

SUSTAINABLE USE AND MANAGEMENT OF SOIL RESOURCES IN THE ALMĂJULUI VALLEY AREA, COUNTY CARAȘ-SEVERIN

Lucian Dumitru NIȚĂ, Simona NIȚĂ, Karel Iaroslav LAȚO, Anișoara Duma COPCEA,
Ioana-Alina HÎNDA, Alina LAȚO

University of Life Sciences “King Mihai I” from Timisoara,
119 Calea Aradului Street, 300645, Timisoara, Romania

Corresponding author email: simona_nita@usvt.ro

Abstract

The proposed scientific paper focuses on "Sustainable use and management of soil resources in the Almăjului Valley area, County Caraș-Severin". It will look at the importance of soils as essential resources for agriculture, biodiversity, sustainability and environmental sustainability. The study will highlight the current practices of agricultural land use (arable, pasture, hayland, trees and vineyards) and the impact of mainly agricultural activities on their quality. In addition, it will examine sustainable management/stewardship strategies that can be implemented to prevent degradation, soil pollution to promote an increase in fertility in the medium and long term. The paper will propose specific and concrete measures to protect and prevent soil clearance, such as crop rotation, use of organic fertilisers according to legal management requirements (SMR) and standards on good agricultural and environmental conditions of land (GAEC), rational grazing, application of agroforestry systems and ecosystem restoration, thus also highlighting the role of local communities in the implementation of these sustainable and sustainable practices.

Key words: soil, use, management, sustainable, resources, fertilization.

INTRODUCTION

Sustainable management of soil resources is essential for maintaining healthy ecosystems, biodiversity and human well-being. Soil is a complex environment that supports agriculture, regulates biogeochemical cycles, stores water and carbon, and serves as a habitat for numerous organisms. The importance and necessity of sustainable soil management derives from the fact that it is a finite resource, vulnerable to degradation due to anthropogenic activities, climate change and economic pressures (Țărău et al., 2019; Niță et al., 2018; David et al., 2018). A fundamental aspect of sustainable soil management is protecting soil quality. Intensive agriculture through the excessive use of pesticides and chemical fertilizers, deforestation and accelerated urbanization contribute to soil degradation, which can lead to degradation processes such as erosion, compaction, decreased fertility and contamination. By implementing sustainable practices, such as crop rotation, agroforestry systems, soil cover with vegetation, the use of organic fertilizers and moisture conservation, the structure can be improved, and thus agricultural production will

be optimized in the long term (Montgomery, 2007; Blaga et al., 2008).

Sustainable soil management plays a crucial role in combating climate change, as soils function as a carbon sink, and proper soil management can help reduce greenhouse gas emissions. Sustainable farming practices not only help to store carbon, but also improve the soil's ability to retain water, which is essential in the context of extreme weather events such as droughts or floods.

Last but not least, the sustainable management of soil resources has a significant social and economic impact because healthy soil is essential for ensuring food security, sustaining local economies and protecting vulnerable communities, so by increasing agricultural productivity and reducing the risks posed by soil degradation processes, favorable conditions can be created for the sustainable development of communities (Quinton et al., 2010).

The sustainable management of soil resources is vital for ensuring sustainable economic development, protecting the environment and promoting social well-being, thus becoming a global priority. The aspects regarding the use of information regarding the soil resources in the

studied area are accumulated from the pedological studies, stored in the archive of the specialized regional institutions, (mostly on classical support, but also on the basis of SPED 1, BDUST information systems) and part of the information and data are taken from the research programs carried out over time by the authors (within USV Timișoara), for the qualitative and quantitative evaluation of the ecopedological resources in the Almăjului Valley and of the possible pressures on them, but also on measures to promote environmentally friendly social practices (Methodology for the elaboration of pedological studies, 1987).

MATERIALS AND METHODS

The soil resources in the analyzed area extend over a total area of 109,518 hectares (Table 1), of which 40,628 hectares (37.11%) are used as

agricultural land, and 60,323 hectares (60.33%) are covered by forest vegetation. These lands are located in the Almăjului Valley and are administered by the seven administrative-territorial units: Bănia, Bozovici, Dalboșeț, Eftimie Murgu, Lăpușnicu Mare, Prigor and Șopotu Nou, all located in Caraș-Severin County (Țărău et al., 2019; Mircov et al., 2021). Analyzing the land use in the depression of the Almăjului Valley, it is highlighted that significant areas are dedicated to pastures and meadows, which constitute approximately 27.5% of the total area and over 74% of agricultural land. In contrast, the area under arable cultivation represents only 21.77% of the agricultural land (Table 1). The area of the Almăjului depression is distinguished by a long tradition in agriculture, this activity having a considerable impact on the economy.

Table 1. Situation of the land fund in Almăjului Valley (Niță et al., 2024)

Crt. No.	Locality	Arable	Pasture	Grassland	Vignards	Orchards	Total agricultural	Forests	Waters	Other categories	Total general
1	Bănia	1720	4566	853	0	377	7516	12437	75	564	20592
2	Bozovici	1177	4300	1514	0	323	7314	11486	69	710	19579
3	Dalboșeț	1224	2674	1201	0	140	5239	3061	61	266	8627
4	Eftimie Murgu	994	1706	478	0	315	3493	6103	63	211	9830
5	Lăpușnicu Mare	707	3281	1444	0	222	5654	6446	57	209	12366
6	Prigor	2089	3591	1714	0	291	7685	22075	60	367	30187
7	Șopotu Nou	935	2058	694	0	40	3727	4495	12	103	8337
Total (ha)		8846	22176	7898	0	1708	40628	66103	397	2430	109518
% total area		8.08	20.25	7.22	0	1.56	37.11	60.33	0.36	2.20	100
% total agricultural		21.77	54.58	19.44	0	4.21	100	-	-	-	-

The research of the ecopedological conditions of formation and evolution of soil resources was carried out according to the national standards represented by the Methodology for the elaboration of pedological studies (vol. I, II, III), developed and created by ICPA Bucharest in 1987. This methodological standard was completed with specific aspects of the Romanian Soil Taxonomy System (SRTS-2012) (Florea & Munteanu, 2012), MADR Order 278/2011 - National Program on the Implementation of the National Soil-Field Monitoring System for Agriculture. The study was based on the pedological data available in the OSPA archive in Timișoara, which contains information from over 68 years, as well as on previous research carried out by various authors,

supplemented with recent data obtained from the field by the authors.

RESULTS AND DISCUSSIONS

The factors that limit the production capacity of soils in the Almăjului Valley include physical features such as the degree of compaction, the slope of the land, the erosion process, the excess of groundwater moisture and rainfall. Also, agrochemical properties, such as soil reaction, humus content and levels of other essential nutrients (such as phosphorus and potassium), play a decisive role in this production capacity. The degree of compaction refers to the densification of soil particles, which leads to excessive compaction.

This can limit the circulation of air and water in the soil, thus affecting root development and nutrient uptake by plants. Compacted soils have a reduced capacity to retain moisture and can inhibit the activity of microbial organisms, which are essential for the process of decomposition of organic matter and nutrient cycling. Compaction can also lead to increased erosion by reducing the stability of soil structures.

The slope of the land greatly influences the erosion process and water runoff. On steeper slopes, rainwater accumulates and flows faster, increasing the risk of surface erosion and transport of fertile soil. This can lead to the loss of the top layer of soil, which is the richest in nutrients. Additionally, steep slopes can also affect water infiltration capacity and lead to landslides.

Soil erosion refers to the process of soil degradation caused by external agents such as water and wind. Erosion can remove the top layer of soil, which contains most of the nutrients needed by plants. Erosion can be accelerated by anthropogenic activities such as intensive agriculture, deforestation, and road construction. This not only reduces soil fertility, but also contributes to the pollution of water sources by transporting sediments and chemicals.

Excess groundwater refers to the level of groundwater. An excess of this moisture can create anaerobic conditions in the soil, preventing oxygen from reaching the roots, which can lead to root apoplexy and root rot. It can also influence the availability of nutrients, as certain nutrients become more soluble and can be washed out of the soil, reducing its fertility.

Excess rainfall moisture can lead to soil saturation, which generates anaerobic conditions similar to those caused by groundwater. Additionally, torrential rains can create excessive runoff and contribute to erosion. This excess moisture can affect not only the roots of plants, but also the activity of beneficial organisms in the soil, thus reducing its ability to sustain agriculture.

Soil reaction (pH) is a crucial indicator of soil health and influences the availability of nutrients to plants. An optimal pH for most agronomic plants is between 6.0 and 7.5. Acidic soils (pH <

6.0) can limit the availability of essential nutrients such as phosphorus, thus reducing soil fertility. In alkaline soils (pH > 7.5), deficiencies in microelements such as iron and zinc may occur. Also, the reaction of the soil affects the activity of beneficial microorganisms and the processes of mineralization of organic matter.

Humus is the stable part of organic matter in the soil and is essential for its fertility. Humus content influences water retention capacity, soil structure, and microbiological activity. A high humus content improves the soil's ability to retain nutrients and water, creating a favorable environment for plant development. Humus also contributes to soil stabilization and erosion prevention. Decreasing humus content, often due to intensive farming practices, can lead to reduced fertility and deterioration of soil structure.

Levels of nutrients such as phosphorus (P) and potassium (K) are essential for healthy plant development. Phosphorus plays a crucial role in the processes of photosynthesis, respiration and root development, being a vital element in the synthesis of DNA and ATP (adenosine triphosphate). A phosphorus deficiency can lead to slow plant growth and poor development of the root system. Potassium, on the other hand, is essential for regulating osmosis and water balance, contributing to the overall health of the plant, including resistance to water stress and disease. If these two nutrients are not available in sufficient quantities, soil fertility is severely affected and agricultural production can suffer.

All these limiting factors interact in a complex way and can influence soil fertility, thus impacting agricultural production and ecosystem health. Sustainable management of these conditions is crucial for maintaining adequate soil fertility.

In the administrative-territorial unit of Bănia, the limiting factors that significantly affect the quality of the soil are determined by the following aspects: a high degree of compaction, which affects approximately 49.8% of the area; the slope of the land and the risk of erosion, which is manifested on 49.5% of the territory; excess groundwater, present on 28.6% of the surface; excess rainfall, observed on 67.9% of the area; and moisture from overflows, which affects 18.9% of the land. In terms of agrochemical characteristics, the soil reaction is

moderately and strongly acidic in proportion of 77.8%. There is also a low content of humus and other essential nutrients, such as nitrogen, phosphorus and potassium, which affect 62.9% of the total area.

In Bozovici, the limiting factors influencing the quality of the soil cover are the following: soil acidity, low level of humus reserve, texture, high compactness (characterized by very low porosity), soil stability, slope, landslides, soil unevenness, surface erosion (including the risk of erosion) and excess moisture (groundwater, surface, from overflows or runoff on slopes). Other aspects include low temperature and moisture deficit.

Soil acidity is a limiting factor on approximately 44.38% of the analyzed area, with low pH values, with the following categories of limitations: moderate on 23.11% and reduced on 21.27%.

The humus reserve, due to its constituent and dynamic features, presents severe limitations on 0.85% of the territory, moderate on 59.16% and reduced on 22.17%.

As for compactness, it has severe limits on 0.50%, moderate on 9.40% and reduced on 0.18%.

The reduced edaphic volume is signaled with the following types of limitations: extremely severe on 0.38%, very severe on 33.28%, severe on 14.40%, moderate on 3.65% and reduced on 4.64%.

Landslides are classified according to severity, with extremely severe limitations on 3.31%, moderate on 1.29% and reduced on 7.05%. These landslides favor the appearance of excess moisture on the slopes, with moderate limitations on 9.98% and reduced on 14.21%.

Excess surface moisture is characterized by severe limitations on 0.93%, moderate on 1.06% and reduced on 0.17%.

In Dalboșeț Commune, the limiting factors that have a significant impact on soil quality include the following aspects: Deficit of the humus reserve, which is moderately manifested on 42% of the surface, severe on 3.8% and very severe on 15%. Humus moisture is essential for soil fertility and health. The acidity of the soil, with moderate limits on 21%, affects the availability of nutrients and biological activity in the soil. The fine soil texture is associated with moderate limitations on 0.5%, and the coarse texture has

severe limitations on 2.8%. The texture of the soil influences its ability to retain moisture and aerate. The useful edaphic volume has severe limitations on 38% of the territory and very severe on 1%. This affects the soil's ability to support vegetation and, implicitly, agricultural production. The slope of the land contributes severe limitations on 48% and very severe on 15%, which can lead to erosion and difficulties in water management. Landslides are characterized by extremely severe limitations on 0.32%, affecting soil stability and infrastructure. Excess groundwater moisture is present with severe limitations on 4.2% and very severe on 3.7%, which can cause drainage problems and affect plant roots. The excess stagnant moisture manifests itself moderately on 10.7% of the territory and severely on 4.2%, and the floodability presents severe limitations on 3.6%, which can complicate the cultivation of plants and affect the quality of the soil as a whole.

Within the administrative-territorial unit Eftimie Murgu, the limiting factors that affect the quality of the soil at the level of the cadastral territory are the following: The soil reaction is characterized by low values, being classified as follows: 32.10% slightly acidic soils, 26.70% moderately acidic and 29.90% strongly acidic. This acidity can influence the availability of essential nutrients for vegetation and the activity of microorganisms in the soil. The excess of surface moisture manifests itself variably, with low levels on 18.60% of the land, moderate on 14.50% and strong on 32.87%. This excessive accumulation of water can lead to stagnation, affecting plant roots and contributing to erosion. Excess groundwater moisture is present in varying degrees, with low humidity at 8.80%, moderate at 11.60%, strong at 7.70%, and excessive at 3.09%. This factor can favor anaerobic conditions, affecting plant development and contributing to soil degradation. The bearing capacity of the land is assessed as temporarily unsatisfactory on 24.05% of the surface, poor on 15.50% and moderate on 12.60%. It affects the soil's ability to support structures and vegetation, thus influencing agricultural production. The slope of the land varies between 5.1% and 35.0% and is over 45.1% on 45.70% of the territory. Steep slopes can increase the risk of erosion and water runoff, affecting soil stability and fertility.

In the Commune of Lăpușnicu Mare, the limiting factors that affect the quality of the soil cover are the following: The reaction of the soil, with acidified values, affects 43.8% of the surface. This acidity can significantly influence the availability of essential nutrients and the activity of beneficial microorganisms in the soil. The low reserve of humus is manifested on 36.3% of the territory, which can reduce the soil's ability to retain water and nutrients, essential for the growth of vegetation. Soil compactness is a major limiting factor, affecting 57.6% of the surface. Excessive compaction can restrict the circulation of air and water in the soil, thus compromising the healthy development of plant roots. The slope of the land contributes to the limitations of the soil, with extremely severe evaluations on 17.3%, very severe on 12.2% and severe on 21.4%. Steep slopes can increase the risk of erosion and affect soil stability, negatively influencing soil fertility. Excess groundwater is another limiting factor, with severe limitations on 6.6% and moderate limitations on 3.6%. This excess groundwater can generate anaerobic conditions, affecting the health of plant roots. Excess stagnant moisture is observed on 8.6% of the land, which can lead to stagnation of water on the surface and deterioration of soil quality, negatively affecting vegetation growth.

In Prigor Commune, the limiting factors that affect the quality of the soil cover within the cadastral territory are the following: The soil reaction is predominantly acidic, with low values: 12.20% of the soils are weakly acidic, 6.20% moderately acidic and 73.85% strongly acidic. This high acidity can negatively influence the availability of nutrients and the activity of beneficial microbial organisms in the soil. The excess of surface humidity is variable, having a low manifestation on 28.30% of the territory, moderate on 12.60% and strong on 19.60%. Excessive accumulation of water on the surface can lead to stagnation, affecting plant root health and the potential for erosion. Excess groundwater is observed with limitations: low on 8.80%, moderate on 10.20%, strong on 9.60% and excessive on 1.95%. This phenomenon can create anaerobic conditions in the soil, affecting root development and nutrient availability. The bearing capacity of the land is assessed as temporarily unsatisfactory on

37.60% of the surface, poor on 12.30% and moderate on 16.20%, which affects the soil's ability to support vegetation and infrastructure. The slope of the land varies, with values between 5.1% and 35.0% and over 45.1% affecting 55.20% of the territory. Steep slopes can intensify erosion and water runoff, influencing not only soil fertility but also its stability.

In Șopotu Nou Commune, the limiting factors influencing the quality of the soil cover within the cadastral territory are the following: The soil reaction presents low values, being distributed as follows: 25.50% of the soils are weakly acidic, 26.80% are moderately acidic, and 32.90% are strongly acidic. This variable acidity can affect the availability of nutrients to plants and the efficiency of biological processes in the soil. Excess surface moisture manifests itself variably, with 8.60% of the surface having low humidity, 6.80% moderate and 9.30% strong. Excessive accumulation of water on the surface can lead to stagnation of grasslands and compromise plant health. The bearing capacity of the land is assessed as temporarily unsatisfactory on 8.20% of the land, poor on 10.10% and moderate on 6.50%. These assessments influence the soil's ability to support vegetation and built structures. The slope of the land has varied values, with over 65.10% of the surface having slopes ranging from 5.1% to 35.0% and the steepest ones, with values higher than 45.1%. Higher slopes can increase the risk of erosion and affect soil stability, negatively impacting fertility.

These factors interact complexly, influencing not only soil fertility, but also its use for agricultural activities and the health of the local ecosystem.

CONCLUSIONS

This paper reveals an extensive research on the sustainable use and management of soil resources in the Almăjului Valley, Caraș-Severin County. The study highlights the importance of soil as an essential resource for agriculture, biodiversity and environmental sustainability. The research uses a rigorous methodology, based on national and international standards, integrating historical data from the O.S.P.A. Timișoara archive with

recent data from the field. The conclusions focus on identifying the limiting factors of soil fertility in different administrative-territorial units in the area.

The study identifies a series of limiting factors that affect the production capacity of soils in the Almăjului Valley. These factors are grouped into physical, physico-mechanical, chemical and biological categories.

Physical factors include the degree of compaction (compaction), the slope of the land, erosion, excess moisture (groundwater, rainwater, overflows). Compaction reduces soil permeability, affecting aeration and water infiltration, which inhibits root development and microbial activity. Steep slopes intensify erosion, loss of fertile layer and can lead to landslides. Excess moisture, regardless of the source, creates anaerobic conditions that limit root development and nutrient availability.

Among the agrochemical properties, acidity (low pH), low humus content and deficiencies of essential nutrients (nitrogen, phosphorus, potassium) stand out. The acidity of the soil affects the availability of nutrients, the activity of microorganisms and mineralization processes. Low humus levels reduce the capacity to retain water and nutrients, affecting soil structure and fertility. A deficiency of essential nutrients limits plant growth and development.

The paper draws attention to the impact of anthropogenic activities, especially intensive agriculture, on soil degradation. Excessive and uncontrolled use of pesticides and chemical fertilizers, deforestation, and accelerated urbanization contribute to erosion, compaction, decreased fertility, and contamination.

The study emphasizes the spatial variability of limiting factors, with significant differences between the administrative-territorial units analyzed. For example, in Bănia, compaction and excess rainfall are major problems, while in Bozovici, acidity, low humus reserve and compactness are main limiting factors. This variability requires management approaches tailored to the specific conditions of each area. From the point of view of sustainable management strategies, the research proposes the implementation of sustainable soil management strategies to combat degradation and promote long-term fertility growth. These

strategies include: crop rotation, agroforestry systems, vegetation cover, use of organic fertilizers, moisture conservation, rational grazing practices, and ecosystem restoration. The involvement of local communities is essential in the implementation of these strategies.

This paper aims to present a complex and detailed assessment of the limiting factors of soil fertility in the Almăjului Valley, highlighting the spatial variability of these factors and emphasizing the need to implement integrated strategies for sustainable soil management.

Combating soil degradation and promoting sustainable agriculture are essential to ensure food security, environmental protection and sustainable economic development of the region.

The conclusions of the research should serve as a basis for the development of effective policies and strategies for the conservation and sustainable use of soil resources in the Almăjului Valley and other regions with similar characteristics.

REFERENCES

- Blaga, Gh., Paulette, L., Udrescu, F., Filipov, I., & Rusu, D. V. (2008). *Pedology*. Cluj-Napoca, RO: Mega Publishing House.
- David, Gh., Țărău D., Șandor C. I., Niță, L. (2018). Soil and climate factors that define land productivity in the lower plain of Banat. *Conference Proceedings, Vol. 18*, Issue: 3.2, Albena, Bulgaria.
- Florea, N., & Munteanu, I. (2012). *Sistemul Român de Taxonomie a solurilor (SRTS)*. Craiova, RO: Sitech Publishing House.
- Mihuț, C., Niță, L. (2018). Atmospheric factors used to characterize soil resources. *Research Journal of Agricultural Science*, 50(1), 143–146.
- Mircov, V. D., Okros, A., Mihuț, C., Jercimovici, S., Dudas, M., Ciulca, S. (2021). Interpretation and Analysis of The Rainfall Regime in the Western Part of the Country for Timis and Caras Severin in 2015-2019. *Research Journal of Agricultural Science*, 53, 142.
- Montgomery, D. R. (2007). Soil erosion and agricultural sustainability. *Proc. Natl. Acad. Sci. U.S.A.*, 104, 13268–13272.
- Niță, L., Țărău, D., Rogobete, Gh., Niță, S., Bertici R., Tuta Sas I., Sas, I., Dicu, D. D. (2018). The role of ecopedological parameters in management sustainability of Banat lands. *Rev. Chim. (Bucharest)*, 69, No. 3.
- Niță, L. D., Niță, S., Imbrea, F., Lațo, K. I., Duma Copcea, A., Hînda, I. A., Bătrîna, Ș. L. (2024). Physico-geographical conditions defining the quality and

- quantity of resources in Almăjului valley area, Caraș-Severin County. *Scientific Papers. Series A. Agronomy*, LXVII(1), 157–163.
- Quinton, J. N., Govers, G., van Oost, K., Bardgett, R. D. (2010). The impact of agricultural soil erosion on biogeochemical cycling. *Nat. Geosci.*, 3, 311–314.
- Țărău, D., Rogobete, Gh., Dicu, D. D., Grozav, A., Niță L. D., Iliuță, A. Ș., Tudor, C. M., Bertici, R. (2019). Pământuri și locuri dintre Dunăre-Vârful Gugu-Crișu Negru. Timișoara, RO: Eurobit Publishing House.
- ***Metodologia elaborării studiilor pedologice, ICPA, 1987, Vol. I, II, III.
- ***Oficiul de Studii Pedologice și Agrochimice, Timiș.
- ***Ordinul 278 al MADR privind aprobarea Programului național privind realizarea Sistemului național de monitorizare sol-teren pentru agricultură (2011).