taking into account the norms of the current legislation (Resolution of the Cabinet …, 2012), we determined the minimum size of land values to achieve cost-effective implementation of high-precision geodetic measurements in the field of inventory of land (table 4).

That is, we justified the marginal market value of the land plot, in which the implementation of topographic and geodetic works of appropriate accuracy will be economically feasible in the field of land cadastre.

From the data obtained (Table 4), it is safe to say that precise geodetic work (determination of the position of the turning points of the land plot to 0.02 m), in view of their high cost, in comparison with other, it is expedient to carry out in cases where the market value of 1 m² the land plot reaches 207.59 m² / $ when establishing boundaries of a land plot with a total area of 0.01 hectares; 64.87 m² / $ –

land area of 0,10 hectares; 41.52 m² / $ – land area of 0.25 hectares; 29.34 m² / $ – land area of 0.50 hectares; 20.76 m² / $ – land area of 1.00 hectares; 9.28 m² / $ – land area of 5.00 hectares.

Table 4

Economic feasibility of the implementation of topographic and geodetic works

I – Economic feasibility of carrying out topographic and geodetic works with high accuracy						
1-a) mean square error of determination of the position of the turning points of the land plot to 0.02 m						
Land area, ha	5.00	1.00	0.50	0.25	0.10	0.01
Error in the area of the land, m²	17.90	8.00	5.66	4.00	2.56	0.80
Market value of land to achieve economic effect, 1m² / $	9.28	20.76	29.34	41.52	64.87	207.59
II – Economic feasibility of carrying out topographic and geodetic works with the correct accuracy						
1) mean square error of the definition of the position of the turning points of the land plot of 0.1 m						
Land area, ha	5.00	1.00	0.50	0.25	0.10	0.01
Error in the area of the land, m²	89.50	40.00	28.30	20.00	12.80	4.00
Market value of land to achieve economic effect, 1m² / $	0.96	2.16	3.05	4.31	6.74	21.56
2) mean square error of the definition of the position of the turning points of the land plot of 0.2 m						
Land area, ha	5.00	1.00	0.50	0.25	0.10	0.01
Error in the area of the land, m²	179.00	80.00	56.60	40.00	25.60	8.00
Market value of land to achieve economic effect, 1m² / $	0.48	1.08	1.52	2.16	3.37	10.78
3) mean square error of the definition of the position of the turning points of the land plot of 0.3 m						
Land area, ha	5.00	1.00	0.50	0.25	0.10	0.01
Error in the area of the land, m²	268.50	120.00	84.90	60.00	38.40	12.00
Market value of land to achieve economic effect, 1m² / $	0.32	0.72	1.02	1.44	2.25	7.19
4) mean square error of the definition of the position of the turning points of the land plot of 0.5 m						
Land area, ha	5.00	1.00	0.50	0.25	0.10	0.01
Error in the area of the land, m²	447.50	200.00	141.50	100.00	64.00	20.00
Market value of land to achieve economic effect, 1m² / $	0.19	0.43	0.61	0.86	1.35	4.31

At the same time, given the high cost of high-precision geodetic equipment and the rapid development of modern telecommunication technologies (smartphones, tablets) with the support of positioning technologies (GNSS-technology), it is extremely important to provide a scientific and practical evaluation of the use of these electronic gadgets in the implementation of land -capital works (surveying, inventory of land, establishing boundaries of the land plot on the ground), especially when the marginal error of the performance of these works must be achieved in range 20 – 50 cm, depending on the location of the land (in other cities and towns – 0.2 meters, in villages – 0.3 meters, outside the settlements – 0.5 meters (Resolution of the Cabinet …, 2012)).

For example, to date, Xiaomi has been developed and offered to users, the new flagship Xiaomi Mi 8, equipped with a dual-frequency GPS module L1 + L2. In fact, the Mi 8 is now the most accurate GPS-module on the market among smartphones, which can actually be used for land cadastral works, provided that there is adequate software (coftu) for receiving RTK corrections from GSM base stations (Groupe Special Mobile) – channel (GPS Worldwide Laboratory …).

The urgency of the use of modern electronic gadgets for geodetic measurements, is confirmed by studies conducted by NextNav (2018) (GPS World Staff, 2018). In the course of the study, vertical position accuracy was determined, with the help of different models of phones and signals from the installed network of beacons NextNav. The services provided by NextNav's Metropolitan Beacon System (MBS) allow mobile phones and other devices to reliably determine their location in space, enclosed spaces, and urban environments where GPS signals can not be obtained.

With regard to special applications for smartphones, for the full use of GNSS technologies, an interesting development is the soft product "GNSS Compare" (Tracy Cozzens, 2018). This software displays general information about GNSS satellite systems, allows the user to choose, the best satellite constellation for precise positioning, compare the performance of signals between different satellite systems, and so on.

Conclusions and proposals

As a result of the calculation, we obtained the following results, in particular, with an average square error of the installation of turning points up to 2 cm, a land plot of 0.01 hectares (rectangular – 4 turning points), the error of the area will be 0.8 m², 0.10 hectares – 2.56 m², 0.25 ha – 4.00 m², 0.5 ha – 5.66 m², 1 ha – 8.00 m², 5 ha – 17.9 m².

Accurate surveying (determining the position of the turning points of land to 0.02 m), because of their high cost, compared with others, it is advisable to in cases where the market value of 1 m² of land reaching 207.59 m² / $ in determining the boundaries of the land plots with a total area of 0.01 ha; 64.87 m² / $ – land area of 0.10 hectares; 41.52 m² / $ – land area of 0.25 hectares; 29.34 m² / $ – land area of 0.50 hectares; 20.76 m² / $ – land area of 1.00 hectares; 9.28 m² / $ – land area of 5.00 hectares..

We are convinced that in the near future the development of technologies (software) in the field of telecommunications, satellite positioning techniques, GNSS-technologies will allow ordinary landowners to carry out land-cadastral surveys of their land plots (up to 0.5 m accuracy) with the help of modern smartphones. This is confirmed by the tendency to use gadgets (special software, in particular, Pix4D, DJI Go, etc.) and UAVs in cadastral surveys, which have changed the general pursuit of aerial photography, photogrammetry as a whole. As a result, existing technologies have allowed users to process the results of photographing automatically.

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EFFICIENCY OF INTERPOLATION METHODS BASED ON GIS FOR ESTIMATING OF SPATIAL DISTRIBUTION OF PH IN SOIL

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Abstract
The main objective of this study is to review and evaluate three common interpolation methods namely: Inverse Distance Weighting (IDW), Radial Basis Function (RBF) and Ordinary Kriging (OK), and generate maps of soil pH using these methods. The accuracy and efficiency of the generated maps have been examined as well as the most fitting technique for estimating spatial distribution of soil pH in the study area is identified. Studies were conducted within the limits of land use of RUP "Uchkhoz BGSHA" (Republic of Belarus, Mogilev region, Goretsky district). The total area of the surveyed territory is 3197.89 hectares. For the analysis data is used about pH_{KCl} of soil solution obtained from materials of an agrochemical survey executed in 2014. Forecasting and visualization of the spatial distribution of pHKCl was carried out using the Geostatistical Analyst module of the ArcGIS software. The experimental anisotropic variograms were calculated to determine the possible spatial structure of soil pH. Based on cross-validation results, a polynomial function was identified as the best variogram model. The model created by the method of radial basis functions turned out to be the most suitable for forecasting purposes (the value of the root-mean-square error was 0.763). In terms of interpolation accuracy, the investigated deterministic and geostatistical methods are located in the next descending row: RBF> IDW> OK.
Key words: geospatial analysis, pH_{KCl} of soil solution, interpolation, spatial distribution.

Introduction

Rational use of land resources is one of the most important factors in the modern development of the Republic of Belarus. Monitoring the state of land becomes a reference point for public authorities for developing regulatory legal acts regarding their use, conducting territorial planning, implementing measures to protect land and reproduce soil fertility. The economic efficiency of land use and the efficiency of agriculture generally largely depend on the quality of land resources the quality of which, in turn, is determined by the fertility of their soil cover.

Acid-baseline state is one of the most important factors of soil fertility and causes numerous features of the behavior of chemical elements in the soil ecosystem. Regimes of organic matter and elements of mineral nutrition are associated with it, as well as the mobility of various compounds, including those that are toxic to plants. Indicators-constants, to which the pH of the soil solution belongs, are the main source of information on basic ecological permanent soil. Therefore, it is extremely important to predict the spatial distribution of soil pH for assessing the state of the soil system and planning measures for the rational use of land resources and the reproduction of soil fertility.

Geostatistics is an effective method for studying the spatial distribution of soil characteristics and their inconsistencies. A number of researchers have used Geospatial methods and the comparison of their effectiveness in assessing the spatial relationship of the agrochemical properties of soils and the geographic variability of soil characteristics (Zandi et all, 2011; Liu et all, 2014; Behera, 2015). In particular, the research of Indian scientists is devoted to the problems of assessing the suitability of various interpolation models for studying the spatial distribution of organic matter in soil depth of 0–20 cm (Gouri et al., 2016). Another study compared the effectiveness of different interpolation methods to estimate the spatial distribution of the upper pH and EC in Hamadan Province, Western Iran (Attaeian et. al., 2016). Scientists from Turkey evaluated interpolation approaches to characterize spatial variability of soil organic matter, phosphorus, lime and boron in soil in the Tuz lake basin (Taha et al., 2017). Scientists from Lithuania tested several geo-statistical and interpolation methods for monitoring the spatio-temporal evolution of ashes in peat soil after a fire (Martin and Jord, 2013). The problems of assessing the suitability of various interpolation models for studying the spatial distribution of soil properties are devoted to studies of Russian (Simbatova et al., 2016; Samsonova et al., 2017) and Ukrainian (Moskalenko, 2012; Kohan et al., 2013) scientists. However, in the scientific literature there is not enough information about the development of this area of research in the territory of Belarus.

In this paper, both deterministic and geostatistical methods were investigated. The choice of methods was based on two requirements: 1) ease of use in practical activities of land management organizations; 2) accuracy in predicting the spatial distribution of the pH of the soil solution. Among the determined methods, the following were investigated: Inverse Distance Weighting (IDW) and Radial base Function (RBF) while among geostatistical methods Ordinary Kriging (OK) was studied. The performances of interpolation methods were evaluated and compared using the cross-validation. Cross-validation model statistics were compared to determine the model with the lowest values of the average error (ME) and the mean square error (RMSE).

Methodology of research and materials

The purpose of this study was to compare the effectiveness of various interpolation methods – the Inverse Weighted Distance method (IDW), the Radial Basis Function method (RBF) and Ordinary Kriging (OK) to estimate the spatial distribution of soil pH within the land use of RUP "Uchkhoz BGSHA" (Fig. 1), and estimate the use of cross-validation to assess the accuracy of spatial modeling and identification the most suitable method.

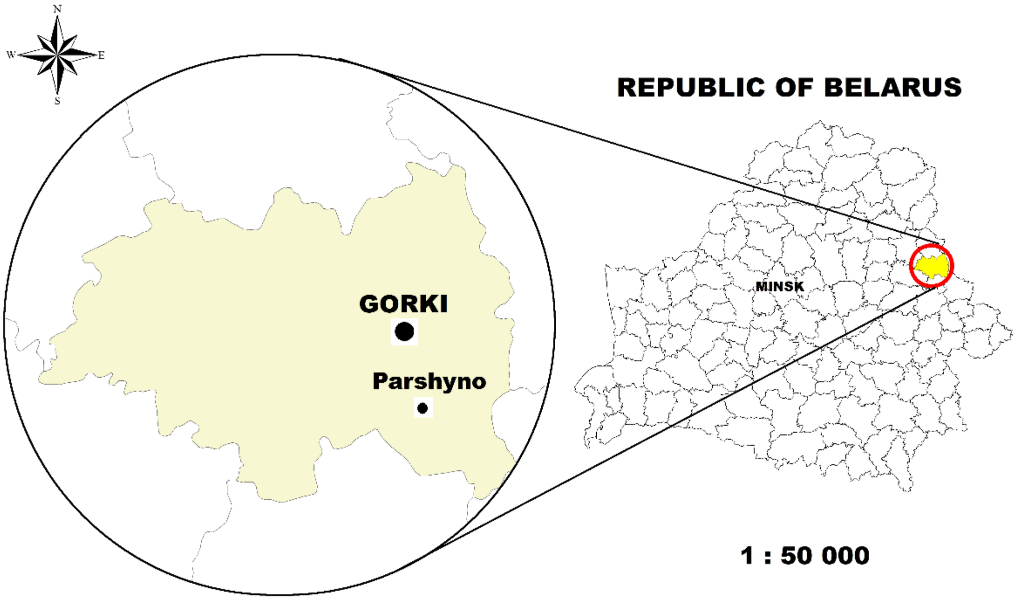

Fig. 1. The location of the studied territory

Geospatial analysis of data was carried out using the Geostatistical Analyst module of the ArcGIS software version 10.2. The data obtained from the materials of the agrochemical survey of the territory of RUP "Uchkhoz BGSHA" (Republic of Belarus, Mogilev region, Goretsky district), executed in 2014 by the Mogilev Regional Design and Exploration Station of Agrochemicalization were used for the analysis. The total area of the surveyed territory is 3197.89 hectares. The soil cover of the study area is represented mainly by sod-podzolic sandy loams on water-glacial sandy loams soils and sod-podzolic loamy on loesslike loams soils.

In the present study, deterministic (create surfaces from measured points) and geostatistical (utilize the statistical properties of the measured points) interpolation methods were used. We used the method of Inverse Distance Weighting (IDW) and the method of Radial Basis Functions (RBF) among the deterministic interpolation methods, as well as Ordinary Kriging (OK) among the geostatistical methods.

The IDW is one of the most applied and deterministic interpolation methods in the field of soil science. IDW estimates were made based on nearby known locations. The weights assigned to the interpolating points are the inverse of its distance from the interpolation point. Consequently, the closest points are made-up to have more weights (so, more impact) than distant points and vice versa. The known sample points are implicit to be self-governing from each other (Robinson and Metternicht, 2006; Gouri et al., 2016).

$$Z(x_0) = \frac{\sum_{i=1}^{n} \frac{x_i}{h_{ij}^{\beta}}}{\sum_{i=1}^{n} \frac{1}{h_{ij}^{\beta}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where $Z(x_0)$ is the interpolated value,

n representing the total number of sample data values,
x_i is the ith data value,
h_{ij} is the separation distance between interpolated value and the sample data value,
ß denotes the weighting power.
Radial basis function (RBF) predicts values identical with those measured at the same point and the generated surface requires passing through each measured point. The predicted values can vary above the maximum or below the minimum of the measured values (Li et al., 2011; Gouri et al., 2016). RBF method is a family of five deterministic exact interpolation techniques: thin-plate spline (TPS), spline with tension (SPT), completely regularized spline (CRS), multi-quadratic function (MQ and inverse multi-quadratic function (IMQ). RBF fits a surface through the measured sample values while minimizing the total curvature of the surface (Johnston et al., 2001; Gouri et al., 2016). RBF is ineffective when there is a dramatic change in the surface values within short distances (Cheng and Xie, 2009; Gouri et al., 2016). In this study spline with tension (SPT) was selected.
Ordinary kriging method incorporates statistical properties of the measured data (spatial autocorrelation). The kriging approach uses the semivariogram to express the spatial continuity (autocorrelation). The semivariogram measures the strength of the statistical correlation as a function of distance. The range is the distance at which the spatial correlation vanishes, and the sill corresponds to the maximum variability in the absence of spatial dependence (Gouri et al., 2016). Kriging estimate $Z(x_0)$ and error estimation variance $\sigma_k^2(x_0)$ at any point x_0 were, respectively, calculated as follows (2) and (3):

$$Z(x_0) = \sum_{i=1}^{n} \lambda_i Z(x_i) \qquad (2)$$

$$\sigma_k^2(x_0) = \mu + \sum_{i=1}^{n} \lambda_i \gamma(x_0 - x_i) \qquad (3)$$

where λ_i are the weights,
μ is the lagrange constant,
$\gamma(x_0 - x_i)$ is the semivariogram value corresponding to the distance between x_0 and x_i (Gouri et al., 2016).
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 (Gouri et al., 2016), the semivariogram is expressed as follows (4) (Wang, Shao, 2013):

$$\gamma(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [Z(x_i) - Z(x_i + h)]^2 \qquad (4)$$

where $\gamma(h)$ denotes semi-variant,
h denotes the lag interval,
Z denotes soil property parameter,
$N(h)$ denotes the number of pairs of places separated by the distance lag h,
$z(x_i)$ and $z(x_i+h)$ denotes the values of Z at the positions x_i and $x_i + h$.
The interpolation accuracy was determined from the mean error (ME), mean square error (RMSE), average standard error (ASE) and standard error RMSS (5), (6), (7) (8) (Myslyva et al., 2018):

$$ME = \frac{\sum_{i=1}^{N} (O_i - S_i)}{N} \qquad (5)$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N} (O_i - S_i)2}{N}} \qquad (6)$$

$$ASE = \sqrt{\frac{\sum_{i=1}^{N} \sigma^2(S_i)}{N}} \qquad (7)$$

$$RMSSE = \frac{RMSE}{\Delta} \qquad (8)$$

where O_i denotes the observed value,
S_i denotes the predicted value,
N denotes the sample size,
σ denotes the dispersion,
Δ denotes the range equal to the difference between the maximum and minimum observable values.

Discussions and results

The application of the module "Geostatistical Analyst" for spatial modeling of distribution pH_{KCl} of soil solution provides a preliminary assessment of the initial data for their suitability for modeling purposes. As a result of the use of tools for exploratory analysis of spatial data, a histogram of the distribution of initial data is created and the form of their distribution is investigated, as well as the basic statistical characteristics of the sample are calculated (Table 1).

Table 1

Statistical characteristics of a sample of data on pH of the soil solution used to construct interpolation models, n = 70

Indicator name	Indicator value			Sd	Cv, %	Med	Kurtosis	Skewness
	min	max	mid					
pH_{KCl}	3.50	7.30	5.93	0.79	13.4	6.10	0.68	-1.03

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

Preliminary evaluation of the data makes it possible to establish the necessity of carrying out their transformation with the subsequent modeling of the distribution surface. If the data distribution differs significantly from the normal one, you need to convert them. In particular, if the data is asymmetrically distributed, the logarithmic transformation that approximates the distribution to normal is applied to such data. In our case, although the variation coefficient of 13.4 % indicates that the data sample is quantitatively homogeneous, the distribution of data is not normal and requires a logarithmic transformation. In particular, this is evidenced by the values of the Kolmogorov-Smirnov coefficient and the Pearson's acceptance criterion (Fig. 2). Moreover, the magnitude of the coefficient of kurtosis less than zero indicates the flatness of the actual distribution of data compared to normal as well as the value of the coefficient of asymmetry -1.03 indicates the skewness of the distribution of data to the left.

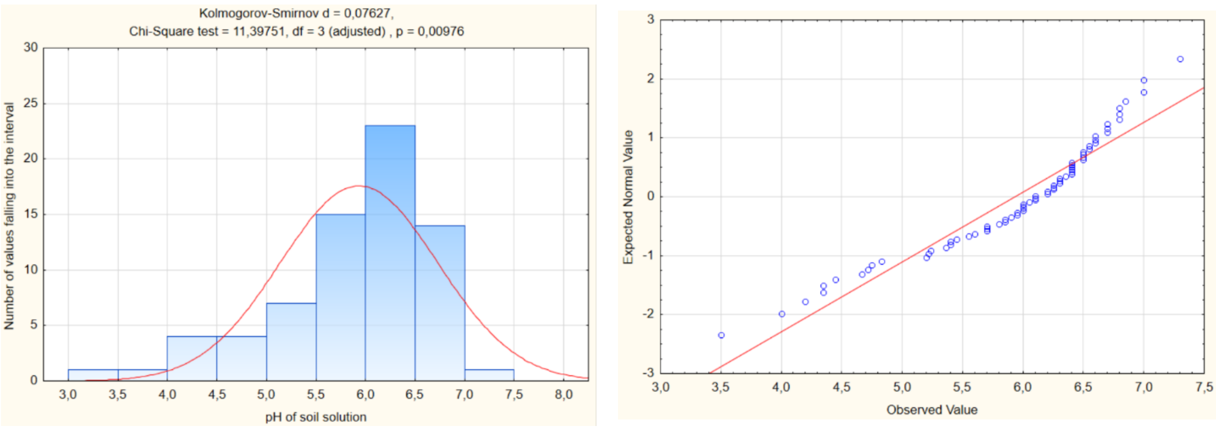

Fig. 2. Frequency histogram and normal probability plot of the pH of the soil solution, soil layer 0-20 cm

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

The experimental anisotropic variograms were calculated to determine the possible spatial structure of pH of the soil solution. The polynomial kernel function and spherical semivariogram model were identified as the best, the type of the circle was standard, the type and the number of sectors was 4 with a displacement of 45^0, and the lag was 100 meters. The results of estimating the predictive models generated by the ordinary kriging method are presented in Table. 2.

The best model was chosen based on five criteria: mean error (ME), mean square error (RMSE), mean square normalized error (RMSS), mean standard error (ASE) and the difference between RMSE and ASE. In this study, the spherical variogram model in most cases meets the requirements for the best model.

Table 2

Results of cross-validation of semivariogram models

Kernel function	ME	RMSE	RMSS	ASE	RMSE-ASE
Semivariogram model – Spherical					
Exponential	0.0072	0.812	0.955	0.872	-0.060
Polynomial	-0.0012	0.772	1.051	0.747	0.025
Gaussian	-0.0013	0.775	1.076	0.738	0.037
Semivariogram model – Exponential					
Exponential	0.0098	0.814	0.905	0.909	-0.095
Polynomial	0.0113	0.822	0.928	0.899	-0.077
Gaussian	0.0130	0.827	0.942	0.896	-0.069
Semivariogram model – Gaussian					
Exponential	-0.0023	0.831	1.021	0.842	-0.011
Polynomial	0.0030	0.822	0.997	0.857	-0.035
Gaussian	0.0046	0.826	1.006	0.855	-0.029

Note: a semivariogram kernel function that allows selecting a function for selection a plane when using kriging

The interpolation methods under study were implemented to estimate the values of the unmeasured data on the pH of the soil solution and to create surfaces from the predicted points. The parameters used in the interpolation models and used to create soil pH prediction maps are presented in Table 3, and the visualization of the prediction results is shown in Fig. 3.

Table 3

Parameters of interpolation methods used to create soil pH forecast maps
(type of search area – standard; sector type – 4 sectors with a displacement of 45^0; angle – 90^0)

Inverse Distanse Weighting (IDW)	Radial Basis Functions (RBF)	Ordinary Kriging (OK)
Power parameter: 2.5335 Search area: min = 10; max = 15	Search area: min = 10; max = 15 Kernel function: spline with tension; kernel parameter: 0.0806	Search area: min = 2; max = 15 Kernel function: polynomial; semivariogram model – spherical

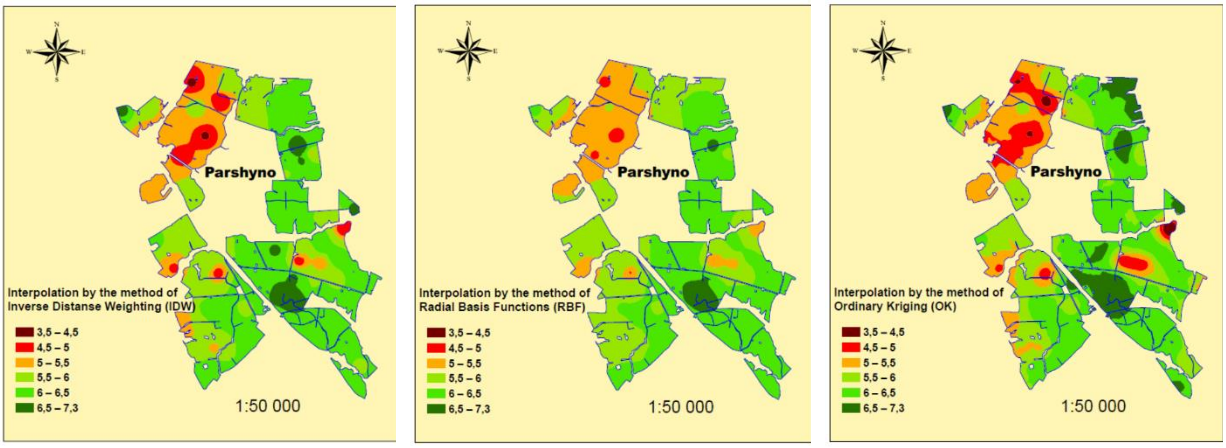

Fig. 3. Prediction maps of soil pH distribution

Because of the interpolation methods of RBF and IDW during the cross-validation procedure only two criteria are defined – the average error (ME) and the mean square error (RMSE), the comparison of the effectiveness of the methods for soil pH prediction was carried out by these indicators. The most suitable for forecasting purposes was the model created by the method of radial basis functions, the value of the root-mean-square error of which was 0.763 (Fig. 4).

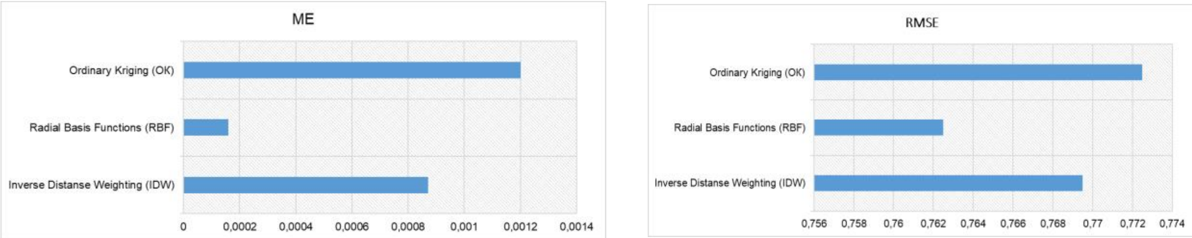

Fig. 4. Results of cross-validation of predictive models of the pH of the soil solution

In terms of interpolation accuracy, the investigated deterministic and geostatistical methods are located in the next descending series RBF> IDW> OK (Tab. 4).

Table 4

Differences between the actual and predicted spatial distribution of the pH of the soil solution

Range of values	**Land area falling in the interval, ha**					
	Interpolation method IDW		**Interpolation method RBF**		**Interpolation method OK**	
	1	**2**	**1**	**2**	**1**	**2**
< 4.5	28.94	26.12	2.11	-0.71	29.45	26.63
4.51–5.0	159.59	117.34	47.54	5.29	246.22	203.97
5.01–5.50	480.89	-91.69	586.21	13.63	515.36	-57.22
5.51–6.0	887.22	-156.99	1021.48	-22.73	797.26	-246.95
6.01–6.50	1488.79	47.21	1449.10	7.52	1278.35	-163.23
6.51–7.0	152.46	58.01	91.45	-3	331.25	236.8

Note: 1 – predicted value; 2 – difference between predicted and actual value.

The IDW method interpolates the surface with sufficient accuracy if the sampling points are relatively normally distributed and the surface is uniform. In our case, none of these conditions is fulfilled: the sampling points are unevenly distributed, clustering takes place, and the steepness of the slopes of the study area varies from 0.5 to 10.0 degrees. Therefore, this method is not suitable enough to predict the spatial distribution of the pH of the soil solution.

Kriging is the optimal interpolation method if the data meets certain conditions: normally distributed, stationary and no trends. Since, in our case, the data are not normally distributed and their transformation is required as well as the presence of a trend in their spatial distribution is established, the use of the ordinary kriging method to predict the spatial distribution of the pH of the soil solution is also impractical.

The RBF method approaches the construction of a surface through measured values while minimizing the total curvature of the surface and is ineffective when an abrupt change in values occurs over short distances. This phenomenon is absent in our case, and the change in the studied indicator is rather smooth, which causes the high efficiency of the RBF method for interpolation. The possibility of using this method to predict the spatial distribution of soil acidity is also indicated in studies carried out by Iranian scientists (Attaeian et al., 2016).

Conclusions and proposals

Among the interpolation methods that have been studied, the most optimal method for predicting and mapping the spatial distribution of soil pH is the radial basis function method, which provides the root-mean-square error of the average predicted values at 0.763. Both the interpolation method IDW and the RBF method require adjusting the power parameter and determining the optimal search radius to improve the prediction accuracy. Although the IDW method is relatively easy to use and does not provide for the calculation of standard interpolation errors, in our case it provided higher accuracy in predicting the spatial distribution of soil pH compared to ordinary kriging.

The choice and use of the most optimal interpolation method for predicting the spatial distribution of soil pH largely depends on the characteristics of a particular set of experimental data as well as on the spatial characteristics of the territory for which the prediction is performed. Consequently, in each particular case, the selection of the optimal interpolation method should be performed according to the specific conditions and characteristics of the data, and the definition of a single universal interpolation method is not possible.

Further studies should be concentrated in the direction of comparing the results of interpolation obtained for the pH of arable and subsurface soil horizons.

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APPLICATION OF UNMANNED FLYING VEHICLE FOR OBTAINING DIGITAL ORTHOFOTOMAPS

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Abstract
Nowadays, surveys using unmanned aerial vehicles is becoming popular. The resulting orthophotomap is the final product for creating digital plans and cardboard.
The objectives of the study are to study the possibilities of obtaining orthophotomaps from survey materials using unmanned aerial vehicles based on the results of the experiment.
The article describes various types of aerial photography. Some types of unmanned flying vehicles to conduct aerial photography for the purpose of monitoring, engineering surveys, inventory of agricultural land, and crop forecasts are considered. A description of aerial photography surveying is given on the example of the city of Dzerzhinsk, Minsk Region, which is performed taking into account the unmanned flying vehicles of GeoScan 201 and the Republican agricultural aero-geodesic unitary enterprise BelPSHAGI. A description of the GeoScan Planner software and basic pre-flight preparation is given. The stages of the preparatory work before the aerial photography, the creation of the planning and high-altitude geodetic justification, the implementation of aerial photography procedures, the steps of the aerial photograph anchorage procedure are considered. Agisoft Photoscan, which allows to get clouds of points, surfaces, 3D models and orthophotomaps using digital raster images are presented. The map of heights (DEM) of the terrain and the orthophotomap was made on the basis of a dense points cloud. According to the results of the research, a conclusion was made on the possibility of using aerial photography materials obtained using unmanned flying vehicles to get orthophotomaps of the required accuracy.
Key words: Unmanned Flying Vehicle, orthophotomap, photographs, Agisoft PhotoScan.

Introduction

Orthophotoplan is a photographic plan of the area on the accurate geodetic basis, obtained from aerial photography or aerospace survey, with the transformation of images by means of orthorectification.
Cartographic information for the construction of orthophotos is collected through aircraft measurements made with analog cameras, however, it’s expensive. Another possibility is to use space-based imagery, but the accuracy of coordinates obtained from these images is insufficient. Unmanned aerial vehicles provide images with sufficient accuracy of coordinate points , and the cost of aerial photography is reduced (Создание ортофотопланов, 2019).
Surveying with the use of unmanned flying vehicles is becoming increasingly popular. Digital orthophotomaps obtained as a result of unmanned aerial photography filled with vector data and linked to external databases are used as the final product in geographic information systems, as well as the planned background for creating digital topographic plans and cardboards. Unmanned flying vehicles provide images with sufficient accuracy of coordinate points, and in this case geometric accuracy of landscape elements on orthophotomaps should be very high according to the current regulatory documents. Aerial photographs from the unmanned flying vehicle GeoScan 201 were used to carry out experiments.

Methodology of research methods and materials

The research methods are the experiment to study the possibility of using materials from unmanned flying vehicles for creating digital models of landscape elements, and for building orthophotomaps. The main source materials are photogrammetric digital aerial photography 1: 2000 scale in Minsk region.

The discussion of the results

Aerial survey of the area for the purpose of creating and updating public topographic maps and plans is carried out in accordance with the long-term general mapping plan for the territory of the Republic of Belarus, which is approved by the State Property Committee of the Republic of Belarus and agreed upon with other involved government bodies in the prescribed manner (Общие технические условия…., 2008).

Aerial surveys are made to create and update public topographic maps of 1:10 000 - 1: 100 000 scales, state topographic plans of 1: 2 000 - 1:10 000, 1:25 000 scales and are carried out by organizations of the State Committee on Property and the Ministry of Defense of the Republic of Belarus.
The dates and venue of aerial surveys are consistent with the Ministry of Defense of the Republic of Belarus and the Aviation Department of the Ministry of Transport and Communications of the Republic of Belarus in the prescribed manner.
If aerial surveys need to be performed for the territory adjacent to the State Border of the Republic of Belarus, it is additionally necessary to coordinate this work with the State Border Guard Committee of the Republic of Belarus, the Ministry of Foreign Affairs of the Republic of Belarus, the State Security Committee of the Republic of Belarus in the prescribed manner.
The object of aerial photography is areas of the earth's surface with defined boundaries indicated in the technical project for the production of aerial surveys.
For the purpose of creating and updating state topographic maps and plans, the following types of aerial photography are distinguished: areas; separate routes; frame route systems.
Aerial photography of the area is made with the purpose of obtaining materials for creating and updating public topographic maps and plans, creating special maps and photographic documents, as well as for drawing up and updating city plans.
Aerial photography of separate routes is carried out with the same purpose of obtaining materials on linear and small terrain objects: railways and highways, gas and oil pipelines, narrow land bands (border areas), small settlements, etc., when aerial photography is impractical.
Aerial photography of frame routes is carried out with the purpose of obtaining materials for creating a planned-high-altitude geodetic base necessary for the subsequent photogrammetric thickening of the network of reference points on the basis of aerial photography materials.
Accounting for the performance of aerial photography, verification of aerial photography materials in terms of completeness and quality, as well as the preparation of these materials for transmission in the prescribed manner to the State Cartographic and Geodesic Fund of the Republic of Belarus are carried out by organizations carrying out aerial survey in accordance with the requirements of technical regulatory legal acts.
Upon completion of the production of aerial surveys, the State Property Committee and the Ministry of Defense do not exceed 15 working days in accordance with the procedure established by the legislation, aimed at excluding images of special regime and regime objects from aerial photography (Общие технические условия…., 2008)..
Unmanned flying vehicles are used for both civil and military purposes: for operational aerial photography, broadcasting, search and rescue, reconnaissance and surveillance, maintaining law and order, etc. Unmanned flying vehicles are of great variety, their design and size depend on the tasks intended.
In addition to topographical surveys, unmanned technologies are used for various forms of monitoring, the objects of which can be unauthorized dumps of solid household waste, linear objects such as power lines, pipelines and transport infrastructure. Also, an unmanned flying vehicle solves the problems of determining the volumes of earth masses and their dynamics in the development of open pit deposits and quarries. Compared to space monitoring, an unmanned aerial vehicle provides disproportionately more relevant information. The agricultural sector has recently become one of the main consumers of this technology. Agricultural holdings and large agricultural associations with large areas of undeveloped and open areas are interested not only in the production of engineering and geodesic surveys for the reconstruction and new construction, but also in monitoring and inventorying farmland, assessing crop germination, yield forecast, monitoring erosion processes (Технический кодекс установившейся …., 2008).
An unmanned flying vehicle is an aircraft without a crew on board that uses the aerodynamic principle of creating lift using a fixed or rotating wing, equipped with an engine and having a payload and duration of flight sufficient to perform special tasks.
To perform aerial photography one unmanned flying vehicle is not enough. Aerial photography complex, which is a combination of an unmanned aerial vehicle, its instrumentation, payload and ground control station, is required.
The payload for aerial photography tasks is a digital camera, as an addition a video camera, a thermal imager, an infrared camera can be used.
Aerial photography from an unmanned flying vehicle with the installation of appropriate imaging equipment allows to get digital images of super high spatial resolution of up to 2 cm.

The ground control station performs the tracking flight, receiving data, transfer of control commands.
Unmanned flying vehicles are distinguished by the method of control: manual control, automatic control, semi-automatic control.
It should be noted that ultralight unmanned flying vehicles do not allow equipping them with sophisticated high-precision imaging equipment, since they are significantly limited in payload weight. In addition, these devices are strongly influenced by weather conditions (Макаров, 2012).
The world has a large number of unmanned flying vehicles, differing in their specifications and characteristics.
In the Republic of Belarus, unmanned flying systems of the “mini” class are being developed with a range of 20 to 70 km, which, depending on the target load, are capable of photo, video, infrared or multispectral imaging using optical systems installed on a gyro-stabilized platform, in the light and dark of a day. A large range of target load capabilities and high aerodynamic qualities of aircraft allow the use of unmanned flying vehicle "Busel" (Fig. 1), "Busel M" and "Busel M50" to detect emergencies, monitor the condition of areas with oil and gas pipelines, combating poaching, keeping animals in check, monitoring traffic flows on the roads, controlling the state border, monitoring the condition of power lines and agricultural land, etc.

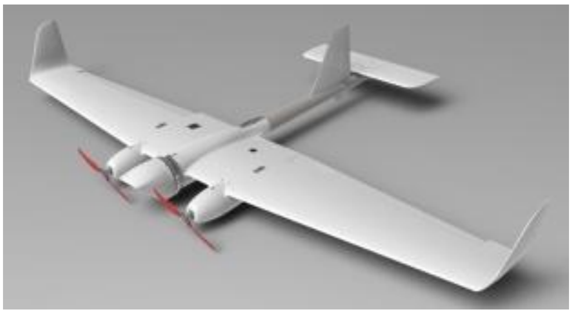


Fig. 1 Unmanned flying vehicle "Busel"

As the use of unmanned aerial vehicles (UAVs) has great potential to support and address some of the most pressing problems, many studies have been carried out in recent years reflecting the possibility of their usage in a great variety of contexts: in land mapping, vegetation state (Солоха, 2018), (Башилов и др., 2016), phenology and health, precision farming, monitoring crop growth, mapping soil surface characteristics (Петрушин и др., 2016).
Some authors analyzed the prospects of using UAVs in agriculture of Tatarstan for monitoring agricultural lands (Логинов и др., 2017), crops surveillance, and predicting crop yields. Still other articles are devoted to UAVs used for precision agriculture (Акинчин и др., 2017).
Within the land management and land cadaster there are also many possible applications of UAV. Descriptions are given of the UAVs use to create a topographic base with processing in photogrammetric software complexes for the purposes of agricultural production. (Линьков, 2018). A modern method for conducting land measurements from the air based on photoplans, the advantage of performing aerial photography using UAVs to obtain orthophotomaps with an accuracy of 3 cm in X, Y is described by several authors Galeev, Beloev (Галеев, 2016), (H. Beloev, 2016)
However, the analysis of the wide range of functionalities provided by UAVs is not sufficient without taking into account the factors that influence the quality of images. Although the issues of UAVs application have been covered sufficiently in literature, some methodological aspects still need to be studied. It is necessary to consider the technology for performing aerial photography and photogrammetric processing of the collected images to obtain high-resolution images of orthophotomaps for land management purposes which is particularly valuable in the case of remote sensing images.
The subject of the footage was the city of Dzerzhinsk, Minsk region. At the footage site, in the field, the coordinates of the markings were determined using GNSS. The number and location of the vertical planning identification is determined by the project.
After obtaining the coordinates of the points of identification marks, using the GeoScan201 unmanned flying vehicle was used for surveying the terrain.
The unmanned flying vehicle GeoScan 201 (Fig. 2) is intended: to obtain geolocated images of objects and areal footage, with subsequent processing of photographic material; for creating orthophotomaps of maps of scale 1: 500, 1: 2000; creating a terrain model in 3D; creating maps of terrain heights;

calculating the volume of rocks in quarries and bulk objects (Руководство по эксплуатации БПЛА, 2019).
The GeoScan 201 UAV has the payload of 7.6 kg, a wingspan of 2225 mm, a side length of 710 mm, a flight duration of up to 150 minutes at the speed of 17-27 m / s and a maximum flight altitude of 1000 m.

Fig. 2. GeoScan 201 unmanned flying vehicle

The flight software is GeoScan Planner, which is designed for: designing a flight task; passing prelaunch; control of the flight task; geolocation footage (Руководство по использованию оператора, 2019).
A fragment of an interactive map, which is used for design, is presented in Figure 3.

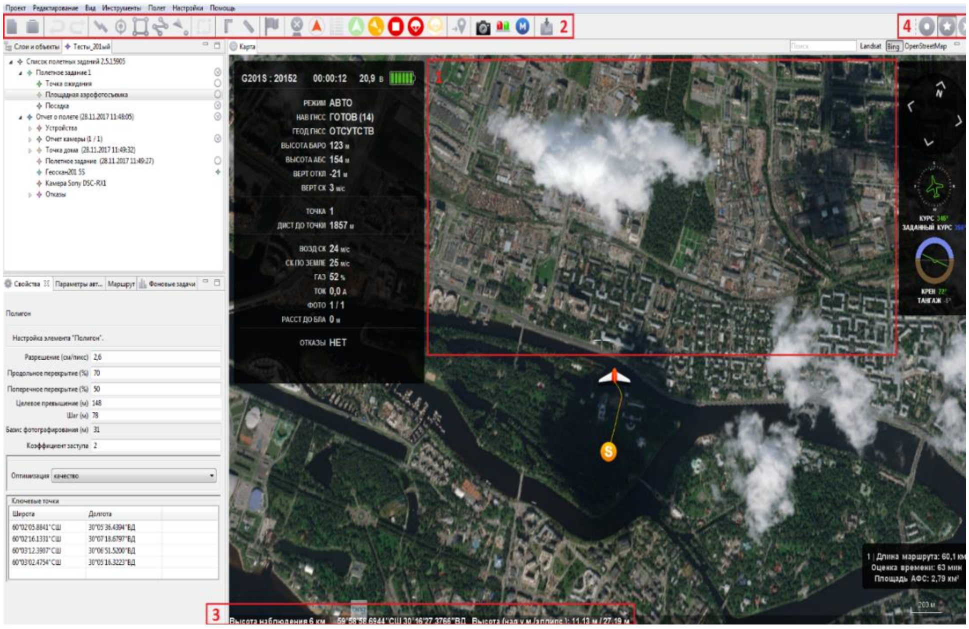


Fig. 3 Displaying an interactive map in Geoscan Planner

The Geoscan Planner program uses several ground data sources as a base map: Landsat, OpenStreetMap or Bing.
To compile a correct flight task, it is necessary to load the entire territory of the intended flight, preferably in maximum detail.
The GeoScan aircraft-type complex provides: areal photography according to a pre-compiled flight task, linear aerial photography based on a pre-compiled flight task, a flight along a predetermined trajectory at specified heights, a waiting point with wind measurement, flight on demand, remote control.
The Geoscan Planner program automatically saves the flight mission project in the computer's memory for future use. This allows to develop a project in advance, before going to the work site. It is enough for the operator to create a polygon directly along the boundaries of the studied area, the program will independently increase the length of the fly lines and their number in accordance with the surveying conditions.
When building a route, the climb and descent of an unmanned flying vehicle in the form of cylinders are displayed if the height difference of neighboring points is at least 30 meters (Fig.4; Fig.5).

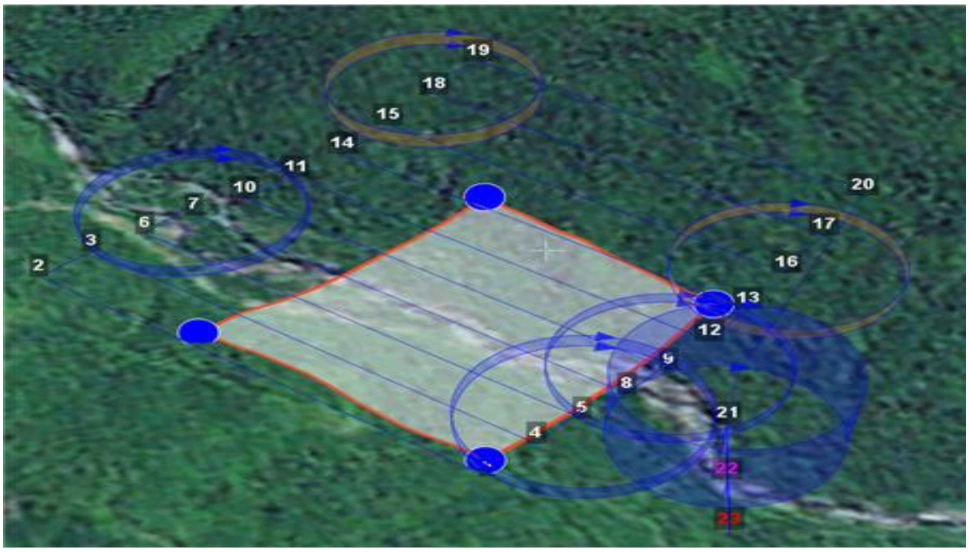


Fig. 4 Accumulation and Drop Cylinders

If the unmanned flying vehicle is gaining height, the cylinder is filled with orange, otherwise it is blue. To perform direct aerial photography from an unmanned flying vehicle, it is necessary to carry out a set of pre-flight operations in advance, including: a desk study of the shooting area and planning a shooting route; departure to the study area; deployment of an unmanned flying vehicle complex; the implementation of pre-flight checks and tests.

The actual preparation of the flight task is carried out on a laptop that is a part of the ground control station, where the supplier installs the Geoscan Planner software. This flight planning software product allows you to create various projects for shooting routes that are transmitted to an unmanned flying vehicle using radio signals. In addition, it is possible to establish shooting parameters such as flight altitude, longitudinal and transverse overlaps, shooting steps, and others, all of which are interrelated, i.e. changing one of the parameters automatically changes the rest. Next, the program automatically builds the most rational shooting route, taking into account the formation of a certain stock of personnel at the edges of the section to be removed, while the operator has the ability to edit the vertices of the polygon after construction, thereby changing the route.

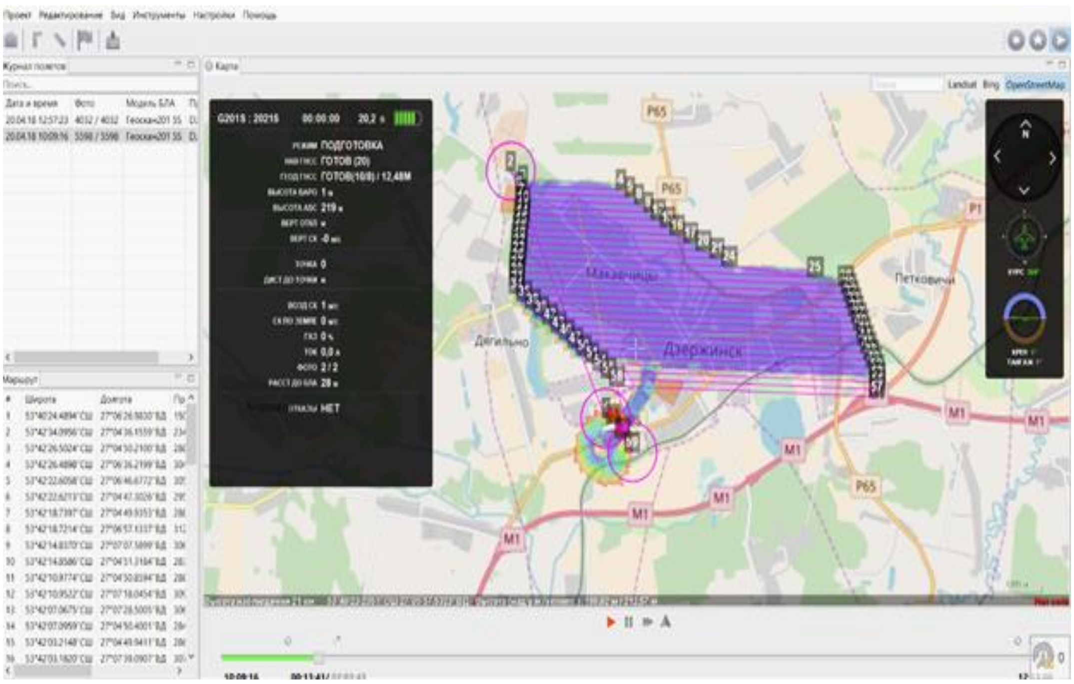


Fig. 5 Creating a flight task in GeoScan Planner software

Having completed the formation of the flight task, a departure to the territory of the survey can be carried out.
Upon arrival, the deployment process of the unmanned flying vehicle complex takes place. As a payload on the unmanned flying vehicle GeoScan 201 can be used 2 types of camera. The first of them - Sony DSC-RX1 - has a high-resolution matrix of 24.7 megapixels.
The resolution of digital camera is 5.1 cm / pix, the focal length is 35 mm. The average errors of determining photographing centers were calculated, which were X = 2.2 cm, Y = 5.5 cm, Z = 1.4 cm. The average photographing altitude was 297.5 m.
After the deployment of the ground control station, the Geoscan Planner software is launched, where the operator will have to indicate the landing point of the unmanned flying vehicle, taking into account the conditions of the terrain to be removed. After the creation of the landing route, a complex of works on prelaunch preparation is performed.
Aerial photography from an unmanned flying vehicle, as well as other types of topographic surveys, requires the creation of a planning and height-altitude geodetic justification. Therefore, the process of flight survey work is preceded by a complex of ground-based geodetic measurements.
The number of marks depends on the scale of the shooting. When shooting at a scale of 1: 2000 and 1: 5000, the identifications are placed in rows across the aerial survey routes. Further, when linking aerial photography materials from an unmanned flying vehicle, these points are used as a geodetic basis for the formation of seamless mosaics, stereo pairs of images and other products. During the flight, the operator is obliged to monitor the climb and the overall stability of the device. The data for the binding is transmitted during the flight by the radio modem, and is recorded by the Geoscan Planner program. If the route is successfully completed by an unmanned flying vehicle, it will drop a parachute and land on reaching the landing point.
To get the binding files, you must save the data to the same folder where the snapshots were saved. The result of the work is a folder with snapshots and a data file of their binding, which can be used for further processing in the PhotoScan software or other software. After completion of shooting, it is recommended to conduct quality control of the aerial survey materials obtained. Next, you need to perform the binding procedure, which consists of several stages: the calculation of the coordinates of the centers of photographing; calculation of coordinates of marks; phototriangulation development.
The main process of processing aerial photography materials from an unmanned flying vehicle is carried out in Agisoft Photoscan software. This software product of automated photogrammetric processing of aerial photography data allows to obtain clouds of points, surfaces, 3D models and orthophotomaps using digital raster images, coordinates of photographing centers, materials for calibrating optical systems of cameras, coordinates of reference points on the ground, and control linear measurements on the subject .
Agisoft PhotoScan software is able to independently determine the position of cameras and build a sparse cloud of points on the basis of images, while it is possible to specify alignment parameters, such as alignment accuracy, the maximum number of points, the maximum number of projections. According to the results of the development of phototriangulation software Agisoft Photoscan allows you to create a large number of diverse products, including orthophotomaps terrain. Based on the camera positions calculated from the results of triangulation, the program calculates depth maps for each camera and builds a dense points cloud (Fig. 6).

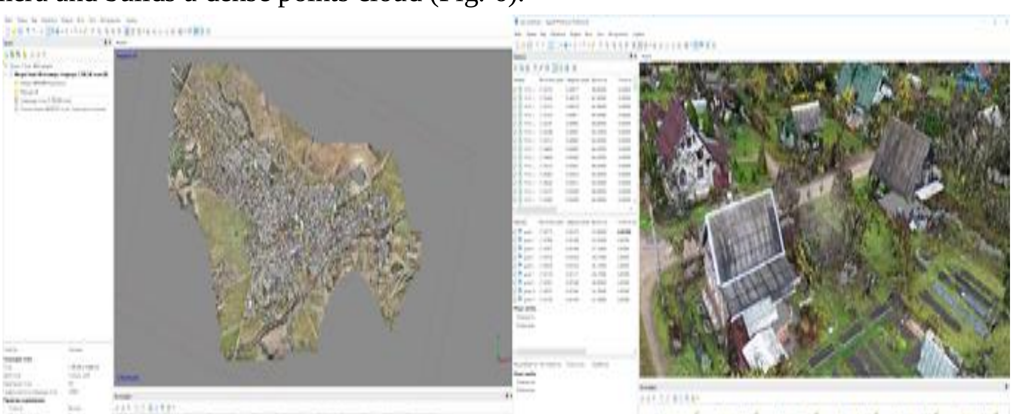


Fig. 6 A dense points cloud, built on the basis of aerial photography using unmanned flying vehicle

Based on a dense points cloud, a map of the heights of the terrain can be constructed (Fig. 7).

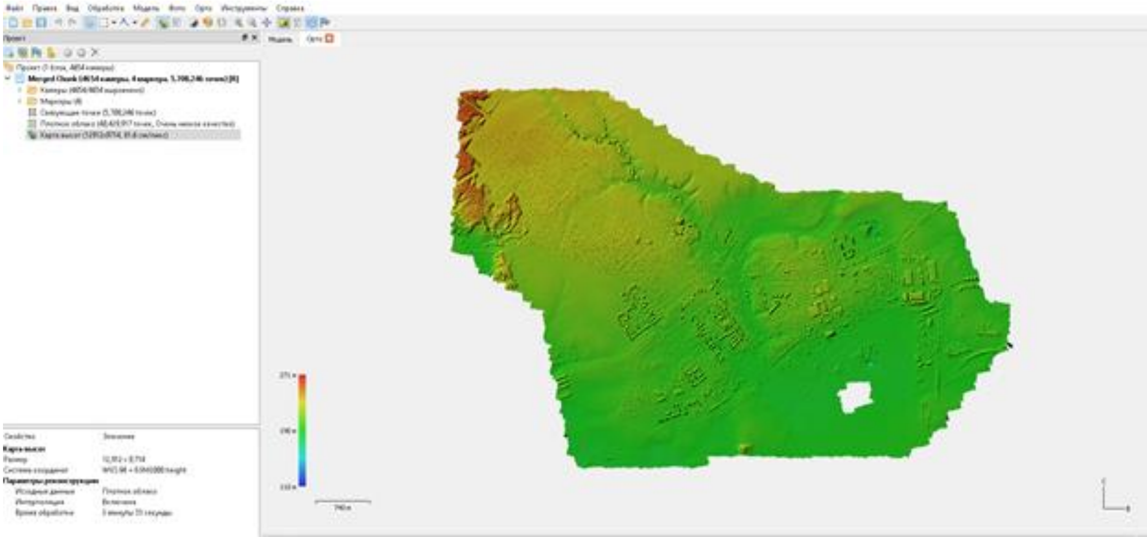
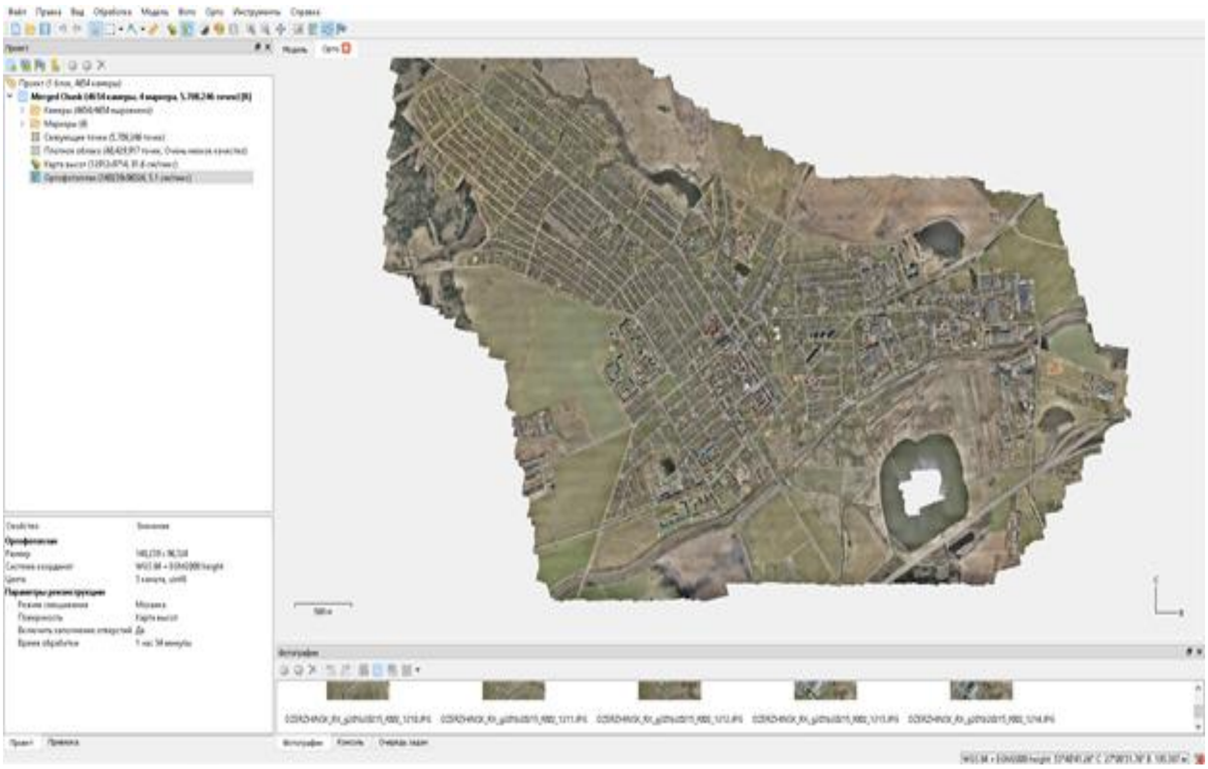
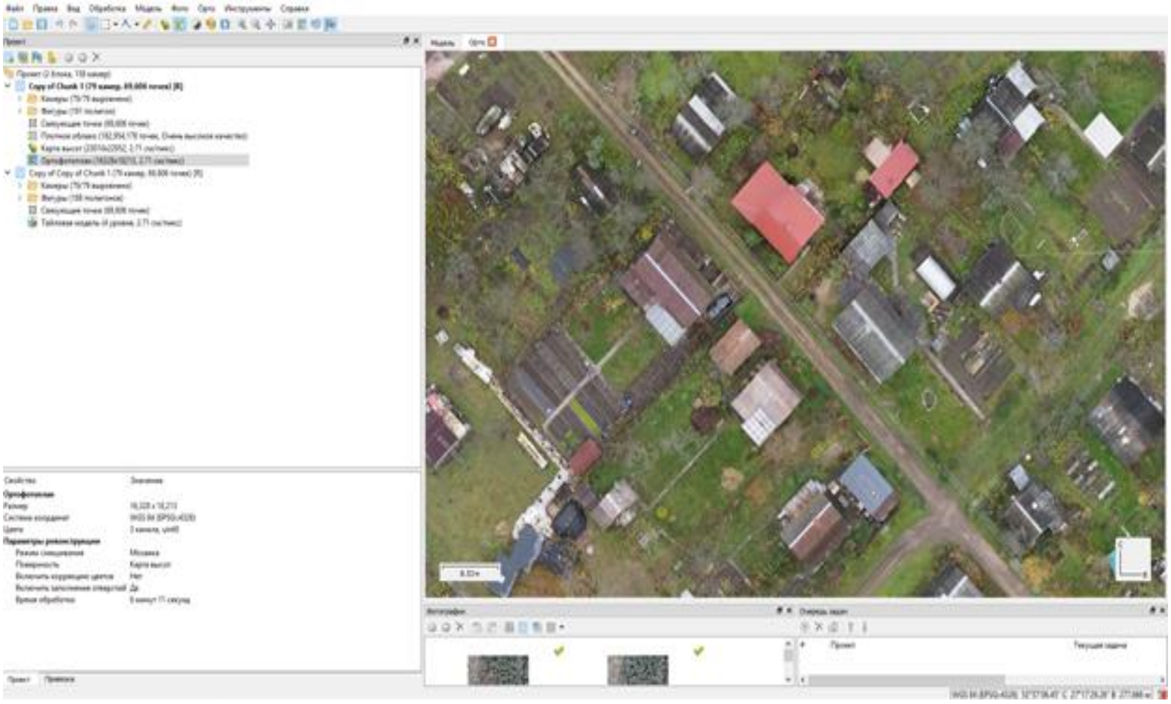


Fig. 7 Map of heights, built on the materials of aerial photography unmanned flyingl vehicle

The coordinate system must match the one used to snap the model. Changing the coordinate system is possible at a later stage of export.
Next is the direct construction of the orthophotomap (Fig. 8).



a)



b)

Fig. 8 Orthophotomap compiled from materials of shooting using an unmanned flying vehicle:
a - general view, b - enlarged view

When compiling an orthophotomap, Agisoft Photoscan builds cuts on its own, which can be edited if necessary (Figure 9).

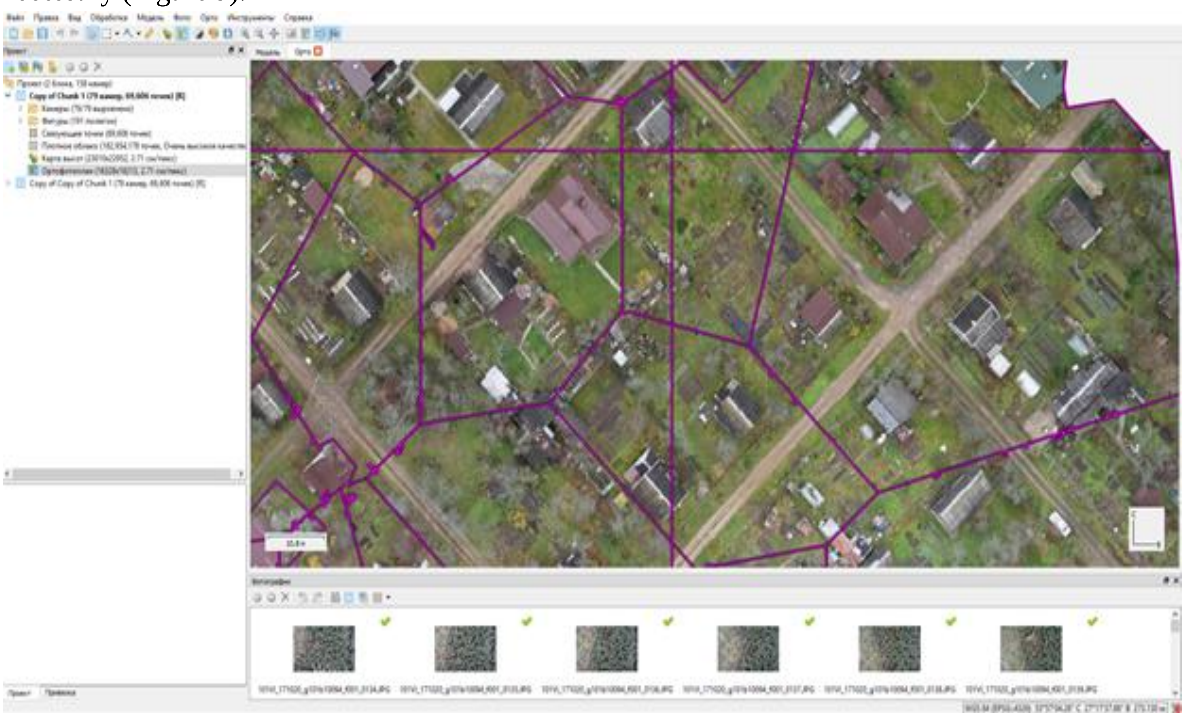


Fig. 9 Automatic construction of cutlines

According to the results of the construction of the orthophotomap, the standard quadratic errors were obtained for the control points X = 1.2 cm, for Y = 1.8 cm, for Z = 3.0 cm.

Digital terrain model editing and vectorization of structural elements of the relief and structures is carried out in stereoscopic mode in the Trimble Inpho software. Using an edited digital elevation model (or terrain), orthotransformation of aerial photographs will subsequently be carried out (Руководство по использованию оператора, 2019).

Conclusion

1. An experiment has shown that aerial photography from an unmanned flying vehicle can successfully replace traditional aerial photography and ground-based methods of collecting spatial data in order to create topographic plans and large-scale maps. The accuracy of orthophotomaps created as a result of processing of aerial photography materials using an unmanned flying vehicle is not inferior to the accuracy of materials of traditional methods, which require a significant investment of time and money.
2. The present study has shown that it is necessary to do more research of the methodology of orthophotomaps construction produced from airborne photogrammetry to meet accuracy.
3. According to the described technology of performing aerial photography and the construction of the orthophotomap and its accuracy, it can be noted that the use of UAVs is economically advantageous.

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SOIL CONSERVATION MEASURES: ASSESSMENT OF ECONOMIC EFFICIENCY IN TERMS OF UKRAINE

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Abstract
The solution of preserving and restoring the soil fertility problem of agricultural lands in the process of economic activity is one of the main tasks in achieving global food security. Implementation of a complex of soil protection measures, as a rule, ensures the preservation and even growth of soil fertility. Therefore, the purpose of the article is to determine the economic efficiency of introducing soil protection measures in the use of agricultural land. For this purpose, the following tasks were set and solved: the analysis of the current state and trends of the land resources use in agriculture; to investigate the tendencies of carrying out measures on preservation of soil fertility and prevention of its degradation; to substantiate scientific and methodical estimation principles of economic efficiency of introduction of soil protection measures in the conditions of Ukraine.
The following basic methods were used to solve the research objectives: monographic analysis – when developing scientific publications on environmentally friendly use of agricultural land; comparative and statistical analysis – in studying the dynamics of the structure of the land fund of Ukraine by main types of land and economic activity; system-structural analysis and grouping – in the study of the nature and content of ecological and economic consequences of soil degradation, as well as approaches to assessing the economic effectiveness of soil protection measures; economic analysis and calculation of relative indicators – to evaluate the economic efficiency of soil protection measures in the process of agricultural land use; abstract-logical method - for theoretical generalizations and conclusions formation, etc.
Established that soil degradation is now one of the most important industrial and environmental issues, which is the main reason for the inability to achieve high rates of environmental and economic efficiency of land use in the future. It was also substantiated scientific and methodical approach to determining the economic efficiency of soil conservation measures in the current market conditions, which is based on the additional income that is received as a result of increase crop yields on protected lands. It is established that effective protection of soils from degradation is possible with the systematic implementation of soil protection measures complex, developed taking into account the specific natural and economic conditions of each region or agricultural enterprise. The priority directions of realization measures on land protection are given.
Key words: land protection, soil degradation, soil conservation measures, economic efficiency, agricultural lands, additional income.

Introduction

During the years of Ukraine's independence, the structure of agriculture and its specialization have changed significantly. Based on market-based land relations, predominantly specialized, commodity-based agricultural production oriented for export is developing. Modern agribusiness dynamically adapts to the needs of the national and world agrarian markets and refuses from unprofitable crops and livestock industries. In order to grow high harvests, the land is used extensively for agricultural purposes, resulting in the destruction of soil cover and the reduction of environmental sustainability of agro-landscapes.
Extensive management causes huge losses to the productive potential of the land fund and greatly reduces the stability of land to degradation processes. Soil degradation has recently been one of the most important industrial and environmental problems, without which it will be impossible to ensure high ecological and economic efficiency of land use by future generations in the future.
The solution of the problem of preserving and restoring the soil fertility of agricultural lands in the process of economic activity is one of the main tasks in achieving global food security. Research by scientists suggests that the implementation of a complex of soil protection measures, as a rule, ensures the preservation and even growth of soil fertility. This makes it possible to preserve the productivity of the land, even in the conditions of intensification of agriculture, to increase yields and gross collections of agricultural crops, and hence the value of agricultural land not only as objects of production activity, but also as components of the biosphere, which have an important environmental significance.
Modern scientific and theoretical provisions concerning the rational use and protection of agricultural land are reflected in the works of such domestic scientists as D. Babmidra (2010), D. Dobryak (2009),

O. Kanash (2013), A. Martyn (2014), L. Novakovskii (1992), I. Rozumnyi (2009), A. Sokhnich (1998), A. Tretyak (2015) and others. On the other hand, the issues of ecological and economic use of natural resources were highlighted in their publications by such scholars as economists I. Bystryakov (2014), S. Ibatullin (2013), O. Sakal (2017), M. Khvesik (2010) and others.

Various aspects of the effective impact of soil protection measures, in particular, on increasing the productivity of agricultural land and suspending various land degradation processes, are reflected in works by M. Belotserkovsky (1984), D. Vanin (1987), P. Kasmir (2007), I. Kovalchuk (2013), M.Kopistinsky (1983), V. Krivov (2002), B. Maslov (1989), V. Medvedev (1977), I. Primak (2001), O. Tarariko (2009), N. Shelyakin (1990), V. Yukhnovsky (2012) and others.

However, many scholars, while investigating the issues of land and soil protection, often rely on the Soviet command and control model for land use management, which was based on central planning and budget financing of practically all soil protection measures, as well as on the assessment of the efficiency of agricultural production, mainly taking into account the volume of products received. In the current conditions, when land use is mostly based on private land and is based on a private entrepreneurial initiative, Ukrainian legislation in the field of land protection often becomes ineffective and characterized by the lack of clear norms (duties) to ensure their protection. Under these circumstances, an important task of the economy of nature management is the assessment of the effectiveness of soil protection measures in the current market conditions on the principle of cost / benefit, when the main measure of the efficiency of agribusiness is profit, rather than gross crop "at any price". Thus, the actual scientific and practical task is the development of modern approaches to the assessment of the effectiveness of soil protection measures, which should be based on market information and be suitable for real introduction into the practice of modern agribusiness.

Object of study – the process of determining the economic efficiency of introducing soil protection measures in the use of agricultural land.

Subject of study – theoretical, methodological and practical principles and directions for improving the assessment of the economic efficiency of soil protection measures in the use of agricultural land.

Methodology of research and materials

The theoretical and **methodological** basis of the research is the general theoretical methods of scientific knowledge, in particular, the dialectical method, system analysis, the fundamental positions of modern economic theory, the economics of nature management and environmental protection, the concept of sustainable development, the work of leading domestic and foreign scientists on the problems of protecting agricultural land. **Materials** of research*:* in the study used data of the state land cadaster, normative legal acts. Data and statistical data of the State Statistics Service of Ukraine and the State Service of Ukraine for Geodesy, Cartography and Cadaster have been used.

Discussions and results

Conducting from the beginning of the 1990s in Ukraine land reform significantly the structure of agricultural land tenure and land use. Thus, almost 12,000 former socialist agricultural enterprises (collective farms and state farms) were originally transformed into collective agricultural enterprises with the transfer of land to collective ownership, and in the future land was divided into separate shares (units). As a result, about 6.77 million Ukrainian citizens became owners of separate land plots of agricultural purpose, the average size of which is about 4 hectares.

During the time of the land reform in Ukraine, the ownership of land has changed significantly. Thus, as of 2016, privately owned 31060.0 thousand hectares (74.8%) of agricultural land, state – 10405.0 (25.1), collective – 17.4 (0.04) and communal – 25. 5 thousand hectares (0.06%) (Fig. 1). However, in recent years, the dynamics of ownership structure has slowed down considerably. In this regard, it can be argued about the actual completion of the transformation of ownership of land, and in agricultural land ownership began to dominate private property.

At present, the shredding and privatization of land shares (shares) by former members of collective farms did not become the basis for the development of a private peasant or farmer. The reason for this situation is that most owners of land shares (shares) are residents of rural areas of the working age who cannot independently process the land they have been given to them. Therefore, it is not surprising that the current land relations in agriculture in Ukraine have become leased. Owners of land shares (shares) transferred more than 2/3 of the total number of land plots to be leased to agricultural enterprises for commercial agricultural production (Dobryak, Kanash, Babmidra, 2009; Koretsky, 2010).

Fig. 1. Distribution of the land fund of Ukraine depending on the forms of ownership as of January 1, 1990-2016, %

Rental of land as the main component of market land relations in agriculture should contribute to efficient management. Particular attention is paid to the improvement of lease land relations, the terms of the transfer of land to rent, which at the present stage of their development are very short. Indeed, the duration of the lease relations is inextricably linked with the tenant's intentions regarding the safe, rational and efficient use of land.

On average, in Ukraine, by the year 2017, there were about 16.5 million hectares of land leased, which was 59.7% of the total area of agricultural land owned by citizens. At the same time, the average amount of rent for land shares (shares) in Ukraine was 1093.4 UAH per 1 hectare. In Ukraine, over the past 17 years, the situation regarding the terms of land lease agreements has improved somewhat. So, if in 2001 the short-term lease for the term up to five years (86.9%) prevailed, then in 2017 - the medium term is up to 10 years (82.0%). At the same time, the share of recent contracts increased from 1.8 (2001) to 18.0% (2017).

In the course of land reform, landowners and land users are becoming more and more and the proportion of offenses in the field of land legislation is increasing proportionally. In order to improve the mechanism for exercising state control over the use and protection of land, preventing offenses in the field of land relations, as well as for the legal enforcement of measures to eliminate the violations of land legislation in Ukraine, a number of legal acts were developed. However, the current legislation of Ukraine in the field of land protection remains virtually inactive and is characterized by the lack of clear norms (responsibilities) regarding the provision of land protection. The only measure that must be met (by March 2015) by large landowners and land users is the drafting of environmental and economic rationale for crop rotation, which are often not followed up frequently (Tretyak and Tretyak, 2015).

Land users are not interested in the long-term preservation of productive properties of land that is not their property and with which they do not have long-term economic interests. In addition, owners of land plots were mostly elderly persons. They will never work on earth and they are mostly interested in maximizing income from leasing property. From the point of view of "big business", agriculture is often viewed as a short-term project aimed at maximizing revenue in current years without strategic plans for the future. Thus, Soviet approaches to land protection, which were based on central planning and budget financing of almost all soil protection measures and continuous land management, are no longer working in modern conditions. Instead, it is necessary to create conditions when the part of the rent received from agribusiness will be directed at financing of soil protection measures while ensuring state control over the rational use of land and observance of ground protection restrictions in land use.

The most important factor in reducing land productivity is their degradation. Even since Soviet times, it was known that the development of land was foreseen at the expense of the growth of agricultural land, especially arable land. This was almost the only measure to increase production. In this pursuit of additional centers of the product everything was ruined: steep slopes, protective zones along the reservoirs, pastures, roadside roads, etc. Extensive agricultural production in the post-Soviet area has led to catastrophic development of degradation processes in large agricultural areas.

Extensive management causes huge losses to the productive potential of the land fund of Ukraine and greatly reduces the stability of land against degradation processes (Fig. 2). Land degradation at present is one of the most important production problems, which does not allow to achieve high ecological and economic efficiency of land use. Among the developed lands, agricultural degradation is most often caused, which is caused by deep, sometimes irreversible transformations of vegetation and soil cover in the process of agricultural production (Dobryak, Babmidr, Slinchuk, 2010; Kovalchuk, 2013).

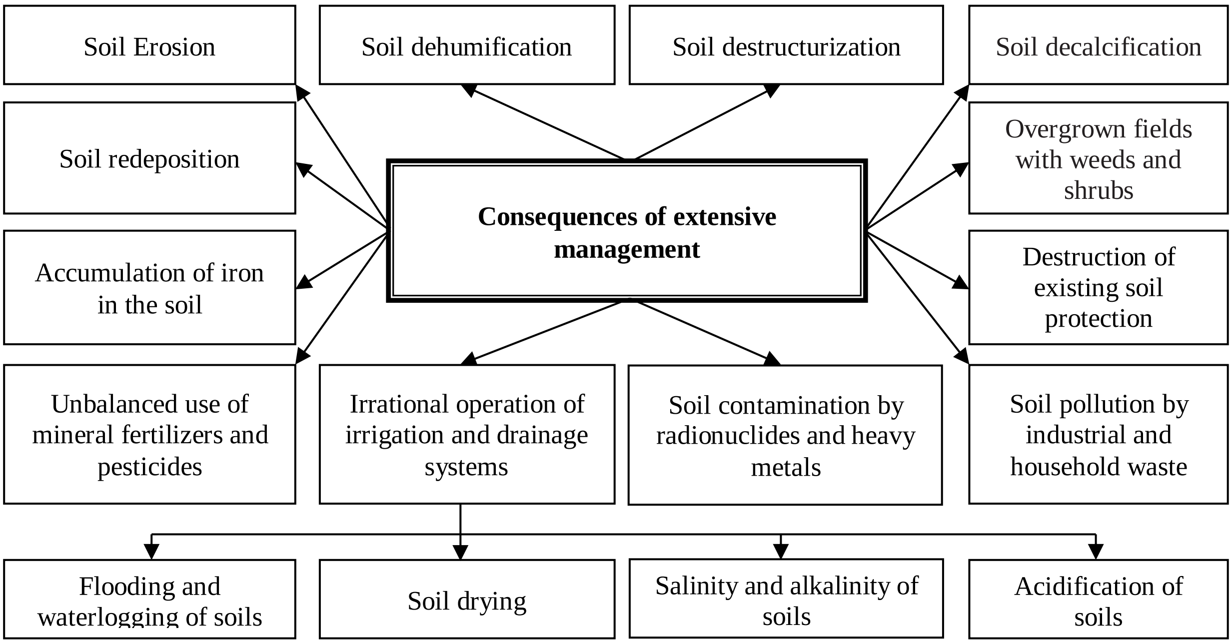

Fig. 2. Consequences of extensive land use

Human economic activity (anthropogenic factor) is the main cause of land degradation. As a result of degradation, the productivity of arable land decreases during their mechanical cultivation, which leads to spraying, flushing and blasting of soil cover and contamination by products of erosion of reservoirs. Therefore, it is necessary to clearly understand that degraded lands are very difficult, and sometimes it is impossible to revive at all.

Agricultural lands are located on 2/3 of Ukraine's territory. Their total area is 42 776.9 thousand hectares, or 70.9% of the total land area, which indicates a high level of development (Fig. 3). Over the last decade in Ukraine, the area of agricultural land has decreased by 280.8 thousand hectares, while forests and other forest cover areas have increased by more than 197.8 thousand hectares; as well as the area of built-up land increased by 66.9 thousand hectares, and open wetlands - by 32.9 thousand hectares. However, the modern use of land cannot be considered ecologically safe. After all, the share of agricultural land accounts for 70.9% of the total area of the territory, which indicates the high level of its development. In addition, arable land occupies 32 498.5 thousand hectares, which makes up 78.2% of the total area of agricultural land.

In Ukraine, rational use and protection of land resources are an important scientific, technical, organizational, agricultural and legal problem. The current land use structure does not meet the current economic and environmental requirements. In particular, the type and methods of using agricultural land have ceased to reflect the optimal correlation between natural conditions, the purpose of land use and the level of development of productive forces. This led to negative changes in the qualitative composition of land resources, especially agricultural land, most of which lose its fertility (very low and average humus content), has high acidity or salinity, is exposed to water or wind erosion (Krivov, 2002; Kanash, 2013).

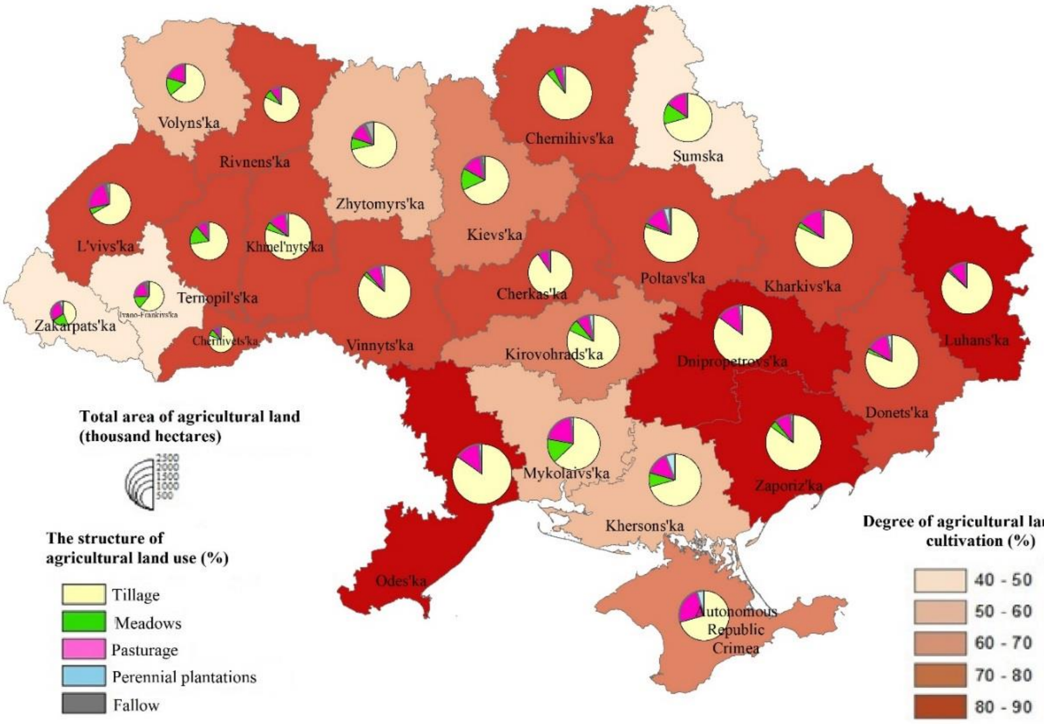

Fig. 3. The structure of agricultural land use in Ukraine

In order to avoid the imbalance and inefficiency of the land fund in modern agriculture, first of all, it is necessary to increase the productivity of the land with the help of scientifically grounded organization of the territory, introducing organizational, economic, agricultural, forest ameliorative and hydro-amelioration measures in each agricultural enterprise; mainly to prevent unfavorable physical and geographical processes (erosion, excessive wetness, salinity, dryness, soil alkalinity, etc.).

Despite the urgent need to implement soil protection measures that will ensure not only preservation but also improvement of qualitative properties of agricultural land, Ukraine's current legislation in the field of land conservation remains low-level and is characterized by the lack of clear norms (responsibilities) for maintaining the quality of soils. Until March 2015, the only groundbreaking event for which failure was to be punished, it was considered mandatory for landowners and land users to develop draft ecological and economic rationale for crop rotation that often existed only on paper and subsequently ignored.

According to the data of the State Service of Ukraine on Geodesy, Cartography and Cadaster as of 01.01.2017, the total area of land that needs to be preserved is 1.1 million hectares, of which 564.9 are degraded, 482.0 are unproductive and 11.8 thousand hectares - technogenic polluted. During 2016, conservation of land with an area of 122 hectares was implemented, of which 56.3 were planted by felling and 65.7 hectares were planted. At the same time, the land, which are in the stage of conservation, cover almost 22.5 thousand hectares. The total area of disturbed lands in Ukraine is 143.4 thousand hectares, of which, during 2016, 146.2 hectares, including more than 81.6 hectares (55%) of agricultural land, were reclaimed. The total area of land that is in the stage of reclamation exceeds 7 thousand hectares. In total, since 2002, only 46.8 thousand hectares of unproductive lands have been improved in Ukraine, in particular in 2016 - 110.6 hectares. At the same time, 315,600 hectares of land are in need of improvement, of which 2,600 hectares of land are under improvement, in particular 986.7 hectares (38%) of arable crops (Коваленко, Щербаков, 1979).

The problem of land protection in Ukraine was particularly aggravated with the onset of the reform of land relations, which was aimed primarily at the privatization of land. If till 1990 the maintenance of soil fertility was based on state support, and agricultural producers practically carried out the whole complex of works on soil protection, then, since the first years of independence of our state, the situation has changed considerably, and issues of protection of agricultural land began to devote less and less attention. Thus, according to the data of the State Service of Ukraine on Geodesy, Cartography and Cadaster, since 2002 construction (reconstruction) of anti-erosion hydraulic engineering structures was carried out: shafts, ditches – 58.6 km (0.5 hectares); terraces - 21.7 km; road rails - 41.9 km; runoff structures - 150 units; terracing of slopes - 6 units. (2.8 ha); anti-erosive ponds - 46 units. (585.1 ha); coastal protection – 120.6 km (0.7 hectares); the other - 658.4 hectares, 17 units, 51.7 km. Due to the very costly logistics costs, in recent years the liming of soils was conducted on the average in the area of 1.9-5.6 thousand hectares from the estimated 40.0-50.0 thousand hectares, while the soil gypsum was practically non-existent (Martyn and Shevchenko, 2014; Shevchenko and Martyn, 2016).

It is impossible to solve the problem of land degradation by some soil protection technique; therefore, it is expedient to implement measures to protect them on the basis of a program-targeted approach. It has been established that the economic effectiveness of soil protection measures will be ensured by preventing losses caused by land degradation and corresponding decrease of their productivity, as well as by obtaining additional income for improving the spatial conditions of agriculture. Effective protection of soils from degradation is possible for the systematic implementation of a complex of soil protection measures taking into account specific natural and economic conditions. Ground-protection measures include a number of anti-degradation techniques, namely: organizational-economic, agro technical, cultural, forest-demanding and hydro-amelioration. Each of them differs as a way to protect and restore the fertile soil layer, as well as economic parameters - the amount of financing for their implementation, the net additional income from their implementation, the payback period of the investment and the amount of the prevented damage.

On the basis of the analysis of the economic efficiency of soil protection measures, it has been established that at present, organizational, economic and agronomic measures are the most suitable in comparison with other soil protection anti-degradation techniques. They are the most affordable, do not require high labor costs and funds, but they give a noticeable increase in yields already in the first years of their application. At the same time, the most time-consuming payback period is hydro-amelioration and other measures that require significant investment in construction work.

Out of the total number of 49 soil protection measures identified, there are 12 measures with a payback of more than 8 years (costs are higher than the profit), the average efficiency is 5 (cost will be paid back in 4-8 years), highly effective, with a payback period of less than 4 years - 33 In addition, a soil protection measure such as conservation of land was investigated, which should be considered only through the ecological effect, in the form of the re-naturalization of the environment (restoration of the natural state) (Table 1) (Медведев, Майоров, 1977; Маслов, Минаев, Губер, 1989; Шелякин, Белолипский, Головченко, 1990).

The results of the study indicate that there is no doubt about the necessity of full-scale practical implementation of soil protection measures in farms. However, the tendency nowadays to implement a system of measures for protecting soils and preventing their degradation is evidence of the opposite. The only correct step in solving this problem is to develop at the legislative level the mechanism of economic stimulation of land owners and land users to implement soil protection measures.

Table 1

Economic effectiveness of soil protection measures implemented in agriculture *

	Measure	Specific costs, UAH/ha	Add. income, UAH	Effect of events, UAH/ha	Effectiveness of active,%	Payback costs, years
1.	Contour-horizontal positioning of the boundaries of the fields	25.00	409.64	384.64	1538.56	< 0.5
2.	Organization of crop rotation	35.00	320.28	285.28	815.09	< 0.5
3.	Strip placement of crops	115.97	426.36	310.39	267.65	< 0.5
4.	Soil processing **	324.27	418.70	94.42	152.04	0.9
5.	Mulching of soil	1080.00	401.28	–678.72	–62.84	2.7
6.	Soil slotting	157.00	476.52	319.52	203.52	< 0.5
7.	Melting the ground	141.30	543.40	402.10	284.57	< 0.5
8.	Transverse bending of the hay	94.20	292.60	198.40	210.62	< 0.5
9.	Intermittent furrowing of the hail	100.48	292.60	192.12	191.20	< 0.5
10.	Cross-fertilization method	233.00	585.20	352.20	151.16	< 0.5
11.	Coulomb (protective) crops	115.97	376.20	260.23	224.39	< 0.5
12.	Buffer strips of perennial grasses	149.50	501.60	352.10	235.52	< 0.5
13.	Clearing of areas from stones (up to 25 m3)	3815.10	459.80	–3355.30	–87.95	8.3
14.	Clearing of squares from shrubs and small-leafed trees	4396.00	359.48	–4036.52	–91.82	12.2
15.	Destruction of shrubs by milling	4710.00	384.56	–4325.44	–91.84	12.2
16.	Plowing shrubs with a shrub and marsh plow	816.40	501.60	–314.80	–38.56	1.6
17.	Roasting of stumps (100 pcs.)	1884.00	418.00	–1466.00	–77.81	4.5
18.	Destruction of bumps at a height of 15-50 cm**	2092.45	334.40	–1758.05	–80.92	6.2
19.	Development (removal) of turf	1238.42	551.76	-68.66	–55.45	2.2
20.	Surface planning and alignment of shafts and heap	376.80	501.60	124.80	33.12	0.8
21.	Snow removal and snowmaking regulation	84.47	367.84	283.37	335.47	< 0.5
22.	Improvement of the areas of natural forage land**	1223.60	892.25	–331.25	32.99	1.2
23.	Conservation of lands (pasture, afforestation)**	3848.38	–	–	–	–
24.	Land reclamation by depth of depth 0.20 m	62 597.10	1162.04	–61 435.06	-98.14	53.9
25.	Falling up and laying the ravines (up to 5-9 m)**	392 500.00	777.48	–391722.52	–99.76	> 100
26.	Steering the steep slopes	20 410.00	710.60	–19 699.40	–96.52	28.7
27.	Liming or gypsum soil (in the norm of 1-8 t/ha) **	910.57	735.68	–174.89	12.81	1.2
28.	Introduction of organic fertilizers (at rates of 10-40 t/ha)**	6364.32	1070.08	–5294.24	–78.38	5.9
29.	Introduction of nitrogen fertilizers (in the norm 200-800 kg/ha)**	1472.00	1479.72	7.72	26.68	1.0
30.	Application of phosphorus fertilizers (in the norm 200-800 kg/ha)**	1222.00	593.56	–628.44	–39.17	2.1
31.	The introduction of potassium fertilizers (in the norm 200-800 kg/ha)**	1912.00	501.60	–1410.40	–66.70	3.8
32.	Application of green fertilizers (green manure crop)	1063.97	978.12	–85.85	–8.07	1.1
33.	Trimming of weeds	198.82	468.16	269.34	135.47	< 0.5
34.	Application of herbicides (at the rate of application 0.4-0.6 l/ha)	273.20	618.64	345,44	126.44	< 0.5
35.	Creation of irrigation system**	12 258.33	1580.04	–10 678,29	–86.47	7.7
36.	Creating a drainage system**	26 452.06	1237.28	–25 214,78	–95.10	21.4
37.	Creation of field protecting forest bands	166.40	618.64	452.24	271.78	< 0.5
38.	Creation of stock-control forest bands	228.59	618.64	390.05	170.63	< 0.5
39.	Creation of riverside and lush forest bands	458.44	601.92	143.48	31.30	0.8
40.	Establishment of afforestation around reservoirs and along the banks of rivers	547.93	543.40	–4.53	–0.83	1.0
41.	Creation of forest plantations on slopes of ravines, etc.	628.00	476.52	–151.48	–24.12	1.3
42.	Creation of forest plantations on sands	384.65	418.00	33.35	8.67	0.9
43.	Construction of water-retaining, ditches	5648.86	451.44	–5197.42	–92.01	12.5
44.	Construction of nautical shafts-terraces	242.09	376.20	134.11	55.40	0.6
45.	Construction of bottom sediments from willow and vines	345.40	376.20	30.8	8.92	0.9
46.	Construction of bottom sediments made of stone	13 816.00	376.20	–13 439.80	–97.28	36.7
47.	Construction of bottom sediments from reinforced concrete	17 270.00	376.20	–16 893.80	–97.82	45.9
48	Construction of fluctuations, fast moving stone	38 936.00	434.72	–38 501.28	–98.88	89.6
49.	Construction of fluctuations, fast-moving concrete from reinforced concrete, concrete	48 670.00	434.72	–48 235.28	–99.11	> 100

Notes: * Calculated by the author; ** Average values

Conclusions and proposals

The problem of preservation and restoration of the soil fertility of agricultural land in the process of economic activity is one of the most important tasks of the society. After all, the implementation of measures for soil protection, reproduction and enhancement of their fertility in the intensification of agriculture contributes to the increase of crop yields and gross crops, as well as increases the value of agricultural land not only as objects of production activity, but also as components of the biosphere, while having a large conservation value.

However, nowadays in Ukraine tendencies of soil protection measures to preserve soil fertility and to prevent their degradation demonstrate a significant reduction in their implementation. In this regard, it is necessary to develop at the legislative level a mechanism for economic incentives for land owners and land users to implement soil protection measures. Therefore, it is necessary for this:

- to encourage land owners and land users to implement soil protection measures through mechanisms of state support for agriculture, rational use of available limited budget resources;
- to motivate landowners and land users to implement soil protection measures based on fiscal instruments, in particular, to allow the use of preferential tax treatment (fixed tax, single tax, special VAT refund regime, etc.) only for those land users who take measures for protection of soils, and in cases of recultivation or the conservation of land is exempt from payment for land;
- to compensate at the expense of budget funds (including those received in order to compensate for losses of agricultural production), the part of expenses of landowners and land users on soil protection measures, especially on medium and low-efficiency ones, which are important ecological significance (construction of hydro-technical structures, filling and laying of ravines, etc.);
- to register ground protection restrictions in land use in the course of conducting the State Land Cadaster, controlling in the future their observance in the order of state, self-government and public control over the use and protection of land;
- to apply a mechanism of preferential lending with state support for those land users who implement soil protection measures;
- to wide promotion of best land-use practices in land use among agribusiness entities, especially those with long-term business strategies, since a significant number of soil conservation measures maintain their economic attractiveness for agribusiness even in market conditions;
- to encourage landowners and land users to comply with soil protection requirements, increasing the amount of fines for violation of norms of rational land use to the level of real social losses due to land degradation.

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