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AN INFOGRAPHIC PERSPECTIVE ON CURRENT CONCERNS REGARDING SOIL PROTECTION IN MARAMUREȘ (ROMANIA)

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Abstract

Soil protection in Maramureș (Romania) has always been, is, and will always be the focus of specialists, environmental engineers, young farmers, local and regional public authorities, etc. Under the current information consumption society, these approaches - according to the international specialized literature, later harmonized at national and regional levels - tend to become increasingly viral in terms of different tools specific to Environmental Information Systems (EISs) and Environmental Informatics. In this context, for this paper, the investigation, analysis, and description of the concerns in question are the prerogative of infographics - extremely useful tools (from our perspective) to present the dynamics of what has been significantly achieved in the research area. The results, synthesized from open-source publications indexed in the Web of Science®, Google Scholar®, and ResearchGate® platforms, covering the period 2000-2024, reveal numerous significant concerns related to the protection of soil resources in the area. As such, we agree that we must continue to contribute to investigating the topic and promote good practices specific to development based on sustainable principles.

Key words*: dedicated infographics, Environmental Information Systems, soil pollution and protection, synthesis study.*

INTRODUCTION

The first concepts regarding soil, subsoil, and biodiversity protection were based on the ideas of Justus von Liebig in the 19th century. According to him, and following the "plant nutrient balance theory", the soil was protected because it was perceived as the reservoir for storing nutrients for plants and animals.

Later, this concept was modified and improved by agronomists who researched soil samples in the laboratory, rarely going below the level of normal plowing. At the same time, geologists and pedologists considered soil as a disintegrated rock, which alteration processes shaped into landforms, capable of supporting the activity of ecosystems through matter and energy (Florea, 2008a; 2008b; Cârstea, 2009; 2010; Hera, 2014).

In the second half of the 19th century, scientists, but especially the governments of Russia and the USA, paid "increasing attention" to soil resources for agricultural purposes, as well as for land taxation. Given the special importance of soil for increasing agricultural production, in more and more countries, especially after WW2, "large-scale research" in the field of soil science was stimulated, imposing attention on the concepts and approach based on economics (Figure 1), that were the basis for the development of the Pedological Schools in Russia and the USA (Cârstea, 2010).

Thus was born the Soil Taxonomy System (STS), which later became "a first-rate tool in the identification, characterization, and classification of soils", or, in other words, "the standard reference used to organize and communicate knowledge on soils" (Munteanu,

2002; Munteanu et al., 2005; Coman, 2006; Florea, 2008b; Coman, 2010; Grigoraș et al., 2010; Florea, 2014). The unique characteristics of the Soil Taxonomy System, with an emphasis on the current approach - Figure 1, but also on the biological, physical, chemical properties and fertility of soils - Figure 2 (Cârstea, 2010), supported the development and interpretation of pedological studies in Russia and the USA, to provide the best possible scientific basis for soil protection measures.

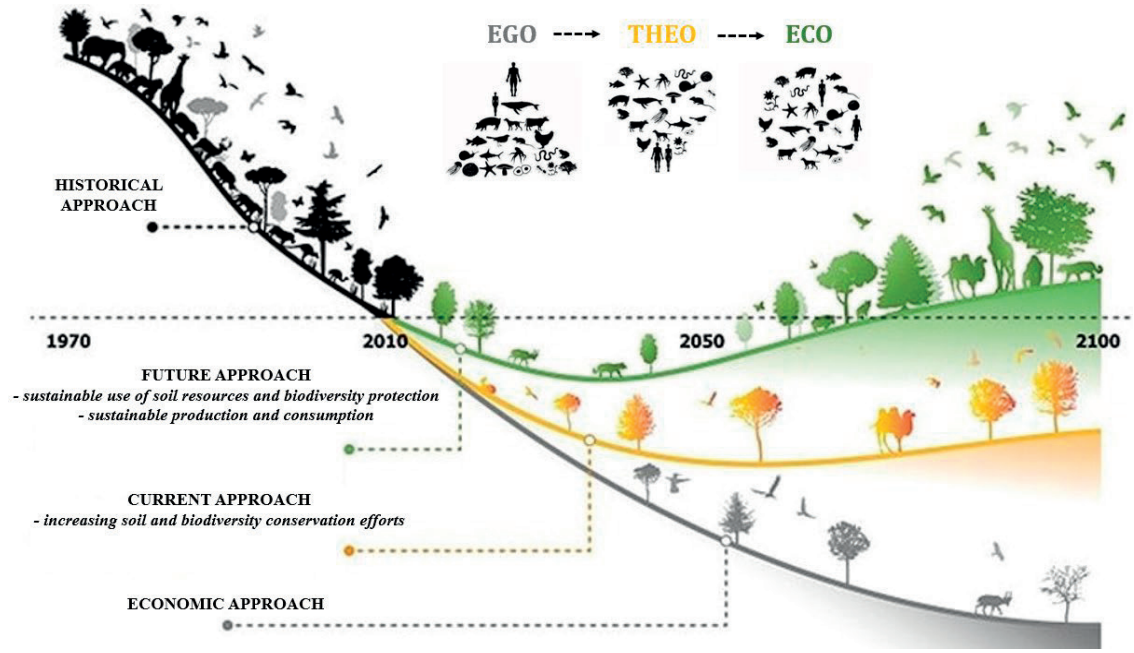

Figure 1. The evolution of different approaches to soil and biodiversity protection (adapted from Leclère et al., 2020)

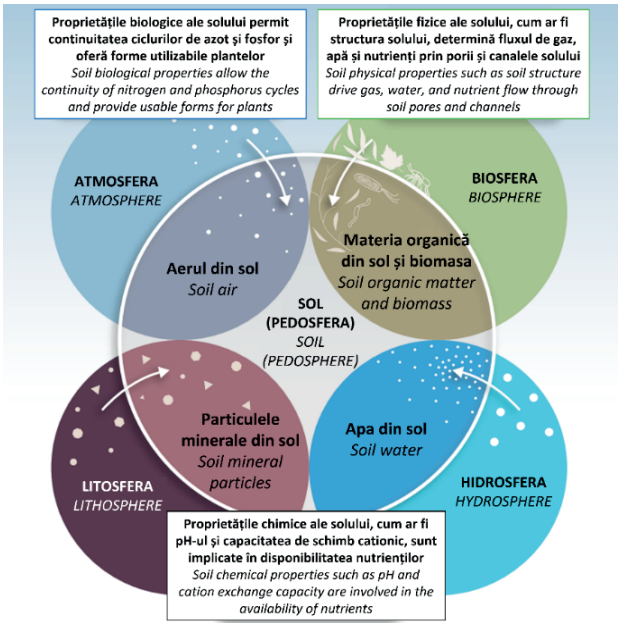

Figure 2. The biological, physical, and chemical properties of soil as the basis of land fertility

In the USA, even many decades before the institutionalization of pedological studies, Ruffin, Hilgard, and other specialists tried to understand the formation and evolution of soil (Cârstea, 2010). To the pressing requirements of agricultural development, they carried out detailed observations in small peasant households, the major objectives being: to provide the necessary information for the intelligent and economic management of soils for agricultural purposes, as well as for the treatment of various identified soils to obtain satisfactory yields for farmers, and evaluating soil resources by establishing the agricultural value and the adaptations of different soils to various uses, mainly agricultural.

At that time, soil scientists were required to examine the soil on every small farm, at least at a few representative points. As a result, in 1909, Milton Whitney developed and published the first American system of soil mapping and classification; the history of the development of soil studies in the United States records the beginning of the Pedological School in 1922, when the emphasis was only on soils within a province consisting exclusively of similar geological materials, and the soil type was the lowest taxonomic and cartographic unit.

The middle period of the Pedological School in the USA is linked to the personality of Marbut, the founder of American pedology. He introduced the concepts of Dokuchaev and his collaborators and published, in 1927, a scientific work in which he classified the soils of the entire American continent.

It was not until 1935 that the soil classification system with 6 taxonomic categories (order, suborder, large group, family, series, and soil type) was proposed (Florea, 2014), which marks the "*beginning of true quantitative classification*", giving importance to the soil as "*a cosmic-telluric-biotic product*".

As the importance of crop forecasting has increased, the concepts of soil study approaches have also changed. Thus, soil profile morphology has become a predictive and relevant tool, thanks to the data provided by the approximately 5,500 officially recognized and registered soil series. Since then, a completely new reporting system has been developed, taking into account the soil as an open and complex system (Figure 3).

The most significant aspect of the contribution of the new soil classification system comes from the concern to ensure the quantitative definition of the boundaries of soil classes, where the user can be assisted by the computer and by the applications proposed by specialists in the field on the occasion of high-level scientific events (Table 1).

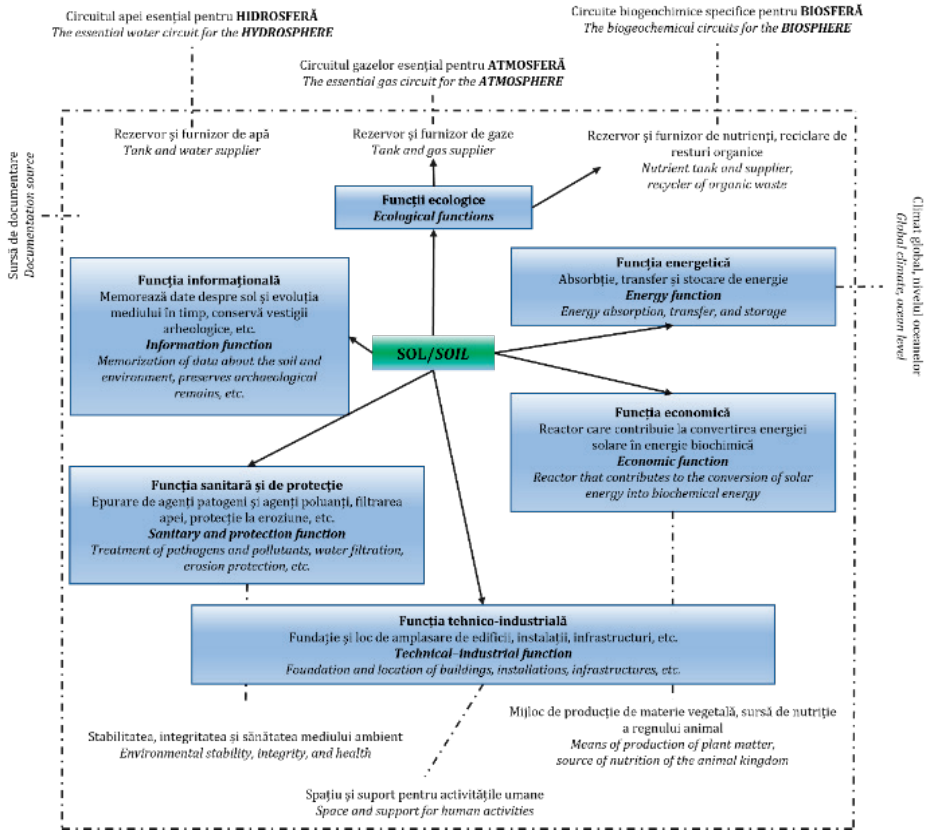

Figure 3. The multiple functions or "ecosystem services" in which the soil participates (adapted from Florea, 2014)

Since 1927, 22 World Congresses on Soil Science have been held, with an emphasis on soil protection and sustainable land use, their promotion being the prerogative of thematic philately, as shown in Table 1.

Next, it is appropriate to review other contemporary initiatives that have taken shape at the international level with soil protection. Thus, on the occasion of the 68th *United Nations General Assembly*, through the resolution adopted on 20 December 2013, we can mention the year 2015 as the *International Year of Soils*. This initiative was initiated as a continuation of the *Decade for Biodiversity* (2011-2020) and the *Post-2015 Agenda for Global Sustainable Development*, precisely to alert people to the direct relationship between soil fertility, food security, essential ecosystem functions, and prosperous societies (Cioruța et al., 2015).

In the same context, the Food and Agriculture Organization (FAO) was designated as the vector entity with responsibilities for implementing and promoting the International Year of Soils within the Global Soil Partnership and in collaboration with governments. Taking advantage of this aspect, postal administrations contributed to promoting the event, which gained momentum at the international level (Figure 4). Adopting and accepting the policy of international entities, postal administrations around the world decided to actively participate in promoting the International Year of Soils, producing and issuing various philatelic effects. By indexing and analyzing them closely, we found that current concerns for soil protection can know the most diverse forms of representation (Cioruța et al., 2015).

However, soil is perceived both as a resource-support of the community and especially as a living and fragile organism (Coman, 2010), which deserves, more than ever, all our care and attention.

In the 19th century, data on Romanian soils were "very few and incomplete; the best known are those of Ion Ionescu de la Brad, Corneliu Roman and Vlad-Cârnu Munteanu, and Matei Drăghiceanu" (Florea, 2008b). Although there was no special research on soils during that period, agronomists of the time, through articles published in the Journal of the Central Agricultural Society, "carried out an activity of disseminating knowledge about soils among the community, based on data from other countries" (Florea, 2008b; Hera, 2014).

Table 1. World Congresses of Soil Science (1927-2022) and some associated philatelic effects

No.	Venue	Period of deployment	Philatelic effects for soil protection
1	Washington (USA)	13-22 June 1927	
2	Leningrad (Russian Federation)	20 - 31 July 1930	
3	Oxford (England)	30 July-07 August 1935	
4	Amsterdam (Netherlands)	24 July-01 August 1950	
5	Leopoldville (Congo)	16-21 August 1954	
6	Paris (France)	1956	
7	Madison (USA)	15-23 August 1960	
8	Bucharest (Romania)	31 August-09 September 1964	
9	Adelaide (Australia)	06 August 1968	
10	Moscow (Russian Federation)	1974	
11	Alberta (Canada)	19-27 June 1978	
12	New Delhi (India)	08-16 February 1982	
13	Hamburg (Germany)	13-20 August 1986	
14	Kyoto (Japan)	12-18 August 1990	
15	Acapulco (Mexico)	10-16 July 1994	
16	Montpellier (France)	20-26 August 1998	
17	Bangkok (Thailand)	14-21 August 2002	
18	Philadelphia (USA)	09-15 July 2006	
19	Brisbane (Australia)	01-06 August 2010	
20	Seoul (South Korea)	08-13 June 2014	
21	Rio de Janeiro (Brazil)	12-17 August 2018	
22	Glasgow (UK)	31 July-05 August 2022	

Figure 4. Examples of representative philatelic effects for the International Year of Soils

In Romania, concerns regarding soil protection have also similarly manifested themselves. In this regard, it is worth mentioning "the scientific activity of Constantin Gregorian, related to the dissemination of data on soil composition, the classification of arable land, the agricultural properties of different classes of land, their cultivation and improvement". This approach is known and unanimously accepted in the history of soil science as the "*agrogeological period*" (Florea, 2008b).

Gh. Murgoci (1872-1925) introduced the genetic concept of soil from the beginning of soil science in this country. On this basis, he defined soil types. His followers developed the first landmark investigations, defined and characterized soil subtypes and types, as well as textural species, families (depending on rock), and soil variants (of anthropogenic nature), as follows from the *Romanian Soil Taxonomy System* (e.g., *RSTS, 2003*, *RSTS, 2012*). In the same context of the attempt to define soil from various perspectives, we will detail some examples below.

Prof. Dr. Eng. d.h.c., Academician Nicolae Florea defines the soil cover as "the thin, loose layer, located on the surface of the land and at the bottom of shallow lakes, in which the interpenetration of the lithosphere with the atmosphere, biosphere, and hydrosphere takes place", as recorded by Florea (2008) and later by Coman (2010). On the same grounds, Prof. Dr. Eng. Dumitru Târziu believes that the naturalistic school founded by V. Docuceaev is right when it considers the soil as "a new, independent natural body, with a dynamic character over time, formed on the surface of the earth's crust through the concurrent action of pedogenetic factors - rock, relief, climate, living organisms and the age of the territory" (Târziu, 1997; Coman, 2020).

The highlighting of different processes and/or changes in the state of the soil, as a whole, can only be achieved through a well-defined unitary procedure, called a "monitoring system". This is defined by a set of sites where the current state of the soil is evaluated, characterized by observations, measurements, and periodic determinations of its various properties (Savopol, 2002; Ţărău & Ianoş, 2002; Munteanu et al., 2005; Grigoraş et al., 2010; Stasiev, 2010; Mihăiescu, 2014).

Soil monitoring - part of the Environmental Information Systems (EISs) involvement - represents the systematic determination of soil variables in such a way as to record both temporal and spatial changes. This complex process is "essential for knowing the current state of the soil and detecting its possible negative changes in time, providing a series of assessments related to the evolution of soil properties" (Florea, 2008; Dumitru et al., 2011). The information obtained is useful in the design and implementation of policies that protect and maintain sustainable soil use while allowing the soil to continue to provide goods and services.

As such, starting in 1977, and according to the recommendations generated by the *United Nations Environment Programme* (UNEP) and the Order of the Ministry of Agriculture no. 111/1977, Romania established the *National System for Monitoring the Quality of Agricultural Soils - NSMQAS*, as an integral part of the *National System for Environmental Quality - NSEQ* (Carigoiu et al., 2009).

Subsequently, in the period 1992-1999, an improved system for monitoring soil quality was initiated, both for agricultural and forest soils. As a result of these concerns, the *Integrated Soil Monitoring System in Romania* resulted, which currently includes two subsystems: the *Agricultural Soil Monitoring Subsystem in Romania* and the *Forest Soil Monitoring Subsystem in Romania*, as recorded by Dumitru et al. (2011). To know and document promptly all the negative effects that industry, urbanization, and agriculture have on the quality, integrity, and security of the soil, the need arose to establish a *National Soil Monitoring System*. Through this instrument, the optimization of the procedures for surveillance, assessment, forecasting, warning, and operative intervention regarding the state of soil quality and its evolution trends was achieved.

In the sense of the above, the *National Soil Monitoring System* has as its object of study the soil-land system, which is in close interdependence, but also the soil cultivation system-production relationship, which depends on the previous state of the soil and the level of biological, ecological, technological factors, etc. (Moraru et al., 2008).

Moreover, the influence of the cultivation system on soil properties is an important indicator in the conservation of soil fertility, as well as in the assessment of the sustainability of the agricultural system (Rusu et al., 2008).

The SNMS is carried out "to know the territory in terms of soil units, of integrating them into land units for adopting optimal agricultural exploitation solutions and for establishing a pedo-agrochemical data bank on administrative territories" (Carigoiu et al., 2009).

To the development of specific operations of the *National Soil Monitoring System*, databases have emerged that directly refer to:

- the situation of the land fund, soil types, and protected natural areas;
- the classification of land into quality classes, macro relief forms, microrelief forms, and pedogeoclimatic microzones;
- surveillance, assessment, forecasting, and warning regarding the state of soil and agricultural land quality on administrative territories;
- measures to protect and improve agricultural land to maintain and increase production capacity and for their sustainable use.

With the ecosystem services provided by soil, it is shown that there are many agricultural areas affected by restrictive factors (e.g., *pollutants*), with repercussions on production and its quality. In this regard, data obtained within the NSMS show that out of 12 million ha of agricultural land, approx. 7.5 million ha are arable lands affected by one or more restrictive factors.

These factors are added to the decrease in the supply of nutrients and the decrease in humus content.

Activities such as agriculture, forestry, and transport use soil resources, changing its natural state and altering its functions.

Many environmental problems arise from the poor use and abandonment of land, which leads to the loss of biodiversity (Figure 5), or even to air, water, and soil pollution.

Figure 5. State of nature and soil in the European Union (adapted from EEA, 2021b)

Impacts on the soil environmental factor can be direct (e.g., *degradation of natural habitats*) or indirect (e.g., *deforestation*), increasing the risks of floods and landslides. Climate change affects the soil and leads to desertification, flash floods, and other similar phenomena.

With 75% of the European Union's population living in cities, urban land use issues are now of major importance for food production and nature conservation. In this context, the latest report by the European Environment Agency (EEA) on the "State of Nature in the EU" presents alarming results for the reporting period 2013-2018 (EEA, 2021a). Thus, unless urgent and sustainable measures are taken in the coming period to reverse the situation (Tsiafouli et al., 2015), many species of flora and fauna and their habitats, including land uses in the EU, will face an uncertain future (Figure 6).

In 2018, for example, biodiversity across Europe continued to be shaped by human activity, with pressures on habitats and species still high - over 67,000 individual pressures were reported (EEA, 2021b). Obvious changes are also taking place in terms of land use. We thus note a decrease in the areas occupied by forests, orchards, and arable areas, with significant increases recorded only in the case of lands occupied by meadows and vineyards. The increase in the area of land taken out of agricultural circulation has led to a substantial increase in the area occupied by buildings.

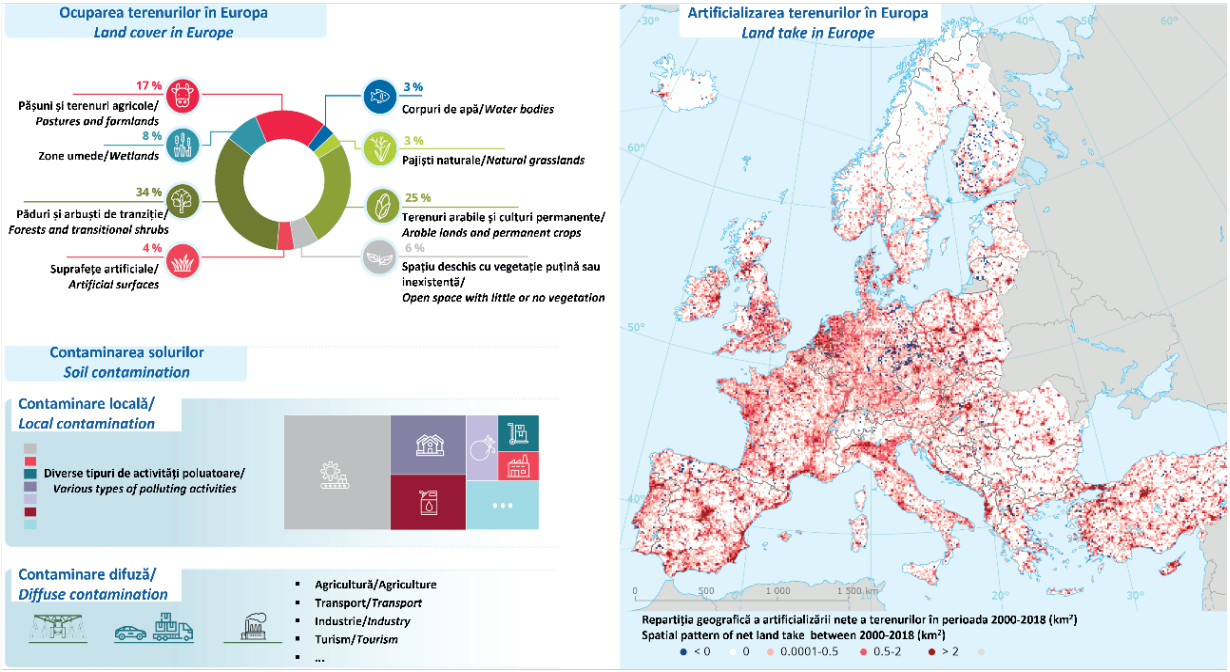

Figure 6. The current situation regarding the occupation and artificialization of land, respectively soil contamination at the level of the European Union (adapted from EEA, 2019)

In the period 2018-2021, of all areas converted into artificial land, 48% were arable land or for permanent crops, and 36% were pastures or mixed agricultural land. We can also record an increase in the occupation of land by infrastructure dedicated to the change of land use (e.g., *buildings and commercial spaces*).

MATERIALS AND METHODS

According to the specialized literature, Environmental Information Systems (EISs) come in a variety of desktop and mobile platforms that are useful for applied ecological studies and industry. Of them, EISs for mobile devices have started to be utilized more frequently in the work of people who are involved in agriculture management and soil preservation (Cioruța & Coman, 2021).

However, for this research, we only aimed to index and analyze the results obtained with the help of EISs within the most significant approaches for the evaluation and protection of soil resources in Maramures.

In this context - as the first step - a database was created (filtering and sorting publications by applying dedicated keywords) with all the corresponding articles (from Web of Science®, GoogleScholar®, and ResearchGate® platforms, and the reference period 2000-2024). Later, for each publication, by manual scrolling, the specific elements generated through the use of different EISs (e.g., *figures/images from the researched area*, *tables with reference indices*, *soil maps, soil testing plans*, etc) were very meticulously recorded and highlighted.

RESULTS AND DISCUSSIONS

Based on research conducted on the most significant publications published in the period 2000-2024 - with direct reference to the Baia Mare area - a research synthesis was developed containing data both on the area considered and the indexed pollutants, and especially on the infographic materials used to highlight the results obtained (Table 2). Indexed reference studies have required sampling and analysis in accredited laboratories of soil samples from the immediate vicinity of historically polluted areas. Heavy metals (most often Cd, Cu, Pb, and Zn) and other soil indicators have been analyzed in order to describe as faithfully and in depth as possible the dynamics of zonal pollution.

The associated EISs tool used to characterize pollution is usually the one offered by the Microsoft® suite, to which, in some cases, other GIS® and SPSS® applications have been added, capable of providing a wider range of graphical representations in relation to soil pollution.

Table 2. A synthesis of current scientific concerns (2000-2024) regarding soil protection in Maramureș (Romania)

Reference (authors, year)	**Area considered** (area, sample type)	**Indexed pollutants**	**Infographic material presented** (e.g., *figures and tables*, *distribution maps*, etc.)
Damian & Damian, 2007	Baia Mare & Zlatna area (soil samples)	Cd, Cu, Pb, Zn	▪ a figure showing the eutricambosol profile in the area; ▪ a table showing the heavy metal concentrations in soils from the Baia Mare and Zlatna areas; ▪ a table showing the chemical properties of polluted soils from the Baia Mare and Zlatna areas.
Damian et al., 2008a	Baia Mare area (soil samples)	Cd, Cu, Pb, Zn	▪ a figure showing the aspects of the soil`s degradation surrounding the metallurgical factories of Baia Mare; ▪ a map of the soil from the Baia Mare zone; ▪ 3 figures showing the profile of the sampled soils (luvosol albic, eutricambosol, and aluviosol); ▪ a table showing the physical and chemical properties of selected pedo-genetical horizons; ▪ 4 frequency diagram for pollutant concentrations; ▪ 4 figures showing the concentration of Pb and Zn within the soil profile, pH, and humus content; ▪ 4 maps of Cd, Cu, Pb, and Zn distribution in the Baia Mare zone at 0-10cm depth.
Damian et al., 2008b	Baia Mare area (soil samples)	Cd, Cu, Pb, Zn	▪ 2 figures showing the soil profiles for sampled luvosol and eutricambosol; ▪ 3 figures showing the variation of Pb and Cd content near the Cuprom and Romplumb areas; ▪ 8 figures showing the Cd, Cu, Pb, and Zn spatial distribution in Baia Mare (Cuprom and Romplumb).
Damian et al., 2010	Baia Mare - Groși locality area (soil samples)	Cd, Cu, Pb, Zn	▪ a figure showing the location of the study area; ▪ a figure (separated pie chart type) showing the land use distribution areas; ▪ a table showing the physical and chemical properties of the sampled soils; ▪ a table showing the geographical position of soil samples and the total contents of the heavy metals; ▪ 4 figures showing the pollutants' distribution in the upper soil horizon.
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Big et al., 2012	Baia Mare area (soil samples and carrot roots)	Cd, Cu, Pb, Zn	▪ a figure showing the soil types map of the Baia Mare area, pointing to the sampled soils; ▪ a figure showing the soil texture map of the Baia Mare area, pointing to the sampled soils; ▪ a table showing the physical and chemical properties and the heavy metals content of the soils around Romplumb; ▪ a table showing the heavy metal content in carrot roots; ▪ a table showing the Pearson correlation coefficients of heavy metals from soil and carrots; ▪ 2 figures showing the relationship between the Cd content in carrots and the total Cd content in soil at 0-10 cm and 20-40 cm depth; ▪ a table showing the transfer factor of heavy metals from soil to vegetables (carrots).
Big et al., 2013	Baia Mare area (soil samples)	Cu, Pb, Zn	▪ 2 figures (clustered column type) showing the heavy metals distribution in the Baia Mare soils, at the 0-10 cm and 20-40 depth, according to the pH values.
Damian et al., 2013	Baia Mare area (soil samples)	Cd, Cu, Pb, Zn	▪ a figure showing the map of Romania with the location of Baia Mare and Zlatna; ▪ a figure showing the vegetation development on luvosol near the copper smelter in Baia Mare;

			▪ a table showing the main properties and the heavy metal content of the soils used in the experiment before treatment; ▪ a table showing the nutrient content, and physical and chemical properties of the soil samples used in the experiment, before and after plants' growth; ▪ 8 figures (clustered column type) showing the total content of heavy metals ($mg \cdot kg^{-1}$) in untreated and treated soil samples before and after plant growth; ▪ a table showing the total contents of heavy metals in aerial and roots part of Lolium perenne grown on untreated soil (O-original) and treated experimental options of soil.
Chira et al., 2014	Băiuț site (soil samples)	As, Cd, Cu, Ni, Pb, Zn	▪ a simplified figure showing the Băiuț site (Baia Mare Mining Region); ▪ a table showing the heavy metal content in soils from the Băiuț mining area; ▪ 6 figures showing the heavy metals distribution in sampled soil; ▪ a table showing the soil samples' (descriptive) statistical results; ▪ a table showing the Pearson correlation coefficients of heavy metal in soil; ▪ 6 figures showing the analyzed heavy metals histograms (using a dedicated software - NCSS '07); ▪ 6 figures showing the distribution maps of the studied elements' concentrations.
Smical et al., 2016	Baia Mare area (soil and grass samples)	Cd, Cr, Cu, Mn, Ni, Pb, Zn	▪ a table showing the primary statistical elements for the characterization of soil and vegetation; ▪ a figure showing the mean values of the transfer factor for heavy metals in soil-vegetation-milk.
Damian et al., 2019	Baia Mare anthrosol area (soil samples - granulometric fractions)	Cd, Cu, Pb, Zn	▪ a simplified map (2-elements type) containing the sampling points and the soil types from the area of interest; ▪ a figure showing the pedogenetic horizons Ao1-Ao2-Bv-C on depth profiles for the sampled eutricambosol; ▪ a figure showing 2 graphics (100% stacked column type) for the particle size distribution in considered soil profiles; ▪ a figure showing 4 graphics (clustered column type) for the heavy metal concentrations in the sampled anthropic soil; ▪ a figure (clustered column type) showing the heavy metal concentrations in each granulometric fraction from each pedogenetic horizon of sampled eutricambosol.
Sur et al., 2022	Baia Mare area (soil samples)	Cd, Cr, Cu, Ni, Pb, Zn	▪ a figure showing the study area and sampling location; ▪ a figure showing 6 images from soil sampling areas; ▪ a figure (clustered column type) showing the pH values in all the 6 soil samples; ▪ a figure showing 16 images with soil sample structure; ▪ 3 figures showing the variation of Cd, Cr, Cu, Ni, Pb, and Zn concentration in the soil samples compared to the normal values, the alert threshold, and the intervention threshold according to Order 756/1977; ▪ a figure showing the calculated values for the contamination factor (Cf), contamination degree (Cd), and pollution load index (PLI); ▪ a figure showing the ecological risk index (Er) and potential ecological risk index (PERI).

Bereș et al., 2024	Săsar River and its main tributaries (sediment samples)	As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Zn	▪ a geological map showing the location of the study; ▪ a map showing the locations of sampling sites and potential contamination sources from mining activities; ▪ a descriptive statistics table of the studied elements' concentration ($mg \cdot kg^{-1}$) and geochemical background in the Săsar River catchment; ▪ a table showing the Pearson correlation matrix of the studied elements; ▪ 10 distribution maps of the studied elements' concentrations in Săsar River sediments; ▪ a figure showing the HCA dendrogram of PTEs analyzed from Săsar basin stream sediments; ▪ a table showing the comparison of toxic element concentrations in Săsar River sediments to Romanian sediment quality guidelines and similar areas; ▪ a figure showing the contamination degree (CD) risk of PTEs in Săsar River sediments; ▪ a figure showing the potential ecological risk index (RI) in Săsar River sediments; ▪ a figure showing the environmental toxicity quotient (ETQ) in Săsar River sediments.

From the analysis of the data obtained (indexed and analyzed to date – April 2024), it emerges that there have been numerous concerns (50+ dedicated articles) both for describing the dynamics of pollution at the local and regional level, and for highlighting and promoting new strategies (as field-validated materials and methods) for investigating the issue.

CONCLUSIONS

The results obtained so far show us that the issue of soil resource protection in Maramures (in general) and the Baia Mare area (in particular) has a special dynamic. This dynamic is interspersed with numerous figures, tables, maps, etc. - as variables obtained through the mediation of EISs - intended to characterize as intimately (naturally and faithfully) the actual state of the soils in the targeted area.

According to the above, we consider that the ecological reconstruction of degraded lands or those affected by various restrictive factors (natural or anthropogenic), as a result of the irrational use of soils or as a result of the influence of industry, is required. An innovative approach in this regard may be the use of EISs and mobile applications as an integral part of EI in correlation with the current legislative framework for soil protection.

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