

# Modeling the Distribution of Lake Reeds Using GIS

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**Abstract**— So far, no significant modeling of reed biomass availability or assessment of the sustainability of reed products based on life cycle analysis has been conducted in Latvia. Nevertheless, these aspects are crucial for the development of reed-based products, as they help evaluate their market potential and overall socio-economic and environmental impact. This work aims to establish a methodology for modeling the extent of available reed distribution to forecast its future availability, as the availability of reed biomass is a vital prerequisite for utilizing this resource in the national economy. The novelty of this research lies in predicting reed areas based on existing historical data. The modeling is performed using GIS and satellite data.

**Keywords**— Reeds, modeling, renewable resources, satellite data, QGIS.

## I. INTRODUCTION

Reed (*Phragmites australis*) [1] is a widespread plant in Latvia, which has so far been considered mainly as a nuisance due to its rapid spread. The area of reeds continues to increase, therefore reed cutting is carried out to limit overgrowth in waterbodies. There is a large amount of reed biomass available in lakes, which has so far been an undervalued renewable resource. Although the availability and potential of reed biomass are large, now reeds are used in Latvia in small quantities, mainly in construction for the production of roofing materials.

The reed and rush belt on the coast reduces the impact of surface runoff on the lake, especially if the coastal belt is wide. The surface vegetation prevents the rapid entry of nutrients into the middle part of the lake. In turn, mowing of already grown reeds removes nutrients from the lake that are in the reed stalks, and as the new reeds grow, they consume nutrients from the coastal soil and water, rather than the decomposition products of the old reeds. If the reeds were not mowed but uprooted, then the

positive/negative impact of this process should be considered more seriously.

Along with economic development, the demand for renewable energy is increasing, due to their longevity and low pollution compared to fossil energy resources. One of the most widely used types of renewable energy is biomass. Now, the demand is focused on the use of various non-traditional types of biomass—cultivated energy plants, wood residues, as well as the use of lake reeds. With the increasing prices of fossil energy resources and the pollution caused by using fossil resources, interest in the possibilities of using local biomass in energy supply is growing. Consequently, the issue of rational use of reed resources is being raised.

In literature sources, the properties of reeds are described using very different data. For example, the amount of reed biomass obtained when mowing reeds in winter varies from 3 to 30 t/ha [2].

To determine the possibilities of reed use, it is very important to determine the area of reeds in a particular lake and to detect changes in reed areas to predict the potential dynamics of increase or decrease. In such a situation, the use of GIS is necessary [3] – [6], which allows for comparing satellite data for different periods, calculating reed areas in a specific reference period, and predicting the trend of changes in reed areas.

The work aims to develop a methodology for determining reed areas in a specific lake to predict changes in the area and predict changes in the foreseeable period. In Latvia, such studies have only been carried out in determining reed areas in a fixed period without forecasting capabilities [2].

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CHAID decision tree or the strongest relationship between the two variables from the found chi-square values.

Random Forest is a method of creating decision trees for classification purposes [12].

The Minimum Distance algorithm (Dijkstra's algorithm) is an algorithm for finding the shortest paths between nodes in a weighted graph. It can be used to find the shortest paths from a source vertex to all other vertices in a weighted graph. The minimum distance calculation is a statistical method for fitting a model to data, which is also used for classification purposes [13].

### III. RESULTS AND DISCUSSION

The research methodology is based on the following sequence of actions:

- we find a suitable lake map with 5% cloudiness for a specific time period with the help of Copernicus;
- we identify appropriate objects for classification purposes in the QGIS environment;
- we select the classification algorithm from the Semi-automatic options;
- we perform classification and analyze the results obtained.

The experimental base was the maps of Lake Rāzna in the years 2020, 2021, 2023, and 2024 (in June) when the reed growth had ended.

Thus, we will have the chance to compare the experiment's results with data from [2], which estimated that in 2008, the reed area constituted approximately 4 percent of the water surface area.

Initial settings for the Random Forest algorithm: number of trees:2000. (Legends from Fig.2.)

Results for 2020 (see Fig. 3 and Table 2).

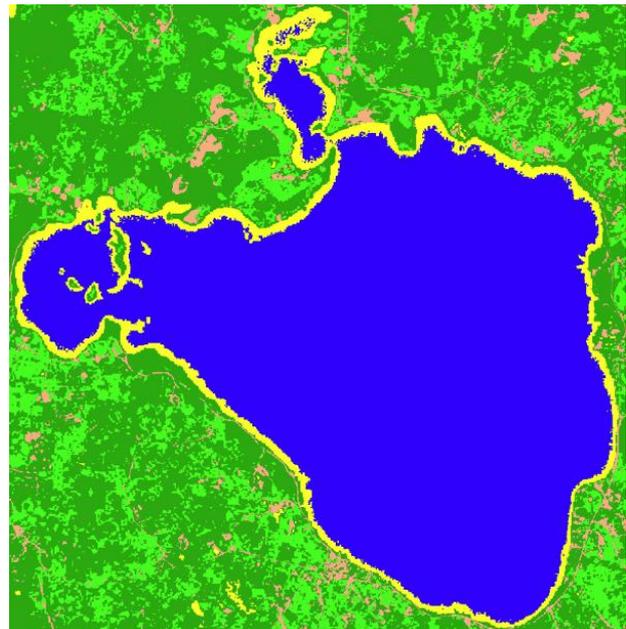


Fig. 3. Lake Rāzna (year 2020).

TABLE 2 CLASSIFICATION RESULTS (YEAR 2020)

Raster value	Pixel Sum	Percentage %	Area (m <sup>2</sup> )	Area (hectare)
1-Water	539828	6.15	53982800	5398.28
2-Reed	315912	3.60	31591200	3159.12
3-Wood	5676862	64.65	567686200	56768.62
4-Soil	535911	6.10	53591100	5359.11
5-Grass	1712223	19.50	171222300	17122.23

Results for 2021 (see Fig. 4 and Table 3).

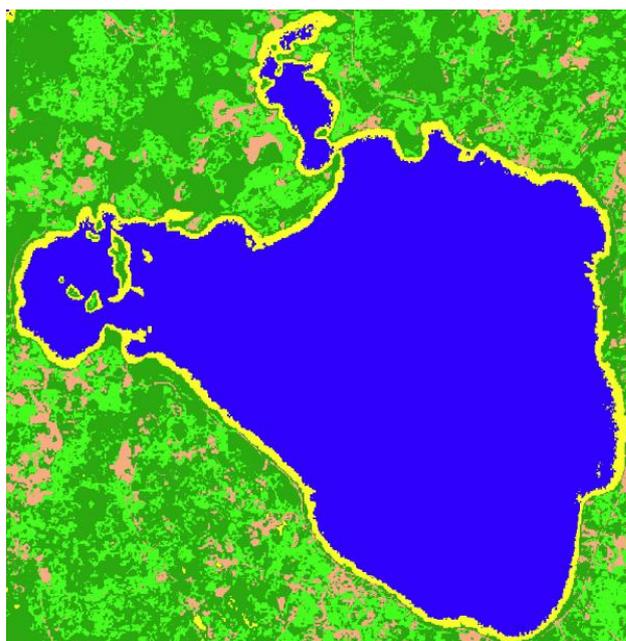


Fig. 4. Lake Rāzna (year 2021).

TABLE 3 CLASSIFICATION RESULTS (YEAR 2021)

Raster value	Pixel Sum	Percentage %	Area (m <sup>2</sup> )	Area (hectare)
1-Water	542226	6.18	54222600	5422.26
2-Reed	259815	2.96	25981500	2598.15
3-Wood	5108106	58.17	51081060	51081.06
4-Soil	687772	7.83	68777200	6877.72
5-Grass	2182817	24.86	21828170	21828.17

Results for 2023 (see Fig. 5 and Table 4).

TABLE 4 CLASSIFICATION RESULTS (YEAR 2023)

Raster value	Pixel Sum	Percentage %	Area (m <sup>2</sup> )	Area (hectare)
1-Water	715762	8.15	71576200	7157.62
2-Reed	288582	3.29	28858200	2885.82
3-Wood	4576958	52.12	45769580	45769.58
4-Soil	1217884	13.87	12178840	12178.84
5-Grass	1981550	22.57	19815500	19815.5

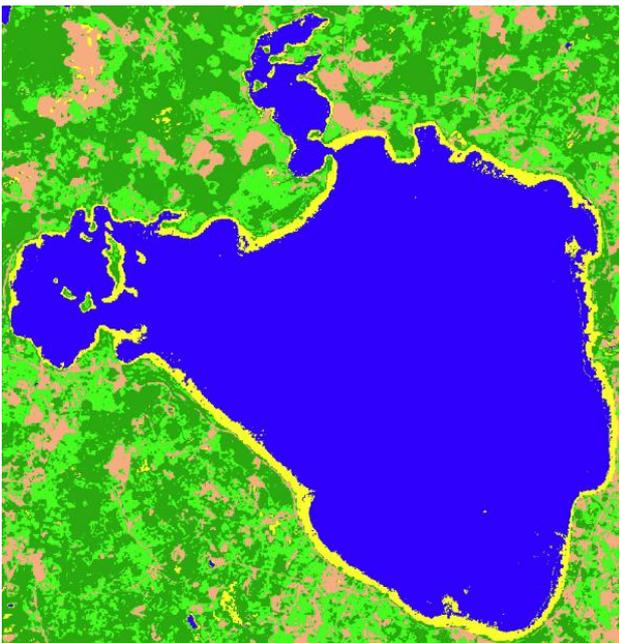


Fig. 5. Lake Rāzna (year 2023).

Results for 2024 (see Fig. 6 and Table 5).

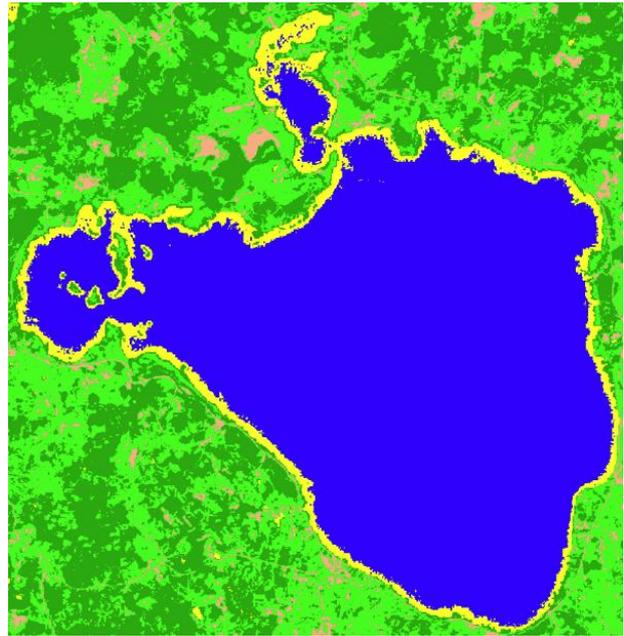


Fig. 6. Lake Rāzna (year 2024).

TABLE 5 CLASSIFICATION RESULTS (YEAR 2024)

Raster value	Pixel Sum	Percentage %	Area (m <sup>2</sup> )	Area (hectare)
1-Water	529140	6.03	52914000	5291.40
2-Reed	266918	3.04	26691800	2669.18
3-Wood	4599805	52.39	45998050	45998.05
4-Soil	412493	4.70	41249300	4124.93
5-Grass	2972380	33.85	29723800	29723.80

A summary of the reed area in the lake is shown in Table 6.

TABLE 6 REED ARE BY YEAR

Year	Area (hectare)	Percentage %
2020	3159.12	3.60
2021	2598.15	2.96
2023	2885.82	3.29
2024	2669.18	3.04

This tabular data allows us to make an initial simple prediction (see Fig. 7).

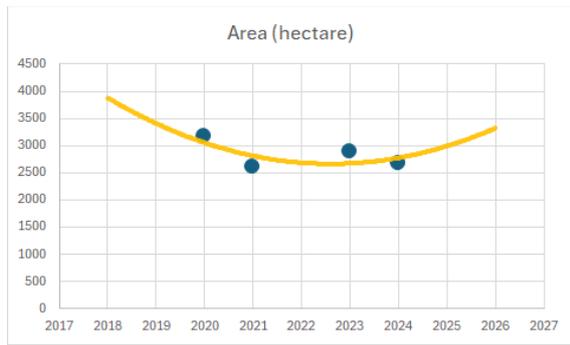


Fig. 7. Reed area prediction graph.

#### IV. CONCLUSIONS

This work is aimed to develop a methodology for identifying reed areas in lakes. Lake maps were taken from the Copernicus Sentinel database. Then the maps were processed in the QGIS environment – known data objects, such as water, wood, soil, grass, and reeds, were identified. The more precisely these objects are described, the higher the quality of the classification. The Random Forest algorithm performed very well in reed classification. The results of the Minimum Distance algorithm were inconclusive, so they were not included in the analysis of the results. A large amount of time had to be spent on the selection of satellite maps, because even in summer in Latvia it is very cloudy, therefore the selection of lake maps is of great importance in terms of data quality. The study showed that the percentage of the reed area of Lake Rāzna correlates with the studies conducted by other scientists, thus the proposed model has prospects for further development. It is planned to continue expanding this model with additional objects to be classified, to develop a more accurate prediction procedure. It is also planned to evaluate the amount of reed biomass depending on the reed areas. The availability of reed biomass is an essential prerequisite for the use of this resource in the national economy as a renewable resource.

#### V. ACKNOWLEDGMENTS

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