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ASSESSMENT OF AGRICULTURAL POTENTIAL AND SUSTAINABLE MANAGEMENT OF SOIL RESOURCES IN THE SEMLAC AREA, ARAD COUNTY, PEDOLOGICAL STUDY AND ECOLOGICAL MODELING

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Abstract. *This document presents a detailed analysis of the evolution and pedological and geomorphological characteristics of the Semlac area, located in Arad County, within the context of soil resource research and management. The methodology section addresses the process of identification, delimitation, and characterization of soil units, utilizing pedological mapping techniques, field analyses, and laboratory investigations, aimed at determining the morphological, physico-chemical, and hydrophysical properties of soils. The study includes the interpretation of natural formation conditions, such as geomorphology, lithology, climate, hydrogeology, and vegetation, identifying their influence on soil evolution. The area primarily features high-fertility soils, predominantly chernozems, which exhibit significant agricultural potential, along with other less extensive soil types such as faeozioms, cambisols, and gleysols, each with specific characteristics and limitations. From a socio-economic perspective, Semlac commune is strongly oriented towards agriculture, with approximately 87% of the arable land being utilized for cereal crops such as wheat, rapeseed, maize, and sunflower. These are managed by several agricultural companies equipped with modern machinery and technologies aimed at minimizing environmental impact. This work underscores the area's high agricultural potential, conditioned by the specific features of fertile soils and favorable natural conditions, but also highlights the importance of sustainable management practices to conserve edaphic resources in the context of increasing global food demand and climate change.*

Keywords *soil, chernozem, fertility, utilization, sustainability, land fund, agricultural technologies*

INTRODUCTION

Pedology, as a branch of soil science, has undergone a remarkable evolution, progressing from empirical and traditional perceptions to sophisticated scientific approaches supported by modern technologies and digital models. In this scientific domain, research focused on the understanding, characterization, and classification of soils has had a direct impact on sustainable development and the management of natural resources (BOCIOACĂ, 2015; BAIZE & TCHOUNDJEU, 2016).

During the 19th and early 20th centuries, scholars such as Thaer, Birnbaum, Knoop (for the German school), Docucheaev (the Russian school), and Storie (the American school) began to develop systematic classifications of soil properties based on morphological, chemical, and mineralogical characteristics.

In Romania, these contributions were adopted and adapted starting from the beginning of the 20th century, with the establishment of the Agropedology Section in 1906, led by Gh. Munteanu Murgoci, regarded as the founder of Romanian pedology. This phase was marked by the creation of the first comprehensive soil map of the country and the beginning of systematic soil surveying.

With technological advancements, soil mapping has experienced a true digital revolution. The use of satellites, Geographic Information Systems (GIS), and remote sensing has enabled the production of higher-quality maps with multidimensional precision at regional and national scales. Furthermore, these technologies facilitate continuous real-time monitoring

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of changes, identification of areas at risk of degradation or desertification, and contribute to the sustainable planning of soil resources (ŠIMANSKÝ et al., 2018).

In the past decade, progress in information technology has dramatically reshaped pedology, placing digital systems, machine learning algorithms, and predictive models at the center of soil mapping activities.

Georeferenced information systems (GIS) allow the integration and visualization of data from multiple sources: remote sensing, satellites, field surveys, laboratory analyses, and topographical data. Using GIS in soil mapping makes it possible to create detailed maps and analyze spatial and temporal variations, as well as model processes of soil formation and degradation (PACHECO et al., 2017).

Artificial intelligence and machine learning models provide a framework for automatic identification of soil types from large datasets, even under conditions of incomplete or highly variable data. Algorithms such as Random Forests, Support Vector Machines, or neural networks can be trained on extensive datasets to classify land with significantly higher accuracy than traditional approaches. This method also enables the prediction of soil types in inaccessible or extensive areas, contributing to the production of high-resolution digital maps (SANTOS et al., 2020).

A major outcome of international efforts remains the World Reference Base for Soil Resources (WRB), a classification system developed by FAO and ISSS (International Society of Soil Science), which was updated in 2014 and has become the global standard for comparison and communication in pedology (FAO & UNESCO, 2015).

The WRB is based on physical criteria aimed at identifying soil profile characteristics, as well as on relationships between pedogenetic processes and properties that can be diagnosed in the field. This system addresses global ecological diversity, being extensively used in research and resource management.

Following its adoption in 1984, the World Reference Base for Soil Resources (WRB), soil systematization and classification have gained a new dimension at the global level. WRB relies on objective diagnostic criteria, such as color, texture, pH, presence of specific horizons (e.g., argilo-illuvial, calcareous, eutric), and formation or degradation processes.

It is a dynamic system, periodically updated to reflect the latest discoveries and methodologies. WRB promotes a unified and comparative approach worldwide, being complemented and integrated with other national systems (DINER et al., 2018).

The historical evolution of soil science reflects not only advances in knowledge but also the impact of available technologies and those necessary for sustainable resource management. Initially, knowledge was empirical and localized, then structured into national and international systems, and recently updated in complex digital environments.

Modern classification systems evolved from approaches based on morphological properties to integrated systems that combine morphological, pedogenetic, chemical characteristics, as well as those generated by digital technology. In Romania, systems like S.R.T.S. 2012 and international ones like WRB allow for standardized, comparable classifications globally, supporting advanced data management and operational decision-making.

MATERIAL AND METHODS

This study aims to establish a comprehensive soil information database that serves as a scientific foundation for the adoption of the most effective technological measures tailored to each studied territory. The main objectives of this research can be summarized as follows:

Identification, delimitation, and inventory of soil-plant units within the analyzed area;

Morphological, physical, hydro-physical, and chemical characterization of these units, in accordance with cartographic data;

Highlighting the nature and severity of natural and anthropogenic factors that limit or constrain the potential for agricultural productivity.

To achieve these objectives, data obtained from both direct field observations and laboratory studies and analyses, as well as from the archives of the Arad Soil Survey Office (O.S.P.A.), were utilized, ensuring a robust and diverse research base.

During the process of identifying and delimiting soil units, multiple pedological profiles were excavated, from which samples were collected both under natural conditions and in conditions of land modification (due to human activities).

To meet the research goals, a series of specific pedological methods were employed, including: soil mapping, morphological description, rapid in-field determinations, laboratory analyses, and the processing and interpretation of pedological data.

Consequently, based on recent data obtained through direct observation and subsequently processed, a specific number of genetic soil types were identified within the study area. Profiles were strategically positioned in representative zones of the terrain to describe the most relevant soil types and subtypes.

Samples for physico-molecular characterization were collected under controlled conditions, using known-volume metal cylinders at the current soil moisture state, and in special containers for micromorphological analyses. Meanwhile, samples for chemical analyses were collected in plastic bags for each genetic horizon.

To determine specific chemical parameters, agrochemical samples were taken from the processed layer, employing standard methods. Morphological descriptions and ecopedological conditions were conducted according to the “Romanian Soil Taxonomy System” (2012), supplemented and adjusted in accordance with the “Methodology for Developing Pedological Studies” (Volumes I, II, III, 1987), elaborated by the Institute of Pedological and Agrochemical Research (ICPA) in Bucharest.

The research results led to the identification of a number of genetic soil types in the studied area, with profiles strategically placed in representative zones. These enable the description and classification of the most important soil types and subtypes, according to national and international systems, allowing for applications in agricultural planning, environmental protection, and land amelioration.

RESULTS AND DISCUSSIONS

1. CONDITIONS OF NATURAL SOIL FORMATION AND EVOLUTION

1.1. Geomorphology

From a geomorphological perspective, the studied area falls within the Arad Plain, which presents a flat landscape punctuated by numerous positive forms (ridges) and negative features (micro depressions, island meanders, etc.).

The Arad Plain extends north of the Mureș River, situated between the Zarand Mountains to the east and the Nădlac Plain to the west, along with the border with Hungary. It constitutes a relatively newer formation compared to the Nădlac Plain, representing a cone of the Mureș River built upon the subsiding area of the Crișul Alb (approximately at the level of terraces 1 and 2).

1.2. Geology and Lithology of Surface Deposits

Lithologically, the investigated perimeter is characterized by a succession of stratified deposits of varying age, thickness, and granulometric composition, depending on the meso- and microrelief features.

Negative landforms, represented by poorly developed depressions, consist of fine-textured deposits (clayey-silted, clayey) at depths of about 1–1.3 meters, transitioning into deposits with medium-fine texture (silty-clayey, silty-clayey-sandy) up to 1.0–1.8 meters. Below this depth, the underlying bedrock generally exhibits medium texture (clayey, silty-clayey, silty-sandy), followed by deposits with coarse textures (sandy, sandy-silty).

1.3. Climate

The study area exhibits a temperate continental climate, characterized by shorter, milder winters. It features a diverse air mass circulation, driven either by dynamics centers (Azores anticyclone and subtropical anticyclone) or seasonal thermal centers (Siberian anticyclone, Asian depression, or Mediterranean depression).

The researched zone is situated at the intersection of air masses of oceanic origin (from the west), which often approach this area with increased continental influence, and east-origin continental air masses. It is also frequently affected by warm southern air masses crossing the Mediterranean Sea. According to Kopen’s (1931) climatic maps, the studied perimeter falls within the c.f.b.x. climatic province.

1.4. Hydrography and Hydrogeology

The Semlac territory lies within the Mureș River basin. The hydrographic network is poorly developed within the plain, with only the Ier and Matca canals, created by depression channels from ancient watercourses. Rarely, in more accentuated depressions, lakes may appear. In the mountainous zone (Zarand Mountains), there are several semi-permanent torrential valleys facilitating drainage of the territory.

1.5. Vegetation

From a vegetative point of view, the studied area belongs to the forest-steppe to steppe zone, with predominant herbaceous associations characteristic of the forest-steppe.

In the recent past, most of the studied territory was covered by forests formed mainly of *Quercus spp*., *Carpinus spp.*, *Populus spp.*, *Fraxinus spp.*, and *Betula spp*. The existence of remnants of natural forest in this area is also attested by isolated trees encountered today. The herbaceous vegetation is adapted to the different soil and microrelief conditions.

In lower-lying areas (valleys and depressions) with excess moisture, the vegetation is characteristic of these conditions and includes species that prefer moist environments, such as: *Phragmites communis* (reed), *Carex spp*. (sedges), *Scirpus spp*. (bulrush), *Juncus spp*. (rush), *Poa palustris* (marsh bluegrass), *Mentha pulegium* (pennyroyal), *Polygonum hydropiper* (water knotweed), and *Typha spp*. (cat-tails), among others.

2. PROCESSES OF SOIL FORMATION IN THE STUDIED AREA

Pedogenetic processes are fundamental to the formation and evolution of soils in the studied region of Semlac commune, Arad County. These soils have developed through the interaction of pedogenetic factors, including climate, vegetation, relief, parent rock, and the groundwater level. Human intervention, such as land cultivation and hydroameliorative works, has also influenced the soil evolution.

Following the retreat of the former Pannonian Lake, the area transformed into a vast plain covered primarily by alluvial and loess deposits, especially on higher terrains. Initially, the soils were of marsh type, characterized by excess moisture. However, as the region elevated, water surplus diminished, and the marsh soils transitioned into gleic soils, which are still evident today in the lower-lying zones.

The stabilization of watercourses, both through natural processes and human-made interventions such as dikes and drainage works, enhanced water removal and, in conjunction with the vegetation typical of the forest-steppe climate, intensified cernoziom formation processes. This led to the development of wet, freatic cernozioms on higher grounds, which exhibit leaching phenomena of carbonates.

In depresional areas, after drainage, the soils were shielded from direct water influence; however, the salinization process was triggered by groundwater rich in salts, which, through evapotranspiration, deposited salts in the soil profile. The sodium-loaded water caused clay dispersion and the formation of an impermeable horizon, typical of solonetzic soils.

The processes of solonetzization and salinization coexist with solodization, which results in the deposition of a colloidal clay layer on the soil surface. In the former floodplain, soil evolution progresses from marsh to cernoziom, driven by internal and external drainage processes.

Human hydroameliorative works have had a positive impact on soil development by improving drainage and permeability, thus enabling the formation of soils with higher fertility.

3. LAND USE AND LAND RESOURCE BASE OF SEMLAC COMMUNE, ARAD COUNTY

Table 1.

Detailed distribution of land in Semlac commune

Locality	Ha	% of Total Agricultural Area	% of Total Area
Arable land	7,156	99.16%	87.07%
Pastures	52	0.72%	0.63%
Hayfields	0	0%	0%
Vineyards	0	0%	0%
Orchards	9	0.12%	0.11%
Total agricultural land	7,298	100%	87.81%
Forests	34	-	0.41%
Water bodies	314	-	3.78%
Other categories	665	-	8.00%
Total area	8,311	-	100%

The data presented in the table reveals a detailed distribution of land use within Semlac commune, providing information about various land categories and their percentages relative to the total agricultural area and the total territorial surface.

The arable land constitutes the majority of the agricultural land, representing a significant proportion of the total area of the commune. Pastures occupy a small share of both the agricultural land and the overall surface area. Essentially, there are no hayfields or vineyards, and the orchards comprise a negligible part of the total surface.

Most of the total arable land is utilized for agricultural activities, indicating a predominantly agricultural land use model. Forests, water bodies, and other categories occupy small areas, with forests being limited and water bodies of moderate extent. This distribution suggests that land use is primarily oriented toward agriculture, with minimal resources allocated for forestry or water resources.

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In conclusion, Semlac commune is strongly focused on agricultural land use, with arable land being predominant, and it has limited natural resources such as forests and water bodies.

4. MAIN SOIL TYPES FOUND IN SEMLAC COMMUNE, ARAD COUNTY

Table 2.

Principal soils identified and delineated within the total arable land of Semlac commune, Arad County

Soil Class	Soil Type	Soil Subtypes	Surface Area (ha)	Percentage (%)
Protisol (Protisoils)	Aluviosol	Gleyic	28	0.39
	Cernisol (Chernozem)	Typical, Cambic, Gleyic, Salsodic	5,264	73.56
	Faeoziom	Cambic, Stagnic	1,228	17.17
Cambisol (Cambisols)	Eutricambosol	Calcareous, Gleyic, Amphi-gleyic	593	8.28
Antrisol (Arenosols)	Antrosol	Erodic	43	0.60
Total	Aluviosol	Gleyic	7,156	100

Figure 1. Distribution of soils in Semlac commune, Arad County

Interpretation and analysis of the table and figure reveal the distribution of various soil types and subtypes according to surface area and percentage share.

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- Protisol class – Aluviosol type (Gleyic subtypes): occupies 28 hectares, representing only 0.39% of the total area. This soil type is characterized by accumulations of recent loose materials, often saturated with water.
- Chernozem class – Cernisol (Typical, Cambic, Gleyic, Salsodic subtypes): covers 5,264 hectares, accounting for 73.56% of the arable land. Chernozems are highly fertile soils, constituting the largest proportion of the surface area. They are essential for agriculture as they are rich in humus.
- Faeozem class: with Cambic and Stagnic subtypes, spans 1,228 hectares, or 17.17%. Although less fertile than Chernozems, Faeozems are still important for agricultural activities.
- Cambisol class – Eutricambosol (Calcareous, Gleyic, Amphi-gleyic subtypes): occupies 593 hectares (8.28%). Cambisols are moderately fertile soils, frequently formed on high terrains, and found across a variety of climates.
- Antrisol class – Antrosol (Roderic subtypes): covering 43 hectares, or 0.60%. These soils are affected by human activity, such as erosion caused by intensive farming.

Total surface area of soils: 7,156 hectares.

The soils in the region are predominantly Chernozems (especially Chernozems), indicating a very favorable territory for agriculture. Other soil types contribute smaller areas, each with unique characteristics that can influence land use. This distribution suggests a predominance of productive soils, highly valuable for agricultural activities.

5. MORPHOLOGICAL CHARACTERISTICS AND PHYSICOCHEMICAL PROPERTIES OF THE SOILS IN THE STUDIED AREA

5.1. Gleyic Alluvial Loamy Soil (Gleic Alluvial Soil), Moderately Gleyed, Proxicalcaric, Fine Sandy Loam / Medium Loamy Sand, on Carbonate River Deposits, Coarse Texture, with Groundwater at 1–2 meters depth.

Formula: AS gc-lu -G3-K1-33/22-21101

Location: Floodplain, undulating plain, groundwater at 1–2 meters.

Arad County, Semlac locality.

Surface appearance: Generally normal.

Soil Characteristics:

Morphological horizons: Apk – Aok – Ck – Ck.

Ațelk (0–13 cm): Yellowish, crumbly due to agricultural activities, friable, with slight effervescence, gradual transition, moderately plastic.

Aok (13–28 cm): Yellow-brown, moderately structured, moist and friable, with a moderately granular structure, plastic, with weak effervescence.

Ck (28–42 cm): Yellow-vine colored, very friable, unstructured, compact, with weak effervescence, slight adhesiveness.

Ck (42–54 cm): Yellow-vine colored, very friable, unstructured, compact, with weak effervescence, slight adhesiveness.

Physicochemical and Hydro-physical Properties:

Texture: Fine sandy loam between 0–28 cm, medium loamy sand between 28–54 cm.

Total porosity: Intermediate values between 0–54 cm.

Bulk density (BD): Moderate values between 0–28 cm, low values between 28–54 cm.

Reaction: Alkaline throughout the profile's depth.

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Calcium carbonate ($CaCO_3$): Low across the entire profile.
Humus reserve: Medium in the top 50 cm.

5.2. Typical Argic Chernozem (Cz ti-ar) – Slightly Salinized and Slightly Alkaline, Proxicalcaric, Medium to Loamy Argillic, on Eolian, Loess, and Medium Carbonate Loessoid Deposits, with Groundwater at 5–10 meters

Formula: Cz ti-ar-S11-A11-K1-52/52-23103
Location: High plain, undulating terrain, groundwater at 5–10 meters.
County: Arad, Semlac locality.
Surface aspect: Generally normal.
Soil Characteristics:
Morphological horizons: Apk – Amk – ACca – CAca – Cca – Cca – Cca.

Apk (0–18 cm): Dark brown, with a crumble structure disturbed by tillage, exhibits slight effervescence, mildly compact, friable.

Amk (18–41 cm): Brown, disrupted structure due to soil work, friable, with fractional effervescence, mildly compact.

ACca (41–56 cm): Dark brownish, weakly structured, moderately developed, compact, with effervescence, indicating a rapid transition.

CAca (56–80 cm): Brown, large polyhedral shape, moderately developed, friable, with moderate to high effervescence.

Cca (80–103 cm): Yellow-brown, unstructured, with $CaCO_3$ crystals, friable, with strong effervescence, and weak roots.

Cca (103–147 cm): Yellowish-brown, diffuse transition, weakly compact, with $CaCO_3$ crystals, friable, with very strong effervescence.

Cca (147–200 cm): Yellow with brownish streaks, gradual transition, compact, with $CaCO_3$ crystals, very strong effervescence, friable.

Physicochemical, Hydro-physical, and Chemical Properties:

Texture: Medium clay loam between 0–56 cm, clay loam / fine clay between 56–80 cm, and clay loam to clay between 80–200 cm.

Total porosity: Intermediate values between 0–56 cm.
Bulk density: Intermediate between 0–50 cm.
Reaction: Alkaline from 0–103 cm, moderately alkaline from 103–200 cm.
Calcium carbonate ($CaCO_3$): Intermediate values from 0–41 cm, higher between 41–200 cm.
Humus reserve: Medium in the top 50 cm.

5.3. Cambic Argic Faeozem, Slightly Gleyed, Endocalcaric, Medium to Loamy Argillic, on Eolian, Loess, and Medium Carbonate Loessoid Deposits, with Groundwater at 2–3 meters

Formula: Fz cb-ar-G2-K3-52/53-23103/50
Location: High plain, undulating terrain, groundwater at 3–5 meters.
County: Arad, Semlac locality.
Surface aspect: Generally normal.
Soil Characteristics:
Morphological horizons: Ațel – Am – AB – Bv – BC – CbK – Ck – Ck – Ck.

Ațel (0–21cm): Dark brown, with disturbed structure due to tillage, moderately friable, plastic.

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Am (21–32cm): Dark brown, disturbed structure, friable, with a diffuse transition, slightly compact.

AB (32–45cm): Dark brown, gradual transition, small to medium polyhedral structure, well-developed, friable, slightly compact.

Bv (45–59cm): Dark brown, gradual transition, medium polyhedral structure, well-developed, friable, dry.

BC (59–84cm): Brown, diffuse transition, large polyhedral structure, poorly developed, friable.

CbK (84–110cm): Yellowish with brownish drips, diffuse transition, unstructured, friable.

Ck (110–150cm): Yellowish with brownish drips, diffuse transition, unstructured, friable, plastic, slightly adhesive.

Ck (150–170cm): Yellow, clear transition, unstructured, rewet, plastic, adhesive, friable, sub-veneous.

Ck (170–200cm): Yellow-vine colored, diffuse transition, unstructured, plastic, slightly unstructured, adhesive, friable, sub-bovine.

Physicochemical, Hydro-physical, and Chemical Properties:

Texture: Sand-lut loam between 0–29cm, clayey loam between 29–72cm, and clay loam to loam between 72–200cm.

Total porosity: Intermediate values between 0–50cm.

Bulk density (BD): Low between 0–50cm.

Reaction: Alkaline throughout the profile.

Calcium carbonate ($CaCO_3$): Midhigh values along the entire profile depth.

Humus reserve: Low in the top 50cm.

5.4. Eutricambosol Calcic-Gleiic-Argic, Strongly Gleyed, Proxicalcaric, Loamy Clay / Loamy Argillic, on Medium Fine Carbonate River Material Deposits, with Groundwater at 1–2 meters

Formula: Ec ca-gc-ar-G4-K1-53/61-21150

Location: Floodplain, depression, with groundwater at 1–2 meters.

County: Arad, Semlac locality.

Surface appearance: Generally normal.

Soil Characteristics:

Morphological horizons: Ap – Aog3 – BVg3 – Cg4 – Cg4 – Cg4 – Cg4.

Ap (0–13cm): Brown, disturbed structure due to tillage, moderately friable, plastic.

Aog3 (13–29cm): Ochre-brown, disturbed structure due to tillage, moderately friable, adhesive.

BVg3 (29–51cm): Dark brown, with a small polyhedral structure, well-developed, adhesive.

Cg4 (51–72cm): Brown, unstructured, moderately compact, effervescent.

Cg4 (72–100cm): Brown with rust-colored and bluish spots (8–10%), unstructured, moderately developed.

Cg4 (100–134cm): Yellow-brown, with rust-colored and bluish spots (20–25%), unstructured, adhesive, compact.

Cg4 (134–200cm): Yellow-vine colored, with rust-colored and bluish spots (35–40%), unstructured, weak effervescence, adhesive, compact.

Physicochemical, Hydro-physical, and Chemical Properties:

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Texture: Sand loam and clayey loam between 0–29cm; clay loam to loam between 29–72cm; loam between 72–200cm.

Total porosity: Intermediate values from 0–50cm.

Bulk density (BD): Low values between 0–50cm.

Reaction: Alkaline throughout the profile (0–200cm).

Calcium carbonate ($CaCO_3$): Midhigh values across the entire profile.

Humus reserve: Low in the first 50cm.

CONCLUSIONS

The studied area, located in the Arad Plain, presents a flat relief characterized by numerous positive features (ridges) and negative features (microdepressions, meander remnants). This geomorphological setting significantly influences pedogenetic processes, the redistribution of parent material, and consequently, the formation of various soil types.

The stratified succession of deposits within the study area reveals the presence of multiple layers with variable granulometric composition, ranging from fine-textured argillaceous deposits to medium and coarse textured materials, culminating in the underlying bedrock. These factors contribute to the diversity of soil types and their physicochemical properties.

The climate in this zone is moderate, characterized by shorter, milder winters and influenced by the circulation of air masses of both oceanic origin from the west and continental origin from the east. The movement of these air masses, combined with the influence of warm Mediterranean air masses crossing the Mediterranean Sea, results in variable climatic conditions that impact the hydrological cycle and pedogenetic processes.

The hydrographic network is poorly developed on the plain, primarily consisting of ancient watercourses' channels—namely, the Ier and Matca canals—created by depositional processes in depressions. In the mountainous zone (Zarand Mountains), semi-permanent torrential valleys provide drainage, directly affecting the formation and evolution of soils.

Vegetation history indicates that the area was historically covered by forests dominated by species such as Quercus, Carpinus, Populus, Fraxinus, and Betula. Currently, the predominant vegetation consists of pastures and herbaceous plants adapted to the silvosteppe environment. The specific vegetation influences soil horizon formation and biological and chemical renewal or degradation processes.

The soils in this region formed through interactions among pedogenetic factors—climate, vegetation, relief, parent rock, and the water table. Pedogenic processes such as cernoziomification were intensified by human interventions, including drainage and land reclamation, leading to the development of fertile cernozioms and other valuable soil types. Salinization and solonetzic processes, combined with solodization, contribute to the diversity and fertility of the soils, especially in wetlands and floodplain areas.

Human hydroameliorative interventions, such as drainage and desiccation, have positively impacted soil development by improving drainage and permeability, facilitating the formation of soils with increased agricultural potential. However, some soils are affected by salinization or solonetzic phenomena, influenced by local conditions and the groundwater level.

In summary, a detailed analysis of the soil profiles in the Semlac area, Arad County, reveals considerable diversity influenced by pedogenetic factors—recent deposits, eolian and loess materials, and groundwater dynamics. Morphological, chemical, and physical characteristics point to a high agricultural potential, especially for Chernozem and certain carbonate and gleic subtypes. Their sustainable use requires specific management measures to prevent degradation phenomena such as solonetzization, salinization, and erosion.

Furthermore, the significance of these soils extends beyond their agricultural potential, contributing to ecological balance and biodiversity through their diversity and spatial distribution.

Recommendations; Continuous monitoring of physicochemical and morphological parameters to ensure sustainable and locally adapted land management.
Implementation of ameliorative measures in areas affected by salinization and solonetzization to enhance fertility and stability.

Optimization of the agricultural potential of Chernozems and carbonate profiles through modern, eco-friendly farming practices.

Thus, understanding and properly managing these soil characteristics are crucial for ensuring the sustainable use of pedological resources, promoting ecological stability, and maintaining biodiversity in the studied area.

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