GIS-Enhanced Wind Erosion Modeling:

Addressing Global Challenges and Solutions for Sustainable Land Management

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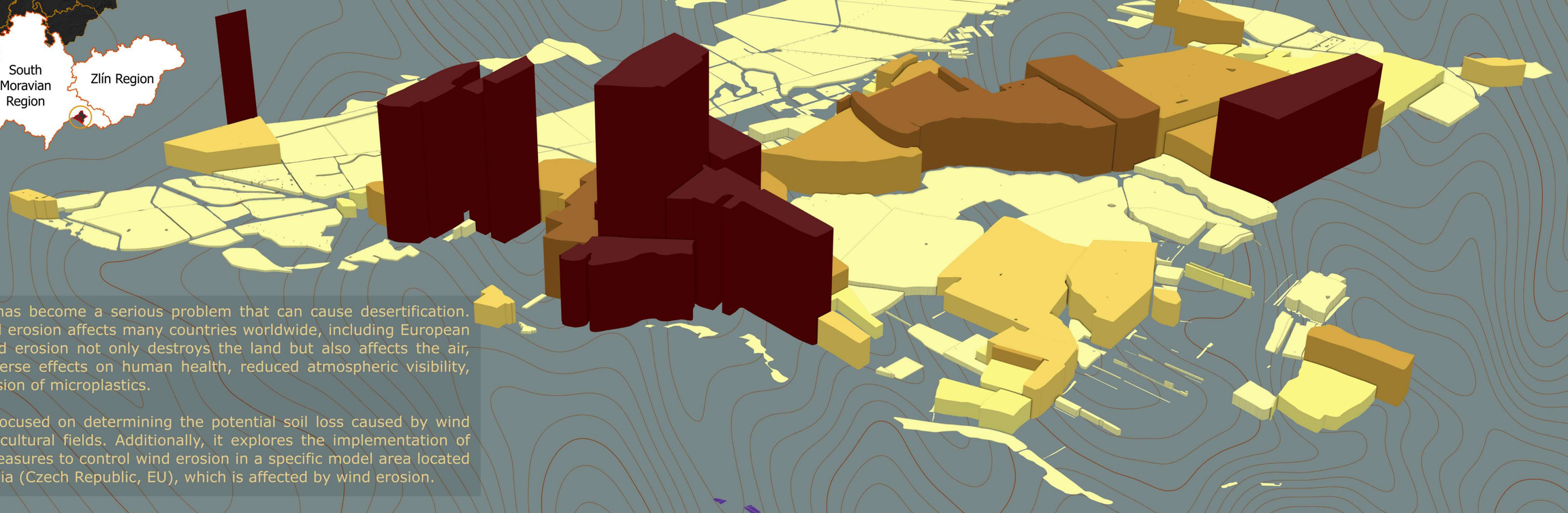
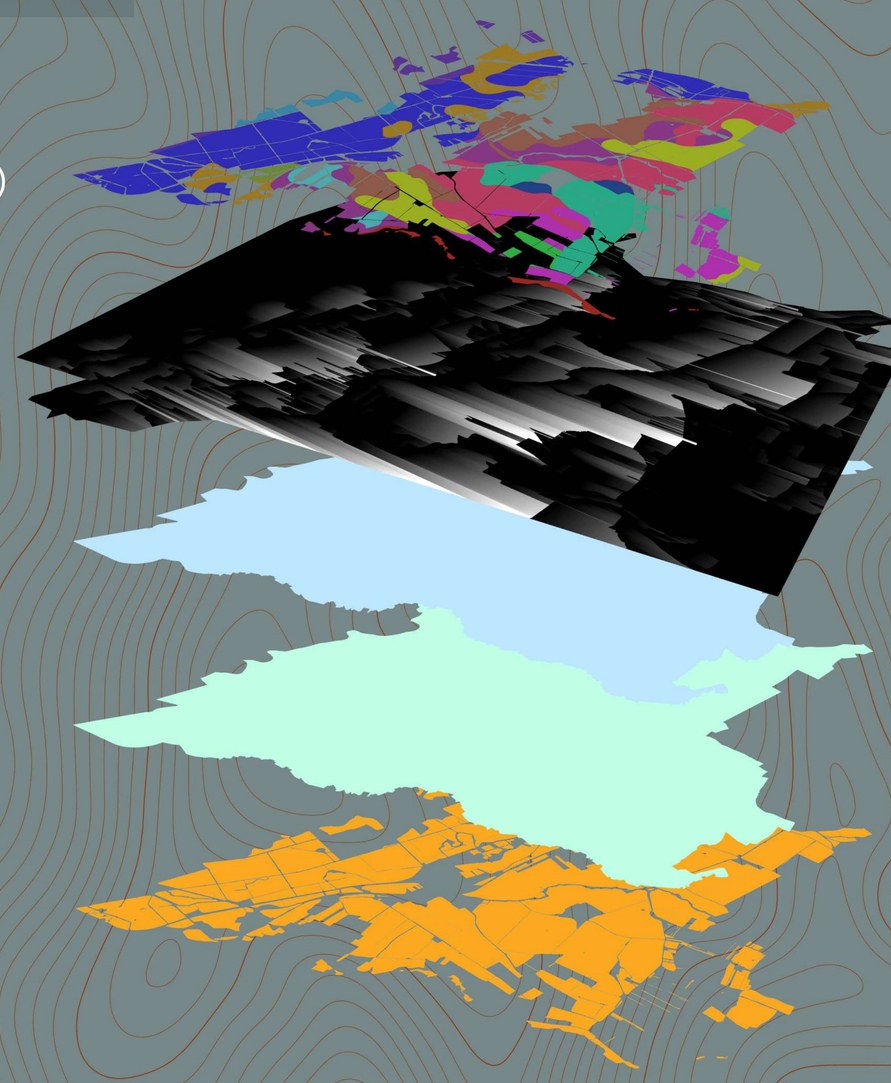


Wind erosion has become a serious problem that can cause desertification. Currently, wind erosion affects many countries worldwide, including European countries. Wind erosion not only destroys the land but also affects the air, leading to adverse effects on human health, reduced atmospheric visibility, and the dispersion of microplastics.

This study is focused on determining the potential soil loss caused by wind erosion in agricultural fields. Additionally, it explores the implementation of biotechnical measures to control wind erosion in a specific model area located in South Moravia (Czech Republic, EU), which is affected by wind erosion.



I – Soil erodibility factor (t ha $^{-1}$ year $^{-1}$)

The soil erodibility factor was determined based on the percentage of non-erodible surface soil aggregates larger than 0.84 mm in diameter in a soil sample collected from a specific surface unit (Chepil, 1942).

L – Unsheltered length of eroding land

The unsheltered length was determined through height analysis using data from the Digital Elevation Model (DEM) and Digital Surface Model (DSM), including consideration of satellite imagery from Sentinel-2 and PlanetScope for correction.

C – Climate factor

To determine climate factors, freely available hydrometeorological data from the Czech Hydrometeorological Institute were utilized, which provided monitoring in the study area.

V – Vegetative cover factor

Vegetation was ignored in determining potential soil loss due to wind erosion.
Vegetation cover factor can be assessed using remotely sensed indices such as the Normalized Difference Vegetation Index (NDVI) and Leaf Area Index (LAI).

K – Soil ridge roughness factor

Soil ridge roughness was ignored in determining potential soil loss due to wind erosion.

Determination of Wind Erosion

There are several methods and methodologies for determining the causes of wind erosion. One of them can be the use of equations and models, which, when implemented with GIS technology, become a very powerful tool due to several reasons such as speed, visualization, and the possibility of using freely accessible data. Many of these models are based on equations, but they differ due to regional characteristics or variations in their demands for input data. One of the most commonly used equations is the Wind Erosion Equation (WEQ).

WEQ was implemented in ESRI ArcGIS Pro 3.0 using raster analysis techniques to determine potential soil loss due to wind. The use of the WEQ in this study represents a versatile method that can be applied in different scenarios and for various purposes.

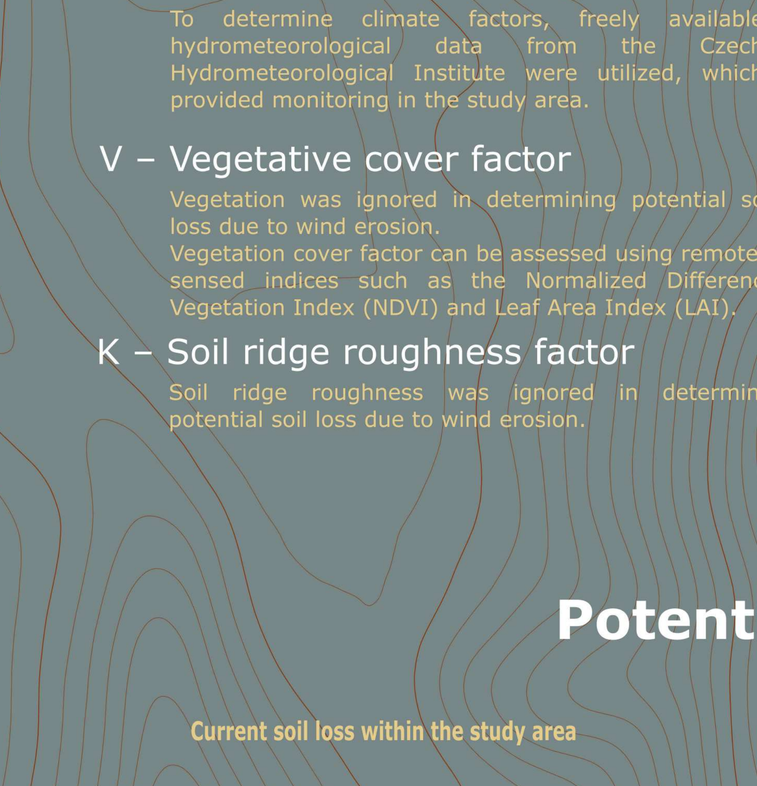
This study focuses on modeling potential wind erosion using the equation published by Schwab et al. (1993).

$$E = 0{,}0015 \times 2{,}718^{-V/4500} \times (I^{1{,}87} \times K^{2} \times (\frac{C}{100})^{1{,}3} \times L^{0{,}3})$$

The estimation of potential average soil loss attributed to wind erosion was conducted using Soil Block Portions sourced from the Land Parcel Identification System (LPIS), which is maintained by The Ministry of Agriculture of the Czech Republic and meticulously records agricultural land use data.

Potential average soil loss due to wind erosion

Current soil loss within the study area

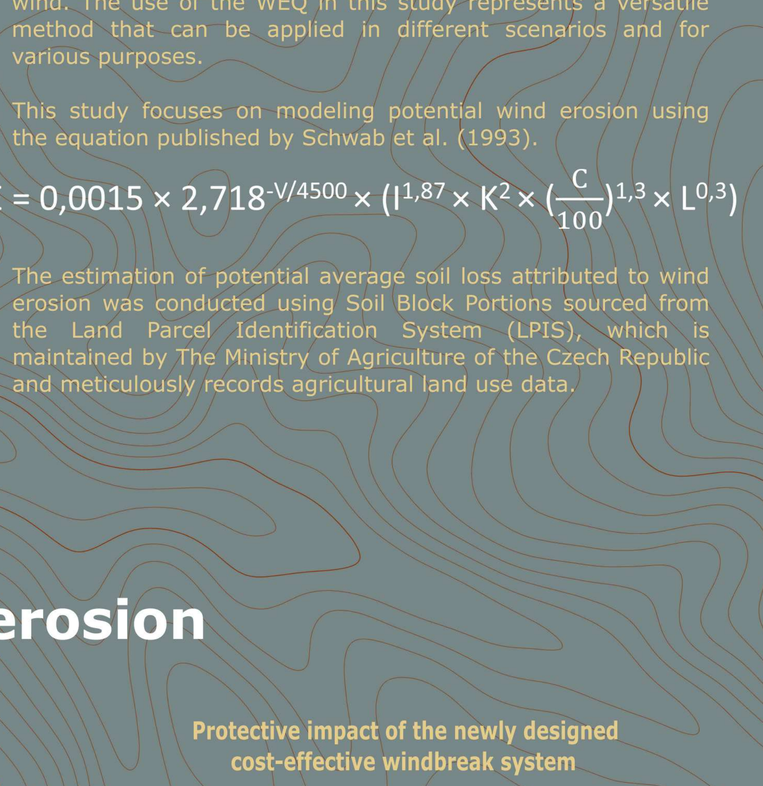


Wind-induced soil loss
Land appropriation for windbreaks
Investment costs for windbreaks
Limited Substantial

Protective impact of the newly proposed comprehensive windbreak system

Wind-induced soil loss
Land appropriation for windbreaks
Investment costs for windbreaks
Limited Substantial

Protective impact of the newly designed cost-effective windbreak system



Wind-induced soil loss
Land appropriation for windbreaks
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Limited Substantial

Soil loss

- < 4 (t ha $^{-1}$ year $^{-1}$)
- 4 – 7 (t ha $^{-1}$ year $^{-1}$)
- 7 – 11 (t ha $^{-1}$ year $^{-1}$)
- 11 – 17 (t ha $^{-1}$ year $^{-1}$)
- 17 – 23 (t ha $^{-1}$ year $^{-1}$)
- > 23 (t ha $^{-1}$ year $^{-1}$)

- Administrative Boundaries of the Cadastre Area of the Area of Interest
- Permanent Grassland
- The comprehensive windbreak system
- The cost-effective windbreak system
- The protective effect of the newly designed windbreak system

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Academic References

Schwab, G., Fangmeier, D.D., Elliot, W.J. et al. (1993). Soil and water conservation engineering. Wind erosion and controlpractices. New York: John Wiley & Sons.

Chepil, W. S. (1942). Measurement of wind erosiveness of soils by dry sieving procedure. Scientific Agriculture, 23(3), 154-160.

Data Sources

State Administration of Land Surveying and Cadastre (ČÚZK)
Ministry of Agriculture of the Czech Republic
State Land Office (SLO)

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