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Environmental sustainability of Bulgarian agriculture

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Abstract

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The concerns of the public and of humankind in the context of ongoing global climate change processes recently have increasingly raised the issue of sustainable development. As a result, it is pointed as one of the key objectives of the Millennium, and in this light, achieving sustainable agriculture is a top priority of the EU's CAP. Most often the understanding of sustainable agriculture is linked to the environment, because by default a farming system cannot be sustainable if it causes environmental damage. In this regard environmental sustainability of agriculture is seen as an integral part of the sustainability model in the agricultural sector. Over the last decades, the importance of environmental sustainability has been expanding and growing, and this trend will continue in the future, making it particularly relevant for research.

The role of the environmental management as part of the sustainable development stands out clearly and differentiated. Environmental sustainability is linked to ensuring better protection of land, water and biodiversity through better utilization of fertilizers, better organization of plant protection, efficient agricultural practices; more efficient use of energy; preserving animal welfare; better waste management in agriculture, etc.

The purpose of the article is to present the main results and the conclusion of a scientific study on the level of environmental sustainability in agriculture, which is part of the scientific project "Sustainability of Agriculture in Bulgaria" (2017-2018). A methodological approach that takes into account the general concepts of environmental sustainability, some peculiarities of agricultural sector and some results of research by the Institute of Agricultural Economics (IAE) in this area are used. The results obtained show that environmental sustainability in agriculture is linked to the good level of the prevailing part of its criteria and principles.

Keywords: environmental sustainability; principles; criteria; indicators

Introduction

In 1987, the World Commission on the Environment and Development at the UN published a report, Our Common Future, known as the Brundtland Report, which offered an official definition of sustainable development, formulating the economic, environmental and social dimensions of sustainability. Following this logic, when we talk about agricultural sustainability, we understand its ability to maintain its economic, social and environmental functions over the long term. These are the three equally important pillars of agrarian sustainability.

However, the most common and primary understanding of sustainable agriculture is environmental sustainability, because by default, an agricultural system cannot be sustainable if it causes environmental damage.

The issue of environmental sustainability as an integral and immanent part of the overall sustainability of agriculture has been the subject of research by a number of authors Bachev (2006); Hansen (1996); Sabiha et al. (2016) etc. In their publications they agree that the environmental sustainability of agriculture is related to the preservation, restoration and improvement of all constituent elements of the natural environment. These include air, water, land, land-

scape, and biodiversity, climate, maintaining animal welfare – farmed and wild. In general, the extent to which agriculture is environmentally sustainable will depend on how compatible it is with environmental protection requirements. While determining the environmental impact, the main factors that have to be considered, are those, covering impacts of the system on living and non-living natural systems, including ecosystems, land, air and water. This is a common general understanding of most of the researchers about defining environmental sustainability, although there are some different frameworks, scales and number of indicators proposed for measuring it Girardin et al. (2000), Sauvenier et al. (2005), Bachev (2016), Bachev et al. (2017).

Bulgarian and international scientific journals have published a large number of reports and studies on the sustainability of agriculture and in particular on the system of principles, criteria and indicators for measuring this sustainability (Bachev, 2017; Girardin et al., 2008; Sauvenier, 2005) and many others. Sustainability assessment approaches are the subject of discussion and, depending on the concept, objectives, time and scope, different conceptual frameworks and approaches are proposed, with different types and numbers of indicators. Examples are the OECD's Pressure-State-Response (PSR) approach; the FAO approach, called SAFA (Sustainable assessment of Food and Agriculture) for assessing the sustainability of agriculture and the food industry, with 118 indicators; the SAFE (Sustainability Assessment of Farming and the Environment) approach for assessing the sustainability of agriculture and the environment, developed by Van Cauwenberg et al. (2005) and others.

The SAFE approach is generally based on the concept that the sustainability of agriculture and the environment can be assessed using a hierarchical framework composed of principles, criteria and indicators and benchmarks in a structured way. The framework is designed for three spatial levels: a plot, a farm and a higher spatial level, which can be a region or a country. It is this approach that underlies the study of the sustainability of Bulgarian agriculture in this paper, within a research project developed by the Institute of Agrarian Economics (IAI) – "Sustainability of Agriculture in Bulgaria" headed by Prof. Dr. Hr. Bashev (2017-2018).

In Bulgaria there are some less favourable environmental impacts as a result of errors in both the implementation of the agrarian reform and environmental policies – for example, the increase of emissions of harmful substances into the air; cases of water pollution; soil losses; change in the number of habitats, etc.

In this context, the issues of establishing the level of environmental sustainability of agriculture are particularly relevant and significant, and this would be an indication of where the weaknesses are and where intervention is needed. The results from the study will aprobate the holistic approach described and support policy making, as the assessment of sustainability performance is an important part of the overall sustainability improving.

The article aims at presenting results and lessons learned from using above mentioned methodology (Bachev et al., 2017) to measure environmental sustainability, while at the same time taking into account the specific features and conditions of Bulgarian agriculture; to estimate the sustainability index for the environmental aspect and to identify the critical areas that lead to improving the level of environmental sustainability in Bulgaria.

Material and Methods

Sustainability assessment approaches are subject to discussion and, depending on the concept, objectives, time and scope, different conceptual frameworks and approaches are available with different types and numbers of indicators.

The development and description of a methodological approach for evaluating environmental sustainability of agriculture is based on the theory of the common concepts of environmental sustainability, on the specificity of the agriculture and on the rich and profound research work and results in this area of research, done by scientists of Institute of Agricultural Economics (IAE).

The developed and applied methodological approach is a continuation (based on) of the methodology for measuring environmental sustainability in the work of Bachev et al. (2017).

Determining the compatibility of agriculture with the environment and assessing its impact on it requires information on certain interactions between them. This information can be obtained through a set of indicators based on principles and evaluation criteria. Based on a critical review of a number of literary sources, studies, official documents and consultations with responsible institutions on these issues, initial principles, criteria and indicators for the ecological sustainability of agriculture in the country were initially proposed. As a next step, the initial version of the selected indicators was sent to two independent experts to evaluate the indicators according to the relevant criteria. The purpose of this assessment was to obtain information on the significance of each indicator and on the extent to which the sustainability of agriculture is reflected. Taking into account the experts' opinion, similar as for the other aspects of sustainability, a model system – methodological toolkit with potential principles, criteria, indicators and reference values for assessing the environmental sustainability of agriculture in Bulgaria

was proposed as an integral part of the system for determining the overall sustainability of agriculture. This is a new holistic approach, which is being adapted to our conditions.

The indicators chosen are only part of the many possible indicators for the environmental pillar of sustainability that is why the analysis does not claim absolute comprehensiveness. Our aim was to cover all the criteria using the most significant indicators and also those metrics for which the necessary information was available.

The research is based mainly on official statistical data. Information on the indicators is taken from various official sources – Executive Agency for the Environment, Ministry of Environment and Water, National Statistical Institute, Ministry of Agriculture, Food and Forestry, Eurostat, Agrarian reports, regulations, programs and agreements, and some indicators used peer reviews. Benchmarks and expert assessments were used to determine sustainability indexes by indicators.

The time horizon for environmental sustainability and assessment implied in this research is 8-10 years**.**

Results and Discussion

For assessing sustainability levels of agriculture at national level and its environmental aspect, a hierarchical system of well determined and selected *principles, criteria, indicators and reference values* is used (Figure 1).

PRINCIPLES	CRITERIA	INDICATORS	REFERENCE VALUES

Fig. 1. Hierarchical levels of the system for assessing agrarian sustainability

Source: Sauvenier et al. (2005): Framework for Assessing Sustainability Levels in Belgium Agricultural Systems – SAFE, Belgium Science Policy, Brussels

A developed scale is used for estimating the appropriate levels of agrarian sustainability.

- High – 0.81 to 1;
- Good – 0.5 to 0.8;
- Satisfactory – from 0.26 to 0.49;
- Unsatisfactory – from 0.06 to 0.25;
- Instability – 0 to 0.05.

The scale presented on the basis of sustainability levels by indicators determines the sustainability levels by criteria and principles, and finally a general assessment of environmental sustainability for the agriculture sector is presented.

The main principles of environmental sustainability in agriculture are presented in Figure 2.

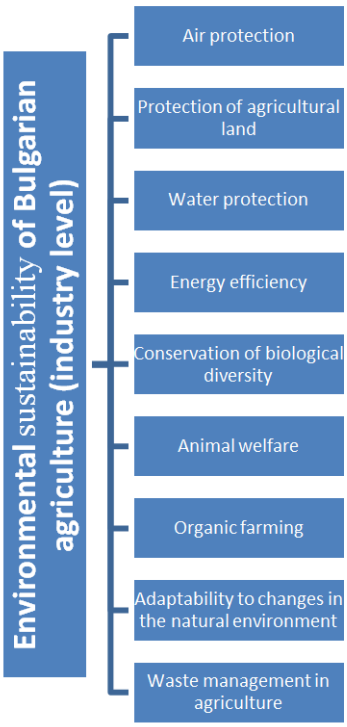

Fig. 2. Basic Principles of Environmental Sustainability in Agriculture

Source: Author graph

Above described principles determine different criteria; for each one of the criteria specific indicators are determined.

In this research there are 9 principles, 14 criteria and 28 indicators used. They are presented in Table 1.

Based on reference value, defined for each indicator, a sustainability index by each indicator is calculated and furthers the level of sustainability of agriculture by indicators, by criteria, by principles and finally overall environmental sustainability of agriculture is determined.

For the analysis it is accepted in the methodology that all principles, criteria and indicators are equally significant and their weight ratio is equal to 1.

Table 2 shows the results obtained by measuring the environmental sustainability in agriculture, using the methodological tools described.

Evaluating the different aspects of the Bulgarian environmental agrarian sustainability is based on the developed methodology and a set of selected indicators. The focus in the research is evaluating the level of sustainability within environmental aspect and identifying the critical elements. Based on the indicators value environmental sustainability score is calculated.

Table 1. Principles, criteria, indicators and benchmarks for assessing the environmental sustainability of the agricultural sector

Principles	Criteria	No	Indicators	Reference values description
I. Air protection	1. Reduction of greenhouse gases	1a	Share of agriculture in greenhouse gas emissions	Change,%, (2016/2007)
		1b	Annual GHG emissions per capita	CO2 / person,%, 2016/1988
	2.Maintaining and improving air quality	2a	Reduction of emissions of harmful substances into the air from agriculture	Change,% (2016/2007)
		2b	Ammonia emissions into the air	Aim of the national program, kt
		2c	Share of agriculture in emissions of harmful substances	Trend,% (2016/2007)
II. Conservation of agricultural land	3. Minimize soil losses	3a	Soil losses from water erosion	2016 soil loss, t / ha /y
		3b	Soil losses due to wind erosion	2016 soil loss, t / ha /y
		3c	Soil wind erosion index	Index of arable land affected by wind erosion
	4. Preservation and improvement of soil fertility	4a	Amount of nitrogen fertilizers	N balance kg / ha (2015)
		4b	Amount of phosphorus fertilizers	P balance kg / ha (2015)
		4c	Animal density, v.es./ha	Animal density (2013)
	5. Maintaining a balanced land structure	5a	Share of arable land from UAA	Share of arable land from UAA (2016)
		5b	Uncultivated land	Share of uncultivated land in UAA (2016)
	6. Preservation of landscape features	6	Amount of area covered by the requirements for "green" direct payments through maintenance of landscape elements	Land receiving green payments to arable land in 2015
III. Water protection	7. Maintaining and improving the quality of surface and groundwater	7a	Nitrate pollution index of groundwater	Share of groundwater with content above the critical level for nitrates,% (2016)
		7b	Average value of groundwater pollution by nitrates	Average for 2012-2015 nitrates, mg / l
		7c	Average value of surface water pollution with nitrates	Average for 2012-2015 nitrates, mg / l
IV. Effective use of energy	8. Minimize the use of conventional energy	8a	Share of final energy consumption in agriculture in total consumption	Share of final energy consumption in agriculture in total consumption, % (2016-2017)
		8b	Final energy consumption / ha in agriculture	(2016/2007)/ Change in energy consumption / ha,%
V. Conservation of biodiversity	9. Maintenance and improvement of natural habitats, conservation and increase of habitat species	9	Change in the number of habitats	Bird index in agricultural lands (2013/2005)
	10. Protected agricultural lands and territories	10	Share of agricultural land in NATURA 2000 and other Protected Areas	Submitted for support under the Natura Measure to the total area of the lands in the NATURA network
VI. Animal welfare	11. Compliance with animal welfare principles	11	Share of animals reared in accordance with the welfare principles	Expert evaluation, %
VII. Organic farming	12. Increase organic production share	12a	Share of organic area	Area under OF/UAA,%(2016)
		12b	Share of organic livestock	Livestock in OF/total number of livestock, % (2017)
		12c	Share of bee families in OF	Bee families in OF/ total number, % (2017)
VIII. Adaptability to changes in the natural environment	13. Sufficient adaptability to climate change	13	Variation of wheat yields	Variation of wheat yields for 5 years
IX. Waste management in agriculture	14. Reduce waste from agriculture	14a	Share of farms with separate landfills from all farms	Share of farms with separate landfills
		14b	Reduce waste from agriculture	Trend % (2016/2006)

Source: Author table

Table 2. Environmental sustainability in Bulgarian agriculture (industry level)

Principles	Criteria	By indicators		By criteria		By principles	
		Sustainability index	Levels of sustainability	Sustainability index	Levels of sustainability	Sustainability index	Levels of sustainability
Air protection	Greenhouse gas reduction	0.52	good	0.53	good	0.62	good
		0.54	good				
	Maintaining and improving air quality	0.74	good	0.70	good		
		1	high				
		0.37	satisfactory				
Protection of agricultural land	Minimizing soil losses	0.61	good	0.75	good	0.74	good
		0.84	high				
		0.81	high				
	Conservation and improvement of soil fertility	0.64	good	0.71	good		
		0.49	satisfactory				
		1	high				
	Maintaining a balanced structure of land resources	0.55	good	0.62	good		
		0.68	good				
	Preserving landscape features	0.88	high	0.88	high		
Water protection	Maintenance and improvement of surface and groundwater quality	0.52	good	0.65	good	0.65	good
		0.71	good				
		0.73	good				
Energy efficiency	Minimizing the use of conventional energy	0.65	good	0.65	good	0.65	good
		0.65	good				
Conservation of biological diversity	Maintenance and improvement of natural habitats. conservation and enhancement of habitat species	0.24	unsatisfactory	0.24	unsatisfactory	0.42	satisfactory
	Protected agricultural lands and territories	0.61	good	0.61	good		
Animal welfare	Compliance with animal welfare principles	0.4	satisfactory	0.4	satisfactory	0.4	satisfactory
Organic farming	Increasing the share of organic production	0.37	satisfactory	0.54	good	0.54	good
		0.25	unsatisfactory				
		1	high				
Adaptability to changes in the natural environment	Adaptability to climate change	0.63	good	0.63	good	0.63	good
Waste management in agriculture	Reduction of agricultural waste	0.07	unsatisfactory	0.36	satisfactory	0.36	satisfactory
		0.65	good				

Source: Author's table

Figure 3 shows that six of the nine principles have good sustainability, 3 of them show satisfactory sustainability.

Analysis of the presented data shows that the environmental sustainability index of Bulgarian agriculture is 0.56. This shows that Bulgarian environmental agrarian sustainability can be defined as Good. This result confirms the conclusion of the other research paper (Bachev et al., 2017), where the environmental sustainability of the Bulgarian agriculture is assessed as Good with a score of 0.53. Nevertheless, it is important to understand and point out to the major bottlenecks, which influence negativelly the environmental sustainability and to try to improve their reflection.

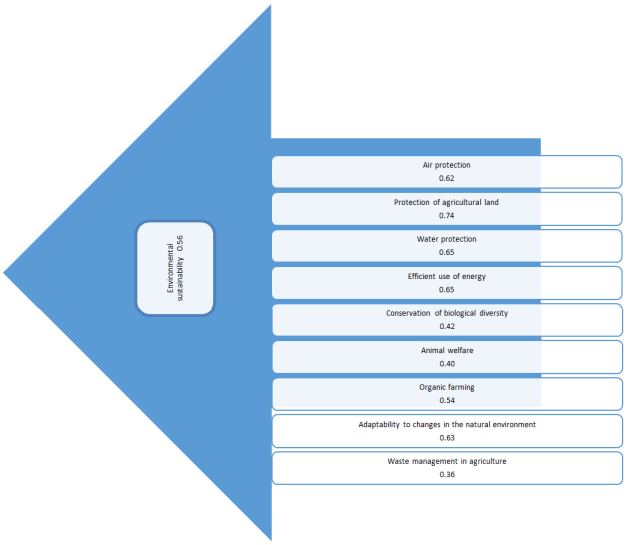

Fig. 3. Overall assessment of environmental sustainability in agriculture (based on the assessment of environmental sustainability by principles)

Some of the principles deviate from the above "good" assessment of overall sustainability – like waste management with value of 0.36; animal welfare with value of 0.40 and conservation of biological diversity with value of 0.42. The extent of this deviation is not very big and it is illustrated from the Figure 4.

Based on the derived indexes of sustainability by indicators, indexes of sustainability by criteria are derived. According to the developed scale, the obtained indexes by criteria and their respective levels of sustainability are presented at Figure 5.

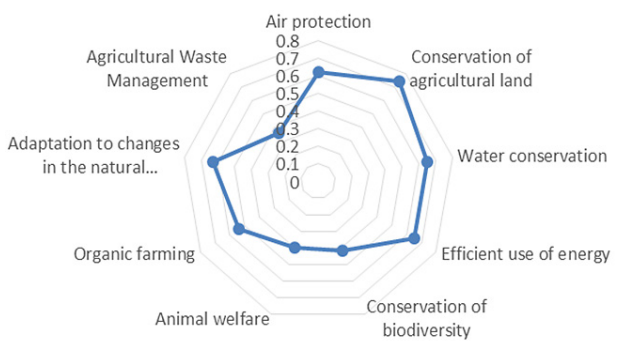

Fig.4. Environmental sustainability indexes of the agriculture sector by prinsiples
Source: Author graph

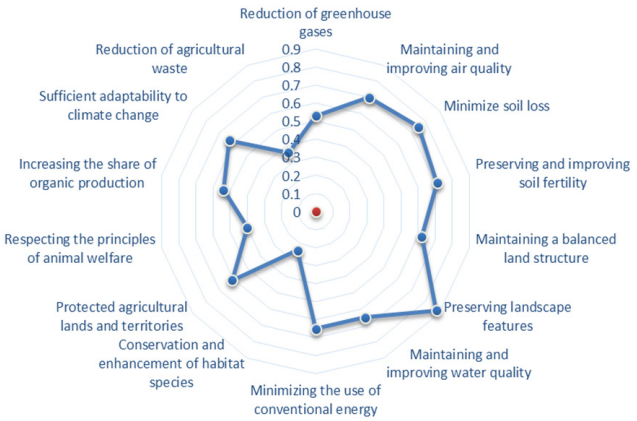

Fig. 5. Environmental sustainability indexes of the agriculture sector by criteria
Source: Author graph

The environmental sustainability in 10 criteria is good, in one (preserving landscape features) is high, in two (compliance with animal welfare principles and in reduction of agricultural waste) is satisfactory and only in one (maintenance and improvement of natural habitats, conservation and enhancement of habitat species), is unsatisfactory – 0.24.

For the maintenance and improvement of natural habitats, conservation and enhancement of habitat species, the change in the number of habitats as an indicator is analysed. The index of the state of bird populations in agricultural lands is used – according to the classification of the Pan-European Monitoring Scheme for common bird species, the assessed species are divided into three groups according to habitat: agricultural land, forests and "other" types of environment. Of the estimated 38 species, 44.7% inhabit agricultural land, 26% are forest species and 29% inhabit other habitat types. The general trend for the period 2005 – 2015 for all 38 species that make up the indicator is to reduce the number by 9%.

An 11-year study organized by the Bulgarian Society for the Protection of Birds within the initiative "Census of Birds Around Us: Monitoring of Common Bird Species (MWP)" shows alarming results for the state of birds in the country, as from all groups of birds, birds in agricultural lands are the most vulnerable. Their condition is determined by an indicator that includes 17 species of birds. The change in its numerical values indicates the change in the state of the environment. The decrease in the index of the state of bird populations is a sign of the deteriorating state of these species and the environment they inhabit. Among the main threats

Table 3. Share of agricultural waste from waste generated by all economic activities, %

	2006	2010	2014	2016
Generated waste from agriculture in Bulgaria, t	632 966	618 107	835 401	617 689
Waste generated from all economic activities in Bulgaria, tons	162 881 368	167 396 268	179 677 011	120 508 475
Share of agricultural waste in Bulgaria to waste from all economic activities,%	0.39	0.37	0.46	0.51
Share of agricultural waste in the EU to waste from all economic activities,%	2.25	0.86	0.75	0.82

Source: Eurostat

to the condition of birds in these habitats are the removals of shrubs, the plowing of grasslands and the use of pesticides. The Rural Development Program (RDP) has adopted the index of the condition of birds from agricultural lands as one of the indicators for the success of its implementation.

There are two main factors that stand out as negatively affecting the condition of birds from agricultural lands. The first involves the removal of shrubs from pastures and meadows. The second significant factor in the reduction of bird populations in agricultural lands is related to the plowing of permanently grassed areas. Most of them are natural and semi-natural pastures and meadows, which by way of permanent use are categorized as arable land, but have not been plowed in the last 5 or more years, and have accordingly become permanent pastures. As a result of this type of plowing, nesting and feeding habitats of birds are destroyed. In the assessment for the period 2005–2013, the birds on the agricultural lands decreased by -21% compared to 2005.

To overcome this situation there is a need for targeted and successful implementation of agri-environmental measures in agriculture and the introduction of adequate standards for maintaining good ecological condition of agricultural land.

For the criterion "Observance of the principles of animal welfare" (satisfactory level of environmental sustainability) the indicator level of compliance with the principles of animal welfare is analyzed. The requirements and rules for the protection and welfare of animals are based on the provisions of national and European legislation, standards and recommendations of the World Organization for Animal Health. Ordinance 16 / 3.02.2006 is in force in Bulgaria, which transposes Council Directive 98/58 / EC of 20 July 1998 on the protection of animals kept for farming purposes.

The total amount of payments under measure 14 "Animal Welfare" of the Rural Development Plan 2014-2020 for 2018 is BGN 2 914 896, paid to 315 farmers. As we do not have a reference value for the evaluation of the analyzed indicator, an expert opinion was used to determine the index of its sustainability and based on the expert evaluation it is determined with a value of 0.4.

For the criterion "Reduction of agricultural waste" the indicators analyzed are:

– Share of livestock farms with manure from the total number of livestock farms

– Reduction of agricultural waste.

In 2003 there were 530 manure farms in Bulgaria, in 2010 their number increased to 5229, and in 2016 – to 7228. In 2016, the number of livestock farms was 134 004. Based on these data, the relevant sustainability index was calculated.

With regard to the waste generated by agriculture in our country, the Table 3 shows that as an absolute value in tons they decreased for the period 2006-2016, but as a share of waste from all economic activities increased, albeit minimally.

According to the two analysed indicators, the sustainability indices have values that form their level of sustainability as "unsatisfactory" and "good", respectively, and in general the criterion "Reduction of agricultural waste" forms a satisfactorily level of sustainability.

All data shown above indicates that the overall environmental sustainability of Bulgarian agriculture is still far from the high level, although it demonstrates high sustainability in some areas- for example in protection of agricultural land. A lot of work is needed in the future to ensure that the agriculture will be friendly to the environment, climate and biodiversity.

Conclusions

The level of sustainability of the environmental pillar in agriculture in Bulgaria at the sectoral level, based on this analysis, is rated as good;

Differences among the sustainability levels of all principles are moderate (except for waste management);

The appearance of environmental sustainability is formed by a relatively good level of the majority of its principles;

The assessment highlights the principles of protection of agricultural land, water and air; of energy use in agriculture and of organic farming with good level of environmental sustainability, as well as good adaptability of agriculture to climate change;

Principles of biological diversity conservation, animal welfare and waste management in agriculture show a satisfactory level of sustainability;

From all of the criteria concerning the environmental sustainability with a high level stand out only the criterion Preserving landscape features;

From all of the criteria concerning the environmental sustainability with a good level stands out the criteria related to the Greenhouse gas reduction, Maintaining and improving air quality, Minimizing soil losses, Conservation and improvement of soil fertility, Maintaining a balanced structure of land resources, Maintenance and improvement of surface and groundwater quality, Minimizing the use of conventional energy, Protected agricultural lands and territories, Increasing the share of organic production, Adaptability to climate change;

From all of the criteria concerning the environmental sustainability with a satisfactory level stands out the criteria Compliance with animal welfare principles and Reduction of agricultural waste;

From all of the criteria concerning the environmental sustainability with an unsatisfactory level stands out the one associated with bad Maintenance of natural habitats, conservation and enhancement of habitat species.

Of course, much work remains to be done to refine and test the holistic approach used, especially in terms of improving the selection of the most appropriate indicators.

Pointing out some of the critical areas which negatively influence the sustainability of agriculture can raise the attention of the respective authorities and help for the elaboration of timely and adequate policy.

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