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Mapping soil formation in Lithuania. A national-scale analysis.

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Introduction

Soil formation is vital for the existence of life. Soil provides a wide range of direct and indirect ecosystem services (ES) such as carbon sequestration, water and flood regulation, food provisioning, raw material culture, and heritage. Soil formation is complex and depends on the parent material, climate, topography, biological activity, and time. This intricate process is strongly affected by human activities (e.g., agriculture, urbanization) that generally result in a degradation process. Mapping soil formation is challenging due to a large number of variables involved and the complexity of their interaction. The objective of this work is to map soil formation in Lithuania.

Materials and methods

Several variables were selected to assess soil formation such as lithology, time (glacial retreat), slope, topographic wetness index, roughness, slope length, soil mineralogy, depth, texture, available water capacity, pH, organic carbon, nitrogen, potassium, phosphorous, January average temperature, June average temperature, annual average precipitation, and land use. To validate the model, we used soil cation exchange capacity (CEC) (Table 1). The variables were ranked according to the least to the most favorable conditions. The weight of the variables was assessed using the Analytic Hierarchical Process and ranked by 20 international experts on the soil. The framework used in this study is shown in the figure 1.

Datasets	
Variable	Reference
Lithology	https://www.lgt.lt/
Glacial retreat	Stroeven et al. (2016)
Digital Elevation model	https://land.copernicus.eu/
Soil minerology	Panagos et al. (2012) and Orgiazzi et al (2018)
Soil available water capacity	
Soil depth	
Soil texture	
Soil pH	
Soil organic carbon	
Soil nitrogen	
Soil potassium	
Soil phosphorous	
Climate data (Precipitation, Temperature) 1997-2010	http://www.meteo.lt
Corine Land Cover (2018)	https://land.copernicus.eu/pan-european/corine-land-cover/clc2018

Table 1. **Datasets used in this work.**

Rank	Variable
1	Average annual rainfall
2	Time (i.e., Glacial retreat)
3	Lithology (bedrock texture)
4	Soil texture
5	Slope
6	Average temperature range
7	Minerology
8	Topographic wetness index
9	Soil available water capacity
10	June average temperature
11	Roughness
12	Land use
13	Organic carbon
14	Depth to rock
15	pH
16	Slope length
17	January average temperature
18	Nitrogen
19	Phosphorous
20	Potassium

Table 2. **Ranking of the variables according to the experts.**

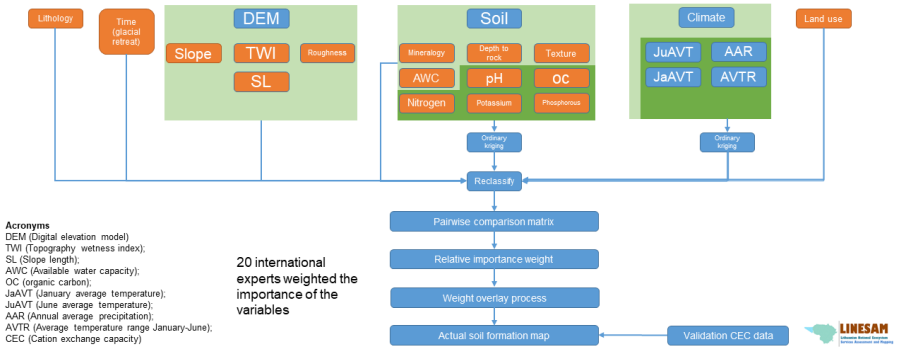

Figure 1. **Framework applied in this study.**

Results and conclusions

- According to the experts the most important relevant variables for soil formation were average annual rainfall, time and lithology (Table 2);
- The areas with high soil formation are observed in the western eastern part of Lithuania, while in the central and southwest part of the country soil formation is low;
- The relation between soil formation index and CEC had a coefficient of determination of 0.48, showing that the model was validated with a moderate accuracy (Figure 3);
- The model has several limitations, especially related to the data resolution and the lack of soil microbiology information at an acceptable resolution to be incorporated in the model. Nevertheless, owning to the complexity of soil formation, we think hat the model do a good estimation;

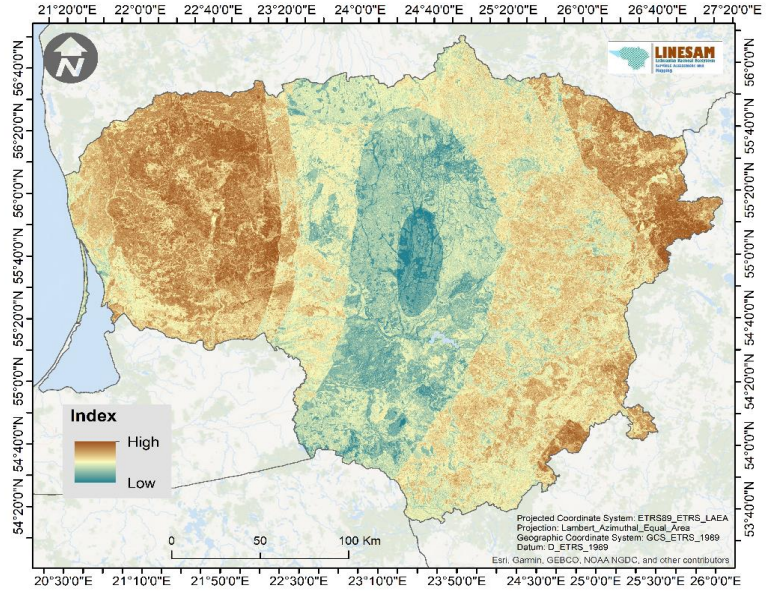

Figure 2. **Soil formation map in Lithuania.**

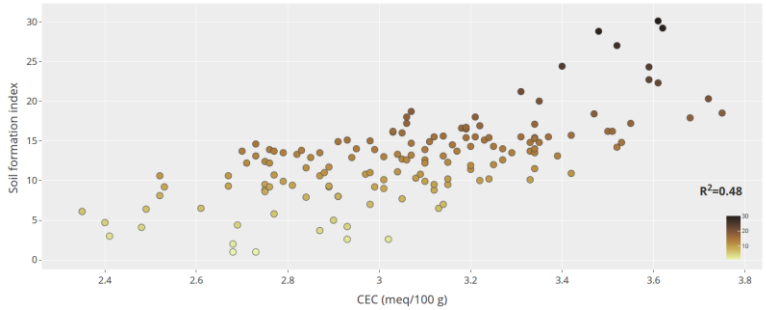

Figure 3. **Relation between soil formation index and CEC (N=150)**

References

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