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ASSESSMENT OF RECLAIMED AGRICULTURAL LAND IN LITHUANIA

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Land reclamation is the improvement of unfavorable natural conditions of used land for human needs, aiming to enhance agricultural crop growing conditions and increase soil fertility. In this regard, Lithuania is unique, as no other country in the world has such a relatively large proportion of reclaimed land—47% of the country or 87% of agricultural land area - drained by drainage systems. Drainage and other reclamation structures have been serving agriculture for almost 50 years, but today their level of depreciation in some areas of Lithuania exceed 73%. For this reason, farmers continuously face various challenges, making investments in the reclamation system essential. To reconstruct and maintain reclamation engineering structures, it is proposed to establish a reclamation fund in Lithuania. However, before assessing the need for reclamation system reconstruction, it is crucial to have accurate information and evaluate the current state of reclamation systems. Therefore, the objective of this article is to analyze the condition of reclaimed agricultural land and reclamation structures in Lithuania. The analysis of reclaimed land conditions was conducted using the Spatial Dataset of Land Drainage Condition and Waterlogging in the Territory of the Republic of Lithuania at a scale of 1:10,000 (Mel_DR10LT). The obtained results suggest that areas with decommissioned or poor-condition reclaimed land in Lithuania likely exceed 6,000 hectares. However, a fundamental problem is that some municipalities do not account for or report any data on the condition of reclaimed land in their regions, which distorts the real assessment of the state of reclaimed land and reclamation structures. Therefore, to ensure effective accounting and rational use of reclaimed land, solutions must be found to address these accounting issues.

Keywords: *reclamation condition of agricultural land, drainage systems, spatial data set of reclamation condition and waterlogging (Mel_DR10LT)*

INTRODUCTION

Lithuania belongs to the region of excessive soil moisture, therefore drainage (land reclamation) systems are highly developed. From the perspective of land reclamation, Lithuania is unique, as it is a country with an exceptionally large area drained through artificial drainage systems (Povilaitis et al., 2018). Overly wet land accounts for about 52% of the country's total territory (Valstybės įmonė …, 2024). Such land can be used for agricultural production or infrastructure development only after being drained and having well-functioning drainage systems, which, according to researchers, ensure the development of agricultural activities (Yannopoulos et al., 2020; Jacobsson, 2024), maintain the productivity (fertility) of agricultural land (Hălbac-Cotoară-Zamfir et al., 2022), and provide optimal air and soil moisture conditions for plant growth (Kirkham, 2005; Strock et al., 2010; Miseckaitė, 2019), for soil cultivation and harvesting (Dijksma, 1997; Maustafa, 2000; Schilling et al., 2012), as well as contribute to mitigating the adverse effects of climate change (Rokochinskiy et al., 2021). The total area of drained land in Lithuania amounts to 2,976.50 thousand hectares (i.e., 47% of the country's territory or 87% of agricultural land) (Valstybės įmonė…, 2024), producing about 90% of all agricultural output. Drainage structures and systems generally serve for about 50 years, yet in most parts of Lithuania, the drainage systems are severely depreciated, and in some areas, they are completely worn out due to insufficient maintenance, thus their renewal is necessary (Valstybės įmonė …, 2021). Due to the lack of funding for drainage system maintenance, the area of land unsuitable for agriculture is increasing every year. According to the Ministry of Agriculture of the Republic of Lithuania, the funds allocated for drainage system reconstruction up to 2023 accounted for only 1–5% of the depreciation value of these engineering structures. As a result of such insufficient financing, the condition of state-owned drainage systems is rapidly deteriorating, while the risk of flooding in residential areas and agricultural land is increasing (Valstybės įmonė …, 2024). Recently, the issue of preserving agricultural land with fertile soils, including those equipped

with drainage systems, has become a major concern. It is estimated that, regardless of the crop type, the productivity of fertile drained agricultural land is about three times higher from an economic perspective, whereas poorly functioning or absent drainage may cause yield losses of up to 20% (Katinas, 2016). Therefore, investment in drainage systems is essential. For this purpose — to ensure the reconstruction and maintenance of drainage and other land reclamation structures — it has been proposed to establish a Land Reclamation Fund in Lithuania. However, in order to effectively assess the need and scope of drainage system reconstruction, it is crucial to have accurate and up-to-date information on these systems and their current condition. Therefore, the aim of this article is to analyze the condition of reclaimed agricultural land and land reclamation structures in Lithuania

RESEARCH METHODS

To achieve the aim of the article, statistical research methods were applied, allowing for the collection, analysis, systematization, and presentation of data both in tabular form and through graphical representation, in order to identify spatial distribution trends of these data across different municipalities of Lithuania. For the identification of spatial trends and data visualization, GIS-based analysis methods were used, involving map creation and spatial data interpretation. For this purpose, the 2024 Spatial Dataset of Land Drainage Condition and Waterlogging in the Territory of the Republic of Lithuania at a scale of 1:10,000 (Mel_DR10LT) was used. This dataset is part of the Land Resources Monitoring Information System (ŽISIS). The dataset, created in Lithuania in 2002, is designed to study and analyze the condition of drainage systems and waterlogging processes. It provides information on soil drainage systems, land reclamation projects, waterlogged zones, and other aspects related to agricultural and environmental processes, and has been regularly updated since 2008. The management and updating of the Mel_DR10LT dataset are carried out in 52 out of 60 municipalities in Lithuania (the eight major city municipalities are excluded). The dataset meets the accuracy requirements of the 1:10,000 scale and is publicly available through the Lithuanian Spatial Information Portal at www.geoportal.lt.

RESEARCH RESULTS AND DISCUSSION

Extent of Land Drainage Works and Trends in Drainage System Depreciation in Lithuania. In Lithuanian history, two periods of intensive land reclamation can be distinguished: 1919–1939 and 1950–1990. During the first period, 19,400 km of streams were regulated and drainage ditches were excavated, resulting in the drainage of 469,561 hectares of agricultural land, of which 11,800 hectares were drained using artificial drainage systems. The second period was more than twice as long and was characterized by more efficient technical indicators. Drainage was widely used for land reclamation, becoming the primary means of regulating soil water conditions, and in 1961, renovation works on 228 drainage systems were initiated. However, since 1991, the scope of drainage system installation and renovation in Lithuania has been steadily decreasing (Gurklys et al., 2011).

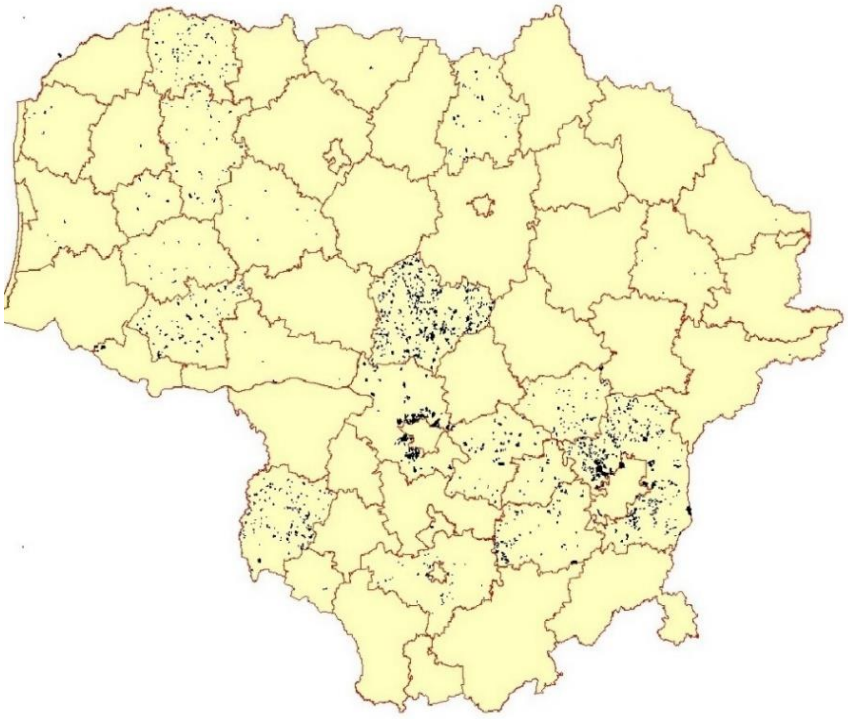
An analysis of recent data (2020–2024) on drained land and reclamation structures in Lithuania shows that the total area of drained land has changed only slightly. As mentioned above, in 2024, the total drained land area amounted to 2,976.50 thousand hectares, of which 2,494.21 thousand hectares, or 87%, were agricultural land (Valstybės įmonė…, 2020–2024) (Table 1).

Table 1. Drained Land and Land Reclamation Structures in Lithuania, 2020–2024 (sourse: Valstybės įmonės …, 2020-2024).

	Units	Quantity, period of the year				
		2020	2021	2022	2023	2024
RECLAIMED LAND						
Total area of drained land	Thous. ha	2,978.11	2,977.83	2,977.32	2,976.89	2,976.50
Drainage area	Thous. ha	2,575.44	2,575.16	2,574.65	2,574.22	2,573.83
Drained agricultural land	Thous. ha	2,495.81	2,495.53	2,495.01	2,494.59	2,494.21
VALUE OF RECLAMATION INFRASTRUCTURE IN EUR						
Residual value	Thous. Eur	664 979.25	648,264.40	629,515.98	625,110.61	612,328.72
Depreciation of land reclamation infrastructure	%	69.64	70.66	71.73	72.35	73.19

The data presented in Table 1 particularly emphasize the continuous decrease in the value of reclamation structures and the increasing level of depreciation, which in 2024 reached over 73% (an increase of slightly more than 3.5% since 2020). The residual value of reclamation structures amounted to over €612 million, or €245.50 per hectare of agricultural land, representing a decrease of nearly €53 million compared to 2020.

Condition of Drained Land and Reclamation Structures. During the latest land reform in Lithuania, initiated in 1991 with the aim of restoring private land ownership by returning land to former owners and their heirs, and transferring state-owned land to rural residents (either free of charge, through sale, or lease), the forms of land and reclamation structure ownership changed. Subsequently, due to various social, demographic, and economic factors, substantial areas of land became unsuitable for agricultural production, and areas with reclaimed agricultural land were decommissioned (Figure 1).



No.	Municipalities	Depreciated land areas in the country's municipalities ha
1.	Alytaus r.	196,26
2.	Birštono	29,44
3.	Elektrėnų r.	144,95
4.	Joniškio	129,18
5.	Jurbarko r.	43,62
6.	Kaišiadorių r.	809,64
7.	Kalvarijos	23,64
8.	Kauno r.	3 683,83
9.	Kėdainių r.	3 700,85
10.	Kelmės rajono	62,65
11.	Klaipėdos r.	35,06
12.	Kretingos r.	60,07
13.	Mažeikių r.	549,31
14.	Pagėgių	130,50
15.	Pasvalio r.	380,51
16.	Plungės r.	3,34
17.	Rietavo	110,12
18.	Šilalės r.	50,37
19.	Širvintų r.	647,94
20.	Švenčionių r.	10,67
21.	Tauragės r.	627,97
22.	Telšių r.	261,26
23.	Trakų r.	640,76
24.	Utenos r.	24,24
25.	Vilkaviškio r.	1 143,03
26.	Vilniaus r.	2 939,27
27.	Zarasų r.	3,07
Total:		16 441,55

Figure 1. Decommissioned Drained Land Areas in Lithuanian Municipalities in 2024 (Source: Mel_DR10LT Layer NURAS_P).

Figure 1 presents the visualized spatial and statistical data from the Land Drainage Condition and Waterlogging Spatial Dataset (Mel_DR10LT), layer: Decommissioned Drained Areas (NURAS_P). According to the data, the total area of decommissioned drained land amounts to 16,441.34 hectares. The largest areas of decommissioned drained land are located in Kėdainiai (3,728.92 ha), Kaunas (3,683.83 ha), and Vilnius districts (2,939.27 ha). The latter two municipalities are suburban districts of Lithuania's major cities (Vilnius and Kaunas), characterized by extensive areas of intensive urbanization and city expansion. Therefore, it can be concluded that such areas generally contain the highest proportion of decommissioned land with non-functional drainage systems, as drained lands that become built-up are effectively decommissioned. This is supported by scientific research, which indicates that the impact of urban development on the agrarian landscape is most pronounced in areas closest to large cities. Consequently, urban development in Lithuania most strongly affects the agricultural territories of Vilnius, Kaunas, and Klaipėda districts (Valčiukienė, 2012). However, no information is available regarding decommissioned drained lands in Klaipėda district. As shown in the figure, only 27 out of 52 municipalities provide data on decommissioned drained areas, i.e., practically only half of Lithuania's municipalities. Nevertheless, this information is crucial for effective management of drained land, planning its use, and assessing and forecasting the need for drainage system reconstruction.

Meanwhile, the areas in poor drainage condition in Lithuania account for about 5.5% to 6.2% of the total drained land area. Although the percentage of poorly drained land is relatively small, it nevertheless represents a considerable area — 164,571.66 hectares, which is unevenly distributed across Lithuania's municipalities (Figure 2).

As shown in the figure above, the smallest area of drained land in poor condition is in Joniškis District Municipality (0.4%), while the largest is in Švenčionys District (18.3%). In the suburban municipalities of major cities, the smallest areas of poorly drained land are in Šiauliai District (3.4%), Kaunas District (4.3%), and Klaipėda District (6.2%), whereas the largest is in Vilnius District (14.2%).

Areas in poor drainage condition can be grouped into two main categories based on the reasons why the drainage systems are not functioning properly. The first category comprises areas with changed land use and purpose. This includes agricultural land on areas with non-functional drainage that has become overgrown with forest and shrubs (33,876.05 ha in Lithuania), drained areas planted with forest according to spatial planning documents or land management projects, or inventoried as forest (5,631.82 ha), and drained areas built over with structures, roads, or other infrastructure (9,660.80 ha).

The second category includes agricultural land where poor condition has arisen due to the technical state of the drainage systems, which are neglected, damaged, improperly used, or otherwise malfunctioning, resulting in waterlogged drained areas (2,838.08 ha) and agricultural land with non-functional drainage systems (388.74 ha). Additionally, poorly drained areas are influenced by soil suction pits in drainage collector lines (5,631.82 ha) and agricultural land on areas with non-functional drainage that has turned into swamp (32,311.26 ha) (Table 2).

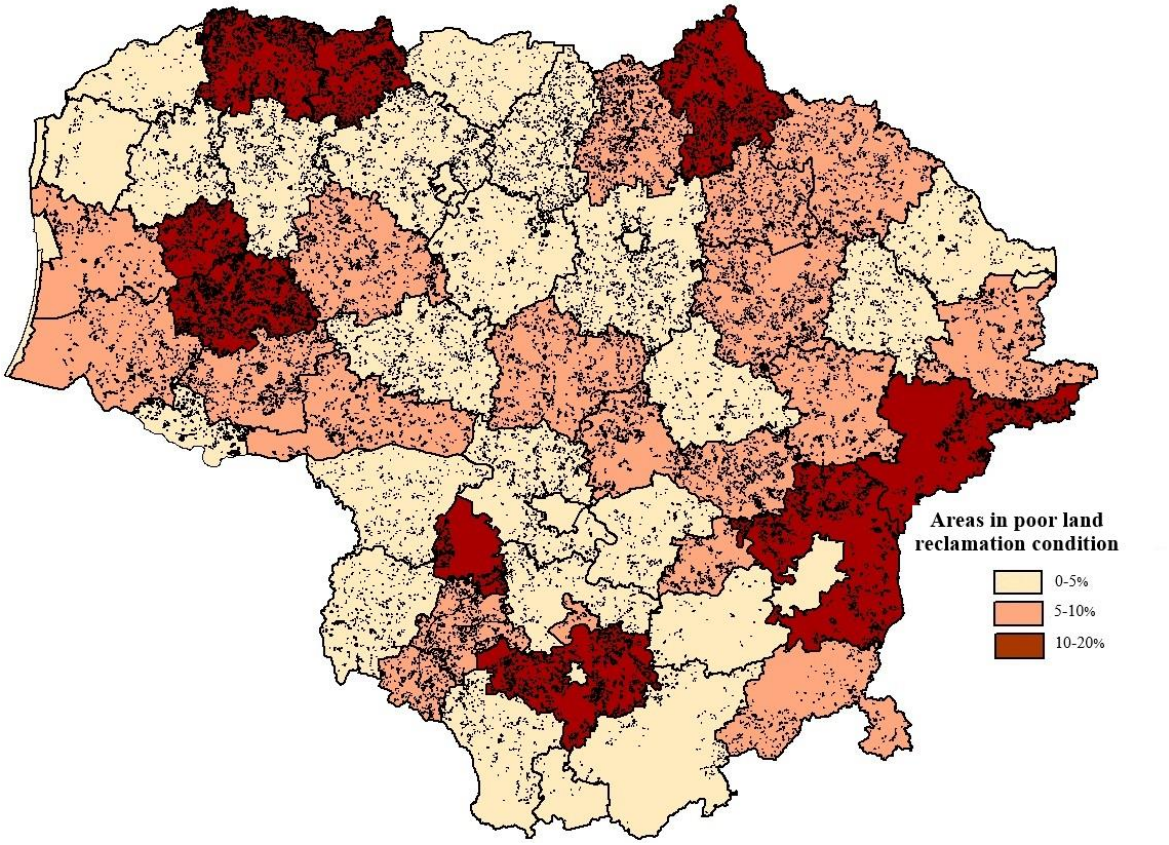


Figure 2. Areas in Poor Land Reclamation Condition and Their Distribution Across Municipalities in Lithuania, 2024 (source: Mel_DB10LT).

Table 2. Causes of Poor Drainage Condition of Drained Areas (ha) in Lithuania, 2024 (Source: MEL_DR10LT)

	Total area, ha	**Types of Violations**						
		DK	**DM**	**DP**	**DZ**	**DG**	**DA**	**DU**
In the Lithuania	62,560.67	33,876.05	2,838.08	32,311.26	388.74	5,631.82	5,631.82	9,660.80

Explanations: DK – refers to agricultural land on areas with non-functional drainage, overgrown with forest and shrubs; DM – denotes waterlogged drained areas; DP – indicates agricultural land on areas with non-functional drainage that has turned into a swamp; DZ – represents agricultural land on areas with non-functional drainage; DG – corresponds to soil suction pits in drainage collector lines; DA – refers to drained areas planted with forest according to spatial planning documents or land management projects, or inventoried as forest; and DU – indicates drained areas built over with structures, or with roads or other infrastructure installed.

In order to verify the actual condition of agricultural land areas identified as being in poor drainage condition in the MEL_DR10LT dataset, several sites were randomly selected and inspected in the field during the study, regardless of the reasons for which they had been classified as being in poor condition (Figure 3).

Based on the field photographic documentation of the selected areas presented in Figure 3 above, it can be concluded that the identification and recording of these areas as being in poor drainage condition in the MEL_DR10LT dataset is questionable. The photographs show effectively cultivated drained arable land, which is declared for EU subsidy payments for crop production.

Figure 3. Field Photos of Areas Identified as Being in Poor Drainage Condition in MEL_DR10LT dataset (authors' photographs)

Nevertheless, according to the available data — although their completeness and reliability may raise some doubts — the extent of drained land in poor condition considered suitable for reconstruction in Lithuania currently amounts to more than 39 thousand hectares, while the area suitable for repair is almost 28 thousand hectares (Table 3).

Table 3. Rationale for Repair, Reconstruction, or Decommissioning of Drained Land (ha) in Lithuania, 2024 (Source: MEL_DR10LT).

	Area in poor condition, ha	**It is expected from them, ha**		
		for repair	**for reconstruction**	**to remove from the accounts of reclaimed areas**
In the Lithuania	164,571.66	27,571.07	39,203.58	8,331.05

In summary, the results of the conducted study indicate that since the restoration of Lithuania's independence, the scope of drainage system installation and renovation works in the country has been continuously decreasing. Despite the fact that the total area of drained land in recent years has changed only slightly and currently amounts to almost 3 million hectares, the depreciation level of drainage systems remains very high — reaching 73%. The total area of decommissioned drained land amounts to 16,441.34 hectares, while areas in poor drainage condition, due to various reasons mentioned above, total 164,571.66 hectares, or 5.5% of the total drained area. The majority of poorly drained land — more than 39 thousand hectares — requires reconstruction to ensure its proper use in the future. However, in order to effectively assess the need and scale of drainage system reconstruction, it is essential to have accurate and comprehensive information on drainage systems and their actual condition across all Lithuanian municipalities. In addition, this is very important when planning funds and investments for the reconstruction of drainage systems, because a draft law on the Land Reclamation Fund of the Republic of Lithuania has been prepared, which aims to establish the Land Reclamation Fund and determine the basis for its formation, administration, sources of financing and principles for the distribution of funds, which is also inseparable from effective and reliable accounting of related data. It is predicted that more than 2.283 billion euros will be needed for the maintenance, repair and reconstruction of land reclamation systems (Parengtas…, 2024).

CONCLUSIONS

1. The area of drained (reclaimed) land in Lithuania amounts to 2,976.50 thousand hectares, which represents 47% of the country's territory or 87% of all agricultural land. However, the depreciation of drainage systems is increasing every year and currently reaches as much as 73%, which in turn reduces their residual value. In 2024, the residual value of these systems exceeded €612 million, or approximately €245.50 per hectare of agricultural land.
2. Areas of drained land in poor drainage condition in Lithuania total 164,571.66 hectares and are unevenly distributed across the country's regions, ranging from 0.4% in Joniškis District to 18.3% in Švenčionys District of the total drained land area within each municipality. A considerable share of poorly drained land is found in the suburban municipalities of Lithuania's major cities, such as Kaunas District – 4.3%, Klaipėda District – 6.2%, while Vilnius District Municipality has the largest share among such municipalities, reaching 14.2%.
3. In the suburban municipalities of major cities, due to intensive urban development, there are also significant areas of decommissioned drainage systems — 3,683.83 ha in Kaunas District and 2,939.27 ha in Vilnius District. In total, across Lithuania, the area of decommissioned drained land in 2024 amounted to 16,441.34 hectares.
4. The majority of poorly drained land — more than 39 thousand hectares — requires reconstruction to ensure its proper use in the future. However, to effectively assess the need and scope of drainage system reconstruction, it is crucial to have comprehensive and reliable information. The results obtained during the study indicate that there are doubts as to whether such information is actually provided in the MEL_DR10LT dataset.
5. To ensure the reliability and completeness of information necessary for the effective management, use, and planning of investments in the reconstruction of drained land and drainage structures, it is essential to guarantee that the data collected in the MEL_DR10LT dataset accurately reflect reality and are mandatorily submitted by all 52 municipalities in Lithuania without exception.

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