https://doi.org/10.61308/BCHB4739

Soil Health Evaluation for Sustainable Farm Management

Martin Banov[*], Viktor Kolchakov[*], Dimitre Nikolov[, 1], Krasimir Kostenarov[**], Ekatherina Tzvetanova[**]**

[*]*Institute of Soil Science, Agrotechnology and Plant Protection "Nikola Pushkarov", Agricultural Academy – Sofia*

[**]*New Bulgarian University – Sofia*

[**, 1]E-mail: dnik_sp@yahoo.com

[**, 1]https://orcid.org/0000-0002-4030-4645

Citation: Banov, M., Kolchakov, V., Nikolov, D., Kostenarov, Kr., Tzvetanova, E. (2025). Soil Health Evaluation for Sustainable Farm Management. *Bulgarian Journal of Agricultural Economics and Management,* 70(4) 33-43.

Abstract: The approach developed by us adheres to the limitation methods recommended by the FAO, and more precisely to those that take into account the number and degree of existing limitations for a certain set of soil characteristics, and is tailored to the specifics of agricultural production at the farm level. The research enables dynamic monitoring of changes in soil quality in accordance with measures taken to improve its health.

This study presents a methodology that combines a limited set of soil characteristics specific to each farm. The aim is to make it easier for farmers to provide the necessary information and to make data-driven decisions, taking into consideration soil health and ensuring sustainable farm management. The suggested methodology will be used as a backbone of software that will be developed for profit optimization at the farm level.

The soil features selected for work are grouped into four large groups, complying with the rule to work with the smallest possible number of characteristics that describe as fully as possible the agroecological conditions in relation to the requirements of the plants, while at the same time not allowing double and triple evaluation of the same characteristic.

The degrees of restrictions (from L_0 to L_4) are determined for each soil feature separately using the developed scales, and based on this, the suitability for agricultural use of the farm is assessed. A comprehensive assessment and classification of farms by suitability for agriculture is carried out.

Keywords: soil characteristics; soil health; assessment; agroecological conditions

Оценка на здравето на почвата за устойчиво управление на фермите

Мартин Банов[*], Виктор Колчаков[*], Димитър Николов[, 1], Красимир Костенаров[**], Екатерина Цветанова – Георгиева[**]**

[*]*Институт по почвознание, агротехнологии и защита на растенията „Никола Пушкаров", Селскостопанска академия – София*

[**]*Нов български университет – София*

[**, 1]E-mail: dnik_sp@yahoo.com

[**, 1]https://orcid.org/0000-0002-4030-4645

Резюме: Разработеният подход се придържа към методите за ограничаване, препоръчани от ФАО, и по-точно към тези, които отчитат броя и степента на съществуващите ограничения за определен набор от характеристики на земята. Съобразен е със спецификата на селскостопанското производство на ниво ферма. Изследването позволява динамично наблюдение на промените в качеството на почвата в съответствие с предприетите мерки за подобряване на нейното здравословно състояние.

Настоящото изследване представя методология, която съчетава лимитиран набор от почвени характеристики на отделното стопанство. Целта е да се улесни предоставянето на необходимата информация от земеделските производители и вземането на решения, основани на данни, като се вземе предвид здравето на почвата и се осигури устойчиво управление на стопанствата.
Предложената методология ще бъде използвана като основа на софтуер, който ще бъде разработен за оптимизиране на печалбата на ниво ферма.
Избраните за работа характеристики на почвата са групирани в 4 големи групи, като е спазено правилото да се работи с възможно най-малък брой характеристики, които описват възможно най-пълно агроекологичните условия във връзка с изискванията на растенията, като същевременно не се допуска двойна и тройна оценка на една и съща характеристика.
Степените на ограничения (от L_0 до L_4) се определят за всеки земеделски обект поотделно, използвайки разработените скали, и въз основа на това се оценява пригодността за земеделско ползване на стопанството. Извършва се комплексна оценка и класификация на стопанствата по пригодност за земеделие.

Ключови думи: агроекологични условия; оценка; почвени характеристики; здраве на почвата

INTRODUCTION

Soil is the foundation of our lives. It is home to a quarter of all terrestrial species and plays a crucial role in nutrient cycling, as well as storing carbon and filtering water, helping to mitigate climate change and prevent floods and droughts. But despite the fundamental role of soils in the functioning of our planet's ecosystems, their condition in Europe (and globally) is deteriorating, with long-term consequences for food security and safety, the integrity of ecosystems, and the services they provide to humanity. This calls for urgent action to restore soil health.

The Common Agricultural Policy (CAP) is perhaps the most significant EU instrument affecting the agricultural production of food and biomass. The focus of this policy is shifting increasingly towards measures that enhance sustainability. An extension of the concept of "greener" agriculture of the CAP, planned for the period 2014 – 2020, includes additional support for farmers implementing environmentally friendly practices that contribute to climate and environmental mitigation.

Several current and upcoming EU policy initiatives place a significant focus on soil protection. Good soil health is essential for achieving the ambitious objectives of the European Green Deal, as well as the targets set in its strategies, in particular the Farm to Fork Strategy and the EU Biodiversity Strategy to 2030. The European Commission is also committed to updating the EU Thematic Strategy on Soils in 2021 and to establishing a common EU framework for action to preserve, protect, and restore soils.

Good soil condition is key to achieving the goals of the European Green Deal – climate neutrality, restoring biodiversity, zero pollution, and a healthy and sustainable food system.

The new EU soil strategy aims to comprehensively address soil, land issues, and help achieve land degradation neutrality by 2030, one of the key Sustainable Development Goals (SDGs). The strategy will focus on protecting fertility, reducing erosion, and increasing soil organic matter. The plan will address challenges such as identifying contaminated sites, restoring degraded soils, defining the conditions for their good ecological status, and improving soil quality monitoring.

In accordance with the project's requirements, we have developed a soil evaluation system for the farm territory, enabling us to assess the risk to soil health and provide recommendations for its improvement.

The system developed by us adheres to the limitation methods recommended by FAO, specifically those that take into account the number and degree of existing limitations for a given set of soil characteristics, and is tailored to the specifics of agricultural production at the farm level. The research enables dynamic monitoring of changes in soil quality in accordance with measures taken to improve its health.

This study presents a methodology that combines a limited set of soil characteristics specific to each farm. The aim is to make it easier for farmers to provide the necessary information and to make data-driven decisions, taking into consideration soil health and ensuring sustainable farm management. The suggested methodology will serve as the backbone of the software that will be developed.

The land features selected for work are grouped into four large groups, complying with the rule to work with the smallest possible number of characteristics that describe as fully as possible the agroecological conditions in relation to the requirements of the plants, while at the same time not allowing double and triple evaluation of the same characteristic.

MATERIAL AND METHODS

The first attempt to introduce a unified system for assessing agricultural soil was made by Evgeni Petrov and his team, who published the "Methodology for the Introduction of a Cadastre of Agricultural Lands in the People's Republic of Bulgaria" in 1970. It is oriented to work in conditions of highly intensive agriculture, developed on large areas.

In the period from 1969 to 1988, researchers in the field of the relative assessment of agricultural soil in Bulgaria conducted several studies to improve the "Methodology". Notable studies include those of E. Hershkovich (1968, 1969, 1970, 1971, 1984) and the classification studies of Hr. Trashliev, Sl. Krastanov, Iv. Kabakchiev (1975); the credit studies of B. Georgiev individually and in a team (1987, 2003, 2007); also of V. Krasteva and colleagues (1987, 2002, 2004), M. Mihaylov, B. Georgiev and colleagues (1988), P. Bozhinova and colleagues (1988, 2001, 2002), and others.

In 1988, the updated version of the "Methodology for working on the cadaster of agricultural lands in the People's Republic of Bulgaria" (E. Petrov and colleagues) was published. The basic principles were preserved. The new methodology is composed of two large sections – credit and agrarian-economic. Subsequently, the Expert Council of the Ministry of Agriculture, for the purposes of the agrarian reform, accepted only the first.

Along with its many better sides, the new version of the methodology continues to bear some of the shortcomings of its predecessor. In this regard, work on its improvement continues, as evident in the developments of V. Krasteva and colleagues (1987), Iv. Kabakchiev, P. Bozhinova, B. Georgiev, and V. Krasteva, co-authored with M. Yolevski and D. Dimitrov, conducted a soil assessment study "Parameterization of the productive potential of ecological conditions in the Lovech region" (1989), V. Krasteva and B. Georgiev (1990).

In 1997, M. Penkov and B. Georgiev presented a paper on the topic "Formulation of new principles for the assessment of agricultural soil in Bulgaria". In it, the authors advocated the thesis for new approaches to soil assessment – assessment of agricultural soil "by general natural indicators" and "assessment of individual types of soil use".

At the international level, scientists from the Food and Agriculture Organization of the United Nations (FAO) propose a panel that defines the concept of "soil use types" and recommends classifications based on assessments for specific types of soil use (FAO, 1976, 1991, 1993, 2001).

According to this classification, two classes are proposed at the highest taxonomic level: "S" – suitable soil and "N" – unsuitable lands.

S – Suitable soil. These are lands characterized by a specific type of sustainable agriculture with a defined purpose and method of land use.

N – Unsuitable soil Land whose characteristics prevent a specific type of sustainable agriculture with a defined purpose and method of land use.

It is recommended that three classes be distinguished in the S class, and two in the N class.

Their designation is in Arabic numerals, as follows:

S1 – suitable soil;

S2 – moderately suitable soil;

S3 – limitedly suitable soil;

N1 – currently unsuitable, but potentially suitable soil;

N2 – currently and potentially unsuitable soil.

It is recommended that the assessment procedure be carried out in three major phases:

• **Phase 1.** Collection of data on the characteristics and/or qualities of agricultural soil.

• **Phase 2.** Determination of the requirements for a specific type of soil use.

• **Phase 3.** Relative assessment by comparing the results of the previous two phases.

The developed evaluation adheres to the limitation methods recommended by the FAO, more specifically those that consider the number and degree of existing limitations for a certain set of land characteristics, and is tailored to the specifics of agricultural production at the farm level. The study offers an opportunity for dynamic monitoring of changes in soil quality in response to measures taken to improve its health.

The purpose of the developed evaluation system for assessing the efficiency of growing agricultural crops and improving soil health in certain farms is, based on preliminary information, to prepare recommendations for the cultivated crops depending on climatic conditions and the state of the soil cover.

Aiming for the simplicity of the developed system and based on stakeholders' and experts' opinions, the finally selected soil characteristics are grouped into four large groups (starting from 6), which we briefly comment on below.

As mentioned earlier, the goal is to simplify the process for farmers to provide the necessary information and make data-driven decisions, taking into account soil health and promoting sustainable farm management. It makes it easier to define the actions required for their rehabilitation.

Based on the selected four groups of characteristics, a soil health assessment could be made and recommendations prepared for its preservation and improvement. This enables the farmer to develop strategies for using the farm's land resources and to organize economic assessments of the achieved results.

The selected approach will be used as the backbone of a web-based tool, which will make recommendations for soil health preservation or improvement.

Group 1. Agroclimatic conditions

Group 1 includes two main characteristics – temperature and natural atmospheric humidity.

• *Active temperature sum* for the period with average daily air temperatures $t^0 > 10^0$C.

$$sat^{0}_{C} = (t_1 + t_2 + t_3 + \ldots + t_n) \qquad (1)$$

Where:

sat – sum of active air temperatures (for the period with average daily temperature >10^0C);

$t_1, t_2, t_3 \ldots t_n$ – consecutive observations of average daily temperatures of the air above 10^0C.

• *The conditions of natural atmospheric humidification* for the period June – August are expressed by the difference between precipitation and evaporation.

Group 2. Relief and stony soil

The relief and stony soil are united in one group, because in fact, the conditions for mechanized cultivation of the land are similar. This group is evaluated by the following two characteristics:

• The prevailing slopes of the slopes (%).

• *Stoniness of the plowed soil layer* (stones and gravel in the plowed soil in volume %).

Group 3. Drainage conditions

The drainage conditions are provided for assessment by the following two characteristics:

• The textural differentiation of the soil profile.

• Groundwater level.

Group 4. Soil fertility

The soil fertility evaluation is based on the following four characteristics:

• *The mechanical composition of the soil* (through the physical clay content).

• *The root space according to the presence (or not) of a root barrier and the depth to it* (cm).

• *Soil reaction* (pH measured in aqueous suspension).

• *The content of organic carbon (humus) in the arable land.*

Based on the collected data, it is suggested to classify the land into the following five levels:

• L_0 – no restrictions.

• L_1 – minor and light restrictions.

• L_2 – moderately pronounced restrictions.

• L_3 – strict restrictions.

• L_4 – stringent restrictions.

The use of the proposed methodology takes place in three main stages:

1. Collection of the necessary primary data on soil features;

2. Individual evaluations of the characteristics according to the developed credit rating scales;

3. Summarization and final classification of soil;

Based on the final classification, recommendations for improving soil health can be made.

RESULTS AND DISCUSSION

The suggested approach assumes working with the smallest possible number of characteristics that describe the agroecological conditions as fully as possible in relation to the requirements of the plants, while at the same time avoiding double and triple evaluation of the same characteristic (Table 1).

The following section presents the adopted evaluation of the suggested groups of characteristics. First, the rating scales are presented, followed by the algorithms for general evaluation and categorization of soil.

1. Rating scales

1.1. Agroclimatic:

1.1.1. Active temperature sum

The evaluation of the active temperature sum is calculated as mentioned in the "Methods and materials section". Table 2 presents the evaluation, taking into consideration the restriction level.

Table 2. Evaluation of the active temperature sum

$\Sigma T^0 > 10^0C$			Restriction levels L^{TS}
>3600			L^{TS}_0
3600	÷	3100	L^{TS}_1
3100	÷	2600	L^{TS}_2
2600	÷	1900	L^{TS}_3
		<1900	L^{TS}_4

Table 1. Selected soil features and their indices

Land features	**Measure**	**Index**
1. Agroclimatic:		
1.1 The active temperature sum for the period with average daily air temperatures $t^0 > 10^0C$	^0C	$\mathbf{L^{TS}}$
1.2. Balance of natural atmospheric humidification for the period June – August	mm	$\mathbf{L^{WB}}$
2. Terrain and stony soil:		
2.1. Prevailing slope gradients	%	$\mathbf{L^{SL}}$
2.2. Rockiness of the arable soil layer	voluminous %	$\mathbf{L^{ST}}$
3. Drainage conditions:		
3.1. Textural differentiation of the soil profile	coefficient	$\mathbf{L^{TD}}$
3.2. Groundwater level	cm	$\mathbf{L^{GWT}}$
4. Soil fertility:		
4.1. Mechanical composition of the soil	physical clay %	$\mathbf{L^{TX}}$
4.2. Root space (depth to root barrier)	cm	$\mathbf{L^{RS}}$
4.3. Soil reaction (pH measured in aqueous suspension)	pH in H_2O	$\mathbf{L^{PH}}$
4.4. Content of organic matter in the topsoil (humus)	%	$\mathbf{L^{HC}}$

1.1.2. Conditions of natural atmospheric humidification

The characteristic represents the balance between the average amounts of precipitation "p" and evaporation "E" for June, July, and August (Table 3).

1.2. Scales for evaluating relief and stony soil

1.2.1. Prevailing slope gradients

When evaluating this indicator, it is necessary to consider the risks of existing or potential soil erosion (Table 4).

1.2.2. Rockiness of the arable soil layer

Stony soils with the content and size of stones and gravel up to certain limits do not hinder agrotechnical measures, but they hinder the development of some plants (especially in the initial phases). In other cases (vineyards for white table wines), such conditions are desired (Table 5).

There are different classifications for stony soils based on the volumetric participation of skeletons, gravels, and stones in the soil profile, as well as their sizes, depth of placement, and other factors (Table 6).

1.3. Scales for evaluating drainage conditions

1.3.1. Textural differentiation of the soil profile

By value, the textural differentiation of the profile is calculated as the ratio of clay content in the heaviest subsurface to the lightest surface soil horizon or layer (Equation 1).

$$Kt = \frac{I_B}{I_A} \qquad (1)$$

Where:

Kt – texture coefficient;

I_B – physical clay content – particles < 0.01 mm (%) in the heaviest layer of the subsurface horizons;

I_A – physical clay content – particles < 0.01 mm (%) in the lightest layer of surface horizons.

Table 7 presents the accepted assessment of the soil profile differentiation.

Table 3. Assessment of natural atmospheric humidification

$p - E_{(VI\text{-}VIII)}$ mm			Restriction levels L^{WB}
> -100			L^{WB}_0
-100	÷	-200	L^{WB}_1
-200	÷	-300	L^{WB}_2
-300	÷	-400	L^{WB}_3
		< -400	L^{WB}_4

Table 4. Assessment of prevailing slopes on the slopes

Prevailing slopes %			Restriction levels L^{SL}
<2		or terraced	L^{SL}_0
2	÷	8	L^{SL}_1
8	÷	16	L^{SL}_2
16	÷	30	L^{SL}_3
		>30	L^{SL}_4

Table 5. Evaluation of the rockiness of the plow layer

Stones and gravel in volume %			Restriction levels L^{ST}	Analysis of the indicator
<5			L^{ST}_0	Non-stone
5	÷	15	L^{ST}_1	Slightly stony
15	÷	30	L^{ST}_2	Medium stony
30	÷	40	L^{ST}_3	Medium stony
		>40	L^{ST}_4	Very heavily stony

Table 6. Degrees of stony soil

Degrees of stony	Content of stones and gravel in the plow layer (% by volume)
Non-stone	0
Slightly stony	0÷10
Medium stony	10÷20
Very stony	20÷40
Very heavily stony	>40

1.3.2. Groundwater level

The high level of groundwater determines the degree of soil waterlogging - a phenomenon that is too restrictive for almost all agricultural crops (Table 8).

1.4. <u>Soil fertility assessment scales</u>

1.4.1. Mechanical composition of the soil

The water-physical, mechanical, and many chemical properties, their air regime, etc., depend on the values of the soil's mechanical composition (Table 9).

1.4.2. Root space

The root space is actually the distance from the soil surface to a root-impenetrable barrier. This can be shallow hard rock, an extremely clayey horizon, compacted deposit materials, etc., through which roots do not grow (Table 10).

1.4.3. Media reaction

The composition, properties, and fertility of the soil largely depend on this soil characteristic. Highly acidic and highly alkaline soils without land reclamation are unsuitable for growing agricultural crops (Table 11).

1.4.4. Content of organic matter in the topsoil (humus) (Table 12).

Table 7. Assessment of textural differentiation of the soil profile

Texture coefficient			Restriction levels L^{TD}
<1.3			L^{TD}_0
1.3	÷	1.5	L^{TD}_1
1.5	÷	2.0	L^{TD}_2
2.0	÷	2.5	L^{TD}_3
		>2.5	L^{TD}_4

Table 8. Groundwater level assessment

Groundwater level, cm			Restriction levels L^{GWT}
>300			L^{GWT}_0
300	÷	200	L^{GWT}_1
200	÷	100	L^{GWT}_2
100	÷	50	L^{GWT}_3
		<50	L^{GWT}_4

Table 9. Evaluation of the mechanical composition of the soil profile

Physical clay %			Restriction levels L^{TX}
<10			L^{TX}_4
10	÷	20	L^{TX}_3
20	÷	30	L^{TX}_2
30	÷	45	L^{TX}_1
45	÷	60	L^{TX}_0
60	÷	75	L^{TX}_1
		>75	L^{TX}_2

Table 10. Assessment of root space

Depth to root barrier cm			Restriction levels L^{RS}
>130			L^{RS}_0
130	÷	100	L^{RS}_1
100	÷	80	L^{RS}_2
80	÷	50	L^{RS}_3
		<50	L^{RS}_4

Table 11. Assessment of soil reaction

Soil reaction – pH in H_2O			Restriction levels L^{PH}
<5.0			L^{PH}_4
5.0	÷	6.0	L^{PH}_3
6.0	÷	6.5	L^{PH}_2
6.5	÷	7.3	L^{PH}_0
7.3	÷	8.6	L^{PH}_1
		>8.6	not evaluated

Table 12. Assessment of humus content

Humus content %			Restriction levels L^{HC}
>3.0			L^{HC}_0
3.0	÷	2.5	L^{HC}_1
2.5	÷	2.0	L^{HC}_2
2.0	÷	1.0	L^{HC}_3
		<1.0	L^{HC}_4

2. Algorithms for general evaluation and categorization of lands

For evaluation purposes, the farmer completes the table shown below (Table 13).

With the obtained values, the degrees of restriction (from L_0 to L_4) are determined for each soil feature separately using the developed scales. On this basis, the suitability of the farm for agricultural use is assessed.

A comprehensive assessment and classification of farms by suitability for agriculture is carried out using the algorithms given below in Table 14.

Placing the lands in the above-mentioned classes allows making recommendations for improving soil health (Table 15).

As mentioned before, the aim is to make it easier for farmers to provide the necessary information and to make data-driven decisions, tak-

Table 13. Farm data

№	Indicators	Value
1.	The active temperature sum for the period with average daily air temperatures $t^0 > 10^0C$	
2.	Balance of natural atmospheric humidification for the period June – August – introduced additionally	
3.	Prevailing slope gradients	
4.	Rockiness of the arable soil layer	
5.	The textural differentiation of the soil profile (textural coefficient)	
6.	Groundwater level	
7.	Mechanical composition of the soil	
8.	Root space according to the presence (or not) of a root barrier and the depth to it (cm)	
9.	Soil reaction (pH measured in aqueous suspension)	
10.	The content of organic carbon /humus/ in the arable land	

Table 14. Comprehensive assessment of agricultural lands and classification by suitability for agriculture

Classes		Units	Criteria
			Land units that:
S_1	Very good soil	(1)	They have no limitations
		(2)	or have up to 5 L_1 level restrictions
			Land units which:
S_2	Good soil	(1)	have more than 5 L_1 level restrictions
		(2)	or have up to 4 L_2 level restrictions
			Land units which:
S_3	Average good soil	(1)	have more than 4 L_2 level limitations
		(2)	or have up to 3 L_3 level restrictions
			Land units which:
N_1	Bad soil	(1)	have more than 3 L_3 level restrictions
		(2)	or have up to 1 L_4 level restriction
			Land units which:
N_2	Unsuitable soil	(1)	have more than 4 L_3 level restrictions
		(2)	or more than 1 L_4 level restriction

Table 15. Recommendations for improving soil health

Land classes	Leading limiting factor	Use	Improvement measures
S_1	Without limitations	For all crops in the given climate	Fertilization and irrigation, bioprotective belts
S_2	Some have high groundwater levels	For all crops for which there are climatic conditions - cereals, root crops and tubers, perennial fodder, essential oil, medicinal, technical, fruit, and berry crops	Fertilization, drainage (if necessary), and amelioration
S_3	Stony, erosion, high carbonate content	Lavender, Walnuts, Almonds, Cherries, Vineyards, Sudanese, Red Clover, Grasslands, Forests	Anti-erosion measures, fertilization, weeding, and cleaning of stones
S_3	Light mechanical composition, high level of groundwater, swamping, unfavorable soil reaction, stony	For lands in class S_2 and S_3 – vineyards, vegetable crops, cereals, fodder, watermelons and melons, pumpkins, herbs, pastures. For land in class N_1-meadows and pastures, woody vegetation (shoreline strengthening)	Fertilization, soil reclamation, drainage, terracing, afforestation, alignment
N_1	Shallow hard rock, erosion, poor in nutrients, acidic reaction or high carbonate content	Potatoes, tobacco, lavender, raspberries, herbs, pastures, forests	Anti-erosion measures, fertilizing, weeding, afforestation, terracing, horizontal processing
N_2	Shallow hard rock, erosion, poor in nutrients, acidic reaction, or high carbonate content	Grasslands, protected areas around settlements, and forests	Anti-erosion measures, preservation of forests, afforestation, and terracing

ing into consideration soil health, and ensuring sustainable farm management. It makes it easier to define the actions required for their rehabilitation.

Based on the selected four groups of characteristics, a soil health assessment can be made and recommendations prepared for its preservation and improvement.

The next step would be to validate the selected approach using farm data from various countries. Moreover, a web-based tool could be developed based on the presented methodology, ensuring easy access and application. As an output, the tool could give recommendations based on the information provided.

CONCLUSIONS

Maintaining good soil health is crucial for achieving the goals of the European Green Deal – climate neutrality, restoration of biodiversity, and a sustainable food system.

This study presents an evaluation system of 4 groups of indicators with data that is easy to collect without or with low costs. The suggested approach is developed based on scientific methods recommended by the FAO and adapted to the specific needs of agricultural production at the farm level.

The four groups cover information on agroclimatic conditions, terrain and stony soils, drainage conditions, and soil fertility. It includes a total of 10 indicators. Additionally, the study proposes ranking all these indicators and algorithms for comprehensive evaluation and categorization of lands.

The evaluation system enables farmers to assess the risk to soil health and receive targeted recommendations for its improvement, ultimately leading to more sustainable and efficient agricultural practices.

The suggested indicators enable dynamic monitoring of changes in soil properties in response to measures taken to improve their health. The next step is to develop a digital tool at the farm level for profit optimization, based on the suggested methodology. It will evaluate which soil restoration practices are appropriate for a given soil based on its characteristics and how these practices would affect the income-cost structure.

ACKNOWLEDGMENT

This paper is prepared as part of the scientific project NOVASOIL "INNOVATIVE BUSINESS MODELS FOR SOIL HEALTH" ID: 101091268, funded by the EU program HORIZONT EUROPE.

Conflict of interest

The authors declare that they have no conflicts of interest.

REFERENCES

Bozhinova P., Krasteva, V., Voinova, Y. (2001). Assessment of the productive potential for growing rye on lands from different agroecological regions of the country. *Soil science, agrochemistry and ecology*, year XXXVI, No 4-6, pp. 37-39.

Bozhinova P., Krasteva, V., Voinova, Y. (2002). Influence of climatic factors on winter barley yields. *Ecology and future*, year I., b. 2-4, pp. 81-83.

Georgiev, B. (1987) Improvement of the moisture coefficients in land improvement in Bulgaria for corn. *Soil Science, Agrochemistry and Plant Protection*, Vol. XII, No. 6, Sofia.

Georgiev, B. (2007). Land reclamation of agricultural lands – theoretical foundations and practical approaches for conditions in Bulgaria. Dissertation, pp. 193, Fund of ISS "N. Pushkarov", Sofia.

Georgiev, B., Krasteva, V. (2003). Basic principles for updating the systems for relative valuation of agricultural lands in Bulgaria. *Collection "Scientific Reports International Scientific Conference 50 Years of LTU"*, pp. 21-24. Sofia.

Hershkovich, E. L. (1968). Agroclimatic characteristics of droughts in Bulgaria. *In: Nature of droughts and the variable irrigation regime of agricultural crops, Bulgarian Academy of Sciences*, Sofia.

Hershkovich, E. L. (1969). Agroclimatic and soil-climatic zoning of the crops rice, cotton, tobacco, potatoes, flax. *In: Soil-climatic zoning of the main field crops*, Sofia.

Hershkovich, E. L. (1970). Agricultural assessment (quality) of climatic conditions in Bulgaria. *Hydrology and Meteorology*, vol. 3, Sofia.

Hershkovich, E. L. (1970). Agroclimatic zoning of Bulgaria. *Institute of Hydrology and Meteorology*, 17, Sofia.

Hershkovich, E. L. (1971). Agroclimatic regions of Bulgaria. *In: Microregions of agricultural production in Bulgaria*, BAS, Sofia.

Hershkovich, E. L. (1984). Agroclimatic Resources of Bulgaria. *Bulgarian Academy of Sciences, Publishing House*, Sofia.

Kabakchiev, Iv., Bozhinova, P., Georgiev, B., Yolevski, M., Dimitrov, D., Krasteva, V. (1989). Parameterization of the productive potential of the ecological conditions in the Lovech region. *Materials from the international symposium "Modeling the productive potential of soils in agroecosystems" – collection Agricultural Academy, Institute of Soil Science and Yield Programming "N. Pushkarov"*, Sofia.

Krasteva V., Kabakchiev, Iv., Georgiev, B. (1987). Land improvement – methodological foundations and possibilities for application in the People's Republic of Bulgaria. *XIVth Review of TNTM – collection Agricultural Academy*, Sofia.

Krasteva, V. (2002). Methodology for the improvement of agricultural lands according to the requirements of winter barley (under non-irrigated conditions). Dissertation, Fund of ISS "N. Pushkarov", Sofia.

Krasteva, V., Georgiev, B. (1990). Influence of the climatic factor on the fertility of lands with carbonate chernozems for some agricultural crops. *Soil Science and Agrochemistry*, vol. XXV, No 1, Sofia.

Krasteva, V., Ilieva, R., Stefanova, V. (2004). Agroecological suitability of the lands of the Southwestern Agrotechpark of Bulgaria for growing cherries. *Ecology and Industry,* vol. 6, No 1, pp. 118-120.

Penkov, M., Georgiev, B. (1998). Formulation of new principles for the assessment of agricultural lands in Bulgaria. *Materials of the Jubilee Conference 50 years of the Institute of Soil Science in Bulgaria, journal "Soil Science, Agrochemistry and Ecology"*, vol. XXXIII, No 3, pp. 35-38, Sofia.

Petrov, E., Kabakchiev, Iv., Bozhinova, P., Stoeva, A., Georgieva, Ya., Hershkovich, E., Dilkov, D. (1988). Methodology for working on the cadastre of agricultural lands in the People's Republic of Bulgaria. Pg. 144. Association of Agricultural Lands, Sofia.

Petrov, Evg., Strashilov, Zh., Kolev, Il., Trashliev, Hr., Krastanov, Sl., Kabakchiev, Iv., Hershkovich, E., Dilkov, D. (1970) Methodology for the introduction of a cadastre of agricultural lands in the Republic of Bulgaria, 167 pp. Ministry of Agriculture, Forestry, Agricultural Sciences, Institute of Agricultural Sciences, Sofia.

Trashliev, Hr., Krastanov, Sl., Kabakchiev, Iv. (1975). Principles of land classification. *Soil Science and Agrochemistry*, vol. X, book 6, pp. 12-15, Sofia.

FAO. (1976). A framework for land evaluation. *Soils Bulletin*, 32; FAO, Rome, 72 pp.

FAO. (1991). Guidelines: land evaluation for extensive grazing. *Soils Bulletin 58*. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO. (1993). Computerized systems of land resources appraisal for agricultural development, *World Soil Resources Report,* No 72, Rome, Italy.

FAO. (2001). *Indicadores de la calidad de la tierra y su uso para la agricultura sostenible y el desarrollo rural*. *Boletín de tierras y aguas de la FAO* No 5. Food and Agriculture Organization of the United Nations, Rome, Italy.

Постъпила – **1 август 2025 г.;** *Одобрена* – **3 октомври 2025 г.;** *Публикувана* – **декември 2025 г.**