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STRATEGIC PRIORITIES OF FINANCIAL SUPPORT FOR SUSTAINABLE SOIL MANAGEMENT IN UKRAINE

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Abstract

The aim of this paper is to justify the strategic priorities of financial provisions for sustainable soil management in agriculture of Ukraine. In conditions of limited financial resources, there is a need to identify the top priorities of sustainable soil management. The study found that the most important priority of financial support for sustainable soil management is to suspend the decrease of the content of humus and achieve its deficit-free balance (global priority – 0.556); the second position is occupied by the protection of soils from erosion (priority – 0.274); third place – enrichment of soils with nutrients substances (priority – 0.101); fourth place – amelioration of acid and solonets soils (priority – 0.069). In the context of identification of priorities of financial support for practical implementation of the proposed conception of sustainable soil management this paper also addresses the empirical expert evaluation of the relative importance (significance) of the principles of sustainable soil management, as well as the level of adherence (compliance) of these principles in agricultural enterprises of Ukraine. The obtained results demonstrate the state of compliance with the principles of sustainable soil management in agricultural enterprises, the availability of opportunities and reserves for improving the situation for their implementation, and as well due to which this should be carried out. Thus, 77.8 % of the principles were implemented at a low level, the rest (22.2 %) – at a very low level, so there are significant reserves to improve the situation.

Key words**:** *soil organic carbon, climate change, low-carbon land use, Ukraine*

INTRODUCTION

The problem of financial support for the agriculture has always been and remains relevant. The results of the analysis of recent publications indicate a significant scientific interest of researchers in the problem of financial support for the agricultural sector of the economy (Kirieieva et al. [8]; Mazur [13]; Kolotukha et al. [9]; Pronko et al. [14] Sakhno et al. [18]; Soliwoda [19]; Wieliczko [24]; Zakaria et al. [26]). The problem of the sustainable soil management is among the most topical scientific and practical issues (Adeyolanu and Ogunkunle [1]; Ansong Omari et al. [2]; Baritz et al. [5]; Helming et al. [6]; Rojas and Caon [15]; Vargas et al. [23]). However, in Ukraine this issue is at the initial stage of research [3]. Ukrainian researchers mainly focus their attention on other issues [20; 21]. Our monograph is a first attempt to close the research gap in the literature and to promote research on the sustainable soil management in Ukraine [12]. In the context of scarcity of financial resources, it is very important to identify strategic priorities that require priority funding. This will make it possible to organize their effective use in order to achieve sustainable competitiveness of land use of agricultural enterprises.

To achieve the strategic goals of the development of agriculture in terms of sustainable soil management in Ukraine, while preventing their degradation along with restoring soil fertility, a whole package of measures has to be implemented; these measures are put forward as strategic state priorities for financial support, taking into account the current state of soil cover and dynamics of its positive renovation suspending of the decrease of the content of humus and achievement its deficit- free balance; enriching the soils with nutrient substances; protection of soils from erosion; amelioration (reclamation) of acidic and

solonets soils [4]. Therefore, the aim of our study is to justify the strategic priorities of financial provisions for sustainable soil management in agriculture of Ukraine.

MATERIALS AND METHODS

The materials of an expert survey conducted in Ukraine are an empirical basis. The study used the following methods: monographic (depth analysis of the issue under study); expert assessments (determination of the main priorities of financial support for sustainable soil management); abstract-and-logical, analysis and synthesis (formulation of conclusions).

In conditions of limited financial resources, there is a need to identify the top priorities of sustainable soil management. For this purpose, we first proposed using a matrix data analysis (or matrix of priorities), which is part of the method of Analytical Hierarchy Process (AHP), developed by the American scientist T. Saaty. For a quantitative expert assessment of the relative importance (priority) of objects, we used the T. Saaty scale (Table 1).

Table 1. Scales of relative importance (priority) according to Saaty

Numerical score	Definition (Verbal judgements of preferences)
1	Equal importance
3	A slight advantage of the importance of one element over another
5	A significant advantage of one element over another
7	Strong advantage of one element over another
9	Absolute advantage of one element over another
2, 4, 6, 8	Intermediate values between neighboring

Source: Saaty, 2008; Khirkh-Ialan, 2013 [16; 7].

RESULTS AND DISCUSSIONS

Expert evaluation of the strategic priorities of financial support for sustainable soil management in Ukrainian agriculture

As a result of the study, we constructed a matrix of pairwise comparisons of the priorities of financial support for sustainable soil management in Ukraine (Table 2). The developed matrix can be used as a mathematical tool for managerial decisions regarding the protection and rational use of soil resources.

Table 2. Matrix of pairwise comparisons of the priorities of financial support for sustainable soil management, determined on the basis of expert assessments

Priorities of financial support for sustainable soil management	Suspending the humus-content decrease and achievement its deficit-free balance	Enriching the soils with nutrient substances	Protection of soils from erosion	Amelioration of acidic and solonets soils	Global priorities
Suspending the humus- content decrease and achievement its deficit- free balance	1.000	5.000	3.000	6.000	0.556
Enriching the soils with nutrient substances	0.200	1.000	0.250	2.000	0.101
Protection of soils from erosion	0.333	4.000	1.000	4.000	0.274
Amelioration of acid and solonets soils	0.167	0.500	0.250	1.000	0.069

Source: author's calculations.

Local priorities (A_i) are calculated by the formula [22; 25]:

$$A_i = \sqrt[n]{\prod_{j=1}^{n} a_{ij}}\ , \qquad \text{.....(1)}$$

where Π – mathematical symbol of the product;

n – number of criteria;

α_{ij} – i-th element of the j-th column of the matrix of pairwise comparisons of criteria.

For example, in our study we obtained the following results:

$$A_1 = \sqrt[4]{1 \cdot 5 \cdot 3 \cdot 6} = 3.080$$

$$A_2 = \sqrt[4]{0{,}200 \cdot 1 \cdot 0{,}250 \cdot 2} = 0.562$$

$$A_3 = \sqrt[4]{0{,}333 \cdot 4 \cdot 1 \cdot 4} = 1.519$$

$$A_4 = \sqrt[4]{0.167 \cdot 0.500 \cdot 0.250 \cdot 1} = 0.381$$

$$\sum A_i = A_1 + A_2 + A_3 + A_4 = 5.542$$

Global priorities (B_i) are calculated by the

formula [22; 25]:

$$B_i = \frac{A_i}{\sum_{i=1}^{n} A_i} \quad \text{.....(2)}$$

Appropriate calculations for our example:
$B_1 = A_1 : A = 0.556$
$B_2 = A_2 : A = 0.101$
$B_3 = A_3 : A = 0.274$
$B_4 = A_4 : A = 0.069$

So, on the basis of the study, it was found that the most important priority of financial support for sustainable soil management is to suspend the decrease of the humus content and achieve its deficit-free balance (global priority – 0.556). The second place is occupied by the protection of soils from erosion (priority – 0.274); third position – enrichment of soils with nutrients substances (priority – 0.101); fourth place – amelioration of acid and solonets soils (priority – 0.069). Such a distribution of priorities confirms our assumption and is quite logical, given the current state of soil resources in Ukraine.

At the final stage, we evaluated the consistency of the results. The maximum eigenvalue of the inverse-symmetric matrix of pairwise comparisons (λ_{max}) was determined by the formula [25]:

$$\lambda_{\max} = \sum_{j=1}^{n} A_j \left(\sum_{i=1}^{n} a_{ij} \right) \quad \text{..... (3)}$$

where A_j – the value of the j-th column of the matrix of pairwise comparisons of criteria.

In view of the above we have obtained the following results:

$$\sum_{i=1}^{4} a_{i1} = 1 + 0.200 + 0.333 + 0.167 = 1.7$$

$$\sum_{i=1}^{4} a_{i2} = 5 + 1 + 4 + 0.500 = 10.5$$

$$\sum_{i=1}^{4} a_{i3} = 3 + 0.250 + 1 + 0.250 = 4.5$$

$$\sum_{i=1}^{4} a_{i4} = 6 + 2 + 4 + 1 = 13.0$$

$$\lambda_{\max} = 0.556 \cdot 1.7 + 0.101 \cdot 10.5 + 0.274 \cdot 4.5 + +0.069 \cdot 13.0 = 4.14$$

Estimates of the relative importance of the comparative priorities must be consistent, so we calculated the consistency index (*SI*) and the consistency ratio (*CR*), using the appropriate formulas [25]:

$$CI = \frac{\lambda_{\max} - n}{n-1} = \frac{4.14 - 4}{4-1} = 0.047$$

$$CR = \frac{CI}{RCI} = \frac{0.047}{0.89} = 0.053,$$

where *RCI* – the value of the random consistency index (Table 3).

Table 3. Reference values of a random consistency index depending on the number of compared objects

Number of objects (*n*)	1	2	3	4	5	6	7	8	9	10
Average random consistency	0.0	0.0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Source: Saaty, 2008 [17].

Therefore, the results of the study are quite consistent, since the actual value of the consistency index (5.3 %) is much smaller than its limit value (10.0 %). A comparison of the relative importance showed that in modern realities, among the priorities considered, the optimization of the content of organic matter in the soil requires priority attention and appropriate measures and their financial support. This issue becomes particularly relevant in the context of climate change [10]. Therefore, the development of low carbon agricultural land use is a strategic priority for financial support [11].

Expert evaluation of the level of adherence (compliance) of the principles of sustainable soil management in agricultural enterprises of Ukraine

In the context of financial support for practical implementation of the proposed conception of sustainable soil management, we conducted an empirical expert evaluation of the relative importance (significance) of the principles of sustainable soil management, as well as the level of adherence (compliance) of these principles in agricultural enterprises of Ukraine. The formed system of special principles for sustainable soil management is

accepted as a basis for the development of methodology of expert evaluation (Fig. 1) and situational analysis of the degree of observance of these principles in agriculture, which it is assumed to be applied along with others for the substantiation of decision-making and actions.

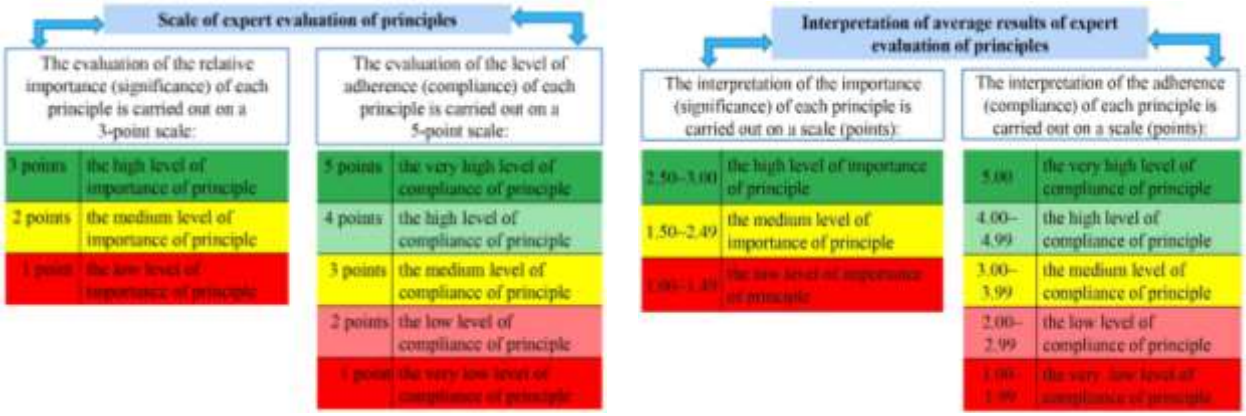

Fig. 1. Methodological framework for expert evaluation of the relative importance (significance) of the principles of sustainable soil management, as well as the level of adherence (compliance) of these principles in agricultural enterprises of Ukraine

Source: built by the author according to the analysis and synthesis of the literature.

A generalization of the obtained results (Table 4) made it possible to group and rank the principles under consideration according to the level of importance:

(i) the high level of importance – enhance soil organic matter content (2.833 points); combination of actions market mechanism and government regulation (2.778 points); combination of economic incentives and responsibility (2.722 points); systematic consideration of a complex of factors (2.611 points); continuous development and implementation of advanced technologies for the reproduction of soil fertility (2.611 points); minimize soil erosion (2.611 points); improve soil water management (2.611 points); focusing on the future, responsibility before the next generations (2.556 points); principle of differentiation (2.556 points); foster soil nutrient balance and cycles (2.556 points);

(ii) the medium level of importance – solidarity responsibility for the preservation and improvement of soil fertility (2.444 points); principle of monitoring and information feedback (2.444 points); priority of social and environmental tasks (2.444 points); principle of harmonious combination of tactical and strategic goals (2.444 points); the unity of economic and natural laws (2.389 points); prevent and minimize soil contamination (2.389 points); prevent and mitigate soil compaction (2.333 points); prevent, minimize and mitigate soil salinization and alkalinization (2.333 points); preserve and enhance soil biodiversity (2.278 points); principle of complexity and synergy (2.222 points); principle of dynamism and adaptability (2.222 points); principle of parametrization (2.222 points); principle of relativity (2.167 points); recognition of land by capital (2.056 points); principle of decomposition (2.000 points); prevent and minimize soil acidification (1.944 points); minimize soil sealing (1.611 points).

None of the principles fell into the low-level group of significance. Thus, the results of the empirical study confirmed the logic of choice and the importance of theoretically sound principles of sustainable soil management.

The generalized average expert level of importance in the context of the three groups of principles of sustainable soil management is: guidelines principles for sustainable soil management – 2.350 points; principles of system management of soil fertility – 2.285 points; principles of organizational-and-economic regulation of soil fertility reproduction – 2.512 points.

Table 4. Results of expert evaluation of the relative importance (significance) of principles of sustainable soil management in Ukraine

No.	Principles	Average rank	Sum of ranks	Average value	Standard deviation
1	Minimize soil erosion	16.639	299.5	2.611	0.502
2	Enhance soil organic matter content	18.917	340.5	2.833	0.383
3	Foster soil nutrient balance and cycles	15.500	279.0	2.556	0.511
4	Prevent, minimize and mitigate soil salinization and alkalinization	12.972	233.5	2.333	0.485
5	Prevent and minimize soil contamination	13.278	239.0	2.389	0.502
6	Prevent and minimize soil acidification	9.000	162.0	1.944	0.639
7	Preserve and enhance soil biodiversity	12.500	225.0	2.278	0.669
8	Minimize soil sealing	6.583	118.5	1.611	0.698
9	Prevent and mitigate soil compaction	13.611	245.0	2.333	0.686
10	Improve soil water management	16.250	292.5	2.611	0.502
11	Principle of differentiation	15.639	281.5	2.556	0.511
12	Principle of monitoring and information feedback	14.833	267.0	2.444	0.705
13	Principle of harmonious combination of tactical and strategic goals	14.722	265.0	2.444	0.705
14	Principle of dynamism and adaptability	11.778	212.0	2.222	0.647
15	Principle of decomposition	9.222	166.0	2.000	0.594
16	Principle of parametrization	11.194	201.5	2.222	0.428
17	Principle of relativity	11.028	198.5	2.167	0.618
18	Principle of complexity and synergy	12.472	224.5	2.222	0.808
19	Combination of actions market mechanism and government regulation	18.750	337.5	2.778	0.548
20	Solidarity responsibility for the preservation and improvement of soil fertility	15.194	273.5	2.444	0.784
21	Priority of social and environmental tasks	14.722	265.0	2.444	0.616
22	Recognition of land by capital	10.500	189.0	2.056	0.725
23	Combination of economic incentives and responsibility	17.889	322.0	2.722	0.575
24	The unity of economic and natural laws	14.556	262.0	2.389	0.778
25	Focusing on the future, responsibility before the next generations	16.667	300.0	2.556	0.784
26	Continuous development and implementation of advanced technologies for the reproduction of soil fertility	16.750	301.5	2.611	0.608
27	Systematic consideration of a complex of factors	16.833	303.0	2.611	0.698

Source: author's calculations on the results of the survey of experts (n = 18).

Summarizing the results of the study (Table 5) showed a low and medium level of compliance of the principles of sustainable soil management in agricultural enterprises of Ukraine. So, the average level of completion guidelines principles for sustainable soil management amounted to only 49.3 %, including by principles: prevent, minimize and mitigate soil salinization and alkalinization – 56.7 %; prevent and minimize soil acidification – 54.4 %; foster soil nutrient balance and cycles – 53.3 %; prevent and minimize soil contamination – 51.1 %; improve soil water management – 50.0 %; minimize soil erosion – 48.9 %; minimize soil sealing – 47.8 %; preserve and enhance soil biodiversity – 47.8 %; prevent and mitigate soil compaction – 43.3 %; enhance soil organic matter content – 40.0 %. So, all the guidelines principles of this group adhere on low level, however, only five out of 10 principles are fulfilled by 50.0 % or more, the rest is less than half, so there are substantial reserves to improve the situation.

Quantitative assessment of the quality of compliance of the principles of system management of soil fertility showed that in this group, one principle (12.5 %) performed at a very low level, namely the principle of harmonious combination of tactical and strategic goals – 37.8 %, the rest (87.5 %) of the principles – at a low level. So, the quality of compliance principle of relativity met the necessary requirements by 55.6 %; principle of dynamism and adaptability – 53.3 %; principle of parametrization – 51.1 %, decomposition – 47.8 %; differentiation – 46.7 %; monitoring and information feedback – 46.7 %; complexity and synergy – 45.6 %. The total average assessment of the quality of compliance of the principles of system management of soil fertility, by the conclusions of experts, amounted to 2.403 points, that is, the necessary requirements were met only by 48.1 %.

The worst situation formed is in compliance the principles of organizational-and-economic regulation of soil fertility reproduction.

The results of the calculations show that on average these principles were compliance in agricultural enterprises of Ukraine only by 39.5 %, that is, most of the principles are kept

at a very low level, in other words, almost not implemented. Very low compliance (very significant deviations, non-compliance) characteristic of the following principles: combination of economic incentives and responsibility – 32.2 %; solidarity responsibility for the preservation and improvement of soil fertility – 34.4 %; systematic consideration of a complex of factors – 35.6 %; focusing on the future, responsibility before the next generations – 38.9 %; priority of social and environmental tasks – 38.9 %. The low level compliance (significant deviations) inherent in such principles: continuous development and implementation of advanced technologies for the reproduction of soil fertility – 41.1 %; recognition of land by capital – 43.3 %; the unity of economic and natural laws – 44.4 %; combination of actions market mechanism and government regulation – 46.7 %.

Table 5. Results of expert evaluation of the level of adherence (compliance) of the principles of sustainable soil management in agricultural enterprises of Ukraine

No.	Principles	Average rank	Sum of ranks	Average value	Standard deviation
1	Minimize soil erosion	15.222	274.0	2.444	0.705
2	Enhance soil organic matter content	10.972	197.5	2.000	0.594
3	Foster soil nutrient balance and cycles	18.083	325.5	2.667	0.686
4	Prevent, minimize and mitigate soil salinization and alkalinization	19.028	342.5	2.833	0.707
5	Prevent and minimize soil contamination	16.722	301.0	2.556	0.705
6	Prevent and minimize soil acidification	17.778	320.0	2.722	0.669
7	Preserve and enhance soil biodiversity	15.167	273.0	2.389	0.698
8	Minimize soil sealing	15.194	273.5	2.389	0.850
9	Prevent and mitigate soil compaction	12.972	233.5	2.167	0.618
10	Improve soil water management	16.194	291.5	2.500	0.707
11	Principle of differentiation	14.556	262.0	2.333	0.767
12	Principle of monitoring and information feedback	13.444	242.0	2.333	0.840
13	Principle of harmonious combination of tactical and strategic goals	10.389	187.0	1.889	0.758
14	Principle of dynamism and adaptability	17.583	316.5	2.667	0.686
15	Principle of decomposition	15.139	272.5	2.389	0.979
16	Principle of parametrization	16.889	304.0	2.556	0.784
17	Principle of relativity	19.278	347.0	2.778	0.548
18	Principle of complexity and synergy	13.861	249.5	2.278	0.752
19	Combination of actions market mechanism and government regulation	14.417	259.5	2.333	0.907
20	Solidarity responsibility for the preservation and improvement of soil fertility	8.250	148.5	1.722	0.461
21	Priority of social and environmental tasks	10.611	191.0	1.944	0.639
22	Recognition of land by capital	13.306	239.5	2.167	0.707
23	Combination of economic incentives and responsibility	7.500	135.0	1.611	0.698
24	The unity of economic and natural laws	13.917	250.5	2.222	0.878
25	Focusing on the future, responsibility before the next generations	10.944	197.0	1.944	0.725
26	Continuous development and implementation of advanced technologies for the reproduction of soil fertility	11.250	202.5	2.056	0.725
27	Systematic consideration of a complex of factors	9.333	168.0	1.778	0.878

Source: author's calculations on the results of the survey of experts (n = 18).

Therefore, in this group, 44.4 % of the principles adhere to on low level; the rest (55.6 %) is at a very low level, so there are significant reserves to improve the situation.

Summarizing the calculation results shows that, on average, the principles of sustainable soil management in agricultural enterprises of Ukraine were observed only 45.7 %. The clearly of results are presented in Fig. 2.

The obtained results demonstrate the state of compliance with the principles of sustainable soil management in agricultural enterprises, the availability of opportunities and reserves for improving the situation for their implementation, and as well due to which this should be carried out. Thus, 77.8 % of the principles were implemented at a low level, the rest (22.2 %) – at a very low level, so there are significant reserves to improve the situation.

For the convenience of situational analysis and management decision-making on financial support, we can use our proposed matrix (Table 6). Depending on the obtained values, there are a possible 15 different cases when the result of the evaluation falls into one or another quadrant.

The higher the level of importance and the lower the degree of adherence to the principle, the priority and faster should be the adoption of measures to improve the situation.

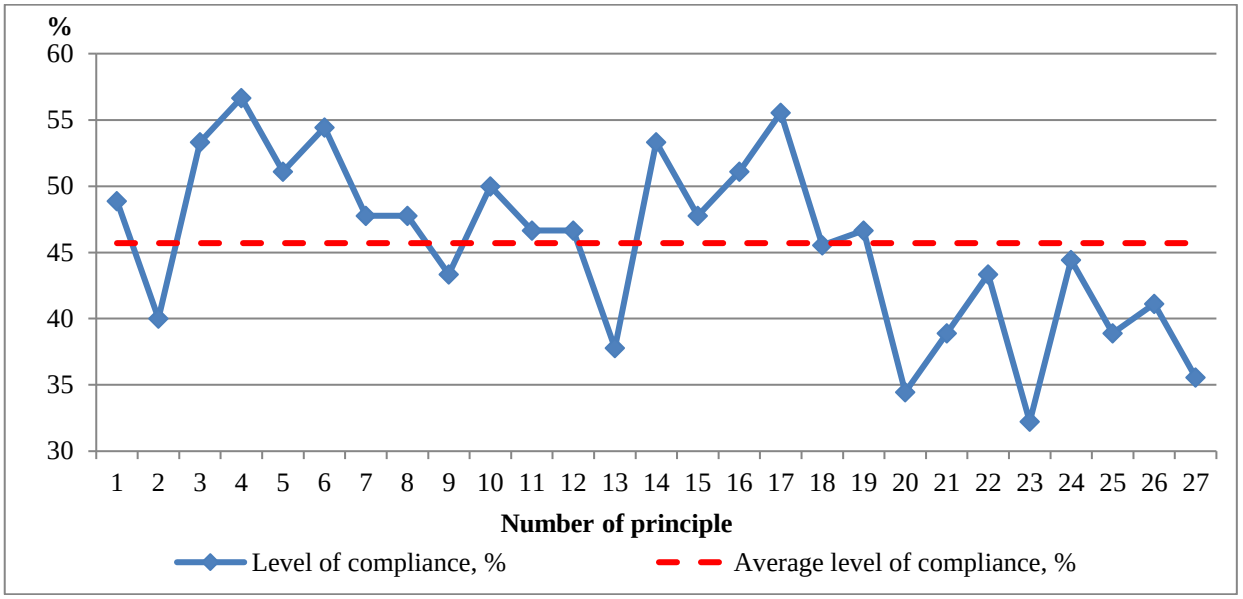

Fig. 2. The average level of compliance of the principles of sustainable soil management in agricultural enterprises of Ukraine, %
Source: developed by the author on the results of the survey of experts.

And vice versa: ceteris paribus, the lower the level of importance and the higher the degree of adherence to the principle, the less attention it requires. The general mechanism of the sequence of managerial decision making can be:

(i) priority decisions about the principles that fell into quadrants No. 1, 2, 3, 6, 7;
(ii) secondary decisions about principles that fall into quadrants No. 5, 10, 15, 13, 14;
(iii) thirdly decisions about principles that fall into quadrants No. 4, 8, 9, 11, 12.

Table 6. Matrix of priorities of financial support based on decisions about «the degree of importance of the principle of sustainable soil management – the degree of its compliance»

Degree of importance (significance) of principle	Level of adherence (compliance) of principles				
	Very low	Low	Average	High	Very high
High	1 *23, 25, 27*	2 *1, 2, 3, 10, 11, 19, 26*	3	4	5
Average	6 *13, 20, 21*	7 *4, 5, 6, 7, 8, 9, 12, 14, 15, 16, 17, 18, 22, 24*	8	9	10
Low	11	12	13	14	15

Note. Italics indicate the order number of the principles being evaluated.
Source: developed by the author.

CONCLUSIONS

Based on this study we can conclude that the most important priority of financial support for sustainable soil management in Ukraine is to suspend the decrease of the humus content and achieve deficit-free balance of soil organic matter (global priority – 0.556); the second place is occupied by the protection of soils from erosion (priority – 0.274); third position – enrichment of soils with nutrients substances (priority – 0.101); fourth place – amelioration of acid and solonets soils (priority – 0.069). The financial mechanism for restoring soil fertility should be focused on the implementation of these priorities, which requires a review and development of a new holistic economic system that can effectively solve the problem of maintaining and restoring soil fertility in the context of

implementing a sustainable development strategy; because many currently active financial-economic and legal instruments are based only on outdated methodological and regulatory framework.

In the context of identification of priorities of financial support for practical implementation of the proposed conception of sustainable soil management this paper also addresses the empirical expert evaluation of the relative importance (significance) of the principles of sustainable soil management, as well as the level of adherence (compliance) of these principles in agricultural enterprises of Ukraine. For the convenience of situational analysis and management decision-making on financial support, for the first time, we proposed the matrix approach. Depending on the obtained values, there are a possible 15 different cases when the result of the evaluation falls into one or another quadrant. The higher the level of importance and the lower the degree of adherence to the principle, the priority and faster should be the adoption of measures to improve the situation.

Development of specific financial-economical levers to sustainable soil management in agriculture would open new prospects for further research. In conclusion, we argue that suspension of humus content reduction and achievement of enhance soil organic matter content is a strategic (global) priority of financial support. Therefore, the next our research is devoted to conceptualization of sustainable management of soil organic carbon in the context of climate change.

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