IDENTIFICATION OF SECONDARY SALINIZATION AREAS ON AGRICULTURAL LANDS IN THE SOUTH-EAST DEVELOPMENT REGION OF ROMANIA

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Abstract

Secondary salinization is an anthropogenic process involving the excessive accumulation of soluble salts and represents one of the most significant threats to agricultural sustainability and global food security. Unlike primary (natural) salinization, this phenomenon is a direct consequence of human activities, primarily the inappropriate water management in irrigated perimeters. The main causes include the use of irrigation water with a high salt content, inadequate internal and external drainage of the land, and the rise of the mineralized phreatic water level into the active soil zone through capillary uplift. The South-East Development Region of Romania is characterized by vulnerability to drought and a history of extensive irrigation systems, and is currently facing an expansion of salt-affected areas. The present study aims to identify the areas affected by secondary salinization using an integrated approach combining Geographic Information System (GIS) technology and validation through field pedological analyses. The results indicate a strong correlation between low-lying, poorly drained areas and long-term irrigation practices, providing a vital tool for the sustainable management of soil and water resources and for prioritizing ameliorative measures.

Key words*:*soil degradation, secondary salinization, electrical conductivity, irrigation management, GIS

INTRODUCTION

Global food security and the sustainability of terrestrial ecosystems rely fundamentally on healthy soil resources. Soil degradation, especially salinization, is one of the greatest challenges of the 21st century, driven by current climatic and demographic pressures. The FAO (2021) warns that over 20% of the world's irrigated land is already salinized, directly threatening agricultural productivity and livelihoods globally.

In Romania, specialized literature indicates that approximately 614,000 hectares are affected by salinization, with an additional 600,000 hectares with a high potential for secondary salinization. Saline soils typically occur in low-lying, depressional areas with poor natural drainage. Irrigation significantly increases salinization risk, especially in drought conditions and where the groundwater table is shallow.

The primary (natural) salinization (arid/coastal zones) is differentfrom the secondary (anthropogenic) salinization, the focus of this research. Secondary salinization is expanding alarmingly due to human activities, particularly inadequate agricultural water management. It is primarily triggered by irrigation systems, especially when drainage is deficient. The constant input of dissolved salts via irrigation water, combined with high evapotranspiration in semiarid zones, causes the mineralized water table to rise. This leads to the progressive concentration of salts in the root zone, resulting in toxicity (osmotic and ionic stress), irreversible soil structure degradation, and eventual land abandonment.

The South-East Development Region of Romania – the country's larger area cultivated with cereals–is strategically important, but paradoxically vulnerable. Although extensive irrigation was developed here in the latter half of the 20th century to address the semiarid climate and pronounced water deficit, the subsequent poor maintenance, low efficiency, and lack of rigorous water management and functional drainage have created optimal conditions for accelerating the secondary salinization.

Overall, land degradation through salinization is one of the most aggressive and dynamic processes diminishing the agro-productive potential of Romanian soils, particularly in the steppe and forest-steppe plain regions.

MATERIALS AND METHODS

The study area is the South-East Development Region of Romania, an area with a high vulnerability to soil degradation phenomena, particularly secondary salinization. Geographically, the region is dominated by plain and floodplain units, such as the Eastern Romanian Plain (especially the Bărăgan Plain) and the Danube Delta, including the Danube Floodplain. The dominant landformsare characteristic to plain and floodplain, with low slopes and frequent microdepressions that favour water stagnation and limit surface drainage. The region is in the excessive temperate-continental climate, characterized by hot and dry summers, with a potential evapotranspiration significantly higher than the mean annual precipitation (which often does not exceed 450-500 mm). This severe water deficit intensifies the capillary movement of water from the groundwater table toward the surface during warm periods, leading to the accumulation of salts in the active soil horizon (Figure 1).

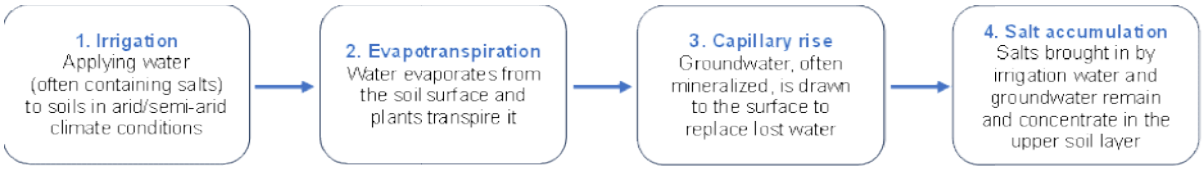

Figure 1.The mechanism of secondary salting

For the purpose of this paper, representative areas were selected from the Brăila, Buzău, Galați, and Vranceacounties, in order to identify secondary salinization areas on agricultural land.

To achieve the aim of this study, the following materials were used: Soil map of Romania (1:200,000); Map of salt-affected soils and soils susceptible to salt affection Romania (1:1,000,000); Groundwater map (or phreatic water map) (1,000,000); Map of landforms (or geomorphological map) (1:200,000); Climatic map (1:500,000); and Topographic maps at 1:25,000 scale, provided as georeferenced images.

RESULTS AND DISCUSSIONS

Through multi-criteria analysis within the Geographic Information System (GIS), by

overlapping and weighting the data from the aforementioned maps, a complex map of secondary salinization on agricultural lands was developed. The areas occupied by lands affected by secondary salinization were calculated, being presented in Table 1 and Figure 2.

Table 1. Distribution of saline and salts affected lands in representative areas (Brăila, Buzău, Galați, and Vrancea counties)

Legend	Formule	Area		
		ha	% from agricultural area	% from administrative area
Groundwater table depth between 0 – 2 m				
<1.5 g salts/l	2As[M-F] / [LQ2-3m1]4-2	1921.08	0.8	0.1
1.5 – 2 g salts/l	2As[M-F] / [LQ2m2]4-2	28521.01	11.3	1.4
>2 g salts/l, fine texture	2Sa[F] / [LQ0-2m3]6-2	22334.55	8.8	1.1
>2 g salts/l, medium texture	2As[M] / [TQ2-3m3]2-2	2241.90	0.9	0.1
Groundwater table depth between 2 – 3 m				
<1.5 g salts/l	2Sa[M] / [TQ3m1]3-2	801.55	0.3	0.0
1.5 – 2 g salts/l				
>2 g salts/l, fine texture	2As[F] / [TQ3m3]4-2	6071.15	2.4	0.3
>2 g salts/l, medium texture	2Sa[M] / [TQ3m3]2-2	7101.28	2.8	0.4
Primary salinization				
Saline soils		166504.62	65.7	8.2
Low risk		17903.72	7.1	0.9
Total agricultural area		**253400.86**	**100.0**	**12.55**
Total administrative area*		**2019166.00**		

*accordingNIS

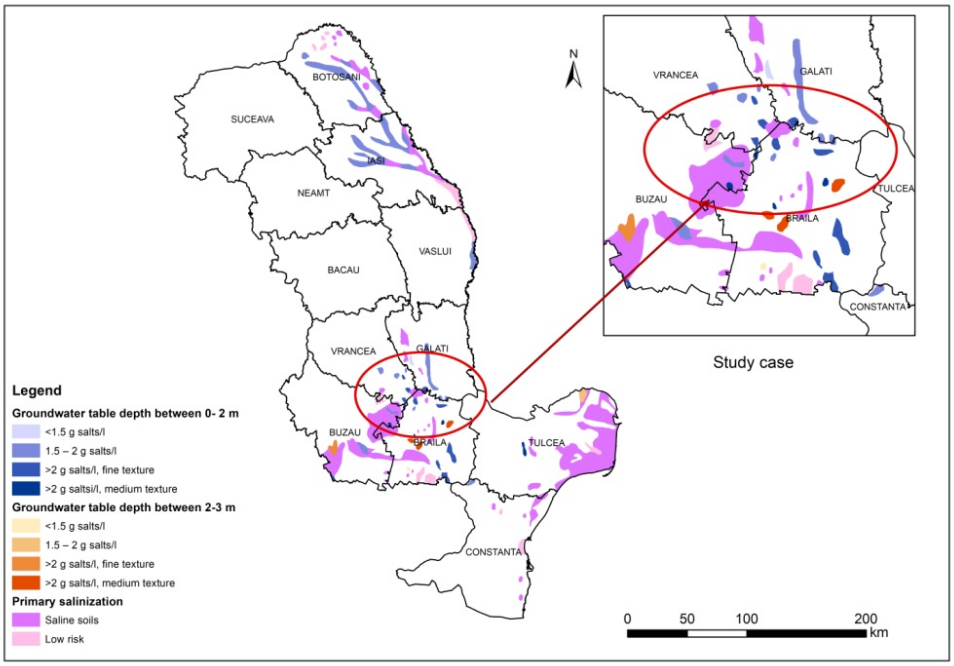

Figure 2. Distribution of saline and salts affected lands in the South-East Development Region of Romania

The main category is the areas where the groundwater table depth is between 0-2 m and the salts concentration is between 1.5 and 2 g salts/l (11.3%) followed by those with >2 g salts/l, fine texture (8.8%).

CONCLUSIONS

The study demonstrates the effectiveness of the integrated approach (GIS and field data calibrated) for the identification and monitoring of secondary salinization at a regional scale. The paper confirms that irrigation practices uncoupled with an efficient drainage system represent the main driver of secondary salinization in the South-East Region. The secondary salinization map for the agricultural lands in the South-East Development Region of Romania represents an essential decision-support tool for agricultural and environmental authorities, allowing for the prioritization of investments in the rehabilitation of drainage systems and in the implementation of conservative agricultural practices (e.g., soil leaching, selection of salt-tolerant crops). Further multiannual monitoring is recommended to capture the dynamics of the phenomenon in the context of climate change.

Directions for action:

- water management: implementing drip irrigation, monitoring irrigation water quality, and improving drainage (subsurface and surface);
- soil amendments: applying amendments to counteract the effects of sodium (reducing SAR – Sodium Adsorption Ratio) in affected soils;
- ameliorative measures: using salt-tolerant crops (e.g., barley, saltbush/salt-tolerant canola) which can aid in salt extraction and soil structure improvement;
- conservative agriculture: increasing soil organic matter content through the introduction of cover crops and performing minimum tillage to enhance soil resilience.

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