LATVIA UNIVERSITY OF LIFE SCIENCES AND TECHNOLOGIES
UNIVERSITY OF WARMIA AND MAZURY IN OLSZTYN (Poland)
VITAUTAS MAGNUS UNIVERSITY (Lithuania)

BALTIC SURVEYING

INTERNATIONAL SCIENTIFIC JOURNAL

2024

Volume 19

ISSN 2255 – 999X (online)

ISSN 2255 – 999X (online)

DOI: 10.22616/j.balticsurveying.2024.19

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INTERNATIONAL SCIENTIFIC JOURNAL

2024 / 1

Volume 19

Published since 2014

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FOREWORD

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Journal is jointly issued by consortium of:

- Department of Land Management and Geodesy of Latvia University of Life Sciences and Technologies, Latvia
- Department of Spatial Analysis and Real Estate Market of University of Warmia and Mazury in Olsztyn, Poland
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The journal includes original articles on land administration, land management, real property cadastre, land use, rural development, geodesy and cartography, remote sensing, geoinformatics, other related fields, as well as education in land management and geodesy throughout the Baltic countries, Western and Eastern Europe and elsewhere. The journal is the first one in the Baltic countries dealing with the mentioned issues. Journal disseminates the latest scientific findings, theoretical and experimental research and is extremely useful for young scientists.

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CONTENT

DOI: 10.22616/j.balticsurveying.2024.19.001

ANALYSIS OF LAND WITH SELF-GROWING TREES IN LITHUANIA

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Abstract
The research is analysis of forest cadastre plots in Lithuania, which are not on forest land, but are covered with forest. The research was carried out in Dubrava regional division of the Lithuanian State Forest Enterprise. The study covers the forest districts of Ežerelis, Karmėlava, Padauguva, Sitkūnai and Vaišvydava. The main aim of the article is analysis of self-growing forest growth on non-forest land. Data from the Forest Cadastre of Lithuania (non-forest plots covered with forest) were used for the research. In this research were analyzed orthophotographic maps of different periods (1995-2023), soil spatial data and other spatial data set. 135 non-forest land plots covered with forest in the Forest Cadastre, with a total area of 146 ha were found after analyzing 5 forest districts. Reasons of self-growing is land abandonment, small plots sizes, less productivity of the land and lack of land reclamation.
Key words: Self-growing trees, Forest cadastre, Land abandonment

Introduction

Although abandoned and unused plots of land in Lithuania are decreasing every year, the problem of abandoned lands still remains. Abandoned lands are overgrown with self-growing trees, which, under favorable conditions, grow into young trees. Lithuania is located in the geographical zone of mixed forests, so there are favorable climatic conditions, environment and soil for the growth of forests. Semi-natural forests are the most common in Lithuania. If people did not use the land for at least a decade, a young forest would begin to form on it, and if nothing was done at all, the entire undeveloped land area of Lithuania would be covered with forest in a few decades (Mozgiris, 2021). When examining the state of forestry at the national level, it is observed that the loss of forest land and the problems of sustainable forest management are related to the difference between developed and developing countries and the amount of land under management (Siry et al., 2015). The Kyoto Protocol of the United Nations General Convention on Climate Change takes into account that the preservation of forestry and the increase of forest areas are of particular importance for mitigating climate change. The need to reduce carbon dioxide is driving competitive policies at the European Union level for greater forest development and protection (Wydra, 2013).

In various strategic programs of the country, in territorial planning documents, the country's aspirational forest cover rate does not correspond to the real possibilities of increasing the forest cover. The 18th Government of the Republic of Lithuania program provides that in 2024 the country's forest coverage must reach 35 percent (now 33.7%). In order to realize this goal, 85.5 thousand ha must be introduced within every years of new forests. Part of this area will be achieved through the accounting of self-growing young trees that have grown on non-forest land. Self-growing tree regrowth on non-forest land and accounting of these areas for forest takes place every year from 2.8 to 7.2 thousand ha area (according to the data of the National Forest Inventory). Forest thinning or spontaneous regeneration is forest regeneration, establishment without human help or by applying measures that promote forest thinning (Forestry..., 2019). On the basis of the data of the inventory of non-forest land areas covered with trees, the areas covered with trees will be entered into the Forest Cadastre, full protection and management of new forests will be ensured, the area covered with forests in the country will increase by 3000 ha (State Forestry..., 2023). This study will aim to assess the reasons that could determine the circumstances of the formation of forested plots.

Research object – self-growing trees growing on non-forest land.

Research aim – to carry out an analysis of land wiht self-growing trees in the part of the Dubrava regional division of the Lithuanian State Forest Enterprise.

To achieve the goal, the following tasks are set:

1. Using forest cadastre data, determine the areas of non-forest land overgrown with self-growing trees.
2. To analyze the reasons for the overgrowth of the land with self-growing trees.

Non-forest land overgrown with trees is included in the forest land as a forest, if after the inventory, the growing tree species, their density, quality and location comply with the Forest Restoration and Planting Regulations, approved by the Minister of the Environment of the Republic of Lithuania in 2008 April 14 by order No. D1-199 "On approval of forest restoration and planting regulations" requirements. When

these requirements are not met, private non-forest land overgrown with self-growing trees is included in the accounting of forest land in accordance with the description of the procedure for planting forests on private non-forest land, approved by the Minister of Agriculture of the Republic of Lithuania and the Minister of the Environment of the Republic of Lithuania in 2004 March 29 by order No. 3D-130/D1-144 "On the approval of the description of the procedure for planting forests on private non-forest land". This procedure does not apply when self-growing tree stands grow in the territories of cultural heritage objects or cultural heritage sites of other purpose or conservation purpose land, except in cases where they are requested to be included in the accounting of forest land by the owner of private land or the trustee of state land.
When an inventorization of self-growing trees with an average age of less than 20 years is carried out, the overgrown non-forest land publishes the inventory data on the website and, within 6 months from their publication, informs the landowners and trustees of the state land in writing about the possibility of including the non-forest land owned by them or managed by the right of trust to the accounting of forest land by entering it in the State Cadastre of Forests. The following land plots were selected for the study, information about which is provided in the Forest Cadastre.

Methodology of research and materials

In the course of the work, normative documents were analyzed, scientific literature was analyzed on the topic. "Non-forest plots covered with forest" parcels in the spatial data set of the Forest Cadastre of the Republic of Lithuania are selected for analysis. This is an area of non-forest land covered with self-growing trees, the average age of which is up to 20 years. During the investigation, it will be determined how many such areas meet these criteria. Also, what were the reasons that could have led to the growth of self-growing trees outside the forest land.
The following spatial data are used to determine the reason for the growth of self-growth:

- Forest cadastre data;
- ORT10LT (2021-2023 years), ORT10LT (2018-2020 years), ORT10LT (2015-2017 years) ORT10LT (2012–2013 years), ORT10LT (2009–2010 years), ORT10LT (2005–2006 years), ORT10LT (1995–1999 m.) – digital raster orthophoto maps of the Republic of Lithuania territory;
- AŽ_DRLT - Spatial data collection of abandoned lands in the territory of the Republic of Lithuania,
- Dirv_DR10LT – soil assessment layers and soil spatial data set of the territory of the Republic of Lithuania,
- Mel_DR10LT – set of land reclamation condition and waterlogging spatial data of the territory of the Republic of Lithuania,
- Data of the Crop Fields Database
- GRPK – Spatial data set of (geo) reference base cadastre,
- Real estate cadastre map.

The research is carried out in the part of the Dubrava regional division of the State Forestry Authority of the Lithtuanian State Forest Enterprise, which includes the Ežerelis, Karmėlava, Padauguva, Sitkūnai and Vaišvydava forest districts.
The research was carried out by analyzing spatial data. The analysis is presented as a generalization of spatial data in search of causes to determine the reasons for the growth of the self-growing trees.

Figure 1. Study area (compiled by the authors)

Discussions and results

Various spatial data sets in the Lithuanian Spatial pnformation portal are analyzed. Orthophotographic maps of different years are visually evaluated. Forest cadastre data (non-forest plots covered with forest), orthophoto maps of different periods (1995-2023), soil spatial data set, land reclamation status and waterlogging spatial data set were used for the research. After analyzing 5 forest districts, 135 non-forest land plots covered with forest were found in the Forest Cadastre, with a total area of 146 ha.
The article provides some visual examples of the study. Analyzing the data of the orthophotographic maps of different periods, the overgrowth of the territory with wild plants was determined in the orthophotographic map of 2009-2010 (Figure 2). Although the area is dominated by sand, part of it is reclaimed.

Figure 2. Spatial data of plot No. 3 (2009-2010; 2018-2020; 2021-2023 years data) (compiled according to: Lithuanian spatial..., 2023)

The 2018-2020 are especially dense self-growing trees, and the area overgrown in the last year has been managed and the inventory will be carried out on the spot, and the territory will no longer have self-growing trees. Another example of area that has been cleared of the forest and the timber removed is presented in Figure 3.

Plot in Forest Cadastre 2009-2010 years 2018-2020 years 2021-2023 years

Figure 3. Spatial data of plot No. 14a (compiled according to: Lithuanian spatial..., 2023)

Self-growing trees growth and changes in use over three different time periods are shown in the figure above, composed of orthophoto images. How self-growing trees spread and how the territory was organized and returned to agricultural activities can be seen. The territory is reclamated, next to the forest, it is dominated by peat. The registered plot in it is currently without self-growing trees.
Another example is presented, where the plots in the forest cadastre are actually used for agricultural activities, and crops are grown and declared (Figure 4).

Figure 4. Spatial data of plots No. 10, 11, 19, 30, 32 (compiled according to: Lithuanian spatial..., 2023)

In Padauguva forest district, near Dubysa, as many as 5 parcels are included in forested areas. Analyzing the data, it was found that the growth of self-growing trees in the plots marked with number 11 and 19 can be seen in the orthophoto maps of 2005-2006. The rest of the plots start to be overgrown with wild plants later, and their overgrowth can be seen on the 2009-2010 maps. At the moment, there are no self-growing trees on the plot marked with number 30, agricultural activities are carried out. In plot 32, only part of the plot is left with self-growing trees, in more than 70 percent of the land there ar agricultural activities. Winter crops are grown in them and they are declared. Therefore, the accounting of these areas is completely wrong. In plots numbered 10, 11 and 19 sufficiently dense self-growing trees, which are interspersed with forests, and will be counted as forests in the future can be seen.

Forest cadastre data is constantly updated after receiving data, information and documents from forest managers and other data providers about the completed inventory of forest plots, implemented economic measures, changes in ownership, administrative boundaries and other changes, newly introduced and self-grown forests. However, in Sitkūnai forest district, large non-updates of data are recorded (example in Figure 5).

Figure 5. Spatial data of plots (compiled according to: Lithuanian spatial..., 2023)

In the picture, there are 17 plots that are classified as forested areas in the forest cadastre, but woody vegetation is visible in only two, the other 15 plots are cultivated land, and some areas are declared. Analyzing in which period these areas could have been included as covered by forest, only the orthophoto maps of 2009-2010 have self-growing trees visible in the areas. Such areas have already been organized according to the data of the 2015-2017 orthophotographic map, but they are still included in the forest cadastre accounting. Another example with cadastral data error in Figure 6.

Figure 6. Spatial data of plots No. 4, 37 and 38 (compiled according to: Lithuanian spatial..., 2023)

There are no reclamation systems in the analyzed area. Area soil assessment up to 29.6. Plot No. 4 does not have any vegetation. Plot No. 38 is already covered with vegetation on the 1995-1999 orthophoto map - it has been more than 20 years for the self-growing trees and they had to be accounted for as forest. Plot No. 4 was never covered with woody plants, which is another error in the cadastral data. The reasons for the abandonment of plots 37 and 38 are the areas near plantations, where the spread of seedlings can easily take place. The plots are not suitable for agricultural activities, not relclamated.
During the analysis, intensively overgrown plots on non-forest land can be seen, which will be counted as forest during the next inventory, if the owners do not remove the self-growing trees (Figure 7).

Figure 7. Spatial data of plot No. 12 (2005-2006; 2015-2017; 2021-2023 years data) (compiled according to: Lithuanian spatial..., 2023)

The plot is currently fully overgrown, the vegetation that may be present in it, judging by the spatial data, meets the criteria of the forest. The forestation of this area, as in the cases mentioned above, occurred due to unsuitable conditions for agricultural activities - the area is not reclamated, it is separated from the existing fields by a ditch and it is inconvenient to enter it, and also the seeds carried by the wind from the nearby forest helped the self-growing trees to plant more quickly.
Systematized study information is presented in Table 1.

Table 1

Plots in State forest cadaster of data on land wiht self-growing trees

Forest district, land area	Number of plots	Plot area, ha	The plot has never been overgrown with self-growing trees	The plot has been arranged, the former self-growing trees have been cleared	Overgrown with self-growing trees
Ežerėlis 18762 ha	8	3.6811		3	5
Padauguva 37209 ha	23	22.6600		4	19
Vaišvydava 35538 ha	16	15.1481	1	6	9
Sitkūnai 42946 ha	39	38.2848	1	20	18
Karmėlava 17932 ha	49	66.0852		7	42
Total:	**135**	**145.8592**	**2**	**40**	**93**

After the analysis, two errors were found, when the plots were marked as covered by forest in the Forest Cadastre, but when examining the orthophoto maps from 1995, none of them showed signs of forest cover with trees. Plot owners must inform the forest cadastre administrator - the State Forestry Service about inaccuracies in accordance with the description of the procedure for submitting data to the state forest cadastre of the Republic of Lithuania, recording and changing them. Of the 135 forest plots found in the cadastre, 40 were returned to agricultural (or other) activities. There is no vegetation in them. Plot sizes are given in Figure 8.

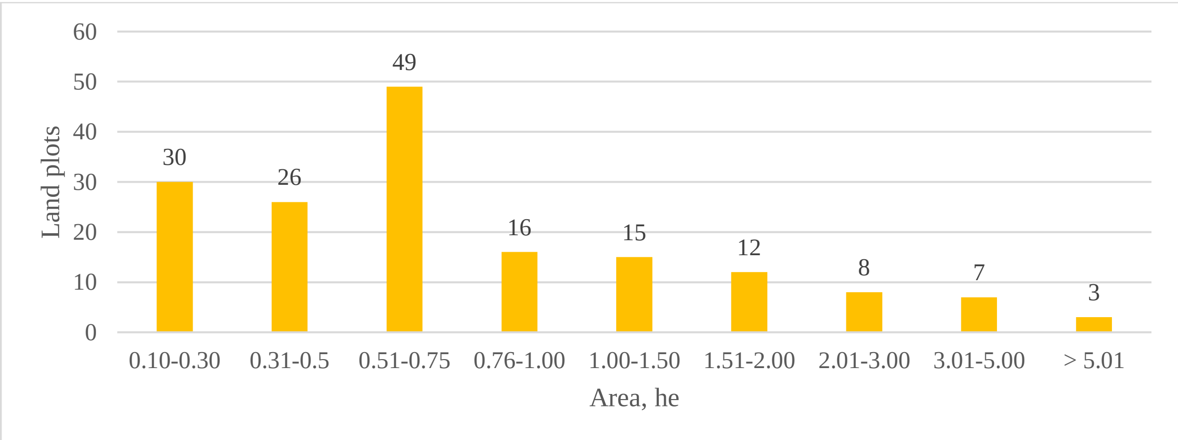

Figure 8. Land plots distribution by area, hectares (compiled by the authors)

The plots covered with self-growing trees are not large, most of the plots are less than 50 ares, there is one plot with a size of 13 ha. This is a plot of land very close to Kaunas, Karmėlava forest district, it is in peat land, unsuitable for work, not reclamated, unsuitable for agricultural activities. Plots covered with self-growing trees are most often located on not reclamated land (Figure 9).

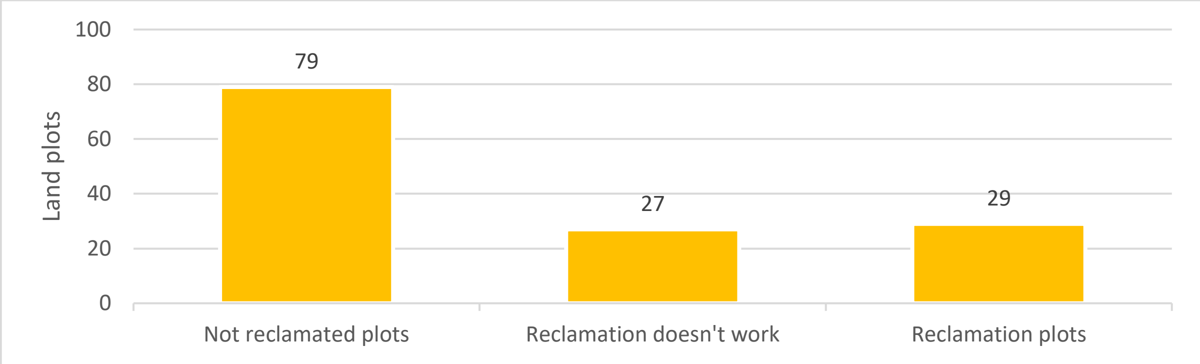

Figure 8. Allocation of plots according to land reclamation (compiled by the authors)

Only twenty-nine plots have reclamation systems, which according to Mel_DR10LT land reclamation state and waterlogging spatial data set of the territory of the Republic of Lithuania are operational. The research was conducted without evaluating the performance of the systems in nature. Soil spatial data sets were used to analyze the soil of the plots (Figure 9).

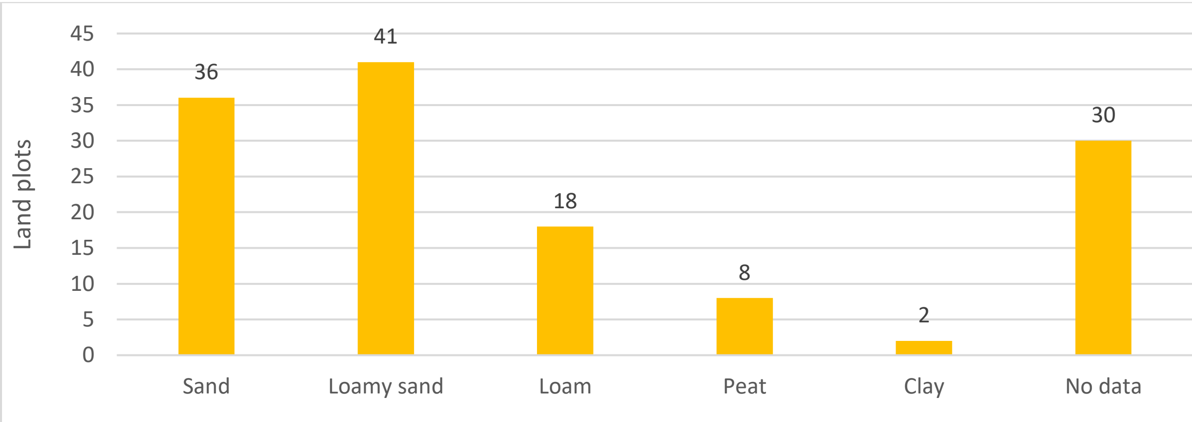

Figure 9. Classification of plots according to granulometric composition (compiled by the authors)

The forest is mainly covered with sand and loamy sand. Those lands that have not been used for their intended purpose for a long time and are covered with self-growing trees if the right conditions are created.

After the research, it can be said that such conditions can be: natural (slope of the plot, land quality, terrain, non-functioning/absence of reclamation systems), social (migration, level of old age of the population). How long the land has been abandoned, how the land areas are laid out, whether the configuration, sizes, and productivity of the land is convenient for cultivation are also important for self-growing trees.

Considering this, it is obvious that turning such lands into forest land is a good way when that land is not suitable for agricultural activities. If it is possible to use it for agricultural activities, it should always be done. Not only intensive, but also extensive land use is possible when it contains perennial meadows and pastures.

Conclusions and proposals

1. The research was carried out in the part of the Dubrava regional division of the State Enterprise, which includes the Ežerelis, Karmėlava, Padauguva, Sitkūnai and Vaišvydava forest districts. Forest cadastre data (non-forest plots covered with forest), orthophoto maps of different periods (1995-2023), soil spatial data set, land reclamation status and waterlogging spatial data set were used for the research. After analyzing 5 forest districts, 135 non-forest land plots covered with self-growing trees were found in the Forest Cadastre, with a total area of 146 ha. At the time of the investigation (january of 2023), 40 of the 135 plots in the forest cadastre have no vegetation, the self-growing trees there have been cleared and the timber removed. Two errors were found when the plots were marked as covered by forest in the Forest Cadastre, but when examining the orthophoto maps from 1995, no signs of forest cover with woody vegetation can be seen in any of them.
2. After conducting the investigation, it was established that the forest cover with self-growing trees of the territories occurred due to unsuitable conditions for agricultural activities - there is no land reclamation, or it does not work. In the plots near the forest, the seeds carried by the wind led to a faster planting of self-growing trees.

How long the land has been abandoned, how the land areas are laid out, whether the configuration, sizes, and productivity of the land is convenient for cultivation are also important for self-growing trees. Considering this, it is obvious that turning such lands into forest land is a good way when that land is not suitable for agricultural activities. Not only intensive, but also extensive land use is also possible when there are perennial meadows and pastures.

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DOI: 10.22616/j.balticsurveying.2024.19.002

TREES AND SHRUBS GREENERY AREA CHANGES IN KLAIPEDA COUNTY (2002-2022)

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Abstract
Greenspaces are an important component of the complex ecosystem. Trees and green spaces are also very important to human well-being as well. It is widely known that trees and green spaces give environmental, social, economic and psychological benefits. For example they affect microclimates to reduce the heat effect, improve air quality. Understanding the relationship between population size and the quality and quantity of green spaces is vital for the sustainability, health and resilience of areas.
Analysis of the current situation of the trees and shrubs greenery area in Klaipeda county was accomplished. The study also provides the trees and shrubs greenery area changes analysis in Klaipeda county and in the municipalities of the county.
In Klaipeda county the area under trees and shrubs in 2002 was 4,758.14 ha. In 2022 the plantation area amounted to 10,793.50 hectares. From 2002 to 2022 the area of tree and shrub plantations in Klaipeda county increased by 6,035.36 ha or 127 percent. The development of plantation areas has been positively influenced by the creation of an appropriate legislative framework and the implementation of plantation programmes in municipalities.
Key words: trees and shrubs, greenery, area change.

Introduction

Article relevance. Environment sustainability progressively requires the abatement of pollution, plus the addition of positive features, especially trees, to improve the new deficiency of healthy environments. An environment with high-quality and plentiful green spaces epitomizes good planning and management, a healthy environment for humans, vegetation and wildlife populations.
Trees and green spaces are very important to human well-being. It is established that trees and green spaces give environmental, social, economic and psychological benefits. They affect microclimates to reduce the heat effect, improve air quality. Trees and green spaces improve public health outcomes, increase social relationship, support biodiversity, and can increase property values, as well (Nesbitt, Metner, 2016).
Contact with nature such as public parks, wellbeing and human health. Access to green space is associated with a greater possibility of being physically active. Species richness present in a green area and perceived by people is positively linked to an excellent connection with nature and a better site fulfillment. If the environment is aesthetically attractive and space allows chance for gardening and for recreation, people are inspired to visit it, ameliorate social relationship within the neighborhood, which in turn can generate adventageous effects on wellbeing. Trees provide few ecosystem services that help to boost human wellbeing and can soften the negative impacts (Battisti, Pille, Larcher, Saumel, 2019).
Greenspaces are an important component of the complex ecosystem. Forests, parks and farmlands are types of greenspace, which have important ecological, social and economic functions. It benefits communities environmentally, recreationally, esthetically, and economically (Li, Wang, Paulussen, Liu, 2005).
Green spaces mean green spaces in parks and other natural areas. They are of strategic importance for carry on a high quality of life in increasingly community. The significance contributions of green spaces to the quality of urban life include (Tian, Y., Tao, Y. (2012):

1. The generally known environmental advantage of green spaces to the air, water, soil, and the ecosystem as a whole;
2. The psychological and physical advantage of reduced stress to people through the stimulation of physical activity, privacy, and intimacy as well as the preservation of aesthetic and historical continuity;
3. The social and economic advantage of increasing social integration and interaction among neighbors and generating revenue and employment.

The authors Mei-Yee Teoh, Michihiko Shinozaki, Kei Saito and Ismail Said (2021) also describe the benefits of green spaces, by stating that: in summer trees and shrubs greenery affects microclimate through temperature, wind and humidity modification. Trees canopies give shading, blocking an essential amount of short-wave radiation by reflection and transmission through their leaves. Also, the tree canopies could detain the long-wave radiation reflectivity from the ground to the atmosphere. The evapotranspiration of leaves helps reduce the surrounding temperature by converting sensible heat into latent heat and increased relative humidity.

Although the cooling effect of greenery has been noticed by various authors, studies that quantify the possible effects of different greenery scenarios (including various vegetation coverage and greenery types) on the thermal environment are deficient (Yang, Liu, Sun, Zhu, Wang, Xiong, Jiang, 2015).

The international minimum standard of urban greenery proposed by the World Health Organisation (World Health Organization, 2012) is 9 m^2 of green space per resident, yet the developed countries have raised their standard to 20 m^2 green space per capita, because of increasingly consciousness and require for greenery areas by community.

Nowadays, functional management of greenery has become necessity in planning, as it is linked to the general health and wellbeing of residents (Darkwah, Cobbinah, 2014).

Methodology of research and materials

Comparative, analytical as well as statistical, and logical analysis methods were used for the investigation.

The article analyses work of foreign scientists, published in scientific publications.

The land fund statistics of the Republic of Lithuania (Nacionalinė žemes..., 2002-2022), graphically depicted in figures, were used for the fulfillment of the research of the trees and shrubs greenery area change in Klaipeda county for the years 2002 - 2022.

The article analyzed and assessed the current state of the trees and shrubs greenery in Klaipeda county. The study provides the trees and shrubs greenery area change analysis in Klaipeda county and in the municipalities of the county. The 20 years period, i.e. the period between the years 2002 and 2022, was selected for the determination of the change. Statistics data were systematized, and analyzed and the expression of the percentage was calculated during the preparation of the research.

The object of the investigation is Klaipeda county's trees and shrubs greenery area.

The aim of the investigation is to carry out the analysis of the Klaipeda county trees and shrubs greenery area during the period between the years 2002 and 2022.

Tasks of the investigation:

1. To analyze the current situation of trees and shrubs greenery in Klaipeda county.
2. To investigate tree and shrubs greenery area change in Klaipeda county during the period between the years 2002 and 2022.
3. To examine the change of trees and shrubs greenery in the municipalities of the county.

Discussion and results

The status quo trees and shrubs greenery in Klaipeda county.

Plots of land set aside for individual green areas are created and managed for recreational, scientific, educational, cultural, cognitive, recreational, aesthetic and other public needs. In order to create new individual public green areas or transform existing individual public green areas, it is necessary to prepare a landscaping project (Lietuvos Respublikos želdynų įstatymas, 2007).

In 2022, tree and shrub plantations in Klaipeda county covered 10,793.50 ha, accounting for 2.07 percent of the county's area.

Today's landscape is not homogeneous. It is cultivated differently in different parts of the territory, with different economic and social functions, cultural and social significance, form, structure, and expression. There are seven municipalities in Klaipeda county where green spaces are unevenly distributed.

An analysis of the area of tree and shrub plantations in Klaipeda municipalities shows that the largest number of trees and shrubs is found in Silute (4,452.53 hectares) and Klaipeda (2,784.31 hectares) districts, while the smallest number of trees and shrubs is found in the municipality of Neringa (20.68 hectares or 0.15 percent) (Table 1).

Table 1

Trees and shrubs greenery area in hectares and percent in municipalities of Klaipeda county in 2022

Municipalities of Klaipeda county	Trees and shrubs greenery area in hectares	Trees and shrubs greenery area in percent
Klaipeda	484.92	4.95
Klaipeda district	2,784.31	2.10
Kretinga district	1,394,56	1,41
Neringa	20.68	0.15
Palanga	326.82	4.13
Silute district	4,452.53	2.65
Skuodas district	1,329.68	1.46

By their very nature, trees and green space provide adventage and add valuation to developments. Preserving trees has affirmative impacts on the image and attractiveness of developments.

Changes in the area of tree and shrub plantations in Klaipeda county.

This paper examines the change in the area of these plantations over 20 years. In Klaipeda county the area under trees and shrubs in 2002 was 4,758.14 ha.

In 2002, an Order of the Minister of Environment of the Republic of Lithuania "On Approval of the Strategy for Protection, Management and Restoration of Green Areas" was adopted, which entered into force in 2003 (Lietuvos Respublikos aplinkos, 2002). This legal document established principles for the protection, management and restoration of green spaces.

In 2007, the Law on Green Areas of the Republic of Lithuania (Law on Green Areas of the Republic of Lithuania, 2007) was adopted. The aim of this Law is to establish a legal framework for the protection, management, creation of green areas and planting of greenery in the territory of the Republic of Lithuania on non-forest land, to ensure the stability of the natural and cultural landscape and the right of the population to environmental conditions that improve the quality of life.

The adoption of this law and the implementation of the strategy stimulated the development of plantations in Klaipeda county. As can be seen from the 1st figure, the analysed area has started to increase since 2007, and in 2022 the plantation area amounted to 10,793.50 ha.

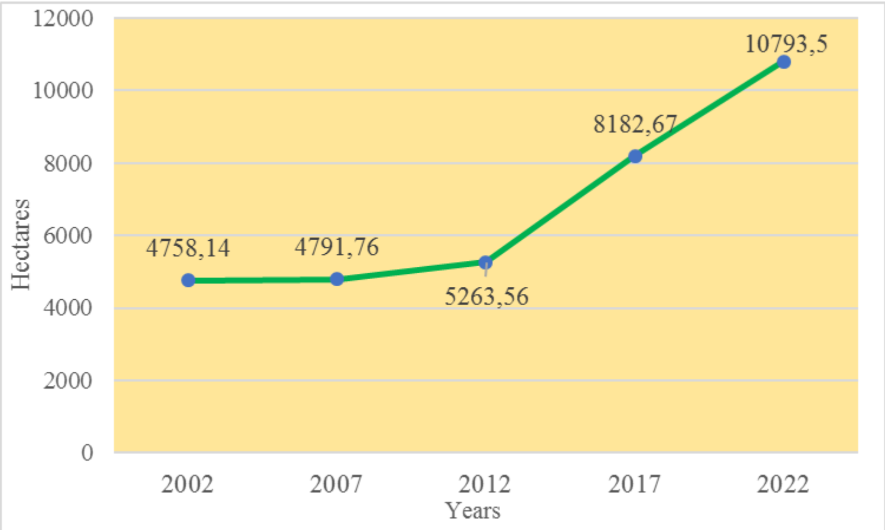

Fig. 1. Trees and shrubs greenery area change in hectares in the Republic of Lithuania in 2002-2022 (Nacionalinė, 2002-2022)

From 2002 to 2022 the area of tree and shrub plantations in Klaipeda county increased by 6,035.36 ha or 126.84 percent. The development of plantation areas has been positively influenced by the creation of an appropriate legislative framework and the implementation of plantation programmes in municipalities.

Changes in the area of tree and shrub plantations in the municipalities.

Tree and shrub plantations are an important part of the landscape. Planting a trees and shrubs is a great way to help fight climate change. Trees not only act as a carbon store, but they also provide huge benefits to the local environment.

Figure 2 shows that the area of tree and shrub plantations in all municipalities of Klaipeda county has increased from 2002 to 2022. This means that all municipalities in the county have expanded their planted areas over the 20-year period.

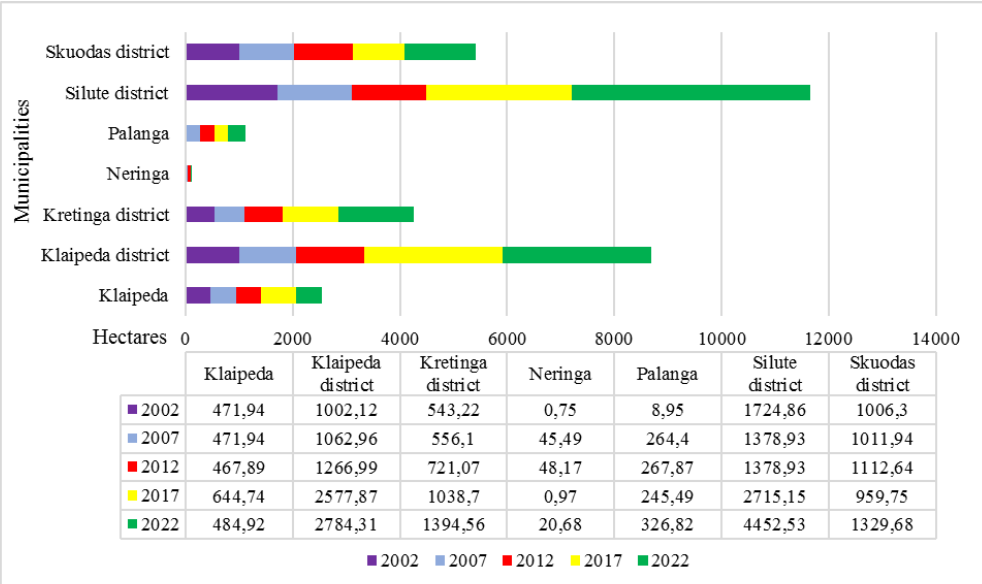

Fig. 2. Trees and shrubs greenery area change in hectares in municipalities of Klaipeda county in 2002-2022 (Nacionalinė, 2002-2022)

However, the increase in the area under trees and shrubs was uneven across the municipalities of Klaipeda county (Table 2).

Table 2

Trees and shrubs greenery area change in hectares and percent in municipalities of Klaipeda county in 2002-2022

Municipalities of Klaipeda county	Trees and shrubs greenery area change in hectares	Trees and shrubs greenery area change in percent
Klaipeda	+ 12.98	+ 2.75
Klaipeda district	+ 1,782.19	+ 177.84
Kretinga district	+ 851.34	+ 156.72
Neringa	+ 19.93	+ 2,657.33
Palanga	+ 317.87	+ 3,551.62
Silute district	+ 2,727.67	+ 158.14
Skuodas district	+ 323.38	+ 32.14

The analysis shows that in the period between the years 2002 and 2022 the biggest increase in the area in hectares of shrubs and plantations took place in Silute district (2,727.67 ha) and Klaipeda district (1,782.19 ha), and the smallest increase in Klaipeda municipality (12.98 ha).

However, when analysing the change data in percentages, it can be seen that the most changes are in the municipality of Palanga (3,551.62 percent), the least in Klaipeda municipality (2.75 percent).

The European Union biodiversity strategy for 2030 (Communication, 2020) is a comprehensive, ambitious and long-term plan to protect nature and reverse the degradation of ecosystems. The strategy aims to put Europe's biodiversity on a path to recovery by 2030, and contains specific actions and commitments. Also, biodiversity strategy encourages bringing nature back into cities by creating biodiverse and accessible green infrastructure. The strategy also emphasizes the importance of developing urban greening plans in cities and towns.

After the implementation of the EU Biodiversity Strategy and the legal acts of the Republic of Lithuania, as well as greenery area development projects in municipalities, it is expected that the area of trees and shrubs greenery will increase.

Conclusions

1. In 2022, tree and shrub plantations in Klaipeda county covered 10,793.50 ha, accounting for 2.07 percent of the county's area.
2. An analysis of the area of tree and shrub plantations in Klaipeda municipalities shows that the largest number of trees and shrubs is found in Silute (4,452.53 hectares) and Klaipeda (2,784.31 hectares) districts, while the smallest number of trees and shrubs is found in the municipality of Neringa (20.68 hectares or 0.15 percent).
3. From 2002 to 2022 the area of tree and shrub plantations in Klaipeda county increased by 6,035.36 ha or 126.84 percent. The development of plantation areas has been positively influenced by the creation of an appropriate legislative framework and the implementation of plantation programmes in municipalities.
4. The analysis shows that in the period between the years 2002 and 2022 the biggest increase in the area in hectares of shrubs and plantations took place in Silute district (2,727.67 ha) and Klaipeda district (1,782.19 ha), and the smallest increase in Klaipeda municipality (12.98 ha). However, when analyzing the change data in percentages, it can be seen that the most changes are in the municipality of Palanga (3,551.62 percent), the least in Klaipeda municipality (2.75 percent).

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DOI: 10.22616/j.balticsurveying.2024.19.003

IMPACT OF CLIMATE CHANGES ON AGRICULTURAL LAND USE IN UKRAINE

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Abstract
Climate change threatens crop yields through changes in temperature, precipitation, and more significant changes in weather conditions. Thus, it is important to monitor the potential impact of changing weather parameters on crop yields in order to adapt to climate change. Ukraine is of particular interest in this regard, as this country is an important player in the world grain market due to its large area of agricultural land. Historical climate data already indicate an increase in temperature in Ukraine, and climate forecasts show a further increase in temperature, especially in the South of Ukraine. Therefore, the purpose of the article is to determine the impact of climate change on agricultural land use in Ukraine.
The global trends of climate change, which is one of the most urgent threats with a long-term negative impact on the population, the environment and the economy, have been studied. The impact of global climate change on land resources, agriculture, forestry, water resources, energy, infrastructure, biodiversity, public health, emergency situations is analysed. The article describes the most noticeable manifestations of global climate changes on the territory of Ukraine, researches and summarizes their consequences on agricultural land use. The potential impact of climate change on the yield of major agricultural crops and possible economic losses are analysed. The article summarizes the results of studies of the dynamics of changes in climate indicators (air temperature and precipitation), the main consequences and risks of climate change for the agricultural sector of Ukraine are given.
Key words: global changes, climate changes, agricultural land use, productivity.

Introduction

Global climate change is one of the more important problems of the 21st century, which is particularly focused on humanity. It is characterized by various manifestations, among which the main are dangerous (extreme) weather cataclysms, sharp changes in weather, floods, floods, rain and rain, hail, strong winds, drought, etc. Such weather phenomena lead to significant ecological and economic losses around the world.
According to the World Meteorological Organization (WMO), the last decades have become the warmest years in the history of observation. At the same time, the period 2016-2021 was the warmest in the last 1400 years. Significant changes in thermal regime have led to the fact that since the mid-1970s the anomaly of the average annual global air temperature has exceeded 0°C both relative to the average temperature in the XX century (1901-2000) and the basic climatic period (1961-1990) (Zhuzel′ ZH., 2012). Since then, the average annual air temperature remains positive, and the speed of its change is steadily increasing.
Thus, in the Northern Hemisphere, such changes have also been noted since the mid-1970s, and in Europe-from the late 80's (Fig. 1). At the same time, 2018 and 2022 were reflected in Europe as the warmest for the entire period of instrumental observations. According to the National Oceanic and Atmospheric Administration (NOAA), the average air temperature during this period was almost 2.82°C higher than the average temperature of the XX century (1901-2000).

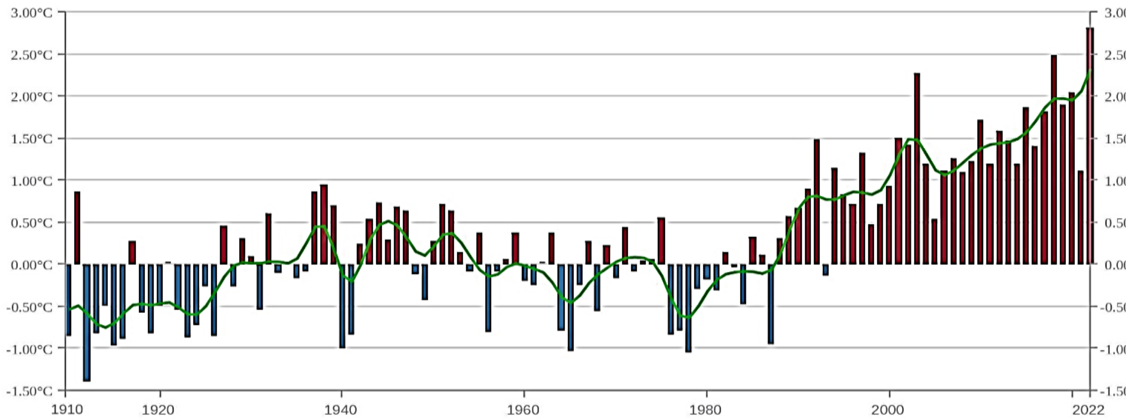

Fig. 1. Average annual anomalies of ground air temperature in Europe (according NOAA)

Increasing the surface air temperature, in particular in the northern hemisphere, led to food producers of food, the inter-year's variability of agricultural productivity. Increasing the unpredictability of climatic conditions threatens the provision of the Earth's population with food. Solving this food problem in the XXI century is the most important strategic task of the new century.
Climate changes affect all regions of the world and all segments of the population. UN data show that more than a hundred millions of people in developing climate change in developing countries can remain outside the poverty line (Climate change and poverty: report…, 2019). Even with the best scenario, most of the population may face food safety, various diseases, deaths and migration. The continuation of such a process will be detrimental to the world economy. Studies show that climate changes can lead to a decrease in global agricultural growth by 2050. More than 500 million small farms can potentially be affected worldwide (Munich Security Report, 2020).
To date, much of the world, through the adoption of international climate agreements, has committed themselves to effectively fight global warming and be carbon neutral by 2050.
However, at this time, the efforts to contain global warming, especially from the economically developed countries, do not produce the desired result. Thus, according to an the Intergovernmental Panel on Climate Change (IPCC) instead of limiting global warming at a level up to 1.5°C within the Paris Agreement of 2015, today the world is on the way to warming at 4.4°C 2100.
Increasing global temperature by 4°C, in the first place, will be accompanied by a reduction in water resources and an increase in competition for them, which will become a factor in the risk of food security on a global scale. The number of people who will not be able to receive enough water for at least one month a year will increase by 2050 from 3.6 billion to more than 5 billion. From the Sahara, by 2050, more than 140 million people can become internally displaced persons (Groundswell: Preparing for Internal Climate…, 2018).
Achievement of 1.5°C is still possible, but it requires a 7.6% reduction in total emissions every year (Climate tipping points…, 2022). In this case, each delay increases the amount of emissions that need to be reduced in the future.
Under these circumstances, an important task of environmental economics is to study the impact of climate change on agricultural land use in Ukraine, as they can help to understand exactly what changes need to be made to agroecosystems and agricultural production to reduce the impact of climate change and increase resilience to its consequences. Thus, the study of the impact of climate change on agricultural land use is an important step in the implementation of sustainable development of Ukraine, which involves a combination of economic growth, social justice and environmental protection.

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, statistical data of the State Statistics Service of Ukraine and the Ukrainian Hydrometeorological Center, Ministry of Environmental Protection and Natural Resources of Ukraine.

Discussions and results

The climate is the determining factor of agricultural production. Agriculture is the most climbing industry. Its vulnerability, caused by the influence of dangerous meteorological phenomena, which largely determines the amount of total losses of the country's economy.
Agriculture is one of the most important sectors of the Ukrainian economy. As of 2020, the share of agricultural products in GDP of the country is 9.3%, which is quite high among other countries in the world. Ukrainian farmers supply agrofood products to 205 countries. In the period 2016-2020, the volume of trade between Ukraine and the EU, between Ukraine and the United States has currently exceeded $ 5 billion USA in a year. The share of agricultural products and food in total exports is about 40%, providing 2/5 of foreign exchange earnings to the country (Trusova N., Radchenko N., Shut′ko T., 2021; How Ukraine can become one…, 2022).
According to the estimates of various experts, there are identified opportunities in Ukraine to feed more than 600 million people, which is 15 times greater than the domestic need for food (How Ukraine can become one…, 2022). Ukraine has significant natural and socio-economic resources, which determines

its sustainable development. At the same time, issues of sustainable development have recently become particularly relevant. After all, both in the economy and in the social life of the population, problems related to climate change are becoming more and more tangible.
The climate of Ukraine is temperate continental with subtropical Mediterranean on the southern coast of Crimea. In the north-western and western parts of the territory of Ukraine, the climate is mild with a moderate temperature regime and excessive humidity, although in the south-eastern and eastern parts there is a deficit of precipitation and a slightly elevated temperature background. The continentality of the climate increases from west to east.
In general, Ukraine receives a sufficient amount of moisture and heat, which causes favorable natural and climatic conditions on its territory. However, during the last thirty years, significant changes in the climate system have been observed in Ukraine. An indicator of these changes is a change in the average annual air temperature of the lower layer of the atmosphere (at a height of 1 meter above the surface), a change in the thermal regime and precipitation structure, an increase in the number of dangerous (extreme) meteorological and weather phenomena, which leads to losses both for the population of the country due to mold and and for various sectors of the economy.
Currently, the climate of Ukraine is in the trend of global warming, which has covered the entire territory of our country. At the same time, the rate of increase in air temperature is even slightly ahead of the global average. Thus, according to the assessment of the National Oceanic and Atmospheric Administration (NOAA), the territory of Ukraine has entered the regions of our planet where the temperature is increasing at the highest rates.
In addition, according to statistical data of the British Meteorological Bureau, February 2019 became the second warmest February in the entire history of observations for most European countries, including Ukraine (Fig. 2). This conclusion was made on the basis of meteorological data that was collected during a two-week period (February 11-25) every year since 2000.

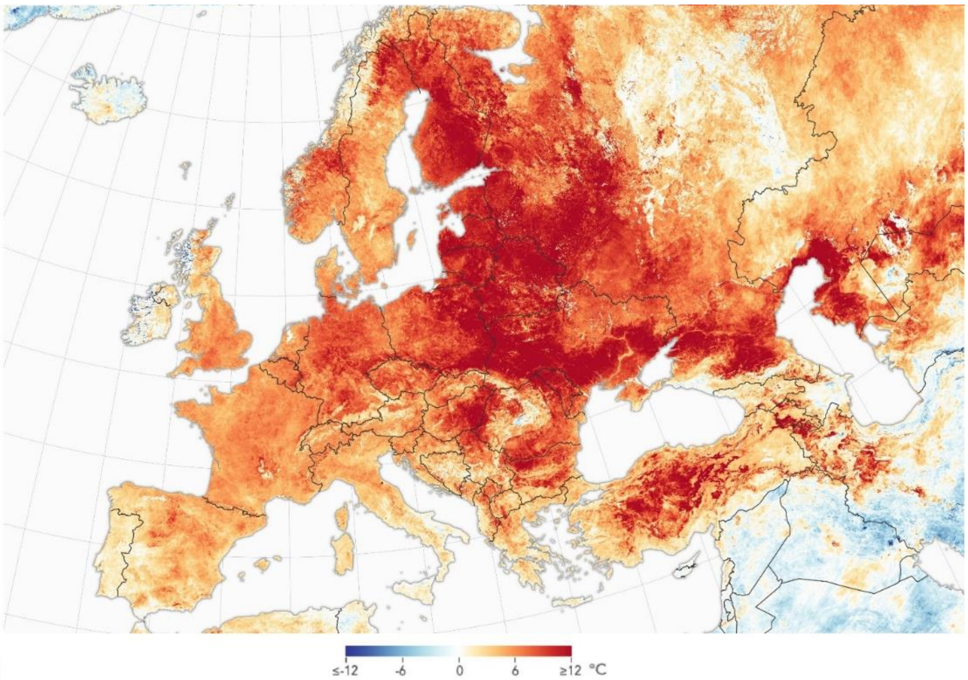

Fig. 2. Anomaly of the average February temperature of the earth's surface in Europe (An Unusually Warm February…, 2021)

Various scientific studies (Babichenko V. and et., 2022; Balabukh V., 2022) indicate that the modern climate of Ukraine is characterized by uneven warming over the territory, which is especially pronounced in the summer and winter months. Over the past 30 years, the average annual air temperature in Ukraine has increased by more than 1°C. At the same time, the increase in air temperature in the cold period (November-March) is on average 1.3°C, and in the warm period (April-October) – 1.1°C. Thus, we observe a clear increase in air temperature in Ukraine for the period 1991-2020 compared to 1901-1990 (Fig. 3).

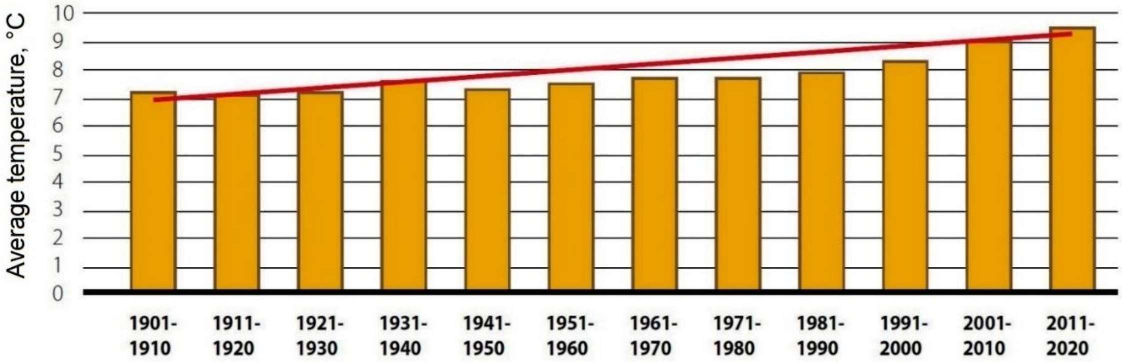

Fig. 3. Average annual surface air temperature in Ukraine

As shown by the given data (see Fig. 3), an increase in the average annual air temperature in Ukraine has been observed since the middle of the 20th century. Moreover, the following decade was warmer than the previous one: 1961-1990, the increase occurred by 0.3°C, 1991-2000 – by 0.5°C, 2001-2010 – by 1.2°C, 2011-2019 – by 1.7°C. In the period 1991-2020, such a positive anomaly (deviation of air temperature from the climatic norm) across the entire territory of the state was the largest in the entire history of instrumental meteorological observations. Such changes indicate a significant change in the climatic norm and acceleration of the increase in surface air temperature in Ukraine.

The change in the temperature regime is not uniform on the territory of Ukraine and has a regional character. The climatic norm of the average annual air temperature increased in the latitudinal direction from south to north and northeast. The greatest increase in temperature occurred in Polissia and in the Forest-Steppe zone, in some places the indicator exceeded 1.5°C (Fig. 4) (Balabukh V., Lavrynenko O., Malyts′ka L., 2014).

a) 1961-1990 *b)* 1991-2020

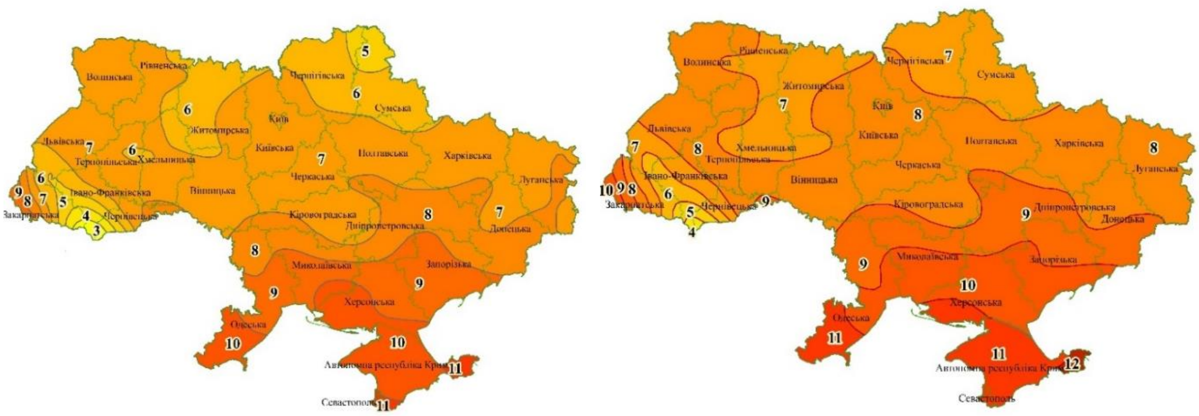

Fig. 4. Average annual surface air temperature in the basic (*a*) and modern (*b*) climate periods

Climate is also one of the main factors that determine the development of agriculture. At the same time, for this type of activity, it acts as a basic natural resource, as well as a risk factor for producers of agricultural products.

The impact of climate on agriculture is obvious. Today, as a result of climate change, agriculture is facing serious challenges, and at the same time, it is one of the main sources of greenhouse gas emissions that cause climate change.

Emission of greenhouse gases occurs at every stage of the agricultural cycle. After all, the production of livestock and crop production leads to emissions of carbon dioxide, methane and nitrogen oxide. According to the reports of the Intergovernmental Panel on Climate Change (IPCC), livestock production is responsible for 39% of anthropogenic methane emissions and 65% of anthropogenic nitrogen oxide emissions. In general, agriculture accounts for about 15% of the global volume of greenhouse gas emissions. Moreover, according to various estimates, by 2050, such emissions may increase to 30%.

According to the National Cadastre of Greenhouse Gas Emissions, the share of agriculture in total greenhouse gas emissions in Ukraine in 2020 was 13.2% (Ukraine's greenhouse gas…, 2022). The main sources in the agricultural sector are intestinal fermentation and agricultural land (soil), which account for 17.9% and 76.4% of the total emissions in the sector in 2020 (Table 1). In general, emissions in this sector decreased by 52.0% compared to the base year, and by 6.9% compared to the previous year.

Table 1

Changes in greenhouse gas emissions in agriculture in Ukraine

Category	Total emissions of direct GHG	Emissions, kt CO2-eq.			
		1990	2016	2017	2020
Enteric Fermentation	CH_4	39311	8789	8596	7447
Manure Managemen	CH_4, N_2O	6775	1957	1920	1945
Rice Cultivation	CH_4	216	89	94	83
Agricultural Soils	N_2O	37678	28431	27619	31846
Liming	CO_2	2592	140	169	131
Urea Application	CO_2	270	451	512	235
Total for the sector		**86542**	**39857**	**38910**	**41687**

Agriculture significantly affects the accumulation of carbon in the soil, as well as the emissions of carbon dioxide as a result of changes in the intended use of land. Such negative phenomena can occur due to the conversion of forest lands to agricultural use, depletion of soil organic matter (humus) (SOM) on arable lands and pastures, etc.

Climate change related to agriculture is truly a global problem today. Agriculture is the most vulnerable sector of the economy to fluctuations and climate changes. This is due to its sensitivity to changes in climatic factors and due to the projected increase in crop yields as a result of the elimination of the technological backwardness of Ukraine's agriculture from the leading countries of the world. As you know, agroclimatic conditions for agricultural activities are determined by three main indicators: the amount of heat and moisture during the growing season, as well as the conditions for overwintering agricultural crops.

In general, the agro-climatic conditions of the territory of Ukraine are quite favorable for the development of agriculture. However, modern warming causes a significant change in the agro-climatic conditions of development, growth and productivity of agricultural crops. Such changes are accompanied by a significant increase in air temperature, especially in the winter months, a temporal shift in the formation of natural processes, an increase in the number of long thaws, an extension of the frost-free period and the duration and heat supply of the growing season of agricultural crops, changes in the duration of individual seasons. In addition, as a result of climate change, an increase in the frequency of extreme weather events, a decrease in soil moisture, depletion of water resources, the development of soil degradation, etc. (Voloshchuk V., Boychenko S., 1998; Krakovs′ka S. and etc., 2008).

In general, according to the research of the Technology Needs Assessment (TNA), which is implemented by the United Nations Environment Program and the Copenhagen Climate Center of UNEP, the agricultural sector of Ukraine is characterized by the following consequences and risks of climate change (Ukraine, Europe, 2022):

1. An increase in the productivity of major agricultural crops in the short term until 2030 and, at the same time, a potentially critical decrease in yields until 2050.
2. An increase in the growing season, which leads to a shift in the start of the sowing campaign by an average of 2 weeks earlier, as well as the possibility of harvesting two crops.
3. Reduction of production productivity due to lack of appropriate technical equipment under the scenario of rapid climate change.
4. The shift from the south to the north of the zones of cultivation of agricultural crops, the formation of a new agro-climatic zone in the south of Ukraine with the annual sum of temperatures exceeding 3400°C.
5. Increasing soil moisture loss due to increased droughts as a result of rapid growth of thermal resources.
6. An increase in the intensity of strong winds, which prevent the timely application of plant protection products and lead to the development of soil erosion.
7. Reducing the capacity of agricultural land use to adapt to climate change.
8. An increase in the level of infectious diseases as a result of changes in the migration routes of insects, birds and animals.

9. An increase in the risk of damage to plants due to diseases and pests due to favorable conditions for their development, especially in the winter period.
10.Reduction in the efficiency of animal husbandry due to a decrease in the gross production of traditional fodder crops and the need to grow non-traditional crops (sorghum, triticale, millet, etc.).
In general, the climate significantly affects the formation of the yield of agricultural crops and the spatial structure of agricultural production. According to many scientists, the warming of the climate in Ukraine as a whole has a positive effect on the productivity of crop production. Thus, according to the results of the research work "Conducting a spatial assessment of the degree of favorability of future climatic conditions for the productivity of the main grain crops and forest plantations" (Final report on the results…, 2014) in Ukraine, an increase in the yield of winter wheat is predicted in all natural and climatic zones. In particular, by 10-15% for the Forest Steppe, by 20-30% for the Steppe and Polissia. Moreover, in favorable years (under conditions of normal moisture), the yield of winter wheat, as well as grain crops in general, can increase by 2-2.5 times in the entire territory of Ukraine. Thus, it is assumed that climate changes will contribute to an increase in the yield of both winter wheat and other cereals in the near future. It is predicted that winter and spring wheat, rice, soybeans, and barley will grow much better, their ripening period will accelerate, and the yield will increase by 20-30%. At the same time, the yield of corn may decrease (Adamenko T., 2008).
In addition, the European Environment Agency (EEA) conducted a study on the change in crop yields in Europe by 2050 (compared to 1961-1990) under the condition of decreasing moisture levels. Therefore, according to the agency (EEA) (Projected changes…, 2022), almost the entire territory of Ukraine falls into the zone of potentially high yield increases (from 5 to 25%) (Fig. 5).

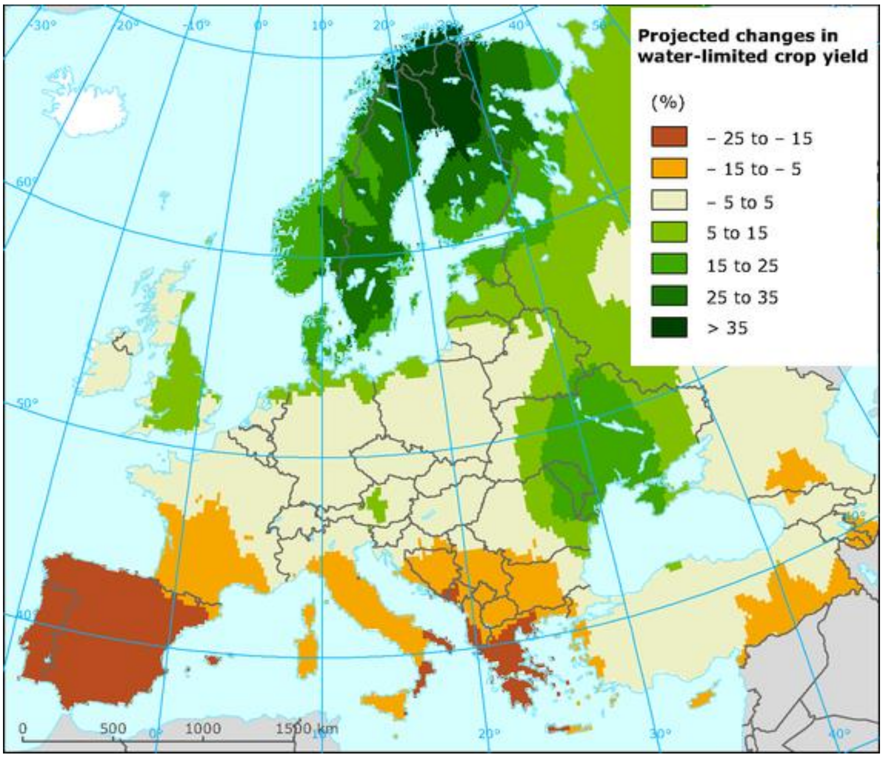

Fig. 5. Projected changes in the yield of agricultural crops in Europe until 2050, subject to a decrease in humidity

It is worth noting that many scientists claim that the increase in the yield of agricultural crops in Ukraine is mainly due to the access of landowners and land users to the latest technologies for the production of crop and livestock products. According to various calculations, the implementation of zonally adapted resource-saving and environmentally safe innovative technologies for the production of agar products will ensure an increase in production efficiency and competitiveness on the domestic and foreign markets due to an increase in the gross production of grain by 10-15 million tons, meat – up to 5.1, and milk – up to 20 million tons, a decrease in specific fuel costs by 26-40%, labor costs by 30-60%, direct operating costs by 22-50%, as well as an increase in the yield of agricultural crops by 30-40% (Yurchenko V., 2017; Tkachuk V., 2014).
It is known that for a comprehensive assessment of the impact of climate changes on agricultural land

use, two main groups of agroclimatic indicators are used – the properties of heat supply and moisture supply, mainly the growing season.
The growth of the heat supply of crops, which is now, is certainly significant factors that contributes to the increase in productivity of agricultural production of Ukraine. However, not only a change in the average annual temperature, but a change in temperature in certain periods of plant life cycle, is important for agriculture. During the period 1991-2019 in the territory of Ukraine, the greatest deviation from the rate of average monthly temperatures of air occurs in winter and in the second half of the summer (Fig. 6).

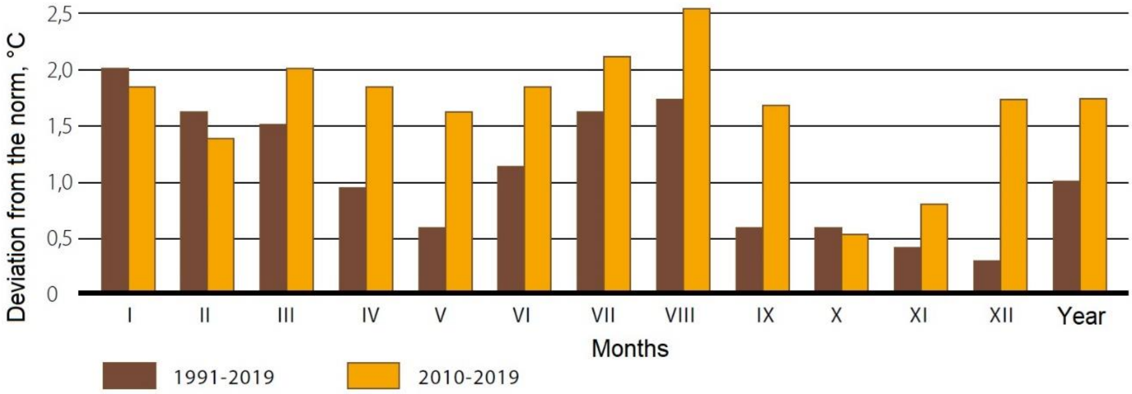

Fig. 6. Deviation from the norm (1961-1990) of average monthly air temperatures for periods of 1991-2019 and 2010-2019 in Ukraine

Climate warming is accompanied by a change in the conditions of moisture of a certain area. Moisture is determined by the ratio of precipitation and evaporation. Soil moisture deficiency in the growing season is a major factor that reduces crop yields. Nowadays, precipitation is characterized by significant spatial heterogeneity, which is caused by various pre -forming processes that prevail in the regions of Ukraine.
It is known that the norm (1961-1990) of the annual rainfall in Ukraine is 578 mm. However, over the last 5 years (2015-2019), on average, rainfall was 569 mm, with their extremely uneven distribution in time and territory-from 500 mm to 659 mm in 2016 (Fig. 7). In Vinnytsia, Donetsk, Zaporizhia, Kyiv, Rivne, Ternopil, Khmelnytsky, Cherkasy and Chernihiv regions, 7-12% fewer than the norm has fallen over these 5 years (Adamenko T., 2019).

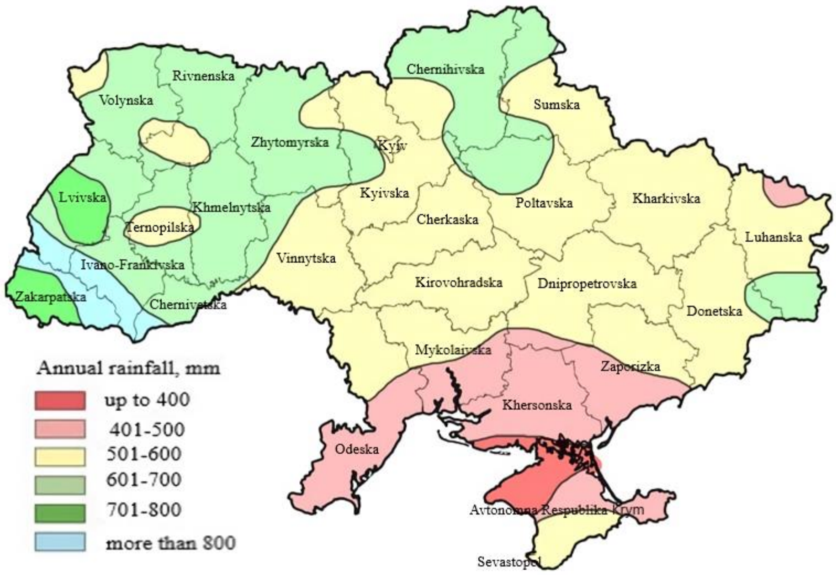

Fig. 7. The average annual rainfall in the territory of Ukraine

It is important that the nature of the rainfall that has become more extreme. In many regions of Ukraine, the intensity of precipitation has increased, the uneven loss of their fall over certain periods of the year, which has led to an increase in the duration of the inflammation. In general, according to the Ministry of Environmental and Natural Resources of Ukraine in 2020, rainfall fell by 13.6% less than the average long-term amount for 1991-2020. Summer and autumn were the most drying in a large territory of Ukraine. Due to the increase in air temperature and uneven distribution of rainfall, which is of storm, does not ensure the effective accumulation of moisture in the soil, which caused the occurrence of arid phenomena. As a result of the drought that arose in Ukraine in 2020, the amount of material losses caused from the area of dead crops amounted to more than UAH 23.4 billion, of which winter crops are over UAH 17.1 billion (National report…, 2020). In addition, there are no losses of natural disasters, losses from changes in the specialization of enterprise, production cycles of growing crops, costs of adaptation to climate change, etc. According to the British economist Nicholas Stern, if countries do not implement measures to reduce greenhouse gas emissions, then losses from climatic changes can reach about 5-20% of GDP annually (The Economics of Climate Change…, 2007).

Conclusions and proposals

Based on the above data, we can conclude that climate change has an ambiguous impact on both agricultural land use and agriculture as a whole. Thus, the impact of climatic changes on land use in agriculture has both positive and negative consequences.

Therefore, the positive effects of climate change can be attributed:

- Increasing the efficiency of agriculture by increasing the duration and heat supply of the growing season throughout the country;
- Increasing the duration of the vomiting period and improving the conditions of wintering of certain field and garden crops;
- Earlier start of spring field work and the onset of sowing of spring crops, as well as acceleration of ripening of cereals and the terms of their harvesting.;
- The possibility of harvesting several crops during the year;
- Expanding the territory of cultivation of traditional crops (wheat, rye, barley, corn, etc.) and the ability to grow more demanding for warm culture (millet, sorghum, melons, sunflower, soybean, grapes, etc.).

The negative consequences of climatic changes in land use in agriculture of Ukraine belong:

- Weakening of hardening of plants with increasing the likelihood of their damage from freezing, soaking, evaporation due to significant changes in temperature, as well as from various fungal diseases caused by warm and snowless winters;
- Changes in temperature regimes in the spring, which led to a shift in the beginning of the sowing campaign, which in recent years begins on average 2 weeks earlier;
- Reducing yield due to the increase in the frequency and duration of dry periods in some regions and increased recurrence, intensity and duration of extreme precipitation (floods) in others;
- Reducing soil productivity due to humus decomposition in soils at higher air temperatures;
- Development of soil erosion due to intensive leaching of nutrients from the soil during heavy rains;
- The development of wind erosion of soil due to strong wind gusts, which also interfere with the timely introduction of plant protection products;
- The spread of new infectious and parasitic diseases that are not peculiar to certain regions, as well as the increase in the reproduction of many thermophilic species of pests of crops.

Thus, given the dependence of agricultural efficiency on weather conditions, it is now necessary to make timely and adequate solutions for complex problems that are caused by climate changes. In order to effectively use some favorable aspects of climate change (for example, through an increase in thermal resources, it is possible to grow a larger set of crops and their varieties) preparation and implementation of special measures for adaptation (adaptation) to the agricultural sector of the country to new natural conditions at all levels. - from each farm to the country as a whole.

In addition, when analyzing the impact of climatic changes on agricultural land use, it is necessary to clearly separate not only what is happening now, but also what awaits us in the future. This is very important, because most of our country is expected to change the existing poorly positive trend for the negative.

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DOI: 10.22616/j.balticsurveying.2024.19.004

LAND CONSOLIDATION URGENCY RANKING FOR THE VILLAGES OF THE BRZYSKA COMMUNE

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Abstract
The present spatial arrangement of rural areas in southeastern Poland stems from socio-economic conditions that originated, for instance, at the time of annexations and Socialist rule. Adverse phenomena in the structure of rural areas, such as fragmentation of land, inhibit the development of farmsteads and lead to ineffective use of the agricultural area, increased financial expenditure and limited options for using the latest technological developments. The land consolidation procedure provides a comprehensive solution to the problem. The procedure, inscribed in the sustainable development of rural areas, aims at optimising the spatial parameters of farmsteads, creating a functional network of roads and reclaiming land, and constructing land improvement structures. Due to limited financial and human resources, consolidation projects cover relatively small areas that are disproportionate to considerable needs. Therefore, determining land consolidation urgency is essential in the context of delimiting priority areas. This paper presents a ranking for the urgency of land consolidation in the villages of the Brzyska commune, in the district of Jasło, Sub-Carpathian voivodeship. The villages were analysed in detail for the presence of 15 features directly affecting the spatial structure quality of the study area. The calculated values were standardised, and afterwards, using zero unitarisation, priorities were set for the analysed villages in terms of their requirement for land consolidation.
Key words: land consolidation, land exchange, spatial structure of land, agriculture, land fragmentation

Introduction

The spatial arrangement of villages is a result of centuries-long human intervention. To make their living, people changed natural landscapes adapting them to their own needs but did not consider the adverse effects their activities could have. The structure of rural areas was altered, to a decisive extent, by human settlement, which divided the area according to specific principles. This division resulted in the emergence of various forms of land use. The economic development of the rural community resulted in continuing transformations of the structure of land taking place at a rate dictated by the stages of development and the economic conditions (Noga, 2001).
The world literature mentions historical socio-economic conditions as the major adverse factor affecting the structure of rural areas, and hence the agricultural activity environment. The negative phenomena include land fragmentation noted down in countries such as Albania, Bangladesh, Bulgaria, China, Czech Republic, Estonia, Ethiopia, Ghana, Hungary, India, Israel, Jordan, Lithuania, Nepal, Peru, Poland, Romania, Slovakia, Syria, Taiwan, Turkey, Ukraine USA and Vietnam (van Dijk, 2003; Demetriou, 2014). Muchová and Raškovič describe historical reasons for excessive land fragmentation in Slovakia, including land property inheritance rules and real property regulations distinguishing between buildings and land (Muchová and Raškovič, 2020). Using the example of Lithuania, Pašakarnis and Maliene highlighted excessive land fragmentation in post-Socialist countries, associated with unregulated privatisation of land (Pašakarnis and Maliene, 2010). Researchers investigating the reality in Ukraine (Martyn et al., 2022) and presenting the results of the analysis carried out in Albania (Deininger et al., 2012) share this view. Jürgenson raises this issue at a deeper level, using the example of Estonia where a need exists for creating proper legal regulations to allow solving the problem of land fragmentation and take the latest technical developments into account (Jürgenson, 2016). Wang et al. see multiple divisions of land, characteristic of conventional agriculture, as the main reason for land fragmentation in China (Wang et al., 2021). Despite the variety of reasons, researchers generally agree on the disadvantages of the internal land fragmentation, defined by van Dijk as a "fragmentation within a farm" (van Dijk, 2003. Thus, the experts emphasise the necessity to undertake corrective actions.
The correct configuration of land is one of the factors allowing profitable agricultural production (Hiironen and Riekkinen, 2016). The following factors play a vital role in the farmstead's spatial structure: number, surface area, shape and elongation of plots as well as their access to a road and adequate location of the farmer's dwelling. As regards production profitability, the number of plots should not be more than six per farm (Noga, 2001). Another factor determining the farm's productivity is the surface area of plots. Plot width, length and shape also affect the farmstead's spatial functionality

and profitability. Literature specifies the desired plot width as 20-40 m. However, the optimum plot width should also take into account land use type, soil type, slope angle and the working width of agricultural machinery. In contrast, in calculating the correct plot length for the farmstead, its surface area, use, soil type and fieldwork mechanisation level should be considered. The expected plot length ranges from 250 to 600 m. Labour productivity increases in proportion to plot length from 210 to 400 m. Plot elongation, expressed as its width to length, affects working time (necessity to reverse) and contributes to crop losses at the plot's border. Studies demonstrated that the optimum plot elongation should be 1:5 (Noga, 2001). Another element shaping the development of agriculture is the previously mentioned access of plots to roads and the condition of existing roads. As the plot fragmentation proceeded, the direct network of roads did not develop. Therefore, most plots lack a direct connection to the farmstead (Noga, 1977). Numerous informal access easements appeared at that time. The problem intensified with the development of technology, preventing the passage of modern agricultural machinery. In the Subcarpathian voivodeship, in southeastern Poland, agricultural land features notably high fragmentation and small plot surface (Wójcik-Leń et al., 2022). The present network of roads offering direct access to agricultural fields is not adapted to access by modern agricultural equipment. These factors constitute a critical barrier to the development of agriculture (Radziszewska, Jaroszewicz, 2012).

The land consolidation process is a comprehensive solution to defects inac the agricultural area (Stręk and Noga, 2019). Since land consolidation projects are expensive, they should be preceded by a thorough land configuration analysis (Leń 2018, Janus and Taszakowski, 2018, Marinković et al., 2022). In the context of delimiting potential areas for consolidation, it is also essential to identify agricultural wasteland (Wójcik-Leń, 2022).

The land consolidation process is commonly used in transforming the spatial structure of rural areas i.a. in Poland and the other countries of the European Union. The Act of 26 March 1982 on the Consolidation and Exchange of Land defines land consolidation as a rural management procedure aiming at the transformation of the spatial arrangement of rural land to create more favourable management conditions by improving the territorial structure of farms, ensuring reasonable configuration of the land, and aligning the limits of real properties with the system of water irrigation structures, roads and terrain (Ustawa, 1982). By contrast, the Polish Rural Development Programme (PROW) for the years 2014-2020, conducted in Poland, describes land consolidation as works during which new plots are formed in a configuration different from that of original plots to reduce the number of small, scattered plots constituting a single farm and to increase their average size (PROW 2014–2020).

A land consolidation procedure is initiated at the request of the majority of plot owners in the projected area or owners of more than half of the surface area of such land in total. It is generally financed by the state budget but also from earmarked funds, the budgets of local administrative units and owners of the consolidated land. This procedure makes it possible to design a new arrangement of farms and enhances the configuration of land by reducing the number of plots, increasing plot surface area, decreasing the distance between the plots and the farmer's dwelling and adjusting their irregular shape. It also improves the agricultural network of roads offering access to plots. In turn, at the post-consolidation management stage, the width, surface condition and density of roads improve, which shortens access to fields.

Land consolidation is the more effective, the worse is the spatial arrangement of the concerned area. Woch found that for the consolidation of land with an average plot surface area of 0.35 ha and, on average, 6.5 plots per farmstead, the plot surface area increased by eight per cent and the number of plots decreased by half. For worse land configurations, the surface area increased up to 200%. Consolidating plots having a better configuration (> 0.80ha) the surface area increased by 50%, and the number of plots decreased by 40% at the maximum. Surveys showed that consolidating poorly configured land, being predominant in southeastern Poland, increased the income derived by its owners on average by 20-30%. A return on land consolidation costs is expected within 4 years, and the post-consolidation management costs - are within 20 years (Woch, 2007). Benefits related to land consolidation are reflected in the present-day surveys on the economic aspects of land consolidation. Janus and Markuszewska analysed the persistence of changes introduced by the land consolidation procedure. They investigated the site where a land consolidation project was completed 40 years earlier. Having analysed the agrarian structure of the land, they found traces of land consolidation effects such as size and the number of plots per farmstead and road access of the plots (Janus and Markuszewska, 2019). Hiironen and Riekkinen evaluated land consolidation in terms of its impact on agriculture, profitability, improvement of the ownership structure and costs of agricultural activity. To this end, they examined 12 land consolidation sites in Finland and found that land consolidation was an effective tool

to improve the ownership structure and decreased production costs by 15% (Hiironen and Riekkinen, 2016).
The aim of the report is to determine a hierarchy of the land consolidation urgency for the villages of Brzyska commune, located in southeastern Poland. The research is based on 15 criteria, selected in accordance to the expert knowledge and the practise of the land cocsolidation works realisation in Poland, in a range of the studial analyses of the rural areas spatial structures (Janus and Taszakowski, 2014) The detailed analysis concerned the elements of the spatial and demogrephic structure, determining the potential needs foe the land consolidation works. Within the research procedure, conducted with the authors' calculating methods, an assessment of the land consolidation urgency for each village has been elaborated. The result of the analysis carried out is the land consolidation urgency ranking for the studied villages.

Methodology of research and materials
The priority of this paper is to analyse and evaluate the spatial structure of rural land in the Brzyska commune, based on the structure of ownership, land use, land fragmentation and road access of plots. All seven precincts in the commune were analysed in detail. Figure 1 shows the location of the Brzyska commune in Poland, Subcarpathian voivodeship and the district of Jasło.

Figure 1. Location of the Brzyska commune on the map of Poland, Subcarpathian voivodeship and the district of Jasło. Source: own elaboration.

The findings provided grounds for describing the specific features of the current spatial structure and preparing suggestions for optimisation methods. We developed a land consolidation urgency ranking, taking the impact of land configuration on the development of agriculture into account.
Adverse land configuration in rural areas is an obstacle to profitable agricultural production. Therefore, the agricultural production areas should be transformed as soon as possible by consolidating land. However, the consolidation of large areas is impossible due to economic, technical and social reasons. Thus, it is necessary to prepare land consolidation needs and urgency ranking. To compare different villages scattered over the area, a relevant evaluation methodology needs to be designed, followed by the ranking in pursuance of the purpose adopted in this paper. The variables adopted in the multiple-criteria assessment should be converted and made uniform. The converted variables are deprived of labels and their values fall within similar ranges. This type of transformation is called the standardising method. The standardised values of diagnostic features are aggregated, which produces a synthetic feature characterising each village depending on the adopted objective (Figure 2.) (Leń, Mika, 2016).

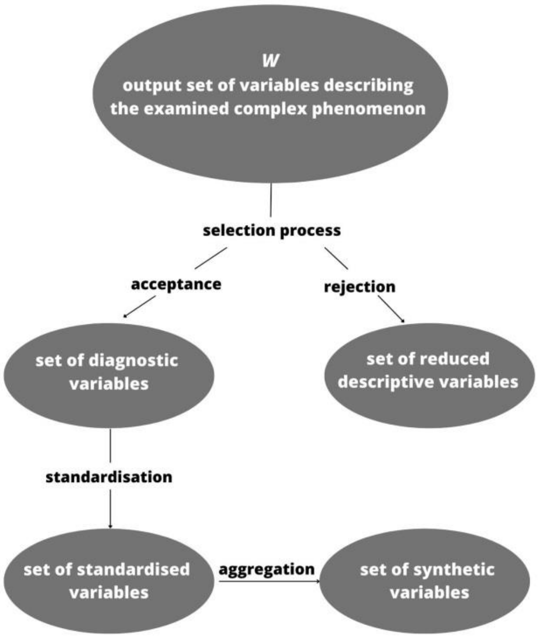

Figure 2. Development of a synthetic variable. Source: [Leń, Mika, 2016]

The synthetic values provide the basis for a ranking to order the villages from the worst to the best synthetic value. Such a list was prepared based on the spatial structure of the land, using zero unitarisation to set the priority in the land consolidation ranking for the precincts of the Brzyska commune. Fifteen diagnostic features, describing each precinct, were adopted (Table 1) for the identification of the areas for land consolidation in the Brzyska commune. The criteria of the analysis were selected with reference to the studial analyses methodology, applied in the land consolidation project assumptions, elaborated at an initial stage of the land consolidation proceeding in Poland (Janus and Taszakowski 2014). The variables were classified as stimulants and destimulants of land consolidation urgency.

Table 1.

Features adopted as stimulants and destimulants Source: own elaboration.

Selected features	Mean	Median	Min	Max	Coefficient of variation (V)
Stimulants					
Total area of the village	641.0	365.6	200.7	1887.1	97.0
Total number of plots	1344.0	1033.0	404.0	3040.0	71.1
Average plot area per village	0.4	0.5	0.3	0.6	29.1
Number of inhabitants	948.1	618.0	356.0	2296.0	76.7
Number of residents per 1sq km	177.5	165.3	86.4	293.4	38.8
% of arable land	53.7	49.9	46.4	70.6	17.3
% of pastures	10.7	10.1	6.8	13.4	22.3
% of land owned by private farmers	72.4	72.6	64.6	82.4	8.0
Number of private sector plots	1108.3	693.0	339.0	2652.0	79.3
% of the number of plots without access to roads	38.9	39.1	30.0	51.2	20.5
% of the surface area of plots without access to roads	39.9	39.7	24.0	46.7	19.6
Destimulants					
% of forests	17.9	21.5	0.0	33.5	73.9
Fragmentation ratio (Leń, Noga, 2010)	3.4	3.4	3.0	4.0	10.2
% of land owned by the State Treasury	12.9	11.9	1.6	27.9	79.6
Average plot area in the private sector	0.4	0.4	0.3	0.6	26.3

The ranking of villages was prepared using the Zero Unitarisation Method (ZUM), which allows for standardizing diagnostic variables by testing the range of the characteristic (Leń, Mika, 2016). There are three groups of diagnostic variables describing the study object (Leń, Mika, 2016):

1) stimulants (the larger-the-better characteristics) – variables that, with increased values, improve the evaluation of a characteristic of the analysed object; then, standardised variables are calculated according to the formula:

$$Z = \frac{(x - x_{min})}{(x_{max} - x_{min})} \tag{1}$$

2) destimulants (the smaller-the-better characteristics) – variables that, with increased values, deteriorate the evaluation of a characteristic of the analysed object; then, standardised variables are calculated according to the formula:

$$Z = \frac{(x_{max} - x)}{(x_{max} - x_{min})} \tag{2}$$

3) neutral variables – variables assuming the highest rank (the optimum) only for a certain value or range of values; the further from the optimum, the lower rank of the phenomenon. Then, standardised variables are calculated as below:

$$Z = \frac{(x - x_{\min})}{(x_{opt} - x_{\min})}, \text{ for } x < x_{opt}, \quad (3)$$

$$Z = \frac{(x - x_{\max})}{(x_{opt} - x_{\max})}, \text{ for } x > x_{opt}, \quad (4)$$

where:
Z – standardised variable,
x – non-standardised variable,
x_{max} – maximum value of the variable in the specific set,
x_{min} – minimum value of the variable in the specific set,
x_{opt} – the optimum value of the variable in the specific set.

Standardisation of diagnostic features is a preliminary stage leading to an overall multiple criteria assessment of each object taken into consideration. Their overall assessment can be achieved through aggregation. To obtain a synthetic measure the mean values are calculated for sets describing the respective characteristics (Leń, Mika, 2016) according to the following formula:

$$z_i = \frac{1}{p}\sum_{j=1}^{p} x_{ij} \quad (5)\ (i = 1,\ldots,m)$$

Standardised measures fall within the range <0;1>. The results can be interpreted as the average optimum value of each object. Thus, the higher the synthetic measure, the higher the object’s position in the ranking being created (Leń, Mika, 2016).

Discussions and results

According to studies presented in Table 2, land consolidation should be carried out in Kłodawa in the first place (synthetic ratio: 0.58). This village features a defective spatial structure. The farms are excessively fragmented (so-called internal fragmentation) (van Dijk, 2003), and plots smaller than 0.30 ha account for 65.1% of all the plots. This is due to the presence of a considerable number of plots without access to roads, accounting for 46.0% of all the plots (327 plots have no road access). In this precinct, a high position in the ranking and potentially satisfactory effects of land consolidation are additionally determined by the high percentage of agricultural land (93.77% of the village area) and the absence of afforested areas. The situation is similar in the precinct of Błażkowa, which ranks second (synthetic ratio: 0.56). All land consolidation works in the Brzyska commune should follow the order shown in Table 2 and Figure 3. These procedures would contribute to improving the configuration of the agricultural production space, being a key condition of agricultural development.

Table 2. Land consolidation urgency ranking of villages Source: own elaboration

Ranking position	Value of synthetic measure	Name of precinct
1	0.58	Kłodawa
2	0.56	Błażkowa
3	0.51	Wróblowa
4	0.51	Brzyska
5	0.46	Ujazd
6	0.27	Dąbrówka
7	0.26	Lipnica Dolna

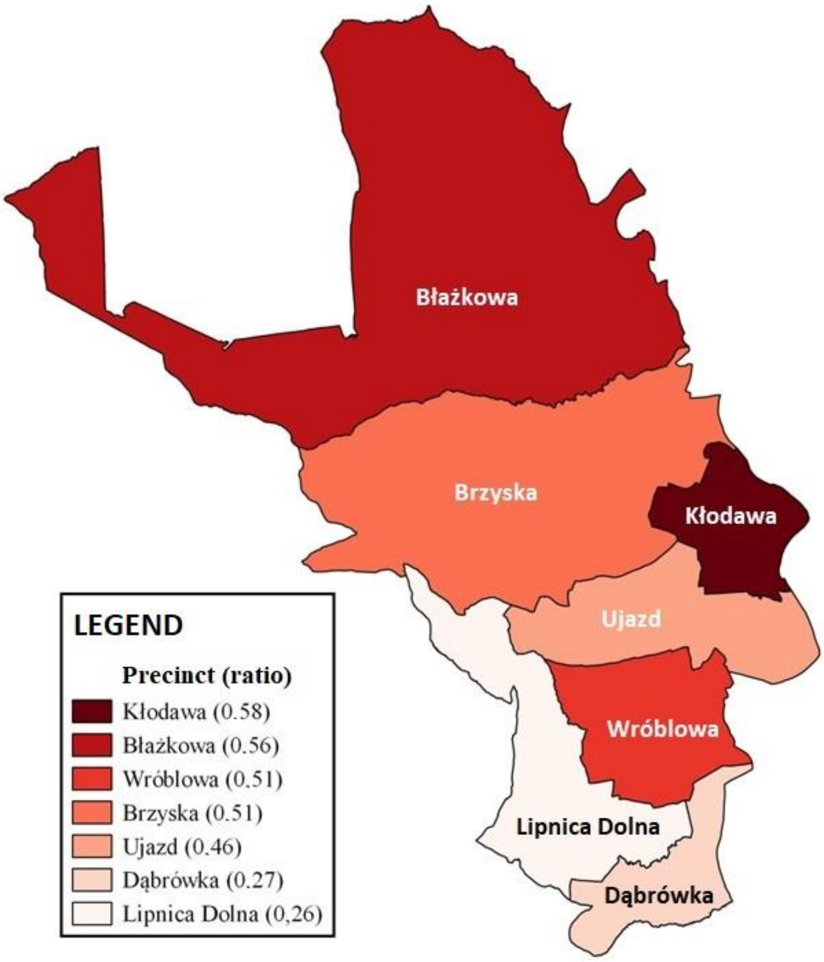

Figure 3. Land consolidation urgency map in the Brzyska commune. Source: Own elaboration

Conclusions and proposals

The analyses demonstrate that the Brzyska commune has a poor spatial structure. The fragmentation of land implies that the average surface area for the commune in the private sector is 0.44 ha. It differs significantly from the corresponding mean value in Poland and the European Union. This phenomenon also adversely affects the development of agriculture, decreasing its economic efficiency. It should be highlighted that plots smaller than 0.10 ha are not eligible for the programme of direct payments from the European Union (Ustawa, 2023) and plots smaller than 0.30 ha cannot be divided (Ustawa, 1997).

Another factor compromising the quality of the spatial structure of the examined area is that the plots have no access to roads. The analysis showed that about 40% of plots have no direct access road. This directly increases the cost of agricultural production due to the cost of transport. Furthermore, an insufficient road network prevents access to modern agricultural equipment, restricting the development of machinery parks. Agricultural activity in such spatial conditions generates extra costs, which compromises its profitability. This phenomenon should be deemed particularly harmful because the agricultural activity is the primary source of livelihood for 48.6% of the commune inhabitants. A farmer running activity in this area will find it difficult to compete with farmers from the member states of the European Union.

Therefore, land consolidation is the right direction to pursue. Commitment to taking action is desirable both from local government authorities and from real property owners who often oppose such operations. The land consolidation process will optimise spatial parameters such as number, surface area and shape of plots, number of plots without road access, and plot width, and reduce the number of plots making a farmstead. This operation also leads to an adjustment of the road network, which reduces the time to reach the fields. All these actions contribute to increasing the profitability of agricultural production. It is worth noting that apart from improved agricultural conditions, land consolidation has additional consequences: socio-economic (improved living and working conditions), environmental and landscape (amelioration, reclamation), organisational and legal (abolishment of land easements, joint property and common land). Consolidated lands become more attractive to tourists and offer better conditions for the development of non-agricultural businesses. It is impossible to carry out an operation transforming a defective structure across the whole area at the same time, at least due to financial reasons. Thus, such works must be carried out as a priority in villages with the most urgent needs.

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DOI: 10.22616/j.balticsurveying.2024.19.005

THE CURRENT STATE, PROBLEMS AND PROSPECTS OF THE USE OF LAND RESOURCES OF UKRAINE IN CONDITIONS OF WAR

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Abstract

The pre-war state of land resources in most of Ukraine was characterized as strained, and sometimes critical, with a tendency to deteriorate, which significantly complicated the socio-economic development of Ukraine and its regions and negatively affected the landscape and biological diversity, health and living conditions of the population. The article examines topical issues of problems and prospects for the use of land resources of Ukraine in the conditions of martial law and post-war reconstruction. As a result of Russia's military aggression, Ukraine faced mass shelling, missile strikes, radiation contamination, air pollution, littering of territories, unburied or chaotically buried bodies of the dead, mining and other challenges. This has led to aggravation of economic, environmental and social challenges of food supply both in Ukraine and in the world. In connection with military actions, the land resources of Ukraine are subjected to large-scale destruction, deterioration of the soil quality, degradation processes are intensified, land resources are damaged, owners and land users suffer material losses.

Agricultural lands suffered two significant types of damage – mine contamination, both on the frontline and in occupied (or formerly occupied) territories, and direct physical damage, from contamination by mines and unexploded ordnance. As of March 20, 2022, the area of damaged soil cover was 6,582.0 hectares, out of 1,655,845.3 hectares of surveyed arable land. For rational use and protection of land, restoration of soils and improvement of their fertility, preservation of productive, ecological and social functions of soil cover, the following important measures should be implemented: actualization of scientific research on the restoration of degraded soils, in particular in the direction of studying the impact of armed aggression of the Russian Federation on the soil cover of Ukraine; determination of the current state of soil health; improvement of the methodology for determining the amount of damage and losses to land and soil resources caused by armed aggression; development and pilot implementation of rehabilitation technologies for war-damaged soils.

Keywords: land protection, mine pollution, dangerous areas, damage to soils and land

Introduction

Ukraine has significant strategic advantages due to the natural resources, geographical position and quality of human capital, which in general can become the basis for rapid economic growth of the state. Instead, a number of obstacles are a hindrance to realising its potential. Ukraine should strengthen its position on the international and regional arena, which will contribute to increasing the level of well-being of the population - the main goal of state policy.

The pre-war state of land resources in most of Ukraine was characterized as strained, and sometimes critical, with a tendency to deteriorate, which significantly complicated the socio-economic development of Ukraine and its regions and negatively affected the landscape and biological diversity, health and living conditions of the population (Bavrovska, 2022).

The main reason for this situation is the irrational use of the land and resource potential of the state, the deterioration of its quality and the decrease in the productivity of land, the misregulated changes in the nature of the functioning of land as a means of production in the market conditions, the absence of a unified state system of land protection (Про Основні засади …, 2019).

As a result of Russia's military aggression, Ukraine faced mass shelling, missile strikes, radiation contamination, air pollution, littering of territories, unburied or chaotically buried bodies of the dead, mining and other challenges (Балюк et.al, 2022). This has led to aggravation of economic, environmental and social challenges of food supply both in Ukraine and in the world. In connection with military actions, the land resources of Ukraine are subjected to large-scale destruction, deterioration of the soil quality, degradation processes are intensified, land resources are damaged, owners and land users suffer material losses (Голубцов et.al, 2023).

Methodology of research and materials

During the study, the following approaches were used: abstract-logical (to substantiate the theoretical generalization of the goal, conclusions and analysis of the results of the study); economic and statistical (to analyze the current state of land use); analysis and synthesis (to analyze the influence of individual factors on the efficiency of agricultural land use), monographic and scientific generalization.

Table 1.

Composition of land resources of Ukraine and some European countries[1]
(Source: compiled by the authors using Worldbank data)

	Ukraine		**Austria**		**France**		**Germany**		**Netherlands**		**Poland**		**Republic of Moldova**	
	thousand ha	**%**	**thousand ha**	**%**	**thousand ha**	**%**	**thousand has**	**%**	**thousand ha**	**%**	**thousand ha**	**%**	**thousan d ha**	**%**
Agriculture	41892,00	69,41	2646,76	31,55	28553,75	52,00	18314,00	51,22	1814,45	43,68	14682,00	46,95	2285,50	67,52
Agricultural land	41311,00	68,45	2646,76	31,55	28553,75	52,00	16595,00	46,41	1814,45	43,68	14461,00	46,24	2264,60	66,90
Cropland	33777,00	55,96	1387,95	16,55	18970,54	34,55	11862,00	33,17	1042,04	25,09	11271,00	36,04	1927,00	56,93
Arable land	32924,00	54,55	1321,08	15,75	17956,56	32,70	11664,00	32,62	1004,83	24,19	10921,00	34,92	1699,80	50,22
Land under temporary meadows and pastures	869,00	1,44	154,89	1,85	3157,45	5,75	3093,00	8,65	205,13	4,94	0,00	0,00	0,00	0,00
Land with temporary fallow	167,00	0,28	50,40	0,60	503,81	0,92	358,00	1,00	8,86	0,21	179,00	0,57	20,60	0,61
Land under permanent crops	853,00	1,41	66,87	0,80	1013,98	1,85	198,00	0,55	37,21	0,90	350,00	1,12	227,20	6,71
Land under perm. meadows and pastures	7534,00	12,48	1258,81	15,01	9583,21	17,45	4730,00	13,23	772,41	18,59	3190,00	10,20	337,60	9,97
Forest land	9690,00	16,06	3899,15	46,49	17253,00	31,42	11419,00	31,93	369,50	8,90	9483,00	30,33	386,50	11,42
Other land	6358,00	10,53	1706,09	20,34	8948,95	16,30	5206,00	14,56	1183,05	28,48	6448,00	20,62	616,46	18,21
Inland waters	2415,00	4,00	135,90	1,62	153,00	0,28	786,00	2,20	372,00	8,96	658,00	2,10	96,54	2,85
Land area	**57940,00**	**96,00**	**8252,00**	**98,38**	**54755,70**	**99,72**	**34939,00**	**97,71**	**3367,00**	**81,05**	**30613,00**	**97,90**	**3288,46**	**97,15**
Country area	**60355,00**	**100**	**8387,90**	**100**	**54908,69**	**100**	**35759,00**	**100**	**4154,00**	**100**	**31271,00**	**100**	**3385,00**	**100**

[1] as of 01.01.2020

Results and discussion

The land fund of Ukraine is characterized by the presence of high bioproductive potential. Its structure is dominated by lands with fertile soils, since 7% of the world's chernozem reserves are concentrated in Ukraine (Про схвалення Концепції …, 2022).

In Ukraine, more than 96% of the entire territory is used for economic purposes. Extremely high is the level of destruction that affect more than 69% of the territory. In the developed countries of Europe, this figure does not exceed 35%. The actual forestation of the territory of Ukraine is only 16%, which is not enough to ensure environmental balance (the average indicator of European countries is from 25 to 30%) (Третяк et.al, 2022).

As part of the lands of Ukraine as of 01.01.2020, agricultural land makes up about 41.31 million hectares (68.4% of the total land area). Of these, arable land takes up the most territory and covers an area of 32.92 million hectares (54.5% of the total land area), which indicates high arability and agricultural development of the territory of Ukraine, compared to 51.22% in Germany, 46.95% in Poland, and 31.55% in Austria (Table 1).

According to the World Bank (based on statistics of the World Food Organization) over 2007–2020 years, the area of arable land in Ukraine has increased by 490 thousand hectares (FAO, 2022). The excessive expansion of the arable land area led to a violation of the ecologically balanced ratio of land: arable land, natural forage land, forests and water bodies, which negatively affected the stability of agricultural landscapes and caused significant man-made damage to the ecosphere (Бавровська, Боришкевич, 2016). As a result, land resources are rapidly degraded, polluted and depleted, while not producing enough food even for the current generation, jeopardizing the needs of future generations (Величко et.al, 2020).

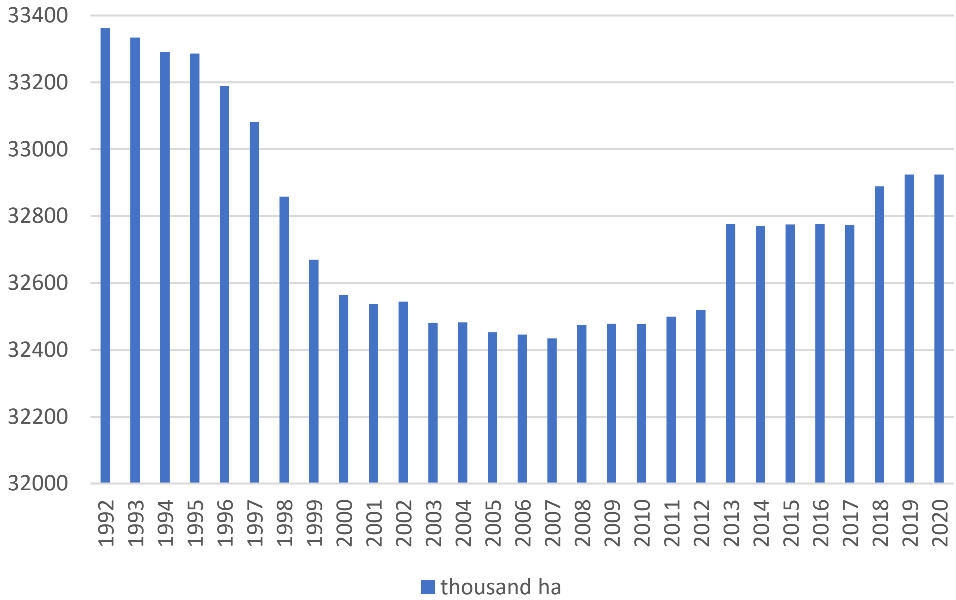

Fig. 1. Dynamics of change of arable land area in Ukraine since 1992 to 2020
(Source: compiled by the authors using Worldbank data))

In Ukraine, there are more than 1.1 million hectares of degraded, low-productive and technologically contaminated lands subject to conservation, 143,769 hectares of disturbed land requiring reclamation, and 294,568 hectares of low-productive land requiring improvement.

Under martial law, the economic, environmental and social challenges of food supply to Ukraine and the world have significantly worsened. One of these challenges is a significant increase in the current problem of land and soil degradation caused by warfare.

In Ukraine, because of the war, thousands of hectares of the land fund are littered with waste, contaminated with harmful substances that are damaged as a result of detonation, and suffer damage to the structure of the soil cover.

Damage to land resources includes all damage to and destruction of the fertile soil layer and damage caused by pollution and blockage of land resources, assessed taking into account the following indicators (Про затвердження Порядку …, 2022):

1. Damage to soils and land due to contamination of soils with substances that adversely affect their fertility and other beneficial properties.
2. Damage to soils and land due to polluting land plots with foreign objects, materials, waste and/or other substances.
3. Costs for reclamation of lands that were affected as a result of hostilities, construction, building and maintenance of engineering and fortifications, fences, border signs, border clearances, the state border facilities.
4. Damage caused to the owners (land users) of agricultural land plots.
5. Reclamation system recovery costs (Про затвердження Методики …, 2022).

Today, the basic regulations that can give an idea of the procedure for compensation for damage and losses caused to the land fund of Ukraine due to the act of war by the Russian Federation are: Land Code of Ukraine, Statement of the Cabinet of Ministers of Ukraine: «On Approval of the Procedure for Determining Damages and Losses, inflicted on Ukraine as a result of the armed aggression of the Russian Federation», «On approval of standards for maximum permissible concentrations of hazardous substances in soils, as well as the list of such substances», «On the Procedure for Determining and Compensating Losses to Land Owners and Land Users», «Rules for Development of Land Management Work Projects», «Methods for Determining Damages and Losses, to the land fund of Ukraine as a result of the armed aggression of the Russian Federation».

To the greatest extent, agricultural lands suffered two significant types of damages: mine and chemical pollution and direct physical damage. Now it can be stated that Russia has turned Ukrainian fertile black soil into the most contaminated with explosives in the world.

Analysis of the damage caused in Ukraine is carried out by analysts of KSE Institute and volunteers from partner organizations: Center for Economic Strategy, Dragon Capital, Anti-Corruption Headquarters, Institute of Analytics and Advocacy, Transparency International Ukraine, SE "Prozorro.Sales," Prozorro, Ukrainian Council of Trade Centers, CoST Ukraine.

According to preliminary data as of November 2022 in Ukraine, the area of land that needed demining and reclamation was 28,387,500 ha, preliminary estimate of direct losses to land resources was UAH 13.9 billion (in Table 2) (Проєкт Плану відновлення…, 2022).

Table 2

Direct loss of land resources due to military aggression against Ukraine, and preliminary assessment of the needs of the industry in recovery
(Source: compiled by the authors using (Проєкт Плану відновлення…, 2022)

Types of losses	**Quantity unit**	**Initial number of objects**	**Number of damaged objects**	**Estimation of losses, billion UAH**	**Loss estimate, million USD**
Contamination with Mines and other explosive objects • require demining • technical inspection	ha	28387500	594456	10,1 2,6	346,6 89,2
Land in need of reclamation	ha	28387500	198152	1,2	39,6

The National Mine Action Authority of Ukraine considers that 30 % of Ukraine's territory has been exposed to the warfare. Priorities in 2023 will include responding to the humanitarian needs outlined in the Humanitarian Response Plan 2023, and a focus on priority areas determined: residential areas; electricity and heating infrastructure; roads, bridges, and railways; and agricultural land (Table. 3). Area considered as exposed to warfare 187,732 km2 and therefore potentially contaminated, including the following regions (Chernihivska, Kyivska, Sumska, Zhytomyrska, Kharkivska, Kherson, Donetska, Luhanska, Mykolaivska, Zaporizka).

The cost for clearance of explosive ordnance across Ukraine is currently estimated at US$37.6 billion (you can see in Table. 3).

According to preliminary estimates, demining of agricultural land on the territory of Dnipropetrovska, Zaporizka, Kyivska, Mykolaivska, Sumska, Kharkivska, Khersonska, Chernihivska, Cherkaska oblasts with a total area of more than 470,854 hectares is required to ensure spring-field work (План заходів із розмінування земель …,2023).

Table 3.

Explosive ordnance contamination and estimated clearance cost

(Source: compiled by the authors using (World Bank. Ukraine …, 2023).

Name of administrative territorial unit	**Km^2 thousand**					**US$ million**
	Oblast area	**% land exposed to war**	**Estimated area**			**Estimated Cost for humanitarian mine action, Total**
			Non-technical survey	**Technical survey**	**Clearance**	
Cherkaska	20.9					
Chernivetska	31.9	80	25.5	1.3	637	2,897.3
Chernihivska	8.1					
Dnipropetrovska	31.9					
Donetska	26.5	64	17.0	1.69	1.27	5101.0
Ivano-Frankivska	13.9					
Kharkivska	31.4	46	14.4	1.4	1.1	4,349.5
Khersonska	28.4	95	27.1	2.7	2	8,153.0
Khmelnytska	20.6					
Kyivska	8.1	23.7	10.4	520	260	1,182.6
Kirovohradska	24.6					
Luhanska	26.7	100	26.7	2.7	2.0	8
Lvivska	21.8					
Mykolaivska	24.6	14	3.4	170	85	386.7
Odeska	33.3					
Poltavska	28.7					
Rivnenska	20.0					
Sumska	23.8	70	16.7	417	208	956.9
Ternopilska	13.8					
Vinnytska	26.5					
Volynska	20.1					
Zakarpatska	12.8					
Zaporizka	27.7	74	20.1	2	1.51	6,052.8
Zhytomyrska	29.8	14	4.2	208	104	473.1
Ukraine	**575.5**		**165.44**	**13.1**	**9.18**	**37,585.4**

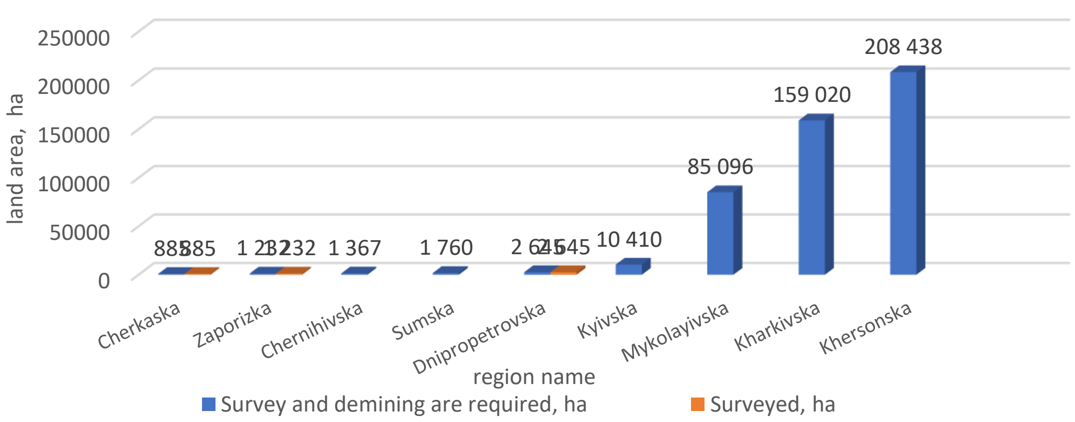

Fig. 2. Areas of agricultural land that require priority survey and demining across regions

Analysing the data in Fig. 2. we can see that to create a safe environment for the use of agricultural land for its purpose and to ensure the conducting spring-field work, the largest areas of land requiring priority demining in the territory of the Mykolaivska - 85,096.0 hectares, Kharkivska - 159,020.0 hectares, Khersonska 208,438.0 hectares. (План заходів із розмінування земель …,2023), (Завершено пріоритетне розмінування сільгоспземель…, 2023).

These are mainly lands located in the Ukraine-controlled territories. In the regions where fighting continues, the list of priority mine clearance lands includes «lands located no closer than 20 km from the line of active hostilities and which are not subject to constant shelling». For humanitarian demining, territorial communities in the regions must submit information on agricultural lands by pollution density and categories of economic expediency to regional military administrations.
For this, the land is divided into three priority categories (low territories where no hostilities were conducted, medium – occupied territories, high territories near the front line), depending on the density of mining of the land.
The most economically justified is the concentration of efforts on demining priority agricultural land in the territories of Mykolaivska and Cherkaska regions, according to the priority demining plan. As a result of the survey, more than 12 thousand hectares of agricultural land, which were determined for priority demining in oblasts: Cherkasska - 885 hectares; Zaporizka (land located in controlled territories) - 1,232 hectares; Dnipropetrovska - 2,645 hectares, at the same time 2,323 hectares were cleared (Завершено пріоритетне розмінування сільгоспземель…, 2023).
The issue of increasing the efficiency of land resources usage is an integral part of the unified environmental and economic state policy, which ensures the rational use, protection and management of land resources (Tykhenko, Bavrovska, 2020). The violation of the ecologically balanced ratio between land categories, the reduction of unique steppe areas, the excessive damage of the territory and military actions exacerbated the problem of soil degradation, and the high intensity of hostilities in certain areas called into question the safety of using the land directly affected by the warfare (Про Основні засади …, 2019).
For rational use and protection of land, restoration of soils and improvement of their fertility, preservation of productive, ecological and social functions of soil cover, the following important measures should be implemented:

- actualization of scientific research on the restoration of degraded soils, in particular in the direction of studying the impact of armed aggression of the Russian Federation on the soil cover of Ukraine; determination of the current state of soil health;
- improvement of the methodology for determining the amount of damage and losses to land and soil resources caused by armed aggression;
- development and pilot implementation of rehabilitation technologies for war-damaged soils.

Conclusion

The main principles of post-war use of the lands of Ukraine should be:
1. Assessment of damage caused by hostilities, natural disasters or technogenic catastrophes to land resources and soils (determination, recording and assessment of damages caused by warfare).
2. Organization of the process of inventory and classification of the land damaged as a result of Russian military aggression.
3. Implementation of measures to preserve, reclaim and improve lands affected by Russian aggression. Creation of an incentive system for land protection and conservation. Development of land management documentation on land reclamation, as well as implementation of land protection measures.
4. Development of comprehensive plans for area development of territorial communities as a tool of post-war restoration, which will include the assessment of losses and the cost of restoring territories and land reclamation, based on the priorities of community development.
5. Expanding the area of the nature reserve fund by including preserved land to meet EU targets.

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DOI: 10.22616/j.balticsurveying.2024.19.006

THE POTENTIAL OF RENEWABLE ENERGY ON AGRICULTURAL LAND

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Abstract. The need for electricity and its extraction without stimulating climate warming processes are currently more relevant than ever. Using wind energy to generate electricity is one of the most promising methods. When designing wind energy parks, it is necessary to choose a suitable place for their installation. This study examined the suitability of plots for the construction of these structures in the areas of abandoned land in non-urbanized and non-urbanized areas. In the course of the research, various limitations were examined, the territory was analyzed using geoinformation systems. Modeling of the selected territory has been carried out, areas suitable for the installation of wind energy plants have been identified. It was established that the total area of land that can be used for the installation of wind energy plants is small and the criterion of abandoned land is not the indicator on the basis of which it can be stated that the territory is suitable for the construction of wind energy plants.
Key words: renewable energy, wind energy; abandoned agricultural land.

Introduction

Reducing the amount of CO_2 in the atmosphere is an important issue in the context of climate change. One option is to generate electricity without increasing carbon dioxide emissions. Renewable energy sources, such as water power, solar power, wind power, etc., are used for this purpose. The European Commission has set a target of reducing greenhouse gas emissions by at least 55% by 2030. In line with these recommendations, the European Union (EU) encourages the installation of power plants that use renewable sources. One such source is wind. In 2022, 19 GW of new wind turbines (WT) will be installed in the EU, but this is not enough to meet the European Commission's climate and energy targets. Between 2023 and 2027, 129 GW of wind power capacity is expected to be installed in European countries, of which 98 GW will be installed by EU countries. Three-quarters of this capacity is expected to be installed onshore and the rest offshore. To meet the targets, the EU must build 30 GW of new wind power capacity annually (https://windeurope.org/intelligence-platform/product/wind-energy-in-europe-2022-statistics-and-the-outlook-for-2023-2027/).

The capacity of all wind turbines built in Lithuania this year exceeded 1 GW. This is only one fifth of the total capacity to be installed in Lithuania by 2030. Onshore wind turbines are expected to have a capacity of 3.6 GW and offshore parks 1.4 GW. Since 2020, there has been an increase in wind power capacity.

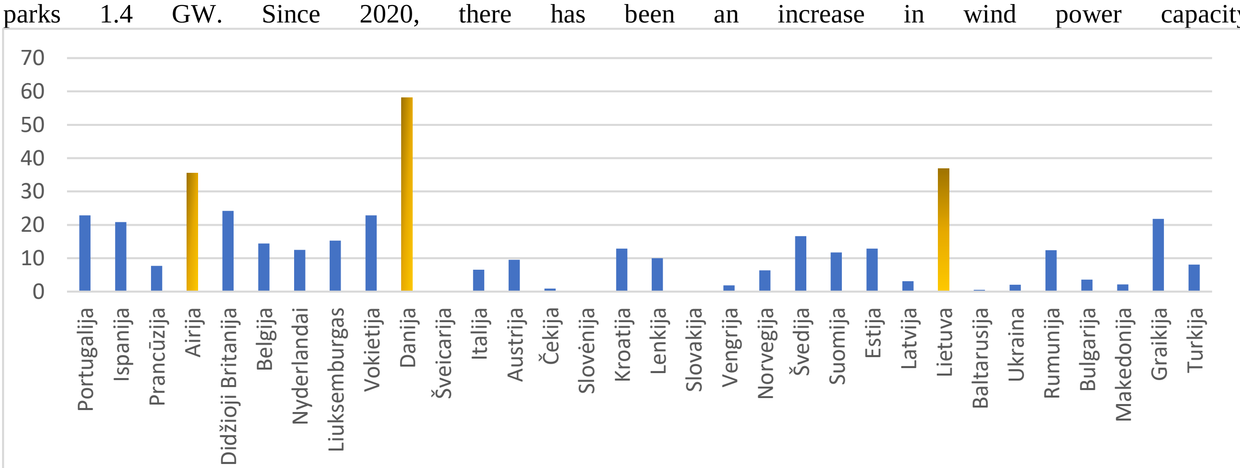

Figure 1. Amount of electricity generated by wind turbines as a percentage of total electricity generated in European countries (percentage) (https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html)

As can be seen from Figure 1, Denmark, Ireland and Lithuania account for the largest share of the country's total electricity generation capacity from wind turbines.

In Lithuania, as in other countries, there are various restrictions that have to be taken into account when installing wind turbines. The choice of site for this type of installation is rather complicated and depends on different terrain conditions. Various authors have investigated the suitability of sites for wind turbines in abandoned mines (Luo, 2014), abandoned agricultural land (Tumeliene *et all.*, 2022), sensitivity analysis of factors affecting site location (Rezaei er all., 2020) and the various criteria selected (Dehshiri et all., 2022). Depending on the number of factors selected, different results can be obtained for the same location. This study will investigate the suitability of abandoned land in the selected area to accommodate wind turbines.
The aim of the study is to investigate the suitability of abandoned land in Tauragnai eldership for the construction of wind turbines, taking into account the criteria restricting their construction.

Methodology of research and materials

The Tauragnai eldership, located in the eastern part of Lithuania, in the Utena district, was selected for the study (Figure 2). The area of the eldership is 213.6 km^2. Part of the eldership is covered by the Aukštaitija National Park, and it contains the town of Tauragnai and 85 villages and farmsteads (http://www.tauragnai.eu/apie-tauragnu-seniunija). The eldership was chosen because it is part of the 'belt' of abandoned land in eastern Lithuania (Puziene, Anikeniene, 2020).

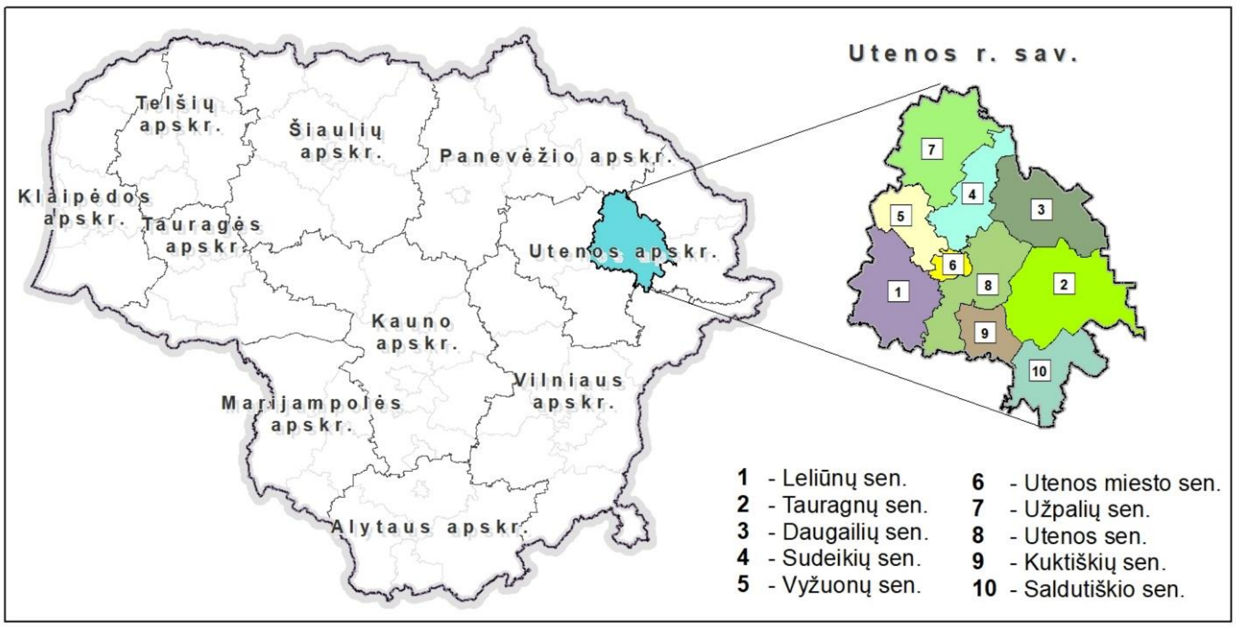

Figure 2. Tauragnai eldership

The following criteria were chosen for the study:
1. On 15 February 2016, by order of the Commander of the Lithuanian Armed Forces, a map of the territories of the Republic of Lithuania, where the design and construction of wind turbines may be restricted, was approved.
2. Aukštaitija National Park.
3. Žiezdriai Landscape Reserve.
4. Ažvinčiai (Gervėčiai Sengirė) Nature Reserve.
5. NATURA2000:
5.1. Aukštaitija National Park (BAST)
5.2. Western part of Aukštaitija National Park (PAST)
6. Natural heritage sites:
6.1. Botanical natural heritage sites,
6.2. Hydrogeological natural heritage sites,
6.3. Zoological natural heritage sites,
6.4. Geological natural heritage sites,
7. Real cultural heritage sites.
8. Sites of importance for the protection of biodiversity

8.1. Forest habitats
8.2. Grassland habitats
9. Mineral deposits.
12. Protected area for water bodies.
13. Water bodies protection zone.
14. Transport and engineering environment.
Spatial dataset on abandoned agricultural land downloaded from www.geoportal.lt.
The data were processed and analyzed using ArcGIS software. The areas of abandoned land in Tauragnai eldership are presented in Figure 3.

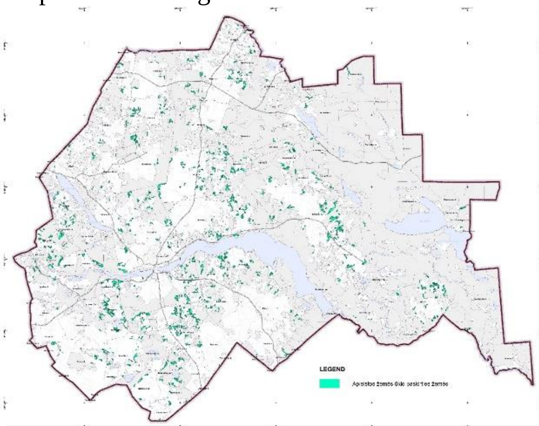

Figure 3. Location of abandoned agricultural land

Discussions and results

Once all the layers were loaded into the software package, the terrain was modelled. The area of abandoned land in the eldership is 278.6 ha and the eldership area is 21355.5 ha. The area of abandoned land covers 1.3% of the total area of the eldership. This does not seem like a lot, but the eldership is one of the areas with the highest percentage of abandoned lands. If the abandoned land criterion were relevant for the selection of sites for the installation of WT, it could be used as one of the main criteria during the preparation of the projects, which would facilitate the work of the designers.
In the first stage of the work, the map of the territories of the Republic of Lithuania where the design and construction of wind turbines may be restricted was uploaded, approved by the Order of the Commander of the Lithuanian Armed Forces. A visual assessment was carried out, and a "cut-off" of the abandoned land layer was made to identify the area prohibited for construction. At the same time, the areas covered by the Aukštaitija National Park were eliminated (Figure 4). As this area is completely unsuitable for wind turbine construction due to the prohibitions in place and covers a continuous area, the abandoned land in these areas was discarded without applying any occupancy survey for buffer strips/protection zones.

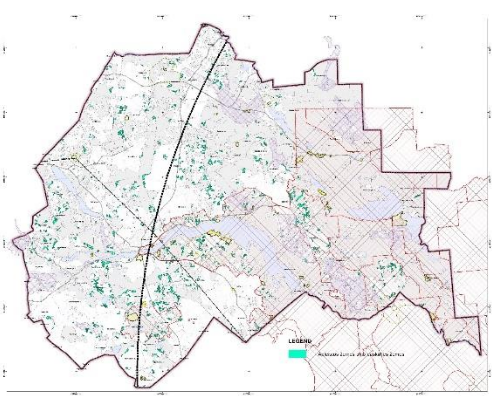

Figure 4. Areas where

Figure 4 shows that when analysing the suitability of abandoned land areas or other selected sites for wind turbines, it is important to analyse all the constraint criteria thoroughly, not just the protected areas, forestry cadastre and water layer, as sometimes chosen by other researchers. The absence of any one criterion may lead to erroneous results in the analysis.

In the course of further research, all remaining boundary layers were activated (Figure 5) and a comparison was made between them and the overlaps of the protection zones with the areas of abandoned land.

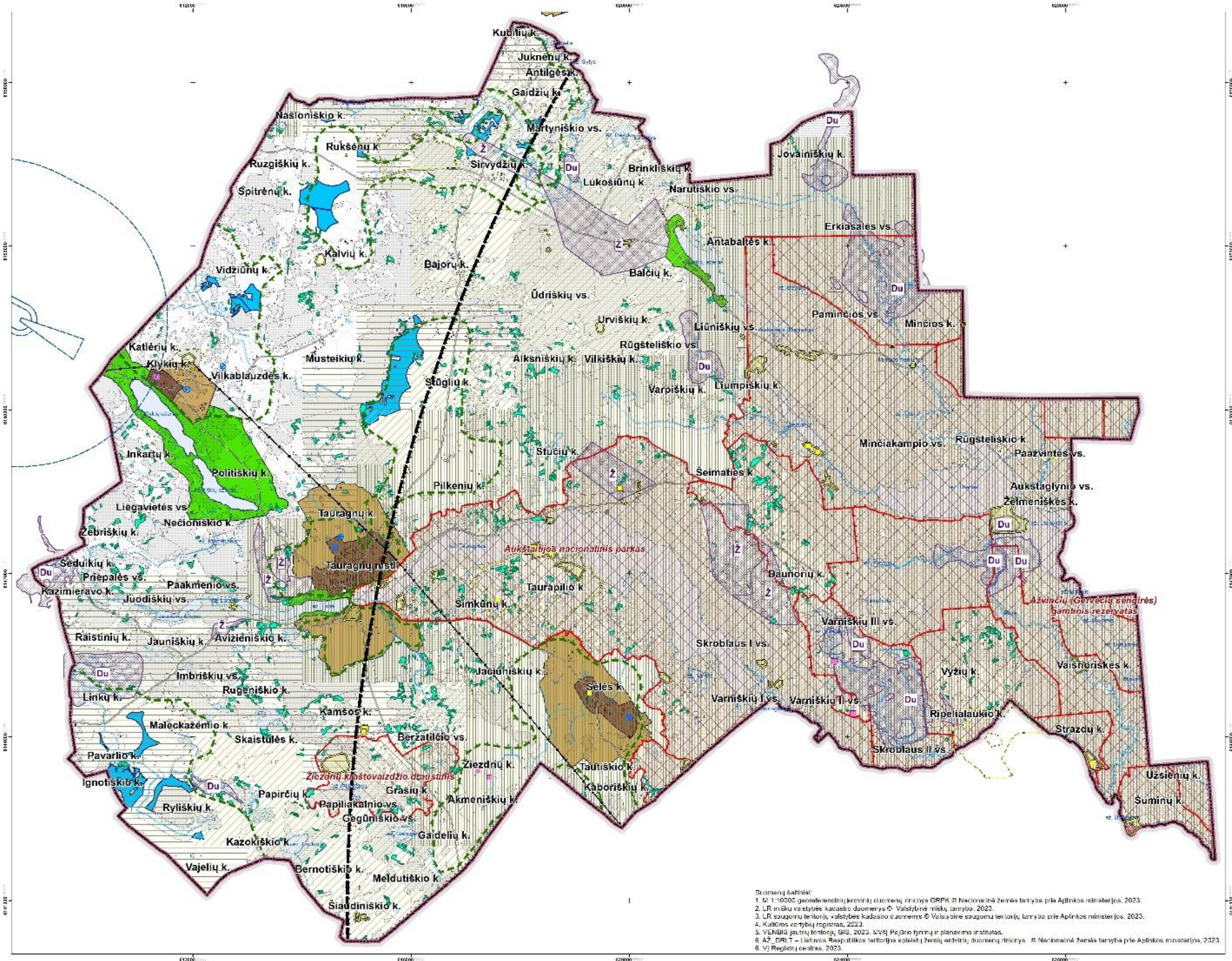

Figure 5. Criteria for limiting the installation of wind turbines in Tauragnai eldership

The amount of abandoned land included in the areas covered by the restriction criteria and the size of the buffer zone applied are shown in Table 1.

Table 1.

Restriction zones and their parameters.

Name of restriction	Area of abandoned land in the protection zone, %	Restriction zone size, m
Aukštaitija National Park	54.8	2000
Žiezdriai Landscape Reserve	24.3	2000
Ažvinčiai (Gervėčiai Sengirė) Nature Reserve	1.8	2000
NATURA2000: Aukštaitija National Park (BAST) Western part of Aukštaitija National Park (PAST)	 54.8 54.8	2000
Natural heritage sites	0.1	100
Real cultural heritage sites	9.2	200
Sites of importance for the protection of biodiversity: Forest habitats Grassland habitats	 0.1 0.3	-
Mineral deposits	2.9	-
Protected area for water bodies.	5.4	500
Water bodies protection zone	17.3	500
Transport and engineering environment	10	20-150*

*depending on the type of transport/engineering environment.

The data in Table 1 shows that the restricted areas cover a significant proportion of abandoned land, however, bear in mind that there may be overlapping areas - the same site may fall within the impact zone of more than one restriction. In order to avoid the possibility that areas may be wrongly excluded for this reason, we carry out a further analysis to identify the area that is generally suitable for wind turbines. We then exclude areas of abandoned land. The results are shown in Table 2.

Table 2.

Areas suitable for wind turbines in Tauragnai eldership.

	ha	**%**
The area falling within the potential construction area of the WT	221.6	1.0
Area of abandoned land falling within the area available for the construction of a WT	5.1	1.8

The areas of visually suitable abandoned land for the construction of a WT are shown in Figure 6. As can be seen from the survey results presented in this figure, the number of potential wind farm sites is limited. The areas of abandoned land in these areas are negligible and insignificant. Of the total area of abandoned land, only 5% is suitable for the construction of wind turbines, which represents 0.02% of the total area of the eldership. As much as 95% of the abandoned land is not suitable for the construction of WT due to the existing restrictions. On this basis, it can be concluded that the criterion of abandoned land is not relevant for the selection of sites for renewable energy plants.

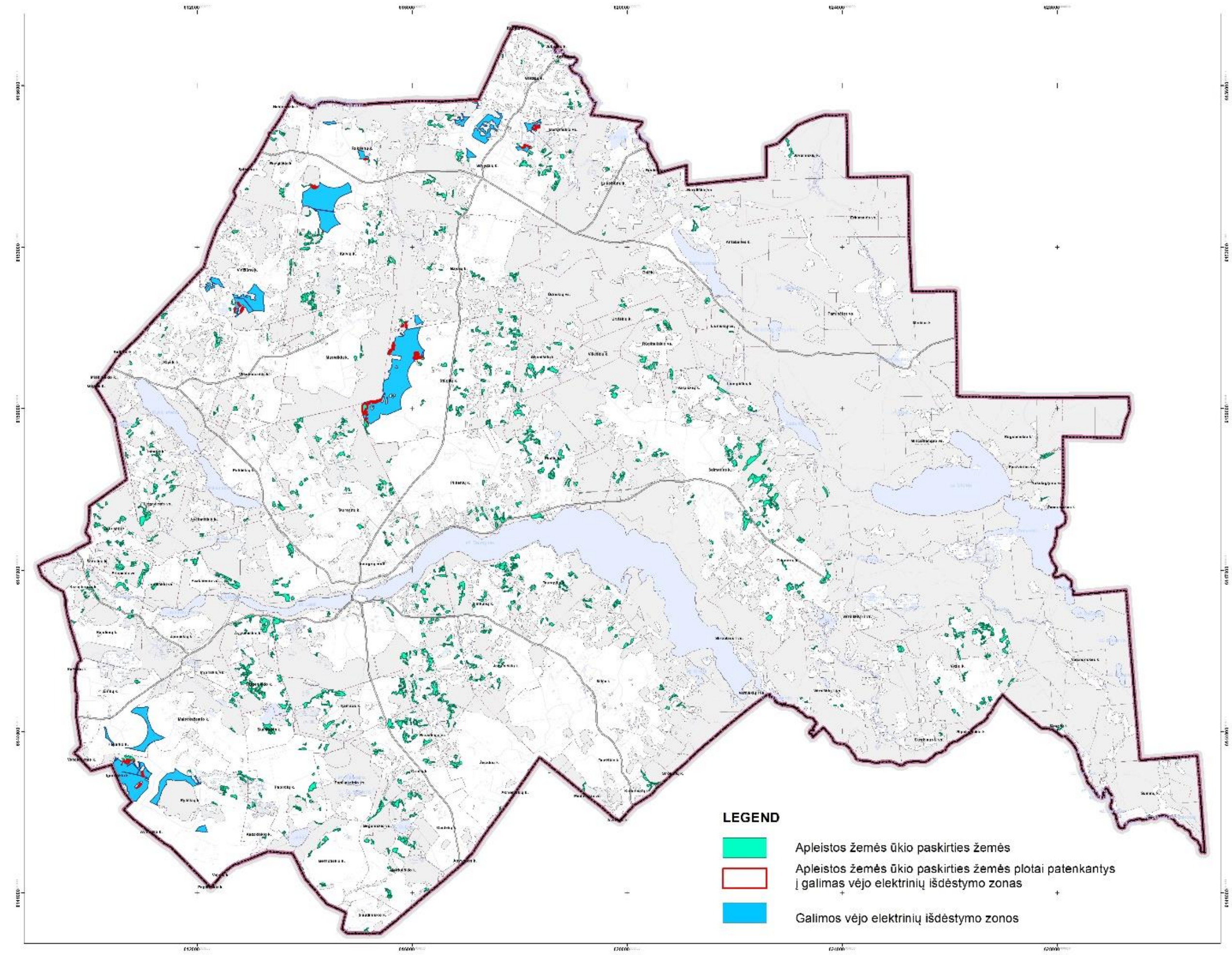

Figure 6. Areas of abandoned land suitable for wind turbines

Conclusions and proposals

Lithuania ranks third in Europe in terms of the amount of electricity generated by wind turbines (as a share of the country's total electricity production). The total capacity of all wind turbines built in Lithuania in 2023 will exceed 1 GW, but this is only a fifth of the total capacity to be installed by 2030.

There are a number of constraints when selecting sites for wind turbine constructions. Comparing the results obtained in the study with those published by other authors, it can be seen that if at least one constraint is not included in the analysis, the results differ significantly.

The Tauragnai eldership has only 221.6 ha suitable for the construction of WT. This area includes 5.1 ha of abandoned agricultural land, which is only 1.8% of the total abandoned land in the eldership. Although this eldership has one of the largest amounts of abandoned land in the Republic of Lithuania, the criterion of abandoned land is neither a decisive one nor a suitable one for selecting a site for a wind turbine.

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DOI: 10.22616/j.balticsurveying.2024.19.007

ASSESSING THE IMPACT OF WARTIME CONDITIONS ON THE LAND SURVEYING INDUSTRY IN UKRAINE: ADAPTATION, CHALLENGES, AND RECOVERY STRATEGIES

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National University of Life and Environmental Sciences of Ukraine

Abstract
This article examines the impact of the Russian federation's full-scale aggression in Ukraine on the market of land surveying and topographic-geodetic services. The study found that the market for land surveying services decreased by 60-70% due to restrictions in the functioning of the land cadastral system, the introduction of the permit procedure for field geodetic works, and the adaptation of procedures for granting land to citizens during wartime conditions. Technological limitations, such as the use of GNSS networks at the beginning of the war, also played a role in the decline of the industry. The article highlights the prospective needs for land surveying work for post-war reconstruction, including accounting for war damage and mapping affected territories, spatial planning for affected communities, infrastructure restoration, and land reclamation in areas where hostilities took place. The article provides insights into the challenges and opportunities faced by the land surveying industry in Ukraine during wartime conditions and emphasizes the importance of adopting appropriate strategies for recovery and growth. It is shown that despite the war, the development of the industry depends on further digitalization, improvement of the cadastral system, gradual liberalization of access to cadastral geodata, the introduction of special rules for regulating the activities of the surveyor in the territories where hostilities were fought.
Key words: land surveying, geodetic works, Ukraine, wartime, land cadaster.

Introduction

On Thursday, February 24, 2022, at 3:40 a.m., the third stage of the Russian-Ukrainian war, initiated by Russia in 2014, began with full-scale military aggression against Ukraine. This escalation followed a long-term build-up of Russian troops along Ukraine's borders with Russia and Belarus since November 2021, culminating in the “recognition” of terrorist organizations on Ukrainian territory by Russian authorities on February 21, 2022. As part of this military campaign, missile strikes were launched throughout Ukraine, and Russian troops invaded various regions, including Kyiv, Kharkiv, Kherson, Chernihiv, and Sumy, entering from Russia, Belarus, and the temporarily occupied Crimea. In addition to Russia, Belarus also actively participated in the war against Ukraine, providing territory for launching missile strikes, deploying combat aircraft for missile and bomb attacks, and providing troop support.
The wide-ranging military aggression has had profound consequences on multiple aspects of Ukrainian society, including its economy. Among the sectors most affected by the ongoing conflict is the land surveying, topographical and geodetic industry. This article aims to examine the impact of the full-scale Russian aggression on the state of land surveying in Ukraine, exploring the challenges faced by professionals in the field, the disruption of essential services, and the potential long-term consequences for both the industry and the country's geospatial infrastructure.
Researching the key challenges faced by the land surveying industry of Ukraine in wartime conditions is essential for several reasons. A comprehensive understanding of the impact of the war on this crucial sector allows policymakers, industry professionals, and stakeholders to make informed decisions and develop effective strategies to address the challenges.
This research aims to find the strategy to minimize the negative impacts on land surveying, topographic and geodetic activities, and ultimately, the Ukrainian economy and infrastructure. Understanding the challenges faced by land surveyors, geodesists, and land appraisers is vital for developing policies and support mechanisms to protect the workforce, retain professional expertise, and ensure the continuity of essential services. Furthermore, identifying and addressing these challenges enables stakeholders to develop and implement recovery plans that support the industry's restoration and growth once the conflict has ended, contributing to the overall rebuilding and development of Ukraine's economy and infrastructure.

Methodology of research and materials

To assess the impact of the full-scale Russian aggression on the land surveying industry in Ukraine, our research methodology relied on the analysis of public data provided by the State Service of Ukraine for Geodesy, Cartography and Cadaster, specifically the "Portal of Electronic Services of the State Land Cadaster."[2] This portal offers monthly statistics on the number of cadastral administrative services, including land plot registration, from 2015 to the present. To estimate the number of land surveyors, geodesists, and land appraisers in the regions of Ukraine where hostilities were fought or temporary occupation persists, we utilized previous studies conducted by the authors [1]. These studies were based on official public data from the State Register of Certified Land Surveyors, the State Register of Certified Geodesists, and the State Register of Appraisers of Expert Monetary Valuation of Land. In addition, we analyzed changes in the regulatory framework of Ukraine pertaining to the adaptation of the land management system, land cadaster, topographic and geodetic activities, and land assessment under wartime conditions. This analysis was based on official documents published in the "Legislation of Ukraine"[3] database of the Parliament of Ukraine. Through this comprehensive research methodology, we aimed to gain a thorough understanding of the challenges faced by the land surveying industry in Ukraine during the ongoing conflict, as well as the potential long-term consequences and strategies for adaptation and recovery.

Discussions and results

The land surveying industry is crucial for Ukraine, as well as for any European country, as it plays a pivotal role in guaranteeing rights to land and other real estate, ensuring the functioning of relevant real estate markets, spatial planning, environment protection etc. These functions are essential for fostering economic growth, maintaining social stability, and promoting sustainable development. Wartime, however, presents a difficult test for land surveyors, geodesists, and appraisers, as their industries primarily serve economic growth, while war leads to a sharp decline in economic activity within a country. This highlights the importance of understanding and addressing the challenges faced by these professionals during conflict to support their resilience and the continuity of their vital services.

We can highlight the following key challenges for the land surveying industry of Ukraine in wartime conditions:

- Reduction in demand for land surveying and topographic-geodetic works, because due to the uncertainty and risks of wartime, investment activity is reduced, construction and development projects are frozen, the state and local communities are almost completely reorienting their budgets to defense and crisis response.
- Impossibility of performing works (including previously contracted ones) due to risks to the personal safety and life of surveyors in temporarily occupied territories, in zones of active hostilities, as well as due to military restrictions or the risk of the presence of explosive objects.
- The introduction of new regulatory rules and restrictions for business during the war, which makes it impossible for land surveying and geodetic companies to operate (permissive procedure for the execution of field surveys, stoppage or limited functioning of the IT systems of the State Land Cadaster and the State Register of Rights to Immovable Property, etc.).
- Temporary or irreversible loss to the industry of highly qualified specialists due to their forced movement within the country and abroad, mobilization to the Armed Forces, repurposing due to economic instability and the inability to receive a stable income working in a specialty.
- Technological restrictions for the performance of work (restriction or complete ban on the use of airspace for UAVs, complications for the use of GNSS equipment in the conditions of the operation of electronic warfare, additional restrictions on the use of GNSS networks, etc.).

Since the Russian invasion was accompanied by a large-scale cyber-attack on the IT systems of the Ukrainian authorities, in the very first days of the war, the administrators physically disabled the servers that hosted state information resources, registers, cadasters (including the State Land Cadaster, the State Register of Real Property Rights etc.). Physical data protection became the main priority.

Captured Russian military documents showed that they often used outdated topographic maps, the relevance of which corresponded to the 1980s. Thus, an important task was to prevent the aggressor

[2] URL: https://e.land.gov.ua/statistics/

[3] URL: https://zakon.rada.gov.ua/laws/main/

from accessing the current geospatial data of Ukraine published on the public cadastral map, the geoportal of the National Infrastructure of Geospatial Data, the geoportals of urban planning cadastres, etc. Obviously, access to modern geospatial data could improve an aggressor's military planning and missile strikes. Therefore, all public geoportals in Ukraine and geodata access services were disabled.
On February 25, 2022, a Russian cruise missile hit a new apartment building in Kyiv on Valery Lobanovsky Avenue. Based on the direction of the missile, the possible target was the data processing center of the State Land Cadaster Center, which stores about 4.6 TB of data, including:

- information of the State Land Cadaster (registration of plots, land use restrictions, administrative boundaries, cartographic basis, etc.);
- scanned land surveying documentation;
- scanned land title documents issued before 2013;
- orthophoto plans, Earth remote sensing materials.

Fig. 1. An apartment building on Valeriy Lobanovsky Avenue, 6A, located near the State Land Cadastre Centre, on February 25, 2022, a few minutes after it was hit by a Russian cruise missile (photo from the Telegram channel of Kyiv Mayor Vitaliy Klitschko).

After that, in February-March 2022, with the help of the Armed Forces, the data storages with the information of the State Land Cadaster server, and later the server equipment itself, were evacuated from Kyiv to one of the western regions of Ukraine. The further chronology of measures to preserve and restore the functioning of the State Land Cadaster in wartime conditions was as follows:

- April 2022 – development of options for restoring the functioning of the State Land Cadaster (in one of the western regions of Ukraine; in one of the EU countries; transfer of the server to a cloud service, etc.), development of a regulatory framework for temporary "paper" registration of plots;
- May 2022 – after the liberation of the north of Ukraine and the improvement of the security situation in Kyiv, the server equipment was returned to Kyiv, the functioning of the system was restored, a "cold" backup copy was created on cloud services;
- May-June 2022 – adoption of legislation and by-laws on the functioning of the State Land Cadaster in wartime, limited restoration of the system, connection of users
- September 2022 – April 2023 – introduction of new functional capabilities of the cadastral system (registration of functional zones in spatial planning, electronic statements on the tax monetary valuation of land, registration of community territory boundaries, etc.);
- December 2022 – February 2023 – audit of software, technical and technological condition of server equipment;

- April 2023 – establishment of a regulatory requirement for the reservation of State Land Cadaster data in the National Center for Reservation of State Information Resources (including the transfer of backup copies of data for storage to foreign diplomatic institutions of Ukraine).

The practice of the first months of the war showed that the services of the State Land Cadaster are extremely necessary and important even in wartime conditions. Cadastral data is necessary for the public land management, the urgent placement and repair of infrastructure facilities, the search for land plots for the evacuation of enterprises from the combat zone, and the construction of housing for displaced persons etc. Therefore, despite the suspension of the IT systems of the State Land Cadaster in the first days of the war and the uncertainty regarding the possibility of restoring their functioning, the development of alternative decentralized "semi-paper" land rights registration systems that could function in the conditions of non-working data processing centers began almost immediately. Therefore, the Law of Ukraine dated March 24, 2022 No. 2145-IX introduced Books of Land Ownership and Land Use Registration under Martial Law, which were kept in paper and electronic forms in district military administrations. These books allowed the registration and transfer of agricultural land rights as early as April 2022. The electronic version of the land survey documentation (certified by the electronic digital signature of the land surveyor) served as an appendix to the title document, if necessary.

The Law of Ukraine dated May 12, 2022 No. 2247-IX made it possible to systematically adapt the land legislation of Ukraine to functioning under martial law. The key novelties that unblocked land surveying work include: restoration of the limited functioning of the State Land Cadaster (without a public cadastral map and with special requirements for state cadastral registrars; permanent disconnection of services in the temporarily occupied territory and in the combat zone); the possibility of quickly providing public land for the most urgent needs without electronic land auctions and approval procedures, etc.

In the first months of the war, intensive anti-sabotage activities were carried out, so in the period from April to November 2022, a permissive procedure for carrying out field geodetic works was legally introduced. Land surveyors and geodesists conducting field surveys using geodetic equipment, as well as wishing to receive cadastral data, had to obtain a special permit from the Security Service of Ukraine. Such permits were issued to land surveyors and geodesists who passed counter-reconnaissance inspection.

In fact, since May 2022, it has become possible to carry out land surveying in Ukraine, but it is practically impossible on 21% of the territory of Ukraine, which is temporarily occupied or where hostilities took place and the liberated territory may be contaminated with unexploded ordnance, which poses a threat to the life of the surveyor (Fig. 2, 3).

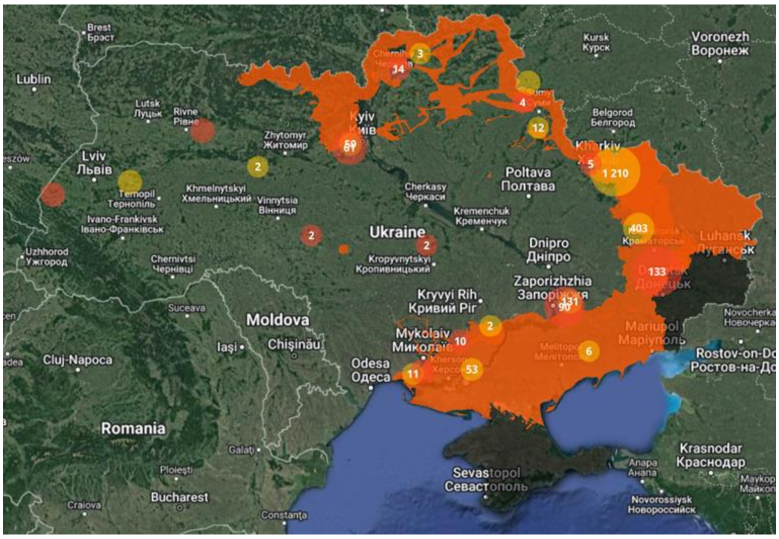

Fig. 2. Interactive map of territories that could potentially be contaminated by unexploded ordnance (according to the State Emergency Service of Ukraine, https://mine.dsns.gov.ua)

Fig. 3. A mine discovered during land surveying in the liberated territories in the Kharkiv region, February 2023.

In recent decades, surveying work relies on GNSS for precise measurements and positioning data. But since the beginning of the war radio-electronic warfare (REW) significantly impacts the civilian use of GNSS equipment and the performance of surveying work in front-line territories and during air attacks. REW systems can interfere with GNSS signals through jamming, which involves broadcasting radio frequency noise at the same frequency as the GNSS signals, effectively drowning out the satellite signals and rendering GNSS receivers unusable. This disruption can lead to inaccuracies, delays, or even complete loss of positioning information. In addition to jamming, REW systems can also employ spoofing techniques (especially during Russian strike drones' attacks), which involve transmitting counterfeit GNSS signals to deceive drone GNSS receiver into calculating false positions. This can cause severe issues for surveying work, as it may lead to incorrect data collection and inaccurate mapping of boundaries.

In the pre-war period, surveyors of Ukraine, thanks to the rather liberal legislation regarding the use of UAVs, quite intensively used drones for operational topographic mapping and creation of orthophoto plans. Since the beginning of the war, the airspace is closed to civilian aircrafts (including unmanned ones), and only a very small part of local cartographic projects (mainly in the western regions) that receive permits from the General Staff of the Armed Forces and Air Defense are being successfully implemented. The received remote sensing data also require additional counterintelligence verification to extract information about the location of defense facilities and other sensitive data.

Considering the aforementioned changes in land surveying in Ukraine under wartime conditions, it is important to evaluate the impact of the conflict on the industry, both in terms of economic and human dimensions.

Since the vast majority of land surveying work performed in Ukraine (about 80%), as in many European countries [2], is related to the definition of boundaries and cadastral registration of land plots, for an approximate assessment of the losses of the land surveying industry in Ukraine as a result of the war, we used such an indicator as the number of land plot registrations.

Comparing the number of applications for the registration of land plots in the State Land Cadaster for 2021 (2.012 million) and 2022 (653 thousand), it can be concluded that the land surveying industry lost approximately 67.5% of its pre-war revenue as a result of the war. Fig. 4, which shows the number of monthly land registration applications for the period from January 2019 to March 2023, clearly illustrates the dynamics of the industry during the wartime period (highlighted in color).

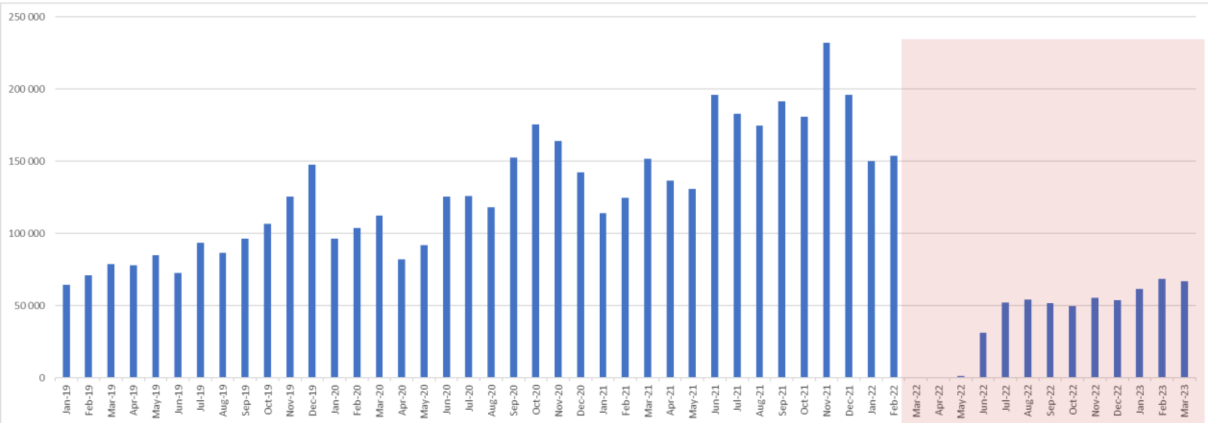

Fig. 4. Number of monthly applications for registration of land plots in the State Land Cadaster of Ukraine for the period from January 2019 to March 2023 (data from the State Service of Ukraine for Geodesy, Cartography and Cadaster).

According to estimates of professional associations of land surveyors in Ukraine, the pre-war volume of the land surveying market amounted to UAH 4.3-4.6 billion per year (€130-138 million). Thus, as a result of the war in 2022, the land management industry of Ukraine lost about UAH 3 billion in revenue (about €90 million).

15-20% of the market revenues decline can be explained due to temporarily occupied / vacated territories, where land management and land assessment works are not performed, or are performed with significant difficulties. For example, the Kharkiv region was one of the pre-war leaders in terms of land surveying and spatial planning works. In 2021, this region was chosen for the pilot development of new

promising types of land surveying documentation – comprehensive spatial development plans for two territorial communities. Their approval was planned for March 2022, but it did not happen due to Russian aggression.
Another 10-15% decrease in the industry's income in 2022 is due to the suspension of funding of land surveying and land assessment works by the state and local communities (state budget cuts for land reform implementation – UAH 139 million; state-wide topographic-geodetic and cartographic works – UAH 32 million, etc.). The corresponding funds were redirected to defense and crisis response. Only in March 2023, the Government of Ukraine restored the possibility of public procurement of land surveying and land appraisal works.
Thus, after the complete stoppage of land surveying production in March-May 2022 due to the suspension of the State Land Cadaster, the gradual recovery of the industry continues. Currently, at the beginning of 2023, the level of only 60-65% of the average monthly indicators of the pre-war level has been reached.
It is also important to examine how the war affected surveyors on a human scale. In this article, based on previous research [1], we have attempted to estimate the number of professional land surveyors, surveyors and land valuers working in the regions most affected by the war (Table 1). These surveyors were forced to become internal and external refugees, they or their relatives may remain in the occupied territories, deprived of the opportunity to work normally in their profession due to existing threats to life, loss of clients and regulatory restrictions. The regions most affected by the war are Luhansk, Donetsk, Kherson and Zaporizhzhia regions. Significant territories of the Kyiv, Kharkiv, Sumy, and Chernihiv regions were liberated from the aggressor, but they suffered the devastating effects of the war.

Table 1

Estimation of the number and share of land surveyors, geodesists and land appraisers who worked in the regions most affected by Russian aggression[4]

Type of region		Land surveyors			Geodesists			Land Appraisers		
		Men	Women	Total	Men	Women	Total	Men	Women	Total
Regions that are partially under occupation	number	146	133	279	56	18	74	56	60	116
	%	8,3	11,5	9,6	8,2	9,0	8,4	9,5	10,9	8,4
Liberated regions that have undergone hostilities	number	508	367	875	194	58	252	240	228	468
	%	28,8	31,9	30,0	28,5	29,0	28,6	40,6	41,5	28,6
Other regions	number	1108	652	1760	430	124	554	295	262	557
	%	62,9	56,6	60,4	63,2	62,0	63,0	49,9	47,6	63,0
In total	number	1762	1152	2914	680	200	880	591	550	1141

As we can see, up to 10% of surveyors of Ukraine were in the regions that are currently most affected by the war, and up to 30% come from regions where hostilities and mass destruction took place. However, it is also worth noting that almost 40% of land surveyors, 23% of geodesists and 48% of land appraisers are women, who in times of war are often forced to take responsibility for the safety of children and elderly family members, seeking shelter in safer regions or abroad, thus losing the opportunity to work by profession.
When examining the primary aspects of the strategy for the recovery of the surveying industry, it is important to emphasize that the principal expectations lie in the post-war restoration efforts. The following important initiatives for the industry can be identified:

[4] We also have to warn that the estimates given by us may be incomplete, since the presented statistics cover only certified specialists registered in the relevant state registers. It is clear that there are a significant number of professional surveyors who work in support positions or in businesses where certification is not required (such as construction companies, agribusiness or universities, etc.)

- Land surveyors are instrumental in evaluating and documenting the extent of damage inflicted on buildings, infrastructure, and natural resources during a war. By utilizing their expertise in geospatial data collection and analysis, land surveyors can create comprehensive maps and reports detailing the destruction caused by the conflict. This invaluable information aids in identifying the most affected areas and prioritizing reconstruction efforts, ensuring the efficient allocation of resources for rebuilding and restoration. Furthermore, accurate damage assessments can support claims, government compensation programs, and international aid initiatives, helping affected communities recover more swiftly from the impacts of the war.
- The project of the National Plan for Recovery from the Consequences of War[5], which was presented in August 2022, provides for new mapping of the territory of Ukraine and the development of the National Geospatial Data Infrastructure (NSDI). It is obvious that without providing up-to-date cartographic data, the post-war recovery and development of territories is impossible. Implementation of NSDI, including land monitoring, will ensure effective adoption of management decisions by state authorities and local self-government bodies, meeting the needs of society in all types of geographic information, integration into the global and European infrastructure of geospatial data. The expected effective use of geospatial data will lead to GDP growth of up to 1% per year. Estimated budget of UAH 3.3 billion. ($110 million).
- The development of comprehensive plans for the spatial development of the territories of territorial communities is considered an important tool for post-war reconstruction. More than 150 communities have already decided to develop such plans, which contain a heavy land surveying part. In 2023, it is planned to develop (update) several pilot comprehensive plans for communities affected by hostilities.
- The identification of areas affected by hostilities and land reclamation efforts are becoming increasingly significant. It is crucial to include information about territories contaminated by explosive objects (accounting for more than 21% of Ukraine's territory) in the State Land Cadaster, ensuring effective information interaction with IMSMA[6]. This step is necessary for implementing fiscal policies and exempting hazardous real estate from taxation. A vital component of restoration efforts includes post-demining land reclamation, soil cover restoration, and exploring alternative uses for lands with long-term contamination.
- The war caused damage to Ukraine, which is measured in hundreds of billions of euros, but currently the estimated annual amount of financing for reconstruction in the post-war years is 15-20 billion euros. Topographical and geodetic support for construction, depending on the types of reconstruction, will be from 0.3 to 1.2% of the estimated cost. Planned expenditures for reconstruction in 2023 in the State Budget of Ukraine - 23 billion UAH (that is, UAH 120-200 million will go to topographic and geodetic support).

Conclusions and proposals

The key provisions of the strategy for the recovery of land surveying in Ukraine from the consequences of the war focus on rebuilding the industry's infrastructure and human resources while adapting to the new realities of a post-war environment. This includes conducting thorough damage assessments to document the impact of the war on buildings, infrastructure, and natural resources, and prioritizing reconstruction efforts. Investment in modern technologies and equipment is also vital to enhance the accuracy and efficiency of land surveying practices, while efforts to re-establish disrupted services, such as the State Land cadaster and other registration systems, will ensure the continuity of land management and spatial planning processes. Another crucial aspect of the recovery strategy is the retention and development of the land surveying workforce. Implementing policies and programs to retain existing professionals, attract new talent, and provide retraining and educational opportunities will help rebuild the industry's human resources. Collaborating with international organizations and experts to exchange knowledge, best practices, and resources will further support the recovery and development of the land surveying industry in Ukraine. Raising public awareness and engaging stakeholders are essential in

[5] URL: https://www.kmu.gov.ua/en/national-council-recovery-ukraine-war/working-groups

[6] The Information Management System for Mine Action is a software designed to support the needs of the mine action community for decision support, monitoring and reporting. Core elements of IMSMA include a PostgreSQL database engine and a GIS for displaying information on maps.

garnering support for the land surveying industry and emphasizing its role in post-war reconstruction efforts. By fostering a broader understanding of the industry's importance and its contribution to rebuilding, the long-term resilience and growth of the land surveying sector can be ensured.

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DOI: 10.22616/j.balticsurveying.2024.19.008

METHODOLOGICAL BASIS OF THE DEVELOPMENT OF THE INSTITUTIONAL ENVIRONMENT OF THE LAND MANAGEMENT SYSTEM

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Abstract. It is substantiated that the institutional concepts of the latest institutional and behavioral economic theory should be placed in the methodological basis of the development of the institutional environment of the land management system. Institutions and institutes are the key to understanding the relationships between all subjects of the economic system of land management, and institutional changes determine the direction of its development and are a defining trend today.
The institutional system in the field of land relations, land use and land management is a set of organically interconnected institutions and institutes that are a certain logically complete, integral unity, capable of self-development and self-reproduction, as well as organizations and individuals that act within given institutional restrictions regarding land relations and organization of land use.
Firstly, the methodology of institutionalization of land management considers socio-economic systems through holistic development. The principle of the integrity of the socio-economic system research includes an interdisciplinary approach. Secondly, individuals receive characteristics through the prism of the existence of institutions and institutes that condition their behavior and interaction. Thirdly, institutional changes require not only quantitative, but also qualitative methods of observation, which analyze not the results of changes (for example, indicators of efficiency and growth), but the direction, strategy and the very process of evolution with the clarification of the causes, all stages and forms of transformations.
Key words: land surveying, economics of land planning, land relations, land use.

Introduction

Economy is a complex adaptive social and behavioral system. The complexity of the system is determined by the presence of many independent elements, each of which can interact with the other. In the process of interaction of elements, they jointly form a certain environment (Arthur, 1994). In the conditions of the institutional transformation of the economy in the system of socio-economic sciences, the search for a new paradigm of economic theory as a set of ideas and concepts, a theoretical and methodological basis, which sets the vector of economic development, does not stop. One such attempt is the emergence of behavioral economics as a science based on a positivist approach to the study of economic processes and phenomena, which provides a psychological explanation for the accumulation of empirical material.
Institutional structure as a complex of economic institutions-norms and institutions-organizations is an orderly arrangement of institutional elements that play an important role in the economic activity of society, that have characteristic relationships inherent only to them and collectively form a certain system of an institutional nature. The orderliness of the location of the elements implies their exact and clear location relative to each other on the scale of the entire system, the selection of levels of their hierarchy and the identification of the corresponding hierarchical relationships. The concept of "economic institutions and institutes" was introduced into scientific circulation by the institutional-sociological direction of economic theory. Representatives of institutionalism are interested in two main problems: economic power and control over the economy, which is why they use the concept of "institutional theory". Given that in the process of land reform, land management as a socio-economic institution (Третяк et.al, 2021) did not develop, and the state removed itself from its implementation (Третяк, 2013), accordingly, for the development of the economy of land management there was a need to develop methodological principles.
Institutions slowly adapt to changes in the surrounding environment, so institutions that were effective in the past become ineffective and remain so for a long time, since it is difficult to return society from the historical path established a long time ago. There is a difference between institutions and institute-organizations. While institutions are a set of rules and laws that determine the interaction and action of individuals, institutes-organizations are corporate actors that can themselves be the objects of institutional restrictions. Institutions have an internal structure, an institutional framework that determines the behavior of individuals who form organizations. New institutionalism ("new

institutionalism") was initiated in the works of B. Moore "Social origins of dictatorship and democracy" (Moore, 1966), S. Huntington "Political order in changing societies" (Huntington, 1991), T. Skocpol "States and social revolutions: a comparative analysis France, Russia and China" and R. Coase "The Nature of the Firm" (Coase, 2007). Starting with T. Veblen (Veblen, 1984), one of the defining elements of institutionalism became an evolutionary approach to economic analysis. J. Hodgson (Hodgson, 2000) singles out 5 methodological provisions of institutionalism, formulated by U. Hamilton (Hamilton, 1932) in 1919: the evolutionary nature of the economy; practical orientation of the theory without reducing it to economic policy recommendations; the main task of economists and land managers, as well as other specialists, is the study of institutes and institutions; interdisciplinary approach; rejection of the theory "man is a utility maximizer" as an unrealistic and erroneous concept. At the same time, the new institutional economic theory (NIET) most often analyzes institutions and institutions as the consequences of the decisions of rational, maximizing agents, so it can be said about the mutual influence of individuals and institutions and institutions on each other. A. Tkach defines the basic elements of the NIET research paradigm as a triad: property rights; transaction costs; theory of contracts (Ткач et.al, 2007).

Methodology of research and materials

The methodology of studying the processes of development of the institutional environment of the land management system includes the study of the regularity of the functioning of the economy of land relations, land use and land management. For this purpose, it is substantiated that institutional changes determine the direction of development of the land management system. The methodological basis is the methods of experimental research, owe to which it is possible to more clearly monitor the conditions of the land use regime and the environment in such a way that, as a result, it will be possible to assess the influence of each of these factors separately.

Discussions and results

In this study, we divide economic institutions and institutes into institutions-norms and institutes-organizations (Третяк et.al, 2021). Economic institutions are understood as the rules of the game in society or formally created restrictions by people that shape the interaction of people. Institutions create a structure of exchange incentives in social, political or economic activity. They are both formal laws (constitution, legislation, property rights, etc.) and informal rules (traditions, customs, codes of conduct). Institutions are created by people in order to ensure a certain order and eliminate uncertainty in relations, including the field of land relations, organization of land use and protection, and land management. Such institutions, together with standard constraints accepted in economics, define a set of alternatives and thus determine rational and sustainable land use. Institutions are a set of rules that structure land relations, the organization of land use and protection and land management in a special way, knowledge that all members of society must possess. Formal institutions are often created to serve the interests of those who control institutional change in a market economy. The pursuit of one's own interests can have a negative effect on others. Public institutions that fulfill ideological and spiritual needs influence social organizations and economic behavior.

Institutions in the field of land relations, organization of land use and protection, and land management can be considered as a component of land capital that can change due to depreciation and new innovations and investments. Formal laws can change quickly, but enforcement and informal rules change slowly. Ukraine, which adapts the relevant economic institutions of foreign countries to the market model of the land market, can serve as an example here. Informal rules, norms, customs are not created by the authorities, they usually develop spontaneously.

At the same time, the dominant systems, and the existing systems in Ukraine of land relations, land use and land management, are not always economically efficient, modern realities require the use of not only economic, but also social and ecological criteria of behavior. The behavior of a person as an individual always has a social character, which is manifested in the close inseparable connection between individual actions and society as a whole. According to the researches of O.M. Nikoliuk (Николюк, 2013), the main properties of an individual from the point of view of institutional theory are: 1) the relationship of his behavior with the process of evolution of economic systems; 2) social nature of actions; 3) partial rationality of behavior.

Based on the above, a person as an individual of land ownership, within the limits of institutionalism, is a partially rational individual, whose social actions are at the basis of the evolution of economic systems and elements of their external environment. At the same time, the influence on the evolution of the economic system related to land relations and the organization of the use of land and other natural resources can be indirect. In particular, her behavior within social, legal, environmental, etc. systems of relations indirectly affects the economic systems of land relations. This is confirmed by the ideas of the new behavioral economy, the laureate of the 2017 Nobel Prize in Economics, Richard Thaler, which reflect the leading trend in economic science - interpenetration and its relationship with other sciences. According to Richard Thaler, traditional economic theory is outdated: "rational man" is too limited a model to explain people's decisions and actions. "Irrationality did not arise by chance and does not make sense - on the contrary, it is completely systematic and predictable" (Thaler, Benartzi, 2004): "a person does not make a choice impartially. His new behavioral economics aims to rethink human behavior, especially in the area of land ownership.

Given that a person as an individual is a central figure in institutional economic theory, it has a significant influence on the adoption of certain decisions, and institutional theory in economic analysis will not be complete if it is not supplemented with behavioral economic theory. In fig. 1 shows a logical-semantic diagram of the tree of the latest institutional and behavioral economics proposed by us (Третяк et.al, 2021).

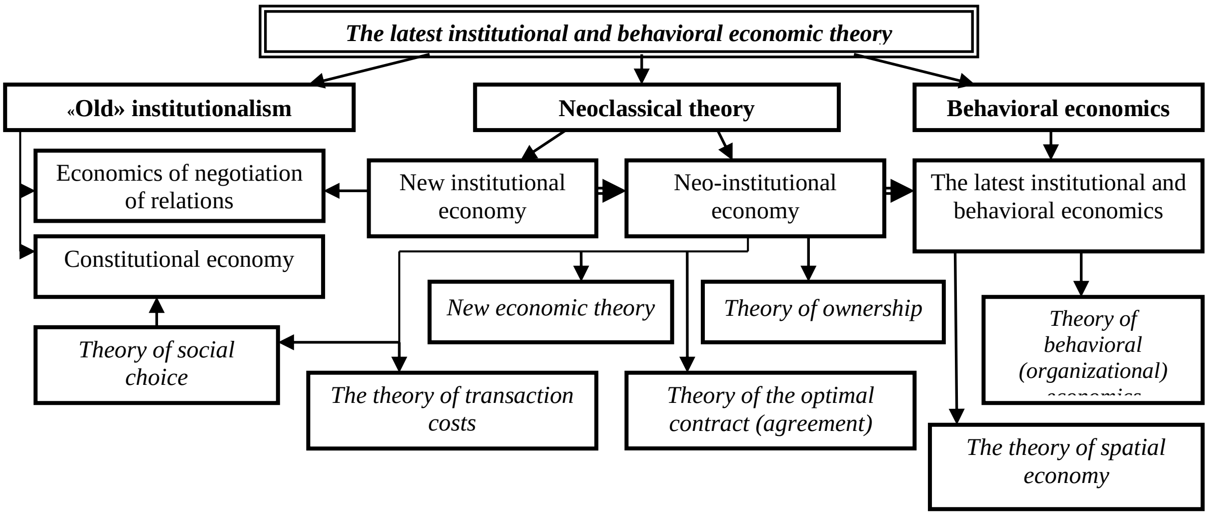

Fig. 1. Logical-semantic scheme of the tree of the latest institutional and behavioral economics (Третяк et.al, 2021)

The main directions of behavioral economic theory research are currently the following (Coursey et.al, 1984): the theory of prospects (the theory of the rational choice of an individual in conditions of risk and uncertainty, the theory of unexpected utility, identified typical deviations, stereotypes in the behavior of an individual, the so-called cognitive heuristics); game theory and bargaining theory (behavioral theories of games, concepts of "fair equilibrium", "ultimatum games" and "dictator games"); theory of auctions, experimental testing of various pricing strategies and finding out the degree of confirmation of the consequences of traditional models on real data. The new behavioral economics now puts Homo sapiens next to Homo economicus, thereby allowing this "contradiction" of A. Smith. This news in R. Thaler's behavioral economics can be represented by the following scheme (Table 1).

Table 1

Characteristic differences in human behavior in R. Thaler's new behavioral economy

Homo economicus	Homo sapiens
Free, independent	Limited independence
Selfish	Altruist
Rational	Relative rationality
Knowledgeable	Incomplete information

This is the sociological approach to a person involved in economic activity in the field of land relations, land use and land management.

The institutional environment of the economy of land management and land management determines the nature of relations and connections between economic entities, that is, the framework for the formation of institutional actions regarding the implementation of land management measures. The institutional structure implies a certain hierarchy of various institutions and institutes, which regulates human relations. The formation of the institutional hierarchy depends both on the types of institutions and institutes, as well as on the level of coverage of their action and duration of functioning (Holling, 2001).

The result is a complex mix of formal and informal constraints. These limitations are embedded in the language of ownership of land and other natural resources as material things and beliefs. Together, they determine the forms of ownership and organization of land use and interaction between people. For example, land is universally valued for its inherent and incredible importance in terms of religion, spirituality, aesthetics, and opportunities for life and recreation.

In the economic sphere of land management, these are first of all models (options of adoption) of land management socio-economic and ecological measures and actions for the formation of balanced land use (Мединська, 2022). The imposition of restrictions using the structure of the institutional hierarchy allows you to organize the choice of options and determine the rules of the game.

The institutional system in the field of land relations, land use and land management is a set of organically interconnected institutions and institutions that are a certain logically complete, integral unity, capable of self-development and self-reproduction, as well as organizations and individuals that act within given institutional restrictions regarding land relations and organization of land use. There is a certain hierarchy and subordination between institutions and institutes included in the system. Institutions and institutes are realized in changing the behavior of individuals, and therefore, the economy of land management should be considered as an institutional system taking into account the individuals themselves (Fig. 2) (Третяк, Гунько, 2022).

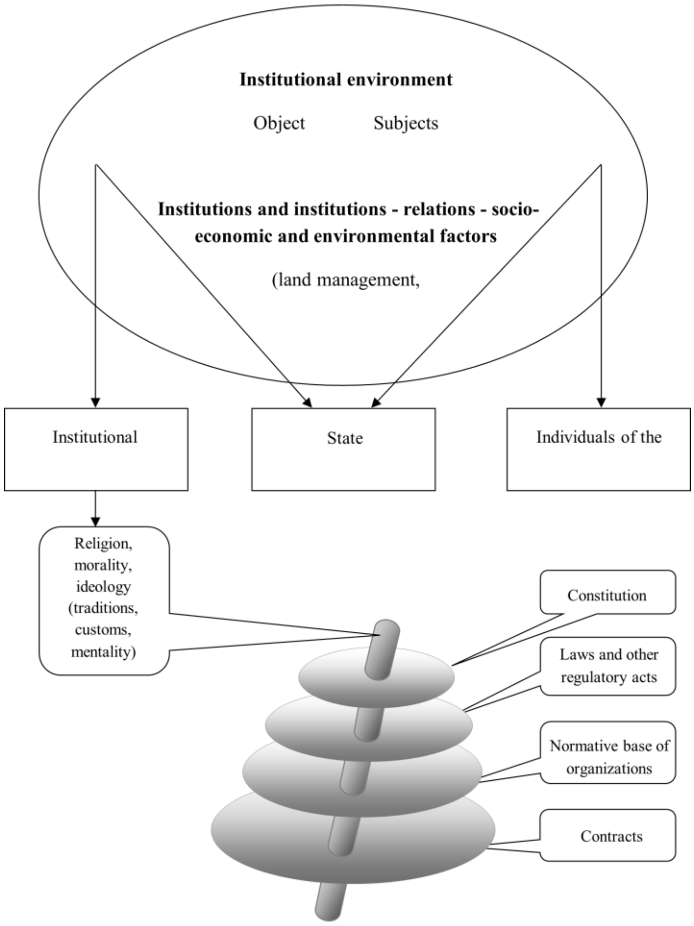

Fig. 2. Logical and substantive model of the institutional system of the economy of land management

Property rights to land and other natural resources and enforcement of contracts (agreements) are two of the most important elements of the institutional structure. Creating a system of guaranteeing ownership rights to land and other natural resources (land system, State Land Cadastre and state registration of property rights) and ensuring their compliance with respect to landowners and other private individuals, the government and the institutional structure provide incentives for innovation and investment in tangible and intangible land assets and risk perception. By ensuring the effective coordination of the interests of all participants in land relations in the process of land management, the institutional structure stimulates market transactions with objects of land management.
The analysis of institutions and institutional systems is based on the following general methodological principles of comparative institutional research: a holistic approach, that is, the focus of the analysis is on the consideration of the system as a whole, and not on the behavior of individuals; development of a universal and system-neutral language for describing the studied systems; definition of the system studied through the institutional structure (the institutional approach involves the construction of the basic structure of institutions and institutes or institutional forms); forming a typology of such systems on this basis (comparatively, a typological method of analysis); interpretive methodology which finds its expression in the discovery of latent generalized structures and then understanding of specific social systems as their individual cases.

Conclusions and proposals

The realization that institutions and institutes are the key to understanding the relationships between all subjects of the economic system of land management, and institutional changes determine the direction of its development, is a defining trend today. Firstly, institutionalization of land management considers socio-economic systems through holistic development. The principle of the integrity of the socio-economic system research includes an interdisciplinary approach. Secondly, individuals receive characteristics through the prism of the existence of institutions and institutes that condition their behavior and interaction. Thirdly, institutional changes require not only quantitative, but also qualitative methods of observation which analyze not the results of changes (for example, indicators of efficiency and growth), but the direction, strategy and the very process of evolution with the clarification of the causes, all stages and forms of transformations.

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