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ANALYSIS OF LAND USE CHANGES IN THE 19TH–21ST CENTURY: THE CASE OF JUODAIČIAI, LITHUANIA

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Abstract
The primary problem of land use changes from the 19th to the 21st century lies in human-driven landscape transformations that impact ecosystems, biodiversity, and sustainable management. The study examines changes in land use in Juodaičiai eldership (Jurbarkas district) during the 19th–21st centuries. GIS technologies and digitized 19th-21st century maps were used to identify changes in land use. The study utilized military-topographic maps of the Russian Empire (1860–1915), interwar Lithuanian topographic maps (1933–1940), Soviet topographic maps (1988), the Lithuanian georeferenced spatial data set, LIDAR data (2009–2010), and orthophoto maps, analyzed using ArcGIS Pro software. The study used 3D terrain models and GIS technologies to analyze land-use changes. It found that from the 19th to 20th century, agricultural land expanded by 39.8%, mainly at the cost of forests, which decreased by 42.4%. During the Soviet era, forest areas increased by 12.7%, while urbanized areas shrank. In the early 21st century, forest and agricultural land remained stable, but intensive logging, affecting 23.6% of current forest areas, continues. This study reveals that while the land use in Juodaičiai eldership has undergone significant shifts over two centuries, the persistent tension between human activity and environmental sustainability remains the defining challenge for future landscape management.
Keywords: land use, land-use change, digital maps.

Introduction

Land use describes how humans utilize the land's surface. It involves the land's resources, the goods and benefits they provide, and the actions and practices employed to manage it (Wang & Yang, 2020).

Land systems represent the terrestrial component of the Earth system, encompassing human land use, socioeconomic activities, technological investments, and both the benefits and unintended consequences of these actions. Transformations within land systems, including human-induced changes to ecosystems and landscapes, are significant drivers of global environmental change (Verburg et al., 2013).

Over the past 60 years, humans have altered nearly one-third of the Earth's land surface. These changes present significant challenges to global food security, climate change, and biodiversity. Rapid shifts in land cover have primarily been driven by intensive human activities, including agriculture and urban development (Wang et al., 2023).

The Earth's land surface is predominantly utilized for agriculture, forestry, and urban activities, including infrastructure and residential areas. Environmental and socio-economic changes drive land-use transformations, which can adversely affect human well-being. Understanding the complex relationships between land-use factors and ecosystem services is essential for mitigating these impacts (Schirpke et al., 2023).

Changes in land systems present significant challenges to sustainability and require a comprehensive understanding of the drivers behind land-use and land-cover change. Land system science makes a substantial contribution by offering innovative methodologies and empirical insights into the patterns, processes, and underlying causes of these changes (Meyfroidt et al., 2018).

In recent decades, climate change, soil degradation, and Land Use/Land Cover Changes have heightened the risk of land degradation, making it one of the most critical ecological challenges on a global scale (Bajocco et al., 2012).

Land use changes impact the variety, quantity, and distribution of ecosystem services. Drivers such as population growth, migration, and socio-economic developments also shape societal demand for these services. The alignment between service supply and demand is crucial for human well-being, as the loss of critical services can have significant social and economic consequences (Sturck et al., 2015).

Land cover and land use changes can cause a variety of ecological effects, particularly on soil health and water quality, are influenced by even minor changes in farming practices in rural areas. Fine-scale analyses are essential for fully understanding these processes. Developing models to predict land cover changes is crucial for identifying areas at risk and informing sustainable policies. Future landscape studies can provide valuable insights to forecast responses to subtle changes, enabling more targeted and effective actions (Houet et al., 2010).

Rapid urbanization has transformed landscape patterns and ecological functions, leading to a reduction in ecosystem services and giving rise to various ecological and environmental challenges. Investigating the spatiotemporal interactions between urbanization and ecosystem services (ES) can offer valuable insights to support regional sustainability and inform policy development (Luo et al., 2022).

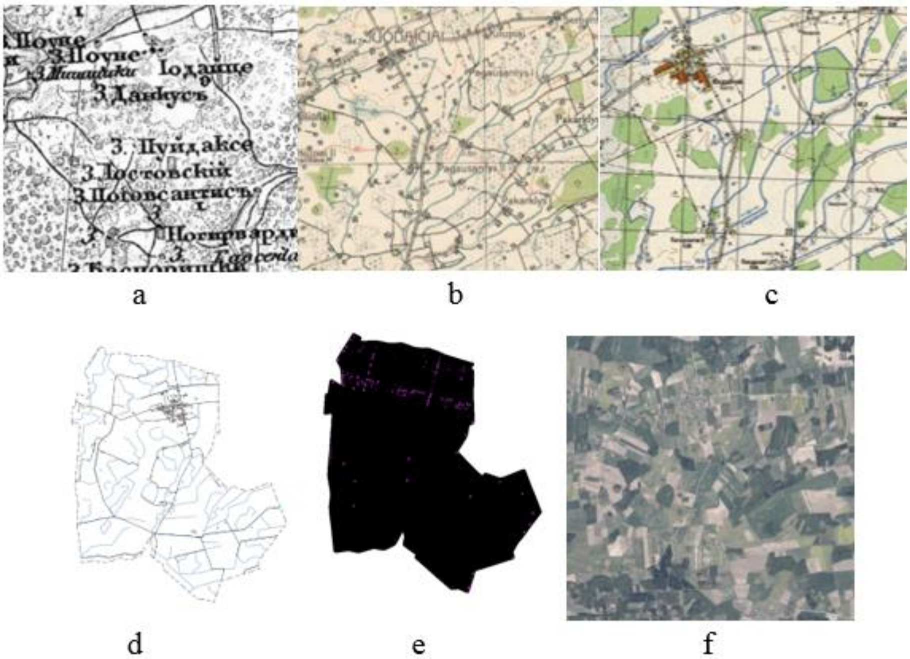
The effect of land use/cover change on the spatial distribution and fluctuation of ecosystem service values is still not well understood, which complicates the development of land use management policies aimed at

promoting harmonious development (Ying et al., 2023).
Land and ecosystem changes, along with their implications for global environmental change and sustainability, present a significant research challenge. Land change models are complex due to the interplay between human and environmental dynamics, necessitating spatial precision. The spatial arrangement of land uses and covers both influences and is influenced by these processes (Turner et al., 2007).
The land use change analysis offers crucial insights for monitoring landscapes, managing land resources, and prioritizing conservation efforts over large areas (Nedd & Anandhi, 2022).
Humans significantly influence landscapes through activities like urban expansion, deforestation, and the restoration of wilderness areas around abandoned mines. While mathematical models can aid in understanding and predicting land use changes, many models either fail to address cause-and-effect relationships or become overly detailed in describing specific processes (Budrikis, 2024).
The land use change models assist in interpreting the causes and effects of land dynamics, providing valuable support for policymakers in decision-making. The literature presents a variety of models from diverse disciplines, each with distinct strengths and limitations, making the selection of an appropriate model a challenging task (Noszcyk, 2019).
The land use and system changes are key to addressing global issues like food security, climate change, and biodiversity. Human activities, such as urbanization and agriculture, have significantly altered ecosystems. Analyzing these changes and using predictive models is crucial for assessing their impact on land use, ecosystem services, and human well-being. Effective land management relies on scientific knowledge to help policymakers prioritize conservation and tackle ecological challenges.
The subject of this article is the agricultural land area of the Juodaičiai eldership, located in the Jurbarkas district, Lithuania.
The objective is to assess the changes in land use areas from the 19th to the 21st century using digital and historical topographic maps, along with GIS technologies.
Tasks:
1. Compare historical and contemporary maps and analyze the changes in forest, agricultural land, and urbanized areas.
2. Assess land use changes over different periods (19th-21st centuries).
3. Calculate the rate of change in agricultural and forest land areas and evaluate potential future land use change scenarios.
4. Use GIS software and LIDAR data to create 3D landscape models and visualize the changes.

Materials and Methods

The distribution of soil fertility scores according to intervals was carried out based on a map obtained from the Lithuanian Geoinformation System (Žemės išteklių…, 2025), and various geographical and historical data were also analyzed.
Selection of the study area: considering the soil fertility score and the impact of urbanization development, the Juodaičiai eldership, which is characterized by high soil fertility and is favorable for agricultural activity was chosen. The Juodaičiai eldership is located in the northeastern part of the Jurbarkas district municipality, which is the smallest eldership in this district. The selected area is based on historical and geographical considerations.
Topographic maps and data sources: various topographic maps were used during the study to help analyze land changes over different periods. To investigate land use changes from the 19th to the 21st century, the study was conducted using historical topographic maps. These maps recorded the situation at the respective periods, and by digitizing them and combining them with modern data, the research was carried out.
The following data sources were used:
1. Military topographic maps of the European part of the Russian Empire, created by the Military Topography Department (1860–1915). Scale: 1:126,000. The map sheet is rectangular, measuring 58x42 cm, covering a 73x53 km area ‛Figure 1a’, in black and white.
2. Interwar topographic maps of Lithuania, scale 1:100,000 (1933–1940). These maps depict the territory of the country at that time; the size of the map sheet is 47x45 cm ‛Figure 1b’, in color.
3. Soviet topographic maps at a scale of 1:50,000 (1988) ‛Figure 1c’, in color.
4. Georeferenced spatial data set of the Republic of Lithuania’s territory (Oficialiosios statistikos…, 2025b) ‛Figure 1d’.
5. LIDAR data (2009–2010), obtained from the Lithuanian Spatial Information Portal (Geoportal, 2024) ‛Figure 1e’.
6. Orthophoto map ‛Figure 1f’.
ArcGIS Pro software was used for the research. GIS technologies provide the ability to extract data from raster images, in this case, from digitized maps. During the research, a situation arose where some of the maps were not georeferenced. Specifically, these were maps from the 19th and early 20th century. In such cases, after conducting a visual analysis of topographic objects, location-based features that had not changed their position over time were selected. Their coordinates were determined in the LKS94 coordinate system, and map georeferencing was performed.
Continuing with the research, databases were created and object vectorization was carried out.
The forest cadastre database was loaded into the ArcGIS Pro file, and data corrections were made. Some data in the loaded database were outdated, so a visual comparison of the cadastre database with the orthophoto was necessary to identify newly performed clearings.

Figure 1
Data sources: a) Fragments of 19th-century maps, b) Fragments of early 20th-century maps, c) Fragments of late 20th-century maps, d) Georeferenced spatial data sets, e) LIDAR data, f) Orthophoto map



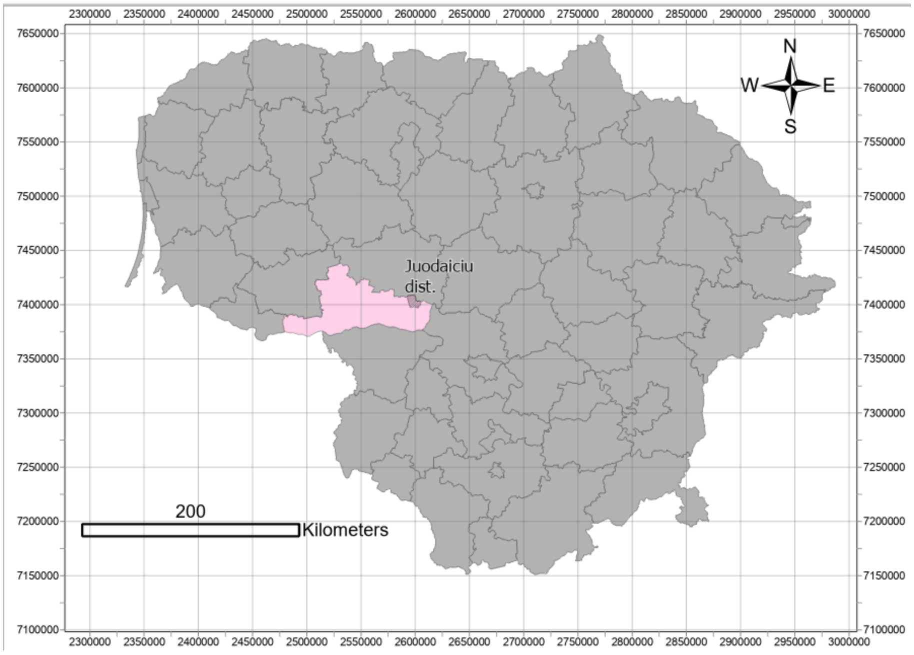
A 3D terrain model was created from the LIDAR point cloud using the IDW interpolation method. 3D landscape models were created to visualize changes in the territories and compare data from different time periods. 3D landscape models, in contrast to two-dimensional representations, enable the visualization of an area's current or historical state in a more realistic and familiar form. They offer a clearer understanding of the interrelationships among hydrography, road networks, forested areas, and built-up territories.
The georeferencing data set was uploaded.
The comparison of the obtained data was performed, and the rate of change of non-forest land use was calculated for different periods using the following formula:

$$v_f = \frac{S_{t2} - S_{t1}}{t_1 - t_2} \quad (1)$$

where:
- v_f is the rate of change in non-forest land use;
- t_1, t_2 are the years of the two time periods;
- S_{t1} and S_{t2} are the non-forest land areas (m²) for the years t_1 and t_2, respectively.
A land use analysis was conducted to assess changes in forest, agricultural, and urbanized areas over time. The study examined shifts in land allocation for forestry, agriculture, and urban development, offering insights into the dynamics of land use transformation.

Results and Discussion
This study provides a unique century-long analysis of land use changes in Juodaičiai Eldership, Jurbarkas District. Using historical maps, soil productivity data, and LIDAR-derived elevation models, it reveals how natural resource potential (e.g., soil fertility) interacts with anthropogenic pressures like agriculture and urbanization.
Description of the object
To determine land use changes, the Juodaičiai eldership, located in Jurbarkas district, was chosen ‘Figure 2’. The municipality is situated in the northeastern part of Jurbarkas district and is the smallest of all the municipalities in the district. The first mention of Juodaičiai eldership, after which the municipality is named, appears in written sources from 1568. At that time, there was very little land used for agriculture, only a few valaks (1 valakas ≈ 21 hectares), and the surrounding area was covered with forests.
The area of Juodaičiai eldership is 31.34 km². The municipality consists of seven elderships: Juodaičiai, Misiūnai, Pagausantys I, Pagausantys II, Pakarklys, Pavietava, and Užringis.
The population density in eldership is 10.3 people/km² (Oficialios statistikos…, 2025a). The population change in the Juodaičiai eldership is shown in ‘Figure 3’. It is evident that the population was at its lowest during the 19th century. In the 20th century, the population significantly increased, but started to decline in the first half of the 20th century.

Figure 2
Administrative division of the Republic of Lithuania; Juodaičiai eldership in Jurbarkas district



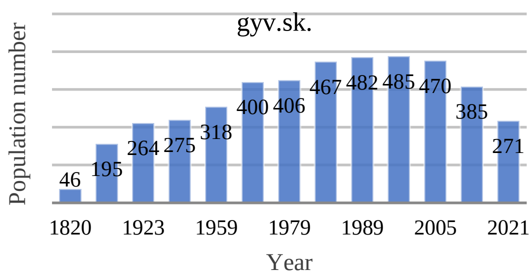
As the population increases and agricultural equipment and technology advance, the opportunity and need to cultivate more arable land and expand settlement areas have arisen. In most cases, this process is carried out at the expense of forested areas.

Soil Fertility Score Determination

The average soil fertility score of the Republic of Lithuania is 39.79 (Žemės išteklių…, 2025). The soil fertility scores in the Republic of Lithuania are divided into the following intervals: 0.01-22.00; 22.01-27.00; 27.01-32.00; 32.01-37.00; 37.01-42.00; 42.01-47.00; 47.01-52.00; 52.01-57.00; 57.01-62.00; 62.01-67.00; 67.01-100.00.

The most fertile lands are in central Lithuania. Since ancient times, soil fertility and a high fertility score have been one of the key factors creating favorable conditions for the expansion of agricultural areas. The Juodaičiai eldership, located in the Jurbarkas district of Lithuania, was chosen for the study due to this factor.

Figure 3
Population change in the Juodaičiai eldership



When selecting this district, the soil fertility scores of all municipalities were determined, and the percentage of municipalities falling into the above intervals was calculated (Table 1). Based on the results of the study, the Juodaičiai eldership was selected.

Table 1
The distribution of soil fertility scores in the municipalities of Jurbarkas district

Soil fertility fcore interval	***Percentage of municipalities in Jurbarkas district based on fertility score***
27.01-32.00	8.3
32.01-37.00	16.7
47.01-52.00	41.7
52. 01-57.00	33.3

According to the 2025 data, the average soil fertility score of Jurbarkas district is 50.49, and in the Juodaičiai eldership, it is 52.58. These data show that the soils of Juodaičiai eldership have a high fertility level, which is among the highest in Lithuania. This high fertility score is particularly important for agricultural activities, as it ensures favorable conditions for growing various crops and developing agriculture. Such favorable soil fertility is a key factor because the fertile soil characteristic of this area not only enables high crop productivity but also creates favorable conditions for the long-term and sustainable development of agricultural activities.

Creating a Surface Model of Juodaičiai eldership

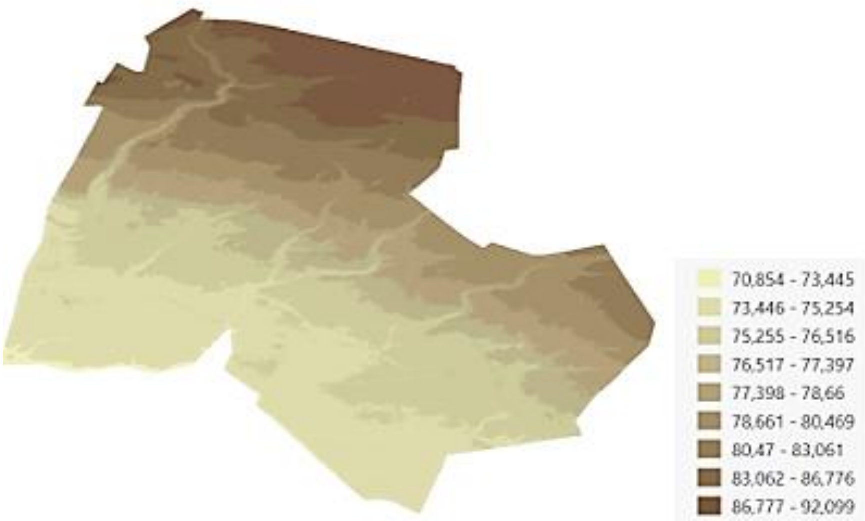
The geomorphological parameters of a territory play a crucial role in determining its suitability for various land uses, including agricultural and other anthropogenic activities. These parameters encompass features such as elevation, slope, landforms, and relief, which can directly impact the effectiveness of land management and the feasibility of cultivation.

For the Juodaičiai eldership, a surface model was created using advanced GIS software, LIDAR point cloud data, and the IDW (Inverse Distance Weighting) surface modeling algorithm. These tools enable the generation of precise digital elevation models (DEMs), providing a detailed representation of the terrain's physical attributes. The resulting surface model ‘Figure 4’ reveals important insights into the spatial distribution of elevation across the area.

The model indicates that the elevation changes by 22 meters as one moves from the southern to the northern part of the eldership. The southern part is characterized by lower elevations, while the northern part is situated at higher elevations. This gradual increase in elevation from south to north implies a relatively smooth terrain, with only minor fluctuations in the landscape. However, more pronounced variations in elevation are observed along the river valleys, where erosion and sediment deposition create more noticeable changes in the landscape.

This steady variation in elevation, coupled with the favorable soil conditions indicated by a high soil productivity index, makes Juodaičiai eldership an ideal location for agricultural activities. The absence of severe topographic changes, particularly in the central and northern parts of the territory, allows for efficient farming practices, including crop rotation, irrigation, and mechanized farming.

Figure 4
Digital elevation model of the Juodaičiai eldership



Land use changes of Juodaičiai eldership

The use of cartographic sources provides the opportunity to obtain data about the condition of the territory during the mapped period, which has since been irreversibly changed. This is particularly relevant when conducting research on changes, taking as a reference the situation from a century or two ago.

In this case, the topographic maps of the late 19th and 20th centuries offer a unique opportunity to examine the agricultural land use, forest areas, and analyze their changes over time. By scanning the data presented in these maps, layers were obtained that store information about forested areas, urbanized areas, and agricultural land. The table below (Table 2) lists the area occupied by various elements of the territory during the studied periods, in percentages and hectares. Considering the technological advancements and population growth during the 19th and 20th centuries ‘Figure 3’, there was an increased demand for cultivated land and urbanized areas.

Table 2
Areas of territorial elements relative to the total area of Juodaičiai eldership, in hectares and percentages

Territory Elements	***19th Century II half***		***20th Century I half***		***20th Century II half***		***21st Century I half***	
	%	***ha***	***%***	***ha***	***%***	***ha***	***%***	***ha***
Forest	46.2	1464.6	5.1	162.8	17.8	563.7	16.8	533.5
Clearings	1.3	42.2	0	0	0	0	0	0
Urbanized area	2.0	62.7	4.6	145.5	2	63.0	0.3	9.5
Agricultural land	50.5	1600.8	90.3	2862	80.2	2543.6	82.9	2627.4

The research results presented in the second table show significant changes that occurred during the study period, especially at the turn of the 19th to 20th century. One of the main changes was the increase in agricultural land, which rose from 50.5% in the 19th century to as much as 90.3% during the interwar period. These changes were largely related to the reduction of forested areas.

Significant deforestation occurred as early as the mid-19th century, which had long-term effects on the area's ecosystem and land use. At that time, the area of cut forests accounted for 2.8% (42 ha) of the total forested area, which was a substantial loss. During this period, forests were not protected by the strict legal framework that exists today, so they could easily be converted into agricultural land. This opened up opportunities for the expansion of agricultural activity as more land was needed to meet the growing population's demands and ensure food supply.

As a result of these changes, the increase in agricultural land became the main factor leading to the significant reduction of forested areas, especially at the beginning of the 20th century. Furthermore, this also created the conditions for urbanization, as the demand for urbanized areas grew alongside the increase in population and diversification of economic activities. The expansion of urbanization and agriculture during the 19th and 20th centuries often went hand in hand, which could have led to further transformation of the landscape and changes in ecological systems.

These processes were most pronounced during the interwar period, when the share of agricultural land reached record levels, and forests continued to decrease. It can be concluded that this period saw the most intense changes in landscape and land use structure, the effects of which were felt in later periods, including the 20th and early 21st centuries. The sizes of land use changes are presented in Table 3.

The results presented in Table 3 and 'Figure 5' show that agricultural land areas increased the most during the period from the 19th century (second half) to the first half of the 20th century, by as much as 39.8%. The rate of change in these land areas was calculated using the 1 Formula provided in the Methodology. It was determined that the growth rate of agricultural land areas during the 19th century (second half) to the 20th century (first half) was the highest compared to all other periods, reaching 18.55 ha/m. During the same period, the greatest increase in urbanized areas was also observed, at 2.6%.

Table 3
Land use changes in Juodaičiai eldership from the 19th to the 21st century

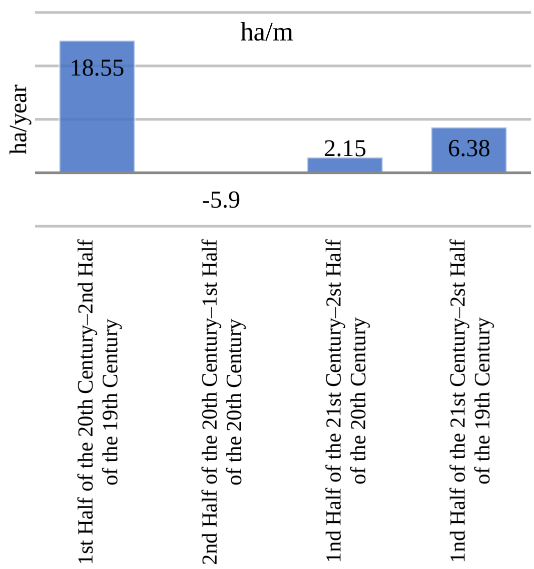
Territory Elements	*20th Century I half - 19th Century II half*		*20th Century II half - 20th Century I half*		*21st Century I half - 20th Century I half*		*21st Century I half - 19th Century II half*	
	%	*ha*	*%*	*ha*	*%*	*ha*	*%*	*ha*
Forest	-42.4	-1344.6	+12.7	+400.9	-1	-30.2	-29.4	-973.4
Urbanized area	+2.6	+82.8	-2.6	-82.5	-1.7	-53.6	-1.7	-53.3
Agricultural land	+39.8	+1261.3	-10.1	-318.4	+2.7	+83.8	+32.4	+1026.6

These changes are likely related to the agricultural technology advancements at the end of the 19th century, the rapid population growth 'Figure 3', and significant deforestation during World War I. Additionally, the land reforms following Lithuania's regained independence and the formation of homesteads contributed to this transformation.

After World War II, during the occupation period, there were land seizures, collectivization, and repression. As a result, the population decreased, and the agricultural land area shrank, while forest regeneration processes took place. This led to a 12.7% increase in forest area (compared to the total area of the municipality), and the forested area grew 3.5 times compared to the early 20th century.

From the second half of the 20th century to the first half of the 21st century, forest and agricultural land areas remained relatively stable. Agricultural land slightly increased, and forest areas decreased. The growth rate of agricultural land was 2.15 ha per year. Urbanized areas shrank, which can be linked to population decline, partly due to migration.

Figure 5
Rate of change of agricultural land areas, ha/year



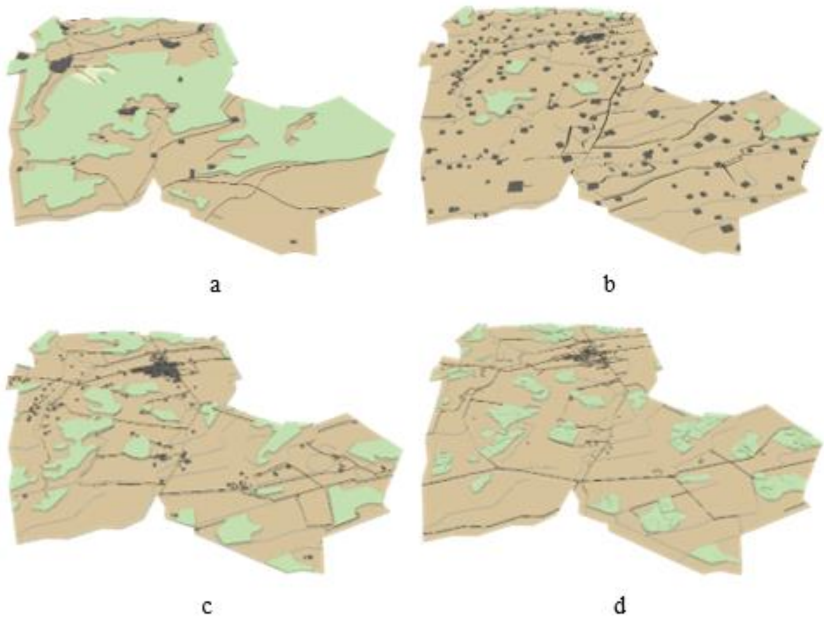
Since the restoration of independence and particularly after joining the EU, environmental regulations have made it more difficult to convert forest land into other land uses. This change is much more complicated than during the 19th and 20th centuries.
However, forest logging still occurs today. The analysis of forest cadastre data shows the current area of deforested land (Table 4).

Table 4
Exploitation of Existing Forests

Forest	***Percentage of total forest area***	***Forest area (ha)***
Cutover forest area	23.6	124.7
Uncut forest area	76.4	404.3

Therefore, the forest is still being intensively logged. In the Juodaičiai eldership, about a quarter of the forested area has been cut. If we calculate the rate of forest area decrease from the second half of the 19th century to the first half of the 20th century, it was 19.1 ha per year. Currently, the rate of logging is 93.2 ha per year, which exceeds the logging rates observed during the studied period. It can be assumed that if the forest areas were not protected by legal frameworks, after the logging, they might have been converted into agricultural land, as the area is known for having one of the highest soil productivity rates in the Republic of Lithuania and is highly suitable for agricultural use. Since this eldership is far from major cities, agriculture is likely the only source of income for local residents.
The 3D landscape models of the Juodaičiai eldership, created using ArcGIS software and presented in 'Figure 6', provide the opportunity to visually compare the relationship between built-up areas, forest areas, and agricultural land across the studied periods.

Figure 6
3D models of the landscape change in the Juodaičiai eldership: a) second half of the 19th century, b) first half of the 20th century, c) second half of the 20th century, d) first half of the 21st century



The analysis determined that in the second half of the 19th century, with a smaller population, landscape development was limited. Built-up areas were minimal, and forested areas covered a significant portion of the territory. At this time, the area of land used for agricultural purposes was relatively small. Forests dominated, and urbanization was underdeveloped. This could be linked to the fact that the region was less urbanized and most of the land was designated for natural use.
In the first half of the 20th century, there was a significant growth in urbanization and agricultural development. During this period, the area of residential and agricultural land increased. Due to rapid technological advancements, agricultural activity and the population grew, which stimulated expansion. Forests remained an important landscape element, but began to shrink due to the increasing demand for agricultural land.
In the second half of the 20th century, the landscape essentially reached stability. This landscape remained relatively unchanged until the early 21st century.
In the first half of the 21st century, the balance between forested areas and agricultural land remained similar. Forest protection and legal regulations prevented a faster decrease in forest areas, but agricultural land continued to dominate the landscape. Urbanization, though slightly increased, still had minimal impact on this district. Therefore, during this period, landscape changes were more related to

stabilizing land use and implementing forest protection initiatives.

These 3D models clearly demonstrate how the landscape has changed over the century and the key factors that led to land use changes. Primarily, this is linked to agricultural development and urbanization, but the role of forests and legal regulations in shaping the landscape cannot be overlooked.

To assess potential future land use scenarios for the Juodaičiai eldership, several factors must be considered, including current trends, historical changes, and regulatory frameworks. Based on this analysis, the following scenarios are possible:

1. Continued agricultural expansion, driven by high soil fertility and limited urbanization. In this case, agricultural land is likely to increase, forests may decrease slowly, and urbanization will remain limited.
2. Forest recovery and stabilization, aimed at strengthening forest protection and sustainability initiatives, could allow forests to regenerate, leading to an expansion of forests, a slight decrease in agricultural land, and low urbanization.
3. Urbanization and infrastructure development could accelerate due to improvements in infrastructure and regional development programs, allowing urbanized areas to expand. Agricultural land may decrease, and forest loss will be minimal.
4. Sustainable land use and integrated development, where a balanced approach is maintained, preserving both agriculture and forests through sustainable practices, would stabilize agricultural land, increase forests, and keep urbanization limited.

The most likely future scenario for the Juodaičiai eldership is continued agricultural dominance with moderate forest protection efforts. However, strong regulatory frameworks and sustainable practices could lead to balanced, integrated development. Urbanization will remain limited, but local growth will depend on infrastructure investments, and climate change will influence land-use decisions.

The landscape and land use structure of Juodaičiai Eldership have undergone significant changes from the 19th to the 21st century, primarily due to agricultural expansion driven by fertile soils and population growth. The most intensive transformations occurred in the early 20th century, when agricultural land rapidly expanded at the expense of forests. In recent decades, land use has stabilized, with agriculture remaining dominant, forest areas relatively preserved due to legal protections, and urbanization remaining limited. Current trends and regulatory frameworks suggest a continued dominance of agriculture, accompanied by moderate forest conservation and minimal urban development.

Conclusions

1. Juodaičiai eldership has undergone significant land use changes over time. In the 16th century, it was sparsely populated with abundant forests and little agricultural land. By the 19th and 20th centuries, population growth and agricultural advancements led to widespread deforestation, peaking in the early 20th century when agricultural land rose to 90.3%, up from 50.5% in the 19th century.
2. Juodaičiai eldership stands out with its high soil fertility score of 52.58, one of the highest in Lithuania, which has been pivotal for agricultural growth. This fertile land supports diverse crops and ensures the long-term viability of agricultural activities. Furthermore, the GIS and LIDAR-based surface model revealed a terrain with minimal elevation changes, making it highly suitable for mechanized farming.
3. Geomorphological analysis of the region confirms that Juodaičiai eldership's terrain is favorable for agriculture. The relatively flat to gently rolling landscape, with only minor variations in elevation (a 22-meter difference from south to north), makes it an ideal location for modern agricultural practices, supporting both crop rotation and mechanized farming systems.
4. Land use underwent significant changes from the late 19th to the early 20th century, marked by a 42.4% reduction in forested areas (1,344.6 ha) and a 39.8% increase in agricultural land (1,261.3 ha). Following World War II, deforestation slowed due to land reforms and legal protections although agriculture continued to dominate. By the early 21st century, agricultural land stabilized at 82.9%, with forests experiencing moderate recovery.
5. The region saw limited urbanization, with urban areas remaining small in comparison to agricultural land. The greatest urban growth occurred during the early 20th century, but due to population decline in recent decades, urbanization has remained minimal. Despite this, infrastructure improvements may lead to some growth in urbanized areas in the future.
6. Forest management continues to be a critical issue in Juodaičiai eldership, where intense logging activities persist. However, forest protection laws enacted after independence have contributed to a reduction in the rate of deforestation. In the absence of these regulations, much of the forested area could have been converted into agricultural land, given the region's fertile soils. As of now, 23.6% of the forested area has been logged, with 76.4% remaining intact.
7. The most likely future scenario for Juodaičiai eldership is continued agricultural dominance, supported by moderate forest protection efforts. With strong legal frameworks and sustainable practices, the region will likely experience a balanced development, where agriculture remains dominant, urbanization is limited, and forest conservation continues to play a significant role.
8. Practical recommendations for future land use in Juodaičiai include strengthening forest protection regulations and promoting sustainable agricultural practices. In particular, efforts should be prioritized to slow the conversion of forested land to agricultural use, especially given the high fertility of the soil, which could otherwise lead to further agricultural expansion at the expense of forests.

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