PEDOLOGICAL RISKS IN ROMANIA. PRELIMINARY ANALYSIS

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ABSTRACT. – Pedological risks in Romania. Preliminary analysis. The pedological resources of a territory lay at the basis of agricultural potential, because they have a direct influence on the favorability or restrictiveness of a territory for a certain use. Therefore, the study of the physical-chemical and morphological characteristics of soils becomes very important when one proposes economically viable agricultural crops. The restrictive climatic and morphological factors may have isolated or cumulative negative effects on the agricultural sector in a certain territory, but the pedological risks are most difficult to mitigate. The purpose of this study is to analyze the distribution of pedological risk classes across Romania, assessing the scientific literature in the field, and to highlight the regions comprising the largest areas affected by soil-related risks.

Key words: pedological risks, pedological drought, soil loss, salinization.

1. Introduction

The environmental changes emerged as a consequence of the present climate changes but also as a result of the anthropogenic influence at global level have an extensive rate of occurrence both in terms of intensity and areal coverage. Among the present hazards and risks that have a direct influence on human life, one highlights the processes of soil degradation due to pedological processes (soil alteration, soil pseudogleization, gleization and pollution) and geomorphological processes (gravitational or water-related processes). Most of the times, the processes of soil degradation are assessed individually or in multidisciplinary studies on smaller areas, or even on larger areas. However, there is no unanimously accepted study methodology, the studies are made at different scales, different resolutions, they are discontinuous in space and time, despite the fact that effects have a large-scale impact by complicating maintenance works and making use of energy-consuming technologies, as well as diminished production in agriculture.

The purpose of this study is to highlight the processes of soil degradation at national scale in order to point out the hotspots which need special attention and

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where mitigating measures need to be applied, to reduce the negative effects of these processes in the terms of land use, without claiming to exhaust the subject matter. Stress will be laid on the creation of a national database regarding the areas impacted by pedological hazards, and the framing of the national territory in a qualitative approach based on expert knowledge in terms of cumulated risk classes for the most relevant risk processes affecting Romanian soils. In practice, a set of synthetic specific indicators are used to assess the quality of soils, according to certain threshold values, therefore soils are distributed among specific classes. It is important to monitor the changes emerged over time in order to identify the trends of evolution and to apply the best measures to mitigate the negative effects.

2. The pedological processes of risk in Romania

The pedological processes of risk in Romania are represented by the soil compactness, their pollution, the erosion caused by wind, the water erosion, the landslides, the salinization and acidification of soils, etc.

Next, we will present each of these risk processes, the area of coverage as well as the effects they have on local communities.

2.1. The pedological drought

The water deficit in the soil is directly proportional to the damage at the level of agricultural crops. To prevent pedological drought and to mitigate the negative effects registered, the National Board for the Mitigation of Drought, Land Degradation and Desertification has been established at national level in 2004 and has functioned ever since, under the coordination of the Ministry of Agriculture and Development.

The studies performed within the RORISK project have the objective of distributing the national territory according to classes of pedological risk, using the Pedological Drought Hazard Indicator (IHSP), as follows:

$IHSP = (ANr \times ANp) + (SMr \times SMp) + (SSr \times SSp) + (SEr \times SEp)$, where:

ANr – the ratings for the probability of occurrence provided for Almost Normal Drought (AP),

SMr – the ratings for the probability of occurrence provided for Moderate Drought (SM),

SSr – the ratings for the probability of occurrence provided for Severe Drought (SS),

SEr – the ratings for the probability of occurrence provided for Extreme Drought (SE)

ANp(=1) – the intensity weights provided for Almost Normal Drought (AP)

SMp(=2) – the intensity weights provided for Moderate Drought (SM),

SSp(=3) – the intensity weights provided for Severe Drought (SS)

SEp(=4) – the intensity weights provided for Extreme Drought (SE).

According to this methodology, one applies the rule that the minimal value of the Pedological Drought Hazard Indicator will be 10 (=1×1+1×2+1×3+1×4) if the rating for the probability of occurrence has values of 1 for all drought conditions – almost normal, moderate, severe and extreme drought, while the maximal value of the Pedological Drought Hazard Indicator will be 40 (=4×1+4×2+4×3+4×4) if the rating for the probability of occurrence has values of 4 for all four types of drought intensity (RORISK, 2019).

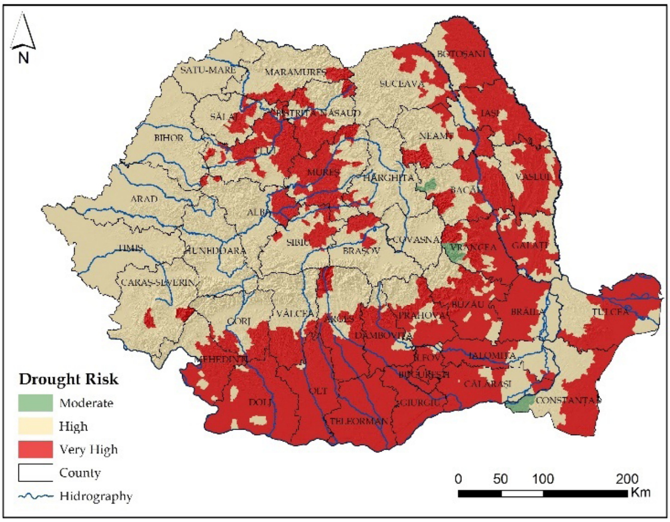

Fig. 1. The map of drought risk (processed according to RORISK, 2019).

Therefore, several counties stand out, like Dolj, Olt, Teleorman, Giurgiu, which are entirely included in the class of very high risk, while Mehedinți, Argeș, Dâmbovița, Prahova, Buzău, Vrancea, Iași, Vaslui, Mureș, Cluj and Bistrița-Năsăud have more than 50% of their area in the same class. The analyses performed on the variation of climatic elements at national level identified a decreasing trend of the average annual amount of precipitation compared to the values calculated for the last 100 years, and an increase of the daily precipitation between 5 and 20 millimeters on the account of precipitation above 20 millimeters. Thus, taking into account that the daily precipitation between 0.1 and 4.9 mm is largely lost due to evapotranspiration, the water deficit in soil has increased and the effects on agricultural crops and forest vegetation are beyond the limits of supportability.

To these territories, one should add the areas affected by soil loss, which also decrease agricultural production across large regions. Solutions are therefore searched for, to improve the irrigation systems in the regions where the needs of water are not covered and to find crops that are more resistant to drought (*Medicago sativa L., Quercus pedunculiflora, Quercus pubescens, Quercus polycarpa,* etc.) (Simonca et al, 2019).

2.2. Soil texture / Soil compactness

The pedological risks that refer to the physical, physical-mechanical and hydro-physical properties depend on the nature of the paternal material and on the environmental conditions over time, as the soil is an open and dynamic system, subject to continuous but functional changes. Thus, certain physical and chemical parameters of soils and the values in excess of those considered the limit may induce a certain degree of risk in the territory, by limiting some types of agricultural crops, considerably diminishing economic profits and changing biodiversity.

The granulometric composition of the mineral part of the soil represented by the soil texture provides a detailed image on the mineral component of soils. According to Atterberg classification, in Romania there are the following granulometric fractions: clay (<0.002 mm), dust (0.02-0.002 mm (P1), 0.01-0.002 mm (P2)), fine sand (0.2-0.02 mm), coarse sand (2-0.2 mm), gravel (2-20 mm), stones (20-200 mm), and rocks (>200 mm). They are grouped on three categories of texture classes: group of coarse-grained soils, group of medium-grained soils and group of fine-grained soils. In the texture class of coarse-grained soils there are soils with sand and clayish sand, which involve restrictions in exploitation, as there is a pedological risk directly proportional to the contents of clay or sand in the soil composition.

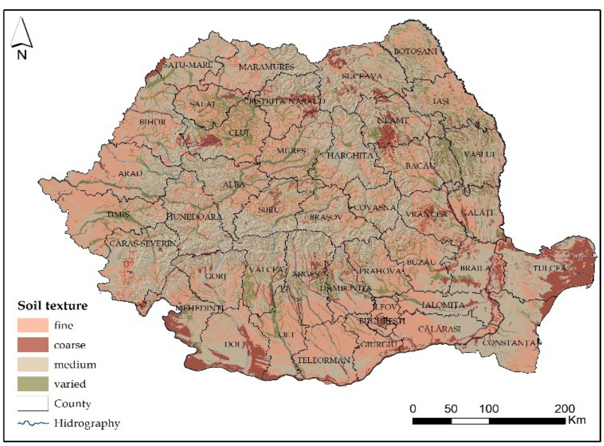

Fig. 2. Soil texture map of Romania

The risk induced by coarse-grained soils are characterized by the easier mobilization both by wind and by water, therefore increasing the risk of emergence for wind and water erosion, as well as the probability of superficial landslides at the level of soils. These types of soils also present a very low capacity of water retention, and therefore may only maintain agricultural crops in periods with uniformly distributed precipitation. Otherwise, irrigations are needed. From a chemical point of view, the risk induced by this type of texture is represented by the low contents of phosphorous, nitrogen and mobile phosphorous, calcium, and magnesium, so the soils need the application of chemical treatments, which involve higher costs. The highest degree of risk induced by soil texture is provided by a texture in which coarse sand predominates.

In the class of medium texture soils there are soils in the category of sandy muds and muds. They are favorable for all types of soil use without generating restrictions and pedological risks from this perspective.

In the class of fine-grained soils there are soils in the category of clayish muds and clays, which have a clay content between 33% and 80%. The higher the clay content, the higher the pedological risk both in case of raised humidity and prolonged drought.

These heavy soils are characterized by a high degree of plasticity, rendering the technical works performed on them difficult. In the case that clays become overwet on medium and high slopes, there is a risk for triggering or reactivating landslide processes. In these soils, in specific conditions, the roots within the soil may become asphyxiated, leading therefore to the loss of crops sensible to the lack of water and air, despite chemical features that do not individually impose restrictions in the case of agricultural crops on such soils.

2.3. The soil acidity and basicity

The soil acidity and basicity determined according to pH values are part of the category of chemical indicators assessing the soil quality, together with the content of organic matter in the soil, salinity, aeration, cation-exchange capacity, etc.

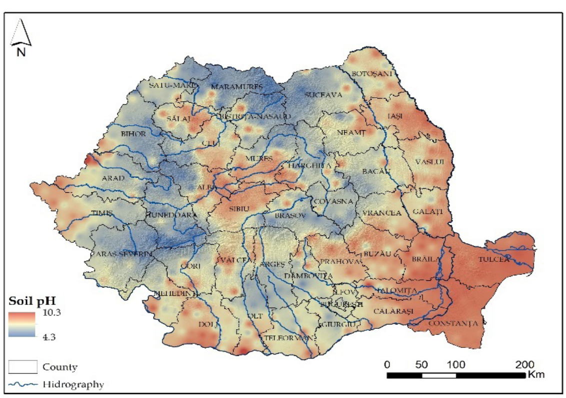

Fig. 3. Soil pH map of Romania

The soil acidification involves the activation of aluminum toxic ions stemming from the minerals and organic compounds in the soil. Conventionally, to classify the soils according to acidity and basicity, the scale used is based on the concentration logarithm according to the proportion of hydrogen ions (H+) against hydroxide ions (OH-). A high degree of soil acidity may be caused by precipitation above 600 mm/year, which penetrate the soil especially during the cold period, therefore washing the alkaline basic substances. It may also be due to gas pollutants reaching the soil because of acid rains or the intensive use of fertilizers like ammonium sulfate that has a powerful acidifying effect, calcium nitrate, mono and diammonium phosphate, manure, etc. Soil pH is also determined to provide indirect information regarding the availability of macro and microelements, and therefore about the crop efficiency and their resistance to stress and weather.

Acid soils are those which present pH values below 6, as well as a base saturation degree below 75%. These soils are characterized by a lower production due to the increase in content of Al^{+3} and Mn^{+2}, which have a toxic action for plants, as well as the appearance of calcium and magnesium deficiency.

Concerning the methods of improvement for acid soils, one recommends the use of native amendments like limestone tuffs, marls, dolomites, or residual amendments such as the carbonated muds originating from nitrogen fertilizer factories, calcium carbide from acetylene factories or slags from the metallurgical industry.

Among the fertilizers that have an alkaline effect, one remarks lime, calcium carbonate, dolomite and calcium oxide.

2.4. Soil pollution

To monitor soils in Europe and to provide information concerning soil properties in the shape of digital databases available online at different scales, the European Commission and the European Environment Agency (EEA) have set up the European Soil Data Centre (ESDAC), within the Common Research Centre of the European Commission. To analyze the degree of soil pollution at national level, we used the database concerning the following pollutants: As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Sb.

Table no.1. Warning and intervention thresholds for polluting substances

Element	Normal values	Warning thresholds/ Types of uses		Intervention thresholds/ Types of uses	
		Sensitive	Less sensitive	Sensitive	Less sensitive
Antimony (Sb)	5	12.5	20	20	40
Arsenic (As)	***5***	***15***	***25***	***25***	***50***
Cadmium (Cd)	***1***	3	5	5	10
Cobalt (Co)	***15***	***30***	100	***50***	250
Chromium (Cr)	***30***	***100***	300	***300***	600
Copper (Cu)	***20***	***100***	***250***	200	500
Manganese (Mn)	***900***	1.5	2	2.5	4
Mercury (Hg)	***0.1***	***1***	4	2	10
Nickel (Ni)	***20***	***75***	200	150	500
Lead (Pb)	***20***	***50***	250	100	1

(according to Order 756/1997)

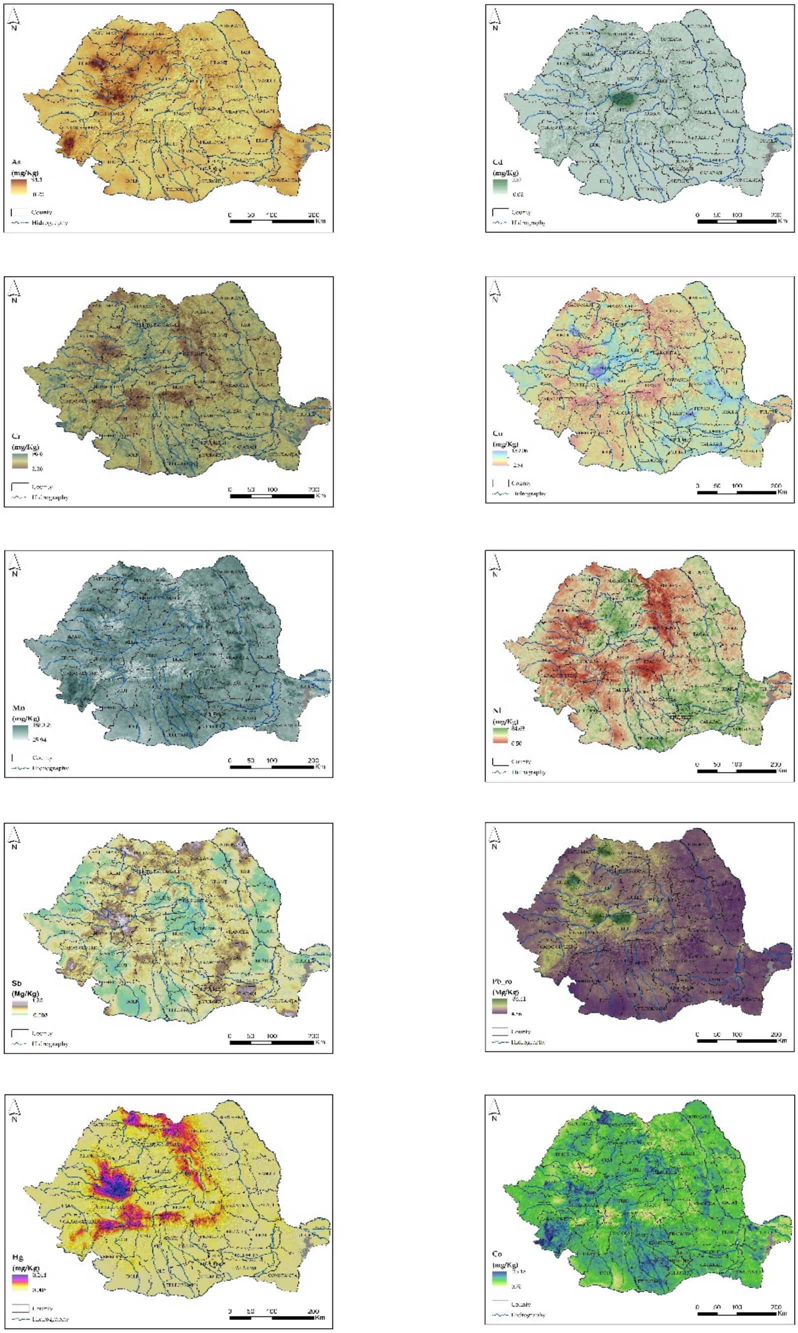

Fig. 4. Maps of soil pollutants in Romania (processed after Panagos et al, 2012).

One remarks therefore areas where the warning thresholds are exceeded for substances like arsenic, copper and cobalt (Table 1), as well as areas which are characterized by values closer to the normal level for manganese, nickel and lead (Figure 4).

2.5. Soil loss

Soil loss due to wind action and slope water run-off involves the detachment, transport and movement of material on and from the slopes (Grecu, 2009) because of the force of rain droplets and concentrated water streams. At national level, there are several methods in use to determine the amount of eroded soil. The most frequently used one is the model set up by Moţoc in 1975, adapted to the climatic conditions in Romania from the model previously imagined by Wischmeier, 1960.

This is based on the soil loss equation according to the formula:

$$E = k * S * C * C_S * L^{0.3} * i^{1.4}$$

where:
E – soil loss annual average (t/hectare/year)
k – rain aggression coefficient
S – soil erodibility coefficient
C – vegetation impact coefficient
C_S – crop system impact coefficient
L – slope length (m)
I – slope average gradient (%).

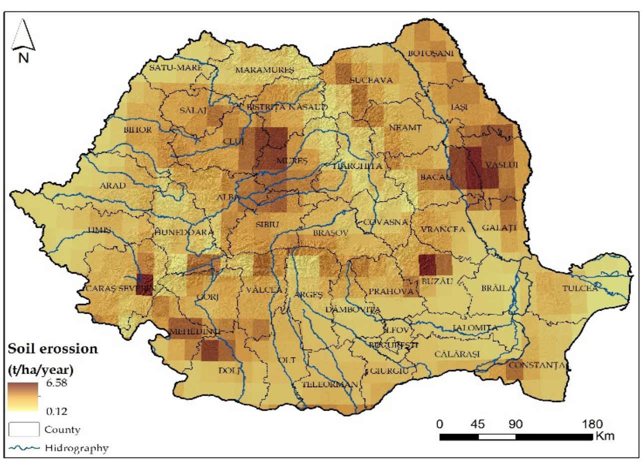

Fig. 5. Soil erosion map of Romania (processed after Borrelli et al, 2020).

The limits taken into account for establishing soil erosion classes are the following: up to 0.5 t/hectare/year of dislodged soil – these are areas without erosion; 0.5 – 5 m^3/ha/year – weak erosion; 5-15 m^3/ha/year – moderate erosion; 15-50 m^3/ha/year – severe erosion; 50-200 m^3/ha/year – very severe erosion. In extreme cases, when values exceed 200 m^3/ha/year, one may speak of catastrophic erosion (Bilasco et al, 2018).

The study performed by Borrelli et al, 2020 took into account the most recent results regarding climate change and land cover. It highlighted the potential rates of soil loss at global level using a 25x25 km resolution working towards the goals of the United Nations working groups under the Inter-Governmental Technical Panel on Soils of the Global Soil Partnership. Therefore, hotspots are highlighted and attention is drawn upon them, so that local measures are taken to preserve soils and to mitigate the negative effects determined by potential erosion. As a result of the application of soil preservation measures, studies show that the soil loss rate might diminish by up to 7.1% (Borrelli et all., 2017). In the case of Romania, one remarks extended territories within the counties of Cluj, Mureș, Bistrița-Năsăud, Sibiu, Vaslui, Bacău, Buzău, etc., which have large areas with moderate and strong erosion (Fig. 5).

2.6. Landslide prone areas

Landslides are part of the category of geomorphological hazards which determine the biggest material damage, and have a high degree of risk both for the natural elements and for the population (buildings, transport infrastructure, services) (Petrea et al, 2014, Bilasco et al, 2019, Sestras et al, 2019).

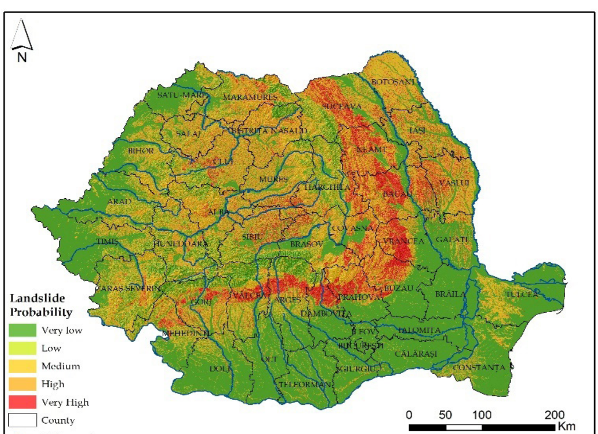

Fig. 6. Landslide probability map of Romania.

These slope processes generate changes at the slope level, modifying their morphology, dislodging soil and rock masses, which are therefore easier to erode, transport and store at the feet of the slope. The intensity and magnitude of landslide events are dictated by the geological features, the slope features, and the slope aspect. The triggering factors depend on frequency and magnitude of seismic movements and on the periods characterized by high precipitation amounts, both in terms of quantity and duration.

Due to the multiple implications triggered by the appearance of new landslides, as well as the reactivation of the older ones, there should be an interdisciplinary study of landslides, as they are the object of research for geomorphologists, geologists, GIS analysts, pedologists, or foresters. Each of them tries to identify the negative effects, the evolution trends, and therefore to provide the best measures to mitigate the negative effects produced by the landslides. There are numerous studies aiming to identify the spatial and temporal landslide probability (Rosca et al, 2015) for diverse territories, but the outcome is influenced by the quality of the data introduced in the model and by the list of active landslides (Balteanu et al, 2020).

In 2016, there was an analysis performed at national level regarding the landslide occurrence probability within the RORISK project, approaching the subject using a Spatial Multicriteria Evaluation type method. It highlights the Romanian territories which have the highest landslide occurrence probability (Fig. 5). Large areas within the counties of Suceava, Neamț, Bacău, Vrancea, Buzău, and Prahova are included in the class of high and very high landslide occurrence probability. To them, one may add large territories in the counties of Cluj, Sibiu, Mureș, Brașov, etc.

2.7. Salinization

The salinization involves the accumulation of salts (chlorides, sodium carbonates, calcium, magnesium, etc.) above and inside the layers of soil. It is triggered by the evapotranspiration at the level of plant leaves, which leads to an increase of evapotranspiration at the level of the soil, exceeding the amount of water received by the soil from atmospheric precipitation. This process determines the accumulation of salts in the upper layers of the soils and raises the phreatic level of ground waters as a result of the water capillary movement upward.

The effects of salinization on plants and agricultural crops are such that they affect the physiological processes at cell level, increasing the osmotic potential of soil solution, hindering the absorption of water and nutrients into the soil. Plants affected by saline stress usually suffer from other deficiencies as well, such as calcium or potassium deficiency, developing their roots at the expense of leaves (Eynard et al, 2006).

There are several methods to identify the risk of soil degradation by salinization, involving both quantitative and qualitative approaches, such as: the measurement of water electrical conductivity in the soil, the analysis of the composition of soil solution both for a viscous soil paste and an analysis of the vulnerability of the plants grown on it, the analysis of the ESP values (the weight of changeable sodium; values above 15% indicate a sodic soil) using the Russian classification system according to anion types (the dangerous salts are represented by NaCl, $MgCl_2$, $CaCl_2$, Na_2SO_4, $MgSO_4$, Na_2CO_3). According to recent studies, the saline and alkaline soils cover 641,000 hectares of the total of 12 million hectares of agricultural land in Romania (ROMSOL).

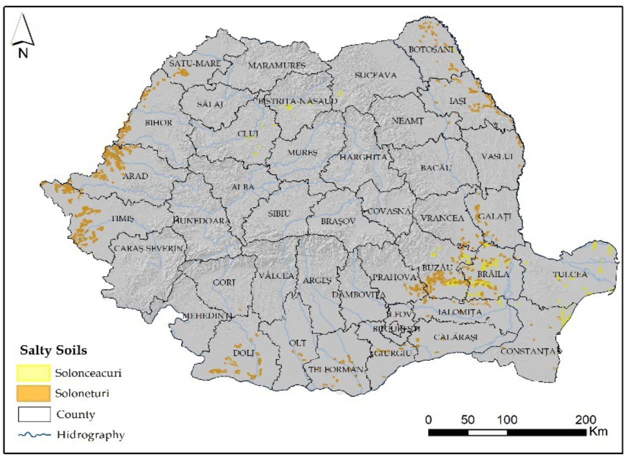

Fig. 7. Map of salty soils in Romania.

The method chosen for this study consists of identifying and mapping the salty soils from the map of Romanian soils. Two types of soils have been taken into account, solonchaks, which include soils that have a high level of salts, and solonetzes, which comprise soils that have an unadjusted balance of cations that determine a negative impact on the soil structural stability.

Large areas in counties like Buzău, Brăila, Dolj, Timiș, Arad, Satu Mare, and Iași stand out from this perspective and would need the application of improvement measures in the case of lands affected by an excess of salt (Fig. 7).

Conclusions

The knowledge of areas affected by natural and anthropogenic processes that have a negative impact on the physical and chemical features of the soils is extremely important both for the authorities and for the farmers who are particularly hit by the negative influence of the expansion of soil degradation processes.

In this study, the risk classes associated to the processes affecting the pedological cover have been analyzed at national level. Thus, the application of structural and non-structural measures for the stability of soils should be applied in the areas affected by soil loss due to wind and water erosion, as well as in the areas affected by landslides. Areas affected by salinization and sodiation would need the application of crop technologies as to avoid the irrigation with sodium-rich waters, the excessive use of chemical fertilizers, etc. There is need for a conservative agriculture that involves a minimal perturbation of soils, their permanent cover, the application of crop rotation and the use of feasible crops from an ecological and economic point of view, as well as the balancing of the use of chemical products to control weeds and pests, at the same time with the purpose to increase productivity.

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