International Journal on Food, Agriculture, and Natural Resources
Volume 04, Issue 02, Page 20-25
ISSN: 2722-4066
http://www.fanres.org

Original Paper

The Role and Functions of Soil in the Information and Knowledge Society

Bogdan-Vasile Cioruța[1,2], Mirela Coman[1,3]*

1) *University of Agricultural Sciences and Veterinary Medicine, Calea Mănăștur 3-5, 400372, Cluj-Napoca, Romania*
2) *Technical University of Cluj-Napoca - North University Center of Baia Mare, Office of Informatics, Victor Babeș 62A, 430083, Baia Mare, Romania*
3) *Technical University of Cluj-Napoca - North University Center of Baia Mare, Faculty of Engineering, Victor Babeș 62A, 430083, Baia Mare, Romania*

*) *Corresponding Author: bogdan-vasile.cioruta@usamvcluj.ro*

Received: 03 January 2022; Revised: 30 June 2022; Accepted: 05 June 2023
DOI: *https://doi.org/10.46676/ij-fanres.v4i2.64*

Abstract **–Much has been written about the soil over time, from different perspectives, however, the soil as an entity, as well as its role and functions are far from being fully recorded. In the Information and Knowledge Society, soil still has a significant role to play, in terms of its functions at the community level. We set out to make some scientific remarks and examples on these issues. Also, the soil is subjected to analysis as a cosmic-telluric-biotic product, in its gradual transition from the Hunting and Agrarian Society to the Society based on technology, information, and knowledge. What we have managed to summarize is a summum of definitions of the soil, and a conglomeration of functions, carefully nuanced and delimited, which open the way for the reader from the soil seen as a resource-support of the technosphere to the soil treated as a primary scientific concern.**

Keywords—Soil protection, The information society, Sustainable agriculture.

I. Introduction

Soil is considered to be one of the most complex natural systems on the planet, a key component of the geographic environment, and also a biological complex that is constantly evolving. The soil is also the equivalent of a multifunctional system that supports the essential functions of life on Earth.

For man, the soil, by its nature, has peculiarities different from those of other environmental factors, as important for the biosphere. As a support and living environment for plants, the soil, through its humus content, makes the main connections in the trophic chains of the biological cycle of the elements, from the synthesis of organic matter to the products of its mineralization. The soil is closely involved in all cyclical biogeochemical processes that contribute to the maintenance and assurance of life on earth. The pedosphere, including both the ground cover of the land and that of shallow aquariums, is irreplaceable in its many functions:

- environment favorable to the development of organisms;
- tank and water source, nutrients, and energy;
- active intermediate in all global biogeochemical cycles of water, oxygen, nitrogen, phosphorus, sulfur, etc.;
- intervention in the processes or mechanisms that determine the bioenergetic balance of the biosphere and landscape.

These functions have acted uninterruptedly in the past, act now, and will continue to act in the future, of course with varying intensities and rhythms in different ecosystems around the globe. Due to its ability to sustain plant life, the soil is the main means of agricultural production, but the existence and development of human society will long be conditioned by the abundance and quality of higher terrestrial plants, which must provide food and raw materials for clothing, shelter and other requirements.

II. Definition of the Soil Concept

A. Defining the soil with the development of society

The word "soil", like many common words, has many meanings, even in soil science [1]. In its traditional sense, to which we are accustomed, the soil is perceived as "the natural environment for the growth of terrestrial plants, whether or not it has distinct horizons" [2-6]. This meaning is still the common understanding of the word, and the greatest interest in the soil is focused on this.

The vast majority of the human population considers soil important because it "supports plants that provide food, medicine and other necessities" [1, 2], and "filters water and ensures waste recycling" [3-6].

The soil covers the surface of the earth as a continuum, except for bare rock, in areas with perpetual frost, in deep water, or on the barren ice of glaciers; In this sense, the soil has a very good thickness, mainly determined by the rooting depth of the plants [1-6].

Throughout history, the concepts of soil, its role, and its importance in the community have evolved, gradually moving, in different stages, from the concept of "naturist" to "technical" one [7]. Thus, for example, the definition of soil is "relative to the function it provides to those who define it" [8].

From a morphological point of view, the US Natural Resource Conservation Service defines soil as: "(...) a natural body made up of solids (minerals and organic matter), liquids and gases that appear at the surface of the land, it occupies space and is characterized by horizons or layers, which are distinguished from the original material by the addition, loss, transfer, and transformation of energy and matter or the ability to support plants rooted in a natural environment." [4-6].

This definition is extended from the previous version of "Soil Taxonomy - A Basic System of Soil Classification for Making and Interpreting Soil Surveys" [2], to include soils in Antarctica, where pedogenesis occurs, but where the climate is too harsh to be able to support the superior vegetal forms. These definitions try to capture the essence of the role that the soil has in the development of society, as in Fig. 1 [9, 10].

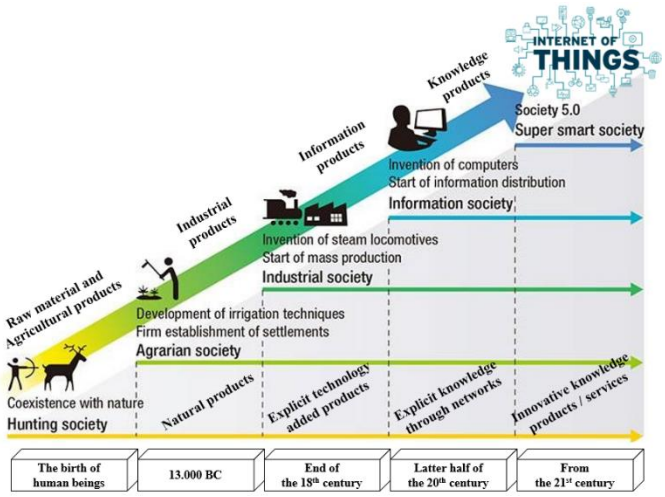

Fig. 1. The soil implications in the development of society [9, 10]

Another definition, which bears the imprint of another entity on American soil, with concerns in the field of soil research and protection, is given by the Society for Soil Science. Depending on its genetic and environmental factors, the soil is considered to be: "(...) unconsolidated mineral or organic matter on the Earth's surface that has effects of climatic factors (including effects of water and temperature) and macro-and microorganisms, conditioned by the relief, which acts on the parental material for a certain period. A soil produced differs from the material from which it is derived by its physical, chemical, biological, and morphological characteristics." [11].

B. Defining the soil with its characteristics

If on the American continent the soil is seen as "a dynamic non-renewable natural resource, essential to life, because the movement and quality of water, land use, and vegetation productivity are all closely related to the soil" [8], in Europe things are slightly nuanced. However, we cannot live without "healthy soil; on land, we produce most of our food and build our houses" [12].

This finding is based on "knowledge of specific characteristics, properties with well-defined numerical values obtained by different methods, procedures of measurement, determination and standardized calculation" associated with the soil [7]. Next, in [13] it is shown that, for the full and correct definition and understanding of the soil at the local level, it is necessary to examine the soil cover or the pedosphere (Fig. 2), in very wide geographical areas, even at the subcontinental level. or continental, in correlation with climatic zones and with the ever-increasing influence of the anthropogenic factor.

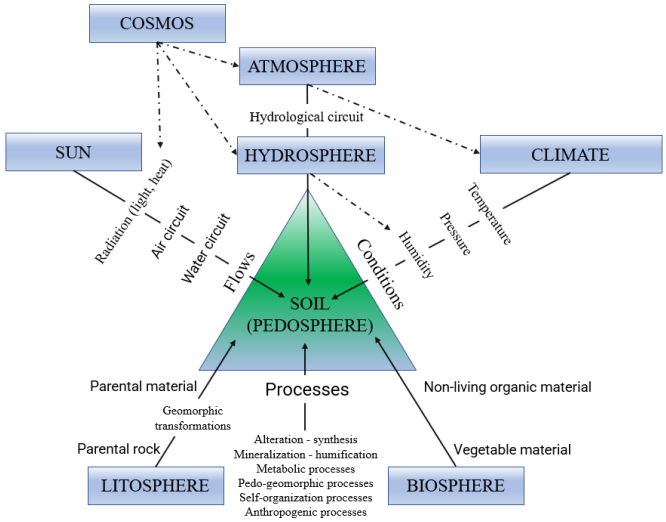

Fig. 2. Soil saw as a cosmic-telluric-biotic product of the synergistic interaction of energy flows, mass, and information with soil processes in various conditions of development, with cyclic dynamics, at the surface of the Earth's crust

The soil is the result of the action of different processes determined by environmental factors, continuously adapting to natural and/or artificial changes in the environment, recording and memorizing, step by step, through certain phenomena, processes and characteristics the main moments of community evolution. We will report in detail on the role and functions that soil imparts at the community level in the following.

III. The Role and Functions of the Soil in the Community

In nature, as in human society, the soil performs important global functions. They are essential for ensuring the existence of biodiversity on Earth, both by accumulating and supplying nutrients and energy to living organisms and by ensuring other conditions conducive to the development of these organisms [18].

Through the functions, it performs (see Fig. 3), the soil is one of the most valuable natural resources used by man to obtain the plant products he needs. Soil, like aquatic bodies, is the most important medium for biomass production. Being used by man in the process of plant production, the soil is the main means of production in agriculture and forestry, being perceived as a renewable resource, as long as its use does not negatively affect its functionality [19]. At this stage, the role of soil is unanimously accepted, not only in the promotion and development of sustainable agriculture, in maintaining the quality of the environment, in global climate change, in

biodiversity conservation, but "the development of the economy as a whole" [7].

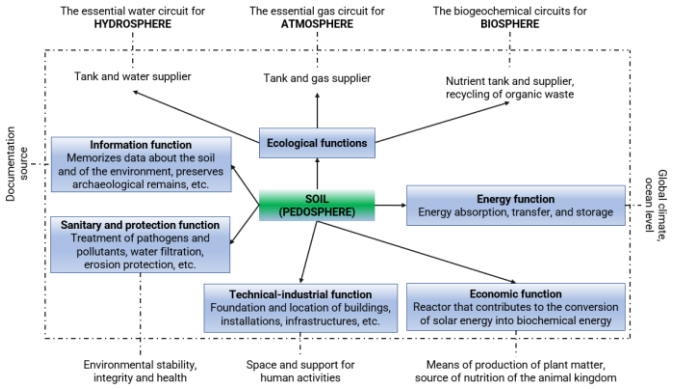

Fig. 3. The multiple functions or "ecosystem services" in which the soil participates

Three other functions are related to non-agricultural human activities: the soil is a physical environment for technological and industrial structures, a source of raw material, and a factor that ensures cultural heritage (situation exemplified in Fig. 4).

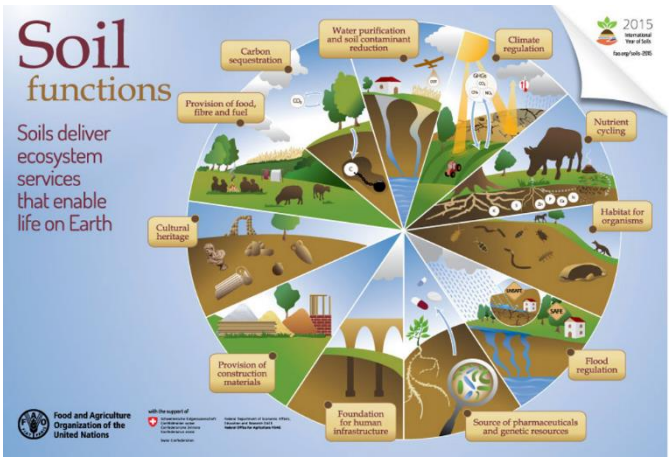

Fig. 4. Soil performs various functions in the community [14]

The following detail some of the functions that the soil performs in society, thus showing, step by step, its undeniable importance, starting with the ecological function and ending with the information function.

The ecological function of soil:

- contributes to the regulation of the composition of the atmosphere and the hydrosphere by the participation of the soil in the circuit of the chemical elements and the water in nature, respectively;
- contributes to the stability of the relief, protecting the deep layers of the bark;
- has the role of attenuating the sudden variations of some soil characteristics, regulating the development conditions of the plants;
- acts as a protection filter, preventing contamination with pollutants;
- has the role of a purification system of foreign organic substances or pathogenic microorganisms that have reached the soil;
- ensures the conditions of protection, functioning, and normal evolution of the biosphere;
- determines the genetic protection of some species and implicitly of biodiversity;
- represents the development habitat of soil organisms.

The economic function of soil:

- contributes to the production of phytomass which serves as a basic raw material for the production of food, clothing, and fuel, through the functions of the soil as a reservoir and continuous supplier of water and nutrients that give it the most important property, namely fertility;
- role in regenerating the production capacity of ecosystems, through the essential contribution to the circuit of chemical elements in nature.

The energy function of soil:

- the accumulation of chemical energy resulting from the conversion of solar energy through the process of photosynthesis into organic substances and their partial accumulation in the soil in the form of humus. This energy can be released into the soil through the process of decomposition (mineralization) of organic substances;
- mediates the exchange of energy and substances between the lithosphere and the atmosphere, and has the role of absorbing solar radiation and heat transfer to the atmosphere.

The industrial function of soil:

- plays an important role in infrastructure for various constructions and installations, roads, highways, aerodromes, stadiums, etc., or space for the installation of underground cables and pipes;
- provides raw materials for various industries (clay, sand, clay, etc.).

The informational function of soil:

- signal for triggering seasonal biological processes;
- records and faithfully reflects the stages of historical evolution by preserving relic characters or archeological relics.

As the interface of the cosmos with the lithosphere and biosphere, the soil plays an essential role in the normal functioning of terrestrial and aquatic ecosystems, as shown in Fig. 5 [15], representing a huge plant, on a global scale permanently producing, through automorphic processes, phytomass which is the basis for the development of organisms. Without phytomass, nutrition with carbohydrates, proteins, and other compounds, as well as the necessary energy, life would not exist and would not unfold.

Soil plays a key role in nature's circuits, including that of nutrients [15], which refers to the amount of organic matter absorbed and stored. Organisms that live in the soil break down organic compounds, such as leaves and root tips, into simpler compounds, which can then be used by plants. Some bacteria in the soil convert atmospheric nitrogen into mineral nitrogen, which is essential for plant growth.

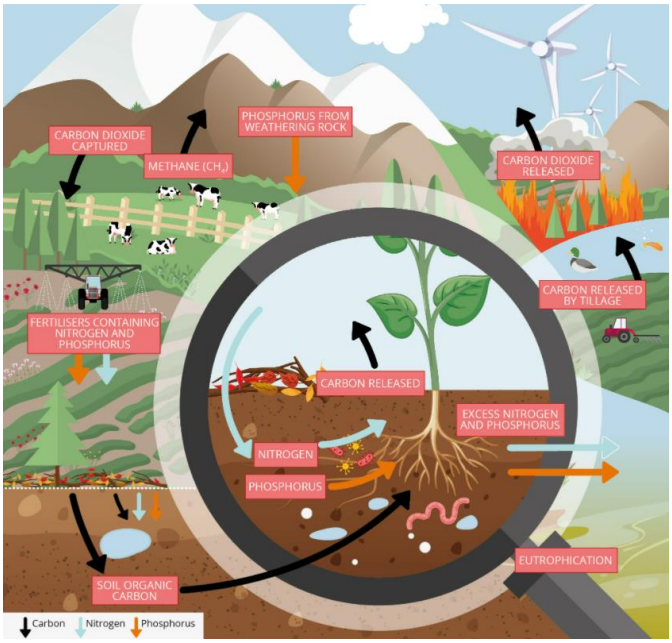

Fig. 5. Soils and nutrient circuits in nature [15]

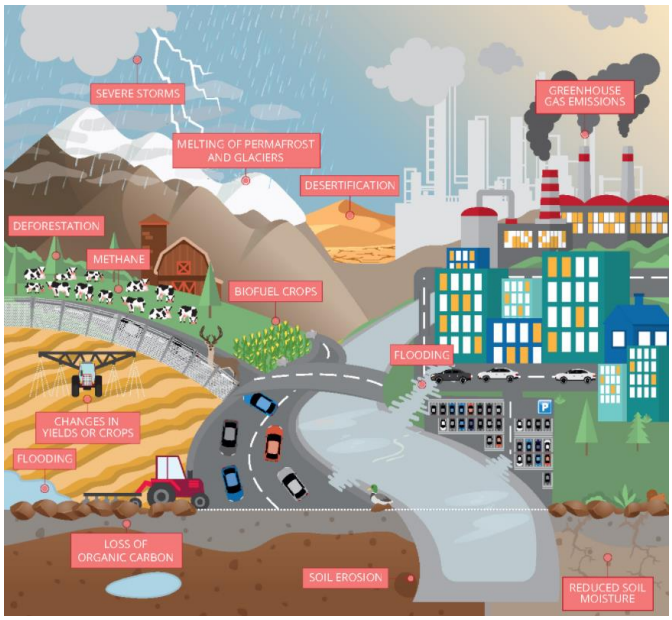

Fig. 6. Soils and climate change [16]

Fertilizers introduce nitrogen and phosphates to stimulate plant growth, but the plants do not absorb the entire amount. The surplus can enter rivers and lakes and can affect life in aquatic ecosystems. Soil is also an important and often neglected element of the climate system. It is the second-largest carbon sink or "CO_2 depression" after the oceans.

Restoring vital land ecosystems and sustainably using land in urban and rural areas can help us mitigate and adapt to climate change. Soils contain significant amounts of carbon and nitrogen, which can be released into the atmosphere depending on current land use (Fig. 6) [16; 21]. Deforestation or forest planting and permafrost thawing can tip the balance of greenhouse gas emissions to one side or the other. Climate change can also substantially affect agricultural production and subsequent land use.

The soil, the object of study of pedology, is the loose layer on the surface of the Earth's crust, formed by the action of the biosphere on the products of disintegration and alteration of rocks, able to sustain plant life. The soil is a system:

- structural - is an organized and structured environment, the constituents being in a close interdependence both vertically and horizontally;
- natural - formed under the influence of natural factors;
- complex – the product of the interaction of 5 factors;
- polyphasic - developed over time in several phases;
- open - exchanges with other geospheres and is in a continuous transformation;
- multifunctional - performs multiple functions;
- polydispersity - its solid phase is in different degrees of dispersion: molecular or ionic dispersions (salts); colloidal dispersions (clay, humus, hydroxides); coarse dispersions or suspensions (dust, sand);
- heterogeneous - because it consists of 3 phases (solid, liquid, gaseous).

In the draft Soil Law (Parliament of the Republic of Moldova, 2008), Article 4, the functions of the soil are mentioned, stating that the soil represents the essence of terrestrial ecosystems, as in Law 246/2020 (Parliament of Romania) [13, 17]:

- specific living environment, the basis of terrestrial ecosystems, the habitat of humans, animals, plants, and soil organisms;
- storage of energy preserved in the form of humus;
- the environment for the decomposition and biochemical transformation of organic residues, of buffering, transformation and filtration of substances, regulating substrate of the circuit, and the formation of surface and groundwater quality and air;
- an archive of natural and cultural history;
- the environment that stores the raw material, the space for localities and recreation, the land for agricultural and forestry use, as well as for other economic and public purposes.

About the above, our opinion is that the soil should be perceived as a multisystem with a special dynamic that in terrestrial ecosystems fulfills various functions: ecological, industrial, social, and technical-economic.

Also, by the established objectives of sustainable development (Fig. 7) [17], the soil has a very significant role, its attributions being about the theme of objectives no. 2, 3, 6, 11, 12, 13, and 15.

Fig. 7. Soil and United Nations Sustainable Development Goals [17]

With the intensification of pollution processes and with the obvious interest in obtaining more and more resources (a specific aspect of the Information and Knowledge Society) the most important functions can be mentioned:

- the function of the filter, buffering, and transformation, is important not only for the protection of the soil fund but also for the prevention of the disturbance of the soil-plant-animal-human food chain;
- the function of water conservation and carbon sequestration in the form of organic matter, the importance of which is amplified by global climate change;
- the function of maintaining genetic biodiversity.

We also believe that both science, and especially society as a whole, has a mission to preserve the soil, to prevent its degradation because the soil - regardless of the perspective of the approach - is and will remain for a long time the foundation of perpetuating our existence.

IV. Conclusion

In the Information and Knowledge Society, the search for new alternatives for the resources so necessary for daily life has made the issue of soil protection an intensely publicized one. And this is even though there are remedial policies and anti-pollution strategies at the international level, which, adopted and applied consistently, can save and conserve many soil resources and affected or degraded lands.

What we noticed, leisurely browsing both articles in the literature and the pages of sites dedicated to soil protection of international organizations (UN, FAO, NRCS, EEA, SSSA, etc.) with established concerns in the field, was the multitude of definitions and functions assigned to the soil.

Thus, we managed to admit in the few pages of this paper the essence of concerns for defining the soil, as a cosmic-telluric-biotic product of the synergistic interaction of energy flows, mass, and information with soil processes in various conditions of development, with cyclic dynamics, on the surface of the Earth's crust. The role of soil is also well-emphasized, with an emphasis on ecological, economic, energy, industrial, and information functions.

References

[1] Soil Survey Staff, 1960, Soil Classification – A Comprehensive System, United States Department of Agriculture, Soil Conservation Service. [Accesat la 01.11.2020]. Disponibil online: www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053109.pdf

[2] SOIL SURVEY STAFF, 1975, Soil Taxonomy - A Basic System of Soil Classification for Making and Interpreting Soil Surveys, United States Department of Agriculture, Soil Conservation Service, Agriculture Handbook no. 436. [Accesat la 01.11.2020]. Disponibil: www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051856.pdf

[3] SOIL SURVEY STAFF, 1999, Soil Taxonomy - A Basic System of Soil Classification for Making and Interpreting Soil Surveys, United States Department of Agriculture, Natural Resources Conservation Service, Agriculture Handbook no. 436. [Accesat la 01.11.2020]. Disponibil: www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051232.pdf

[4] SOIL SURVEY STAFF, 2003, Keys to Soil Taxonomy, United States Department of Agriculture, Natural Resources Conservation Service, Agriculture Handbook, [Accesat la 01.11.2020]. Disponibil online: www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051544.pdf

[5] SOIL SURVEY STAFF, 2006, Keys to Soil Taxonomy, United States Department of Agriculture, Natural Resources Conservation Service, Agriculture Handbook, [Accesat la 01.11.2020]. Disponibil online: www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052172.pdf

[6] SOIL SURVEY STAFF, 2014, Keys to Soil Taxonomy, United States Department of Agriculture, Natural Resources Conservation Service, Agriculture Handbook, [Accesat la 01.11.2020]. Disponibil online: www.nrcs.usda.gov/wps/PA_NRCSConsumption/download.pdf

[7] DUMITRU M., MANEA A., CIOBANU C., DUMITRU S., VRÎNCEANU N., RÎȘNOVEANU I., CALCIU I., TĂNASE V., PREDA M., MOCANU V., EFTENE M., 2011, Monitoringul stării de calitate a solurilor din România, Institutul Național de Cercetare-Dezvoltare pentru Pedologie, Agrochimie și Protecția Mediului - ICPA, Editura SITECH, Craiova. [Accesat la 05.04.2021]. Disponibil online: www.icpa.ro/proiecte/Proiecte%20nationale/monitoring/atlasICPA.pdf

[8] SCHOONOVER J.E., CRIM J.F., 2015, An Introduction to Soil Concepts and the Role of Soils in Watershed Management Universities Council on Water Resources, Journal of Contemporary Water Research & Education, issue 154, pages 21-47. [Accesat la 05.04.2021]. Disponibil online: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1936-704X.2015.03186.x

[9] Coman M., Cioruța B., 2018, From Human-Environment Interaction to Environmental Informatics (III): the Social-Ecological Systems dynamics in Knowledge-based Society, Magazine of Hydraulics, Pneumatics, Tribology, Ecology, Sensorics, Mechatronics, nr. 1, pg. 124-134 www.hidraulica.fluidas.ro/2019/nr1/124-134.pdf

[10] Cioruța B., Coman M., 2021, Implications of Mobile-based Information Systems in Contaminated Soils Characterization, Natural Resources, and Sustainable Development (NRSD), 11(2): 135-142. [Accesat la 01.12.2021]. Disponibil online: https://www.nrsdj.com/issues-year-2021-2/implications-of-mobile-based-information-systems-in-contaminated-soils-characterization.html

[11] SOIL SCIENCE SOCIETY OF AMERICA (SSSA), 2008, Glossary of Soil Science Terms, Soil Science Society of America, Madison, WI. [Accesat la 05.04.2021]. Disponibil online: www.soils.org/publications/soils-glossary#

[12] EUROPEAN ENVIRONMENT AGENCY (EEA), 2019a, Signals 2019 - Land and soil in Europe, Publications Office of the European Union, Copenhagen. [Accesat la 05.04.2021]. Disponibil online: www.eea.europa.eu/publications/eea-signals-2019-land

[13] Legea nr. 246/2020 privind utilizarea, conservarea și protecția solului, publicată în Monitorul Oficial nr. 1057 din 10 noiembrie 2020. Accesat la 06.04.2021. Disponibil online: http://legislatie.just.ro/Public/DetaliiDocument/232879

[14] FAO, 2015, Soil functions, [Accesat la 06.04.2021]. Disponibil online: https://www.fao.org/resources/infographics/infographics-details/en/c/284478

[15] EUROPEAN ENVIRONMENT AGENGY (EEA), 2019b, Semnale de mediu - Circuitul nutrienților în natură, Publications Office of the European Union, Copenhagen. [Accesat la 09.04.2021]. Disponibil online: www.eea.europa.eu/ro/semnale/semnale-2019/infografice/circuitul-nutrientilor-in-natura/view

[16] EUROPEAN ENVIRONMENT AGENGY (EEA), 2019c, Semnale de mediu – Solurile, terenurile și schimbările climatice, Publications Office of the European Union, Copenhagen. [Accesat la 09.04.2021]. Disponibil online: www.eea.europa.eu/ro/semnale/semnale-2019/infografice/solurile-terenurile-si-schimbarile-climatice/view

[17] EUROPEAN ENVIRONMENT AGENGY (EEA), 2019d, Semnale de mediu – Solurile și obiectivele de dezvoltare, Publications Office of the European Union, Copenhagen. [Accesat la 09.04.2021]. Disponibil online: www.eea.europa.eu/ro/semnale/semnale-2019/infografice/solurile-si-obiectivele-de-dezvoltare/view

[18] Cioruța, B., & Coman, M. A. 2022. Ensuring sustainable agriculture by analyzing the European Union and Romanian legislation on soil resources protection. International Journal on Food, Agriculture and Natural Resources, 3(2), 1–4. https://doi.org/10.46676/ij-fanres.v3i2.65

[19] Mohammed, S., Alsafadi, K., Hennawi, S., Mousavi, S. H., Kamal-Eddin, F. B., & Harsanyie, E. 2021. Effects of long-term agricultural activities on the availability of heavy metals in Syrian soil: A case study in southern Syria. Journal of the Saudi Society of Agricultural Sciences. https://doi.org/10.1016/j.jssas.2021.06.001

[20] Guji, M., & Asfaw, M. 2022. Compost enriched with effective microorganism and Bordeaux mixture on ginger bacterial wilt (Ralstonia solanaceurum) Epidemics in southwestern, Ethiopia. International Journal on Food, Agriculture and Natural Resources, 3(1). https://doi.org/10.46676/ij-fanres.v3i1.60

[21] Qiu, H., Hu, B., & Zhang, Z. 2021. Impacts of land use change on ecosystem service value based on SDGs report--Taking Guangxi as an example. Ecological Indicators, 133, 108366. https://doi.org/10.1016/j.ecolind.2021.108366