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GEOSPATIAL DATA ANALYSIS OF THE DEGRADED AREAS OF KURZEME AND ZEMGALE REGIONS OF LATVIA

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Abstract
The use of degraded areas reduces the burden on the use of agricultural land for industrial purposes. After the restoration of the country's independence in 1991, the area of agricultural land in Latvia has decreased by 21.7%. Taking into account climate change and the current geopolitical situation, it is necessary to look for suitable territories for the production of electricity with renewable energy sources in order to ensure the country's energy independence. In the study, 158 pcs.geospatial analysis of land units containing contaminated or potentially contaminated territory. The goal was to find out which of the land units, on which the municipal waste collection and storage sites of rural areas were historically located, would be suitable for the possible construction of solar and wind power plants. Measurements were made from the geometric center of the land unit to electrical networks, settlements, access roads, nature protection objects. It was determined that the state and the municipality own 71% of the land units with degraded territory. Of the land units included in the study, up to 10% have potential for electricity generation with renewable energy resources.
Key words: degraded area, renewable energy, geospatial analysis.

Introduction

After the restoration of the country's independence in 1991, the area of agricultural land in Latvia has decreased by 21.7%. In order to mitigate climate change and strengthen the country's energy independence, it is necessary to increase the use of renewable energy resources in electricity production. In the sustainable development strategy Latvia 2030, it is defined as one of the state's strategic goals [10]. The rational use of the land must be the focus of attention when it is necessary to determine new territories for the placement of electricity production with renewable energy resources (sun, wind, etc.). Latvia, like the other Baltic states, is an energy deficit country on an annual basis. The amount of water in the cascade of hydroelectric power stations of the Daugava River is important for Latvia. Unless there is a rainy summer or a snowy winter, it should be calculated that from the total annual gross electricity consumption of ~ 7 TWh, around 70% of the required amount of electricity is produced on site. The rest must be procured from international markets. In 2022, 67.6% of the total electricity consumption of 7.13 TWh was produced locally in Latvia [2], [20]. Under the influence of the geopolitical situation, regulatory acts have been approved in Latvia, which also allow the use of agricultural and forest land for the placement of solar and wind power plants [7]. The aim of the study is to search and evaluate alternative places for the placement of renewable energy resources - solar and wind power plants, thus reducing the impact of the placement of power generation equipment on agricultural and forest land. The Land Management Law stipulates that degraded areas should be primarily selected for construction [21]. Land units were selected for the analysis, on which the territories of former rural collective farms and village communal waste dumps were historically located, which are considered polluted or potentially polluted territories according to the regulatory framework [17]. In the article, we will designate them as degraded areas. These areas seem to have several important features. They are located at a certain distance from populated areas, access roads were built on them, and in some cases, connection to electrical networks was provided. The listed factors are important in determining the construction sites of solar and wind power plants, which is confirmed by previous studies [1], [8], [12], [13], [16]. In Latvia, the use of degraded areas has been little studied. The issues of degraded territories and guidelines for their research, planning and use are determined within the Interreg Latvia - Lithuania cross-border cooperation program 2014 - 2020 [5]. So far, in-depth studies have been carried out on the determination of potentially advantageous places for the placement of solar and wind energy equipment in the EU countries and the USA, both for the entire national territory and for local governments. In all cases, geospatial information analysis was used for data extraction. The use of brownfield sites for the construction of solar and wind energy facilities has been studied relatively less. So far, studies on degraded areas have focused on areas of former construction and mineral extraction sites. In the USA, guidelines have been developed for the use of brownfield sites for the placement of solar and wind power plants directly in the areas of former waste dumps [22]. However, in the studies so far, there has been less analysis of the land units in which the degraded area is located, the composition of the land use types, the areas of the areas suitable for the construction of solar and wind power plants, the legal ownership, the purpose of real estate use. The researched data are important in the feasibility study of the choice of possible construction sites, which is an essential part of the construction process of solar and wind power plants [9], [19]. The first results of the study are analyzed within the framework of the article. These are the 139 units of land located in the territory of the historical districts of Kurzeme (western part of the national territory) and Zemgale (central part of the national territory) of the Latvian state, where the degraded areas are located. The article provides an analysis of roughly 40-50% of the total research area. (Figure 1).

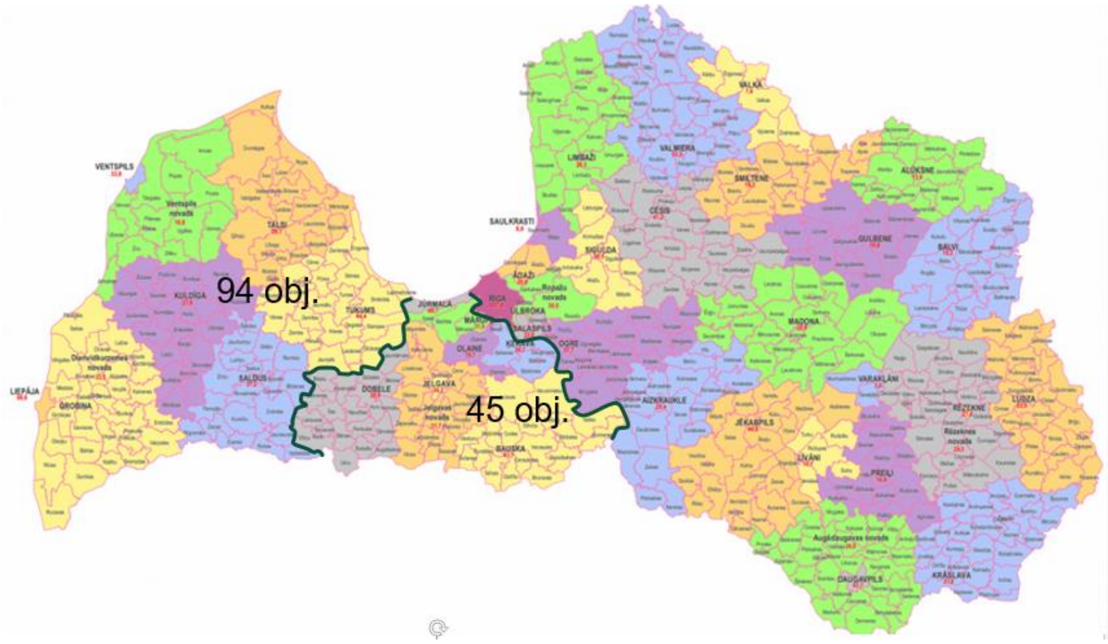

Figure 1. Location and number of objects to be analyzed in the Kurzeme (94 obj.) and Zemgale (45 obj.) regions of Latvia.

Methods and materials.
The database of the Latvian Environment, Geology and Meteorology Service (*lvgmc.lv*) was used to identify the territories, which contained the registration numbers of polluted and potentially polluted places and the cadastral designations of the relevant land units [11]. The area of the contaminated or potentially contaminated territory (ha) was determined from the data of the cadastral register according to the type of land use - "other land" or calculated [15]. Distances to objects of interest were measured in geospatial materials from the visually determined geometric center of the land unit, for which geographical and Latvian LKS-92 TM coordinates were fixed (Figure2). Using the availability of the *Balticmaps.eu* navigation function, the distances along the road network to the parish center and the capital Riga were determined (Figure 3) [3].

Figure 2. The geometric center of the land unit.

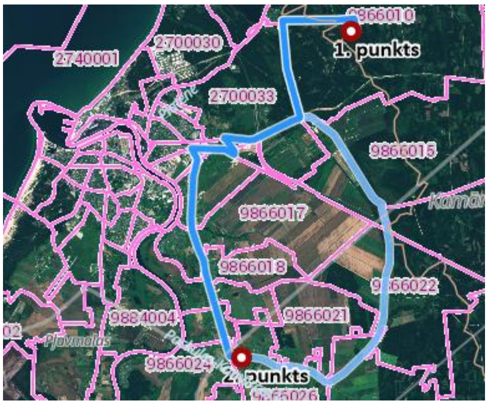

Figure 3. Distance measurements along roads

Figure 4. Location against electricity networks

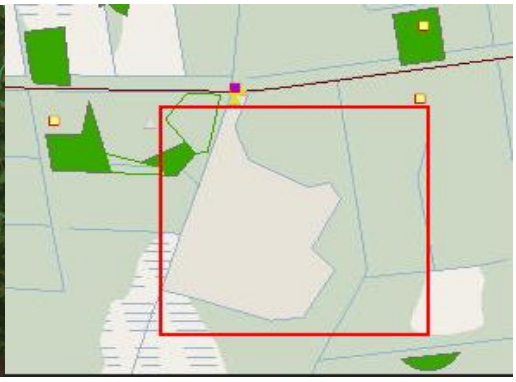

Figure 5. Location against nature protection objects

Distances to the nearest inhabited place (homestead) and electric network lines are only determined by measuring the shortest distance along the air line from the geometric center of the land unit to the nearest homestead or distribution electric network (0.4 to 20kV), hereinafter referred to as ST, and high-voltage network (110) up to 330 kV), hereinafter referred to as AST, for the line (Figure 4). Taking into account the addresses of AST 110/20 kV substations, the distance along the road network from the degraded area to the nearest AST substation was measured. Distances to nature protection objects are only determined in two ways [6]. First, by recording whether or not there is a nature conservation object in the land unit. Secondly, in geospatial data, the distance far from the geometric center of the land unit to the nearest nature protection object is measured (Figure 5). In addition to the geospatial analysis of the land units of the degraded areas, the theoretical potential of electricity generation was calculated according to the following scheme. Land units owned by the municipality were selected with the purpose of use (NLM1005) – construction of waste management companies [14]. Next, the areas of the land use type "Other land" of the specified land units were summed up . Taking into account that in this study we adopted approximate calculations, it was assumed that the sun is used for 1800 hours, the average solar radiation per unit of area is 1180 (kWh/m2) per year, the placement factor of solar panels is 0.5 (50% of the area can be placed), the efficiency factor is 0.2 (the panels use 20% of the possible solar radiation) and the total amount of energy produced by the sun is calculated according to the following formula:

$$E1 = P \cdot A \cdot K1 \cdot K2, \text{ where} \tag{1}$$

E1 - the total amount of electricity produced by solar radiation (GWh) per year;
P - average amount of solar radiation (kWh/m2) per year;
A - usable land area (m2)
K1 – placement ratio of solar panels;
K2 – efficiency factor of solar panels.

The potential of electricity produced by wind energy was calculated assuming that the average number of operating hours of the wind generator per year is 2000 hours (h) and the average wind power per unit area is 165 W/m2. The wind power utilization factor was set at 0.5. The total amount of electricity produced by wind was calculated according to the formula:

$$E2 = A \cdot K1 \cdot K2 \cdot K3, \text{ where} \qquad (2)$$

E2 – total amount of electricity produced by wind power (GWh) per year;
A – in the area available for wind flow;
K1- wind power per 1m2;
K2 – time of wind operation in hours per year;
K3 – efficiency coefficient of wind use.

Discussion and results

Analyzing the cadastral information of land units, it was calculated that out of the total 139 pcs. of the total area of land units 1412.9 ha, degraded areas made up 21% or 296.2 ha. Considering that 60.2% of the total number of land units and 45.2% of their total area belong to the state and local government, it can be predicted that the rest of the degraded land unit territory could also be used for the placement of solar and wind power plants. Additional analysis confirmed this, as 31.6% (44 units) of land unit use purposes were code 1005 (Waste management). On the other hand, 37.4% (32 units) and 15.1% (21 units) of land units had the purpose code of 0101 (agricultural land) and 0201 (forestry land), which indicated that more than half of 52.5% of degraded land units have been recultivated and returned to the economy. The results on legal ownership of land units are summarized in Table 1.

Table 1

Ownership of land units with degraded areas

Land ownership	Quantity, pcs.	Including, %	Area, ha	Including, %
Country	8	5,8	293,8	20,8
Municipality	77	55,4	344,7	24,4
Individual	37	26,6	588,2	41,6
Legal person	17	12,2	186,2	13,2
In total	139	x	1412,9	x

By carrying out geospatial measurements, it was confirmed that the land units with degraded areas are provided with an access road, as 60.4% (84 units) of the land units are accessed by a public road. At a distance of up to 0.5 km, the access road was available for 33.8% (47 units) of land units. Taking into account that the distance from the geometric center of the land unit to its border could also be added here, the access road provision was 94.2% of the total number of land units. Looking at the distances to the nearest inhabited places (detached houses), it can be seen that the weighted average distance of 0.5 km is greater than the minimum distance of 0.8 km, which is defined in the regulatory acts as the minimum distance in relation to the wind power plant. However, these were separate areas of rural homesteads and not a village. The measurement results of average and average weighted (the number of land units is taken as weight) geospatial distances are summarized in Table 2.
The distances to the nearest ST (0.4 – 20kV) and AST (110 – 330 kV) objects were measured in geospatial materials in the location of solar and wind power plants against the electric networks. Current regulations stipulate that power plants with a capacity of up to 14.99 MW are connected to distribution networks, but starting with a capacity of 15.0 MW, plants are connected to a high-voltage (110-330kV) network [18]. The results of the measurements showed that the location of the ground units in relation to the distribution networks is in a better position compared to the high-voltage

Table 2

Measurement results up to the road and settlements

Indicators	Distance, km				
	Public road	Inhabited Place	Parish center	County center	Riga
Kurzeme objects	0,14	0,45	5,94	24,51	123,93
Zemgale objects	0,15	0,6	5,99	22,82	78,54
Weighted average distance	0,14	0,5	5,96	23,96	117,71

networks. The average weighted distance from the border of the land unit to the nearest object of distribution networks is 0.49 km, which can be assessed as satisfactory. Wind and solar power plants with a capacity greater than 14.99 MW are built near high-voltage (110-330kV) networks. The average weighted distance to the high-voltage line (10.31 km) and the 110/20 kV substation (14.9 km) obtained in the study would not be satisfactory for the potential investor. However, this does not mean that you should not look for and find individual land units, where the distance to the electric network line is not greater than 0.5 km. However, in these cases, the area of the land unit should be taken into account. Swedish experience indicates that the minimum area that would be economically justified for the construction of a solar power plant is 2 ha [12]. The results of measurements up to the electric grids in the cross-section of regions are summarized in Table 3.

Table 3

Measurement results to electrical networks

Objects of electrical networks	Distance, km			
	Kurzeme objects	Zemgale objects	Average distance	Weighted average distance
0.4 - 20kV line	0,42	0,64	0,46	0,49
110 -330 kV line	7,72	15,56	6,68	10,31
110/20 kV substation	17,2	9,72	15,56	14,9

When conducting a geospatial analysis of the location of land units in relation to nature protection territories, it was found that 22% (31 obj.) of land units had protection zones of nature protection objects, which impose restrictions on economic activity. The average distance from the boundary of the land unit to the nature protection object outside was 1.87 km in the Zemgale region, 3.94 km in the Kurzeme region. The average results of the study initially show a sufficiently large margin of distance to nature protection objects. However, this does not allow us to draw the conclusion that there could not be obstacles in the construction of power plants, because the study included only the open data of nature protection objects, and also did not look at bird migration routes. According to the methodology determined in the study, 10 units suitable for electricity production were found. (7.2%) land units with a total area of 81.13 ha and a degraded area of 68.13 ha, for which electricity generation potential calculations were made. The calculated results of 80.44 GWh of solar and 112.48 GWh of wind energy potential for electricity production are considered sufficient to continue research. Estimates of electricity produced by wind should be further analyzed, as they look very optimistic in a relatively small area. The results were compared with the annual electricity consumption of Bauska, a separate Latvian county town of 58.4 GWh [4]. From the obtained results, it can be concluded that up to 10% of degraded areas have potential for electricity production. Considering that the average values of solar and wind power (W/m2) in the country were taken into account in the calculations, further studies should take into account the values characterizing the geography of a specific land unit. For each land unit found, more detailed analysis and calculations may be made in the future.

Conclusions and proposals

The state and the municipality own 61% of the total number of land units in which degraded areas are located.

According to the analysis of Kurzeme and Zemgale objects, up to 10% of the total territories would be suitable for electricity production with solar and wind energy.

In order to clarify the possible potential of electricity production, it is necessary to look in detail at each land unit found in the study separately.

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