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GEOSPATIAL ANALYSIS OF ARABLE LAND AND SOIL EROSION IN SIC AREA USING PYTHON AND GIS

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Abstract. *This study presents an integrated geospatial analysis of arable land in the Sic area, aiming to highlight the relationships between agricultural land use, soil units, erosion processes, and the delineation of homogeneous territories through the use of Python and GIS techniques. The research is based on the processing and integration of multiple thematic spatial datasets, including land use categories, soil types, erosion intensity, and territorial characteristics of the study area. The methodological workflow involves the use of specialized Python libraries for geospatial analysis, such as GeoPandas, Rasterio, Matplotlib, and Shapely, enabling efficient data import, management, overlay operations, and spatial interpretation of both vector and raster data. Arable land areas were extracted and spatially correlated with existing soil units, followed by the assessment of erosion patterns and the identification of homogeneous territorial units based on similarities in pedological and morphometric characteristics. The results highlight the spatial distribution of agriculturally suitable lands, areas affected by erosion, and zones with relatively uniform territorial behavior. These findings provide valuable support for agricultural management strategies, soil conservation measures, and sustainable land-use planning. Furthermore, the study demonstrates the effectiveness of integrating Python-based workflows with GIS technologies in conducting reproducible, scalable, and analytically robust spatial assessments of rural environments.*

Keywords: *GIS, Python, arable land*

INTRODUCTION

Arable land is one of the most important resources in rural areas, as it directly supports agricultural production, food security, and the sustainable development of local communities. However, the productivity and long-term stability of agricultural land are strongly influenced by natural factors such as soil characteristics, relief, slope, hydrological conditions, and erosion processes.

In the Sic area, the interaction between land suitability and soil erosion is particularly relevant because erosion can reduce soil fertility, affect crop development, and limit the efficient use of arable surfaces. Identifying the areas where arable land overlaps with different erosion intensity classes is therefore essential for understanding agricultural vulnerability and for supporting sustainable land management decisions.

This study applies Geographic Information Systems and Python-based spatial analysis to evaluate the distribution of arable land affected by soil erosion in the Sic area. The thematic layers representing arable land suitability and soil erosion intensity were processed, overlaid, and analyzed in order to calculate the surface

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affected by low, moderate, and high erosion. The use of Python allowed the automation of geospatial operations, including spatial intersection, area calculation, classification, and statistical summarization. The results of this analysis provide a clear spatial overview of the relationship between arable land and erosion intensity. They can support agricultural planning, the identification of vulnerable areas, and the implementation of appropriate soil conservation measures.

MATERIAL AND METHOD

The study was carried out in the Sic area, located in Cluj County, Romania, an area characterized by agricultural land use, varied relief conditions, and soil erosion processes that influence the suitability of land for cultivation. The analysis focused on identifying and quantifying the arable land affected by different erosion intensity classes. The spatial database used in this study included thematic layers representing arable land suitability and soil erosion intensity. These layers were processed in a Geographic Information System environment and analyzed using Python-based geospatial tools. [1] The arable land layer was used to identify agricultural surfaces suitable for cultivation, while the soil erosion layer provided information regarding the spatial distribution of erosion classes. Before performing the spatial analysis, the input data were checked and prepared to ensure geometric and spatial consistency. The layers were projected into a common coordinate reference system, and invalid geometries were corrected where necessary. This step was important in order to obtain accurate overlay results and reliable surface calculations. [2]

The main spatial processing operation consisted of overlaying the arable land layer with the soil erosion layer using a spatial intersection method. [3] Through this operation, new polygons were generated, representing the areas where arable land overlaps with different erosion intensity classes. For each resulting polygon, the surface was calculated in square meters and then converted into hectares. [4]

The attribute data were then processed in Python in order to classify the resulting areas according to erosion intensity. The erosion classes were grouped into three main categories: low erosion, moderate erosion, and high erosion. For each class, the total affected surface was calculated, together with its percentage from the total analyzed arable land area.

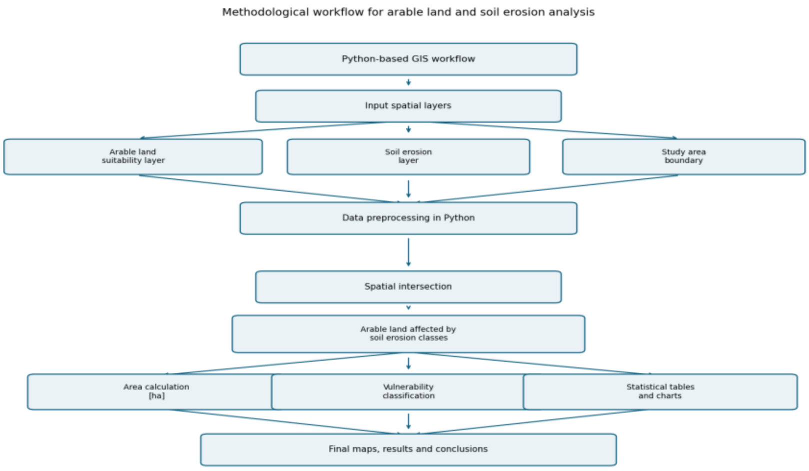

Figure 1. Methodological workflow

The figure 1 presents the methodological workflow used for the analysis of arable land and soil erosion. The process begins with a Python-based GIS workflow, which integrates several input spatial layers. These layers include the arable land suitability layer, the soil erosion layer, and the study area boundary.

After the input data are collected, they are preprocessed in Python to ensure spatial consistency and prepare them for analysis. This stage may include checking the coordinate reference system, correcting geometries, clipping the layers to the study area, and organizing the attribute data.

The next step consists of a spatial intersection between the arable land suitability layer and the soil erosion layer. This operation identifies the areas where arable land overlaps with different soil erosion classes. As a result, the analysis highlights the arable surfaces affected by low, moderate, or high erosion intensity. The resulting data are then used for area calculation in hectares, vulnerability classification, and the generation of statistical tables and charts. These outputs support the interpretation of the spatial distribution of erosion-affected arable land. Finally, the workflow leads to the production of final maps, results, and conclusions, which can be used to support sustainable agricultural planning and soil conservation measures in the study area.

The workflow was automated using Python libraries for geospatial and tabular data processing. GeoPandas was used for reading, processing, and intersecting vector layers, while Pandas was used for statistical summarization and table generation. [5] Matplotlib was used for creating graphical representations of the results. This automated workflow ensured reproducibility, reduced manual processing errors, and allowed a rapid extraction of relevant spatial indicators. The final outputs consisted of thematic maps, statistical tables, and graphical representations showing the distribution of arable land according to soil erosion intensity. These results were used to assess agricultural vulnerability and to support the identification of areas where soil conservation measures are necessary.

RESULTS AND DISCUSSION

The results obtained from the spatial analysis highlight the relationship between arable land suitability and soil erosion intensity in the Sic area. By applying the Python-based GIS workflow, the input thematic layers were processed and intersected in order to identify the arable surfaces affected by different erosion classes. The spatial intersection generated new polygons that combine information from both the arable land layer and the soil erosion layer. This made it possible to quantify the affected areas and to classify them according to erosion intensity. As a result, the analysis provides both a spatial and statistical overview of agricultural vulnerability in the study area.

The interpretation of the results is based on thematic maps, area calculations, and summary statistics. The maps illustrate the spatial distribution of arable land affected by erosion, while the statistical tables and charts provide quantitative information regarding the surface occupied by each erosion class. Overall, the results indicate that GIS and Python-based spatial processing represent an efficient approach for evaluating erosion-related constraints on agricultural land. The following maps and statistical outputs present in detail the distribution of arable land affected by low, moderate, and high erosion.

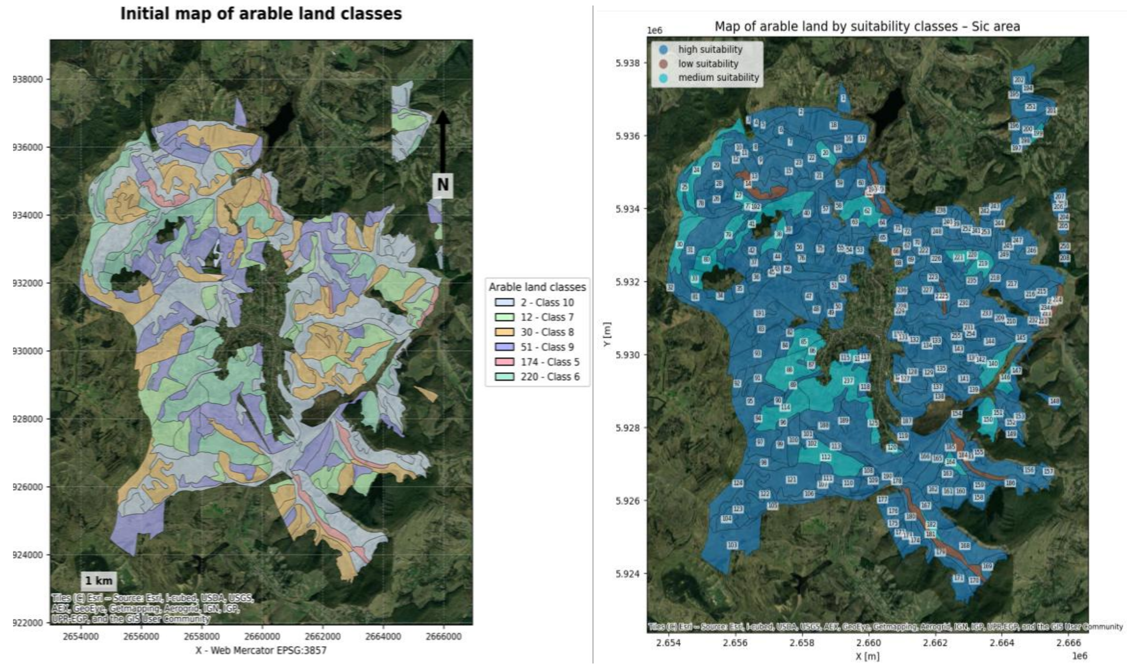

Figure 2. Initial map of arable land suitability classes (left) and arable land suitability score map (right).

Figure 2 illustrates the spatial distribution of arable land suitability in the Sic area. The map on the left presents the initial arable land classes, while the map on the right shows the reclassified suitability map, grouped into low, medium, and high suitability categories. These classes provide an initial overview of the agricultural potential of the study area before integrating the soil erosion factor.

The results indicate that high-suitability arable land is widely distributed across the study area, especially in the central and eastern sectors. Medium-suitability areas are also present, mainly forming transitional zones between the most favorable arable surfaces and areas with lower suitability. Low-suitability arable land occupies smaller and more fragmented areas, indicating zones where natural conditions may limit agricultural use.

This classification is important because it represents the starting point for evaluating agricultural vulnerability. When combined with the soil erosion layer, the arable land suitability classes allow the identification of areas where productive agricultural land may be affected by erosion processes. Therefore, Figure 2 provides the spatial basis for the subsequent intersection analysis between arable land and soil erosion.

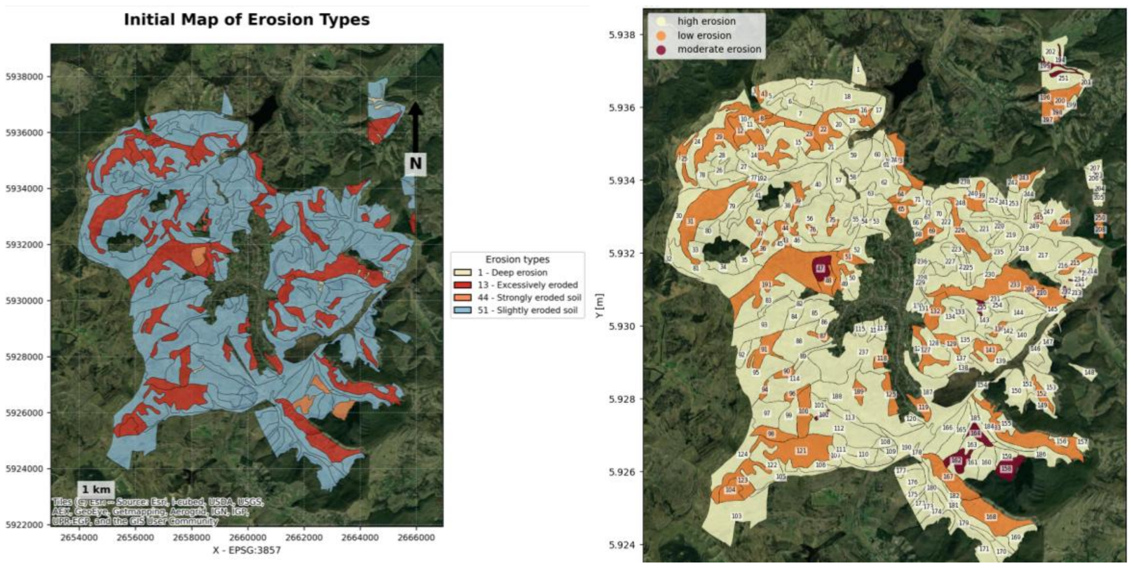

Figure 3. Initial map of soil erosion types (left) and soil erosion intensity map (right).

Figure 3 illustrates the spatial distribution of soil erosion types in the Sic area. The map on the left presents the initial erosion classification, including deep erosion, excessively eroded soil, strongly eroded soil, and slightly eroded soil. The map on the right shows the reclassified erosion intensity map, grouped into low, moderate, and high erosion categories.

The results indicate that low erosion areas are widely distributed across the study area, especially in the central and northern sectors. Moderate erosion appears in more fragmented zones, mainly along slopes and transitional areas. High erosion occupies smaller surfaces but represents the most vulnerable zones, where soil degradation processes are more intense.

This classification is important because soil erosion directly affects the agricultural potential and long-term productivity of arable land. When combined with the arable land suitability layer, the erosion intensity classes allow the identification of agricultural areas exposed to different levels of degradation risk. Therefore, Figure 3 provides the spatial basis for assessing vulnerable arable land and for supporting soil conservation measures in the Sic area.

Figure 4 illustrates the spatial intersection between the arable land suitability layer and the soil erosion intensity layer in the Sic area. The maps on the left represent the input thematic layers used in the analysis: the arable land suitability map and the soil erosion intensity map. These layers were overlaid in order to identify the arable surfaces affected by different levels of erosion.

The map on the right presents the result of the intersection analysis, highlighting the areas classified as vulnerable agricultural land. The red areas indicate arable land affected by soil erosion and therefore represent zones with increased agricultural vulnerability. The light-colored areas correspond to low vulnerability zones, where the impact of erosion on arable land is reduced.

The results show that vulnerable agricultural areas are widely distributed across the study area, with several concentrated zones in the central, western, and eastern sectors. This spatial pattern indicates that soil erosion represents an important limiting factor for agricultural use in the Sic area.

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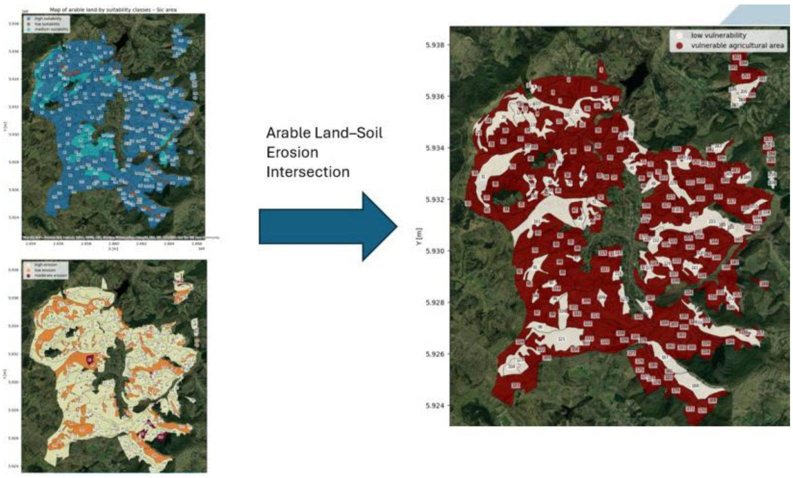

Figure 4. Arable land suitability map and soil erosion intensity map used for spatial intersection (left) and resulting vulnerable agricultural areas (right).

This analysis is important because it combines land suitability information with erosion intensity, allowing a more detailed evaluation of agricultural vulnerability. Therefore, Figure 4 provides the basis for calculating affected surfaces, generating statistical tables, and identifying priority areas where soil conservation and sustainable land management measures are required.

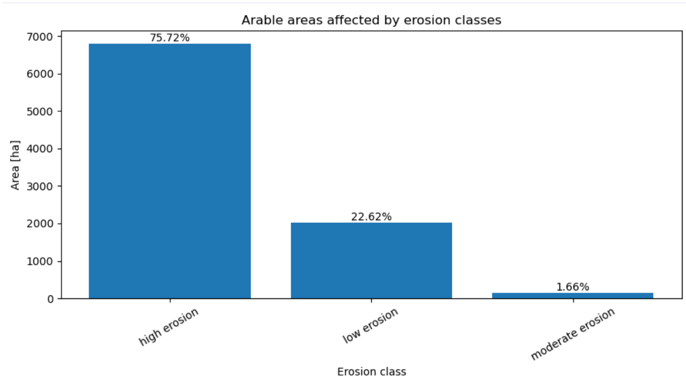

Figure 5. Distribution of arable areas affected by soil erosion classes

Figure 5 presents the distribution of arable land affected by different soil erosion classes, expressed both in hectares and percentages. The results show that the largest share of the analyzed arable land is affected by high erosion, representing **75.72%** of the total area. This indicates that a significant part of the agricultural land in the Sic area is exposed to severe erosion-related constraints.

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Low erosion affects **22.62%** of the arable land, representing areas where soil degradation is less intense and agricultural use is less restricted. Moderate erosion occupies only **1.66%** of the total analyzed area, indicating a limited spatial extent compared to the other erosion classes.

The dominance of high erosion areas suggests a high level of agricultural vulnerability in the study area. These results confirm the importance of integrating soil erosion data into arable land suitability analysis. The affected areas should be considered priority zones for soil conservation measures, sustainable land management, and erosion control practices.

Figure 6 presents the distribution of agricultural land according to vulnerability level after the spatial intersection between arable land suitability and soil erosion intensity. The results show that the largest part of the analyzed agricultural area is classified as vulnerable agricultural area, covering 6,946.46 ha, which represents 77.38% of the total area.

In contrast, areas with low vulnerability cover 2,030.09 ha, representing 22.62% of the total analyzed agricultural land. These areas indicate zones where the impact of soil erosion on arable land is lower and where agricultural use is less constrained by erosion processes.

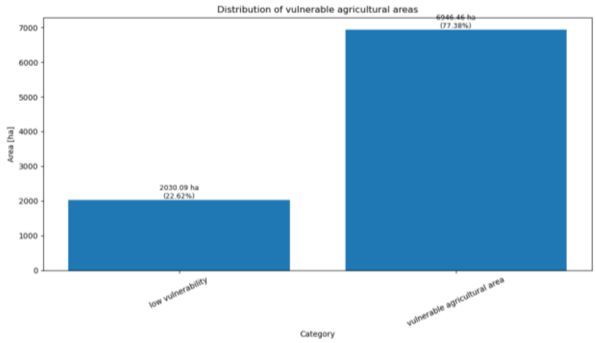

Figure 6. Distribution of vulnerable agricultural areas in the Sic area.

The dominance of vulnerable agricultural areas suggests that soil erosion has a strong influence on the agricultural potential of the Sic area. This result highlights the need for targeted soil conservation measures, especially in zones where arable land overlaps with high erosion intensity. Therefore, the vulnerable agricultural areas identified in this analysis should be considered priority zones for sustainable land management and erosion control interventions.

CONCLUSIONS

The study demonstrates the usefulness of integrating GIS techniques with Python-based spatial processing for the assessment of arable land affected by soil erosion in the Sic area. By combining the arable land suitability layer with the soil erosion intensity layer, it was possible to identify, classify, and quantify agricultural areas exposed to different levels of erosion risk.

The results show that soil erosion represents an important limiting factor for agricultural land use in the study area. A significant proportion of the analyzed arable land was classified as vulnerable agricultural area, indicating that erosion processes strongly influence the agricultural potential and long-term productivity of the territory. The spatial intersection analysis provided both cartographic and statistical outputs. The thematic maps allowed the visualization of vulnerable zones, while the calculated areas and percentages offered a quantitative basis for interpreting the severity of erosion impact on arable land.

The Python-based workflow proved to be efficient, reproducible, and suitable for automated geospatial analysis. It allowed the rapid processing of spatial layers, area calculation, vulnerability classification, and the generation of statistical tables and charts. Overall, the results can support agricultural planning and sustainable land management in the Sic area. The vulnerable agricultural areas identified in this study should be considered priority zones for soil conservation measures, erosion control practices, and future land-use planning decisions.

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BIBLIOGRAPHY

BILAȘCO Ș., S. ROȘCA, I. PĂCURAR, N. MOLDOVAN, A. BOȚ, C. NEGRUȘIER, P. SESTRAȘ, M. BONDREA AND S. NAȘ, "Identification of Land Suitability for Agricultural Use by Applying Morphometric and Risk Parameters Based on GIS Spatial Analysis," *Notulae Botanicae Horti Agrobotanici Cluj-Napoca,*, Vols. 44(1),, p. 302–312., 2016.

CEBALLOS-SILVA A. L.-B. J., " Evaluating biophysical variables to identify suitable areas for oat in Central Mexico: a multicriteria and GIS approach,," Agriculture, Ecosystems & Environment, 95(1), p. pp. 371–377, 2003.

CHEN C. J. J. &. H. D., *PyLUSAT: An open-source Python toolkit for GIS-based land use suitability analysis,* Vols. Environmental Modelling & Software, 151,, p. 2022.

COROIAN I., D. FICIOR, S. BRUMĂ, R. SOBOLU, T. SĂLĂGEAN, M.-E. NAP, I. D. POP, F. MATEI, J. DEAK AND E.-E. SUBA, "Development of Gis and web maps in order to extend water supply and sewerage infrastructure in Lechința Village, Iernut Town, Mureș County.," *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Horticulture,* vol. 79, no. 2, pp. 22-28, 2022.

CRISTA FLORIN , RADULOV ISIDORA , BERBECEA ADINA, LATO ALINA, 2022, Sustenability of natural resources in Romania-Serbia cross-border area, Ed.Eurobit Timisoara/ ISBN 978-973-132-957-4

DORNIK A. e. a., "Geospatial evaluation of the agricultural suitability and land use compatibility in Europe's temperate continental climate region,," *International Soil and Water Conservation Research,* , Vols. 12(4), , p. 908–919., 2024.

LATO, A; BERBECEA, A ; LATO, I; CRISTA, F ; CRISTA, L; SALA, F; RADULOV, I, 2025, Mitigating Soil Acidity: Impact of Aglime ($CaCO_3$) Particle Size and Application Rate on Exchangeable Aluminium and Base Cations Dynamics, MDPI-SUSTAINABILITY

LATO A., BERBECEA A., RADULOV I., LATO I., CRISTA F., NITA L., NEACSU A., 2023, Correlation between soil pH measured in two eluents in the case of agricultural land: conclusions regarding soil reaction classes, Applied Ecology And Environmental Research vol. 21(1), page 373-392, ISSN 1785 0037

LATO K.I., LATO A., NITA L.D., DUMA-COPCEA A., CORCHES M.T., 2022, Pedo-genetical factors implicated in soil degradation (lower Timis river basin area), Scientific Papers-Series A-Agronomy, Volume 65, Issue 1, Page 91-96, ISSN 2285-5785, eISSN 2285-5807

LATO K. I. , POPA M., LATO A., CORCHES M., RADULOV I., BERBECEA A., CRISTA F., 2019, Economic efficiency of main soil types from west region of Romania for various agricultural crops, Journal Of Environmental Protection And Ecology vol. 20, (2), ISSN 1311-5065

MALCZEWSKI J., "GIS-based multicriteria decision analysis: a survey of the literature,," International Journal of Geographical Information Science, 20(7), , p. pp. 703–726., 2006.

NITA L.D., TARAU D., ROGOBETE G., CRISTA F., NITA S., LATO K.I., COPCEA A.D., LATO A.; OKROS A., Physical-geographical and socio-economic conditions defining the quality of the eco-pedological resources in the Timişoara metropolitan area, Scientific Papers-Series A-Agronomy, Volume 66, Issue 1, Page 793-804, ISSN 2285-5785, eISSN 2285-5807

RADULOV I., BERBECEA A., CRISTA F., LATO A., CRISTA L., LATO I., 2025, Agroecosystems: Building Resilience Through Soil, Water, and Carbon Stewardship, INTECHOPEN.

ZAKARYA Y. M. M. A. M. M. M., "Optimized land use through integrated land suitability and GIS approach in West El-Minia Governorate,," Upper Egypt, Sustainability, 13(21), article 12236., 2021.

Research Journal of Agricultural Science, 58 (2), 2026; ISSN: 2668-926X;

http://doi.org/10.59463/RJAS.2026.2.04

YALEW S. G. v. G. A. v. d. Z. P., "Land suitability analysis for agriculture in the Abbay basin using remote sensing, GIS and AHP techniques,," *Applied Water Science*, *6*, , p. 433–443., 2016.