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AN EVALUATION OF THE SOCIO-ECONOMIC AND ECOLOGICAL SUSTAINABILITY OF AGRARIAN ECOSYSTEMS IN BULGARIA[1]

The ecosystem approach has been widely incorporated in the management and evaluation of agrarian sustainability. Despite enormous progress in this new evolving area, still there is no consensus on how to assess the sustainability of agro-ecosystems due to the diversity in understandings, approaches, methods, employed data, etc. In Bulgaria there are no comprehensive studies on the integral, socio-economic and ecological sustainability of the different types of agro-ecosystems. This paper makes a first attempt at assessing the sustainability of agro-ecosystems in Bulgaria. Initially, a holistic framework for assessing the integral, economic, social and ecological sustainability of agro-ecosystems, which includes 17 principles, 35 criteria, and 46 indicators and reference values, is suggested. After that, the integral and the multi-aspect sustainability of 7 generic and 10 specific agro-ecosystems in Bulgaria are assessed. The estimates are based on first-hand information collected by the managers of "typical" farms operating in different agro-ecosystems in 4 geographical regions of the country. The study has found out that there is a substantial variation in the level of integral and multi-aspect sustainability of the different types of agro-ecosystems, as well as in the level of contribution to the sustainability of various sub-sectors of agriculture and farms of different juridical type and size, where the individual indicators with the highest and lowest values show the (critical) factors which enhance or deter sustainability.

JEL: Q12; Q18; Q56; Q57

Keywords: sustainability; economic, social, ecological, integral agro-ecosystems

The assessment of the sustainability of the various types of agricultural systems has become one of the most topical issues over the last decades (Bachev, 2017; Bachev and Che, 2018; Ivanov et. al., 2009; Tsvyatkova, Sarov, 2018; Candido et al., 2018; FAO, 2013; Fuentes 2004; Hayati et. al., 2010; Gliessman, 2016; Gemesi, 2007; Gitau et al., 2009; Jalilian, 2012; Irvin et. al., 2016; Lopez-Ridauira et. al. 2002; Sauvenier et al., 2005; Todorova and Treziyska, 2018; VanLoon et al. 2005). In recent years, an "ecosystem approach" has been widely incorporated in the management and evaluation of agrarian sustainability (Belcher, 1999; Bohlen and House, 2009; MEA, 2005; De Oliveira, 2018; Ramírez-Carrillo et. al., 2018; Sidle et al., 2013). Despite enormous progress in the theory and practice in this new evolving area of research, there is still no consensus on how to assess the sustainability of agro-ecosystems due to the diversity in understandings, approaches, methods, employed data, etc. In Bulgaria the comprehensive sustainability assessments are carried out mostly on the sectoral (Pistalov, 2009; Ivanov et. al., 2009; Bachev et. al., 2017) or farm (Bachev, 2016, 2017a; 2017b; Bachev and Terziev, 2017) levels while there is practically no in-

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depth study on the sustainability of agro-ecosystems. This paper makes a first attempt at assessing the sustainability of the different types of agro-ecosystems in Bulgaria.

Methodological framework

A holistic system is applied for the evaluation of the sustainability level of agro-ecosystems in Bulgaria, which includes 4 hierarchical levels with 3 pillars (aspects), 17 principles, 35 criteria, and 46 indicators and reference values of sustainability (see Table 1).

Table 1

System of principles, criteria, indicators, and reference values for assessing the sustainability level of agro-ecosystems in Bulgaria

Principles	Criteria	Indicators	Reference values
Economics aspect			
Financial stability	Reducing dependence on subsidies	Share of direct payments in Gross Value Added	Expert estimates/ Trend
	Sufficient liquidity	Ratio of overall liquidity	Expert estimates/ Trend
		Ratio of quick liquidity	Expert estimates/ Trend
	Minimizing dependence on external capital	Share of owned capital in the total capital	Expert estimates/ Average for the sector
Economic effectiveness	Positive or high profitability	Cost - effectiveness	Expert estimates/ Average for the sector
		Profitability of capital	Expert estimates/ Average for the sector
	Maximizing or increasing labour productivity	Labour productivity	Expert estimates/ Average for the sector
	Maximizing or increasing land productivity	Productivity of the land	Expert estimates/ Average for the sector
	Maximizing or increasing livestock productivity	Livestock productivity	Expert estimates/ Average for the sector
Competitiveness	Supporting or increasing marketed output	Share of marketed output	Expert estimates/ Trend
	Supporting or increasing sales	Sales growth in the last 3 years	Expert estimates/ Trend
Adaptability to the economic environment	Sufficient adaptability to the market environment	Ratio of gross income to fixed costs	Expert estimates/ Trend
	High investment activity	Investment growth	Average for the sector/ Trend
Social aspect			
Welfare of the persns employed in the field of agriculture	Equality of income with other sectors	Ratio of farm income to the average income in the region	Expert estimates/ Trend
	Fair distribution of income in agriculture	Ratio of payment for hired labour in the farm to average income in the region	Average for the sector/ Trend
	Sufficient satisfaction from farm activity	Degree of satisfaction from farm activity	Farmer's assessment
	Satisfactory working conditions	Correspondence to official norms	Official norms
Conservation of farming	Preserving the number of family farms	Existence of a heritor ready to take over of the farm	Expert estimates/ Trend
		Number of family workers	Expert estimates/ Trend
		Age of the manager	Farmer's assessment/ Trend
	Increasing the knowledge and skills	Level of participation in the training programs	Expert estimates/ Trend
		Level of education of the manager	Expert estimates/ Trend
	Maintaining and increasing the level of agrarian education	Number of employed with special agricultural education	Expert estimates/ Trend

Table 1 (continued)

Principles	Criteria	Indicators	Reference values
Gender equality	Equality in men-women relations	Degree of participation of women in farm management	Half/Trend
Social capital	Participation in professional associations and initiatives	Number of participations in professional associations and initiatives	Expert estimates
		Level of hired labour membership in labour unions	Expert estimates/ Trend
	Participation in public management	Public position	Expert estimates/ Trend
	Contribution to the development of regions and communities	Participation in local initiatives	Expert estimates/ Trend
Adaptability to the social environment	Sufficient ability to respond to the ceasing farming activity and the demographic crisis	Number of vacant job positions in the farms to the total number of employed	Expert estimates/ Trend
Ecological aspect			
Air quality	Maintaining and improving air quality	Growth of carbon emissions for the past three years	Trend
Land quality	Minimizing soil losses	Soil erosion index	Scientific norm/ Trend
	Preservation and improvement of soil fertility	Amount of nitrogen fertilization	Scientific norm/ Average for the sector
		Amount of potassium fertilization	Scientific norm/ Average for the sector
		Amount of phosphorus fertilization	Scientific norm/ Average for the sector
	Maintaining a balanced land use structure	Share of arable land (without fallow) in the total agricultural areas	Scientific norm/ Average for the sector
	Preservation of landscape features	Amount of area covering the requirements for “green” direct payments through maintaining landscape elements	Expert estimates/ Trend
Water quality	Maintaining and improving water quality	Index of groundwater pollution	Scientific norm/ Average for the sector
Effective energy consumption	Minimizing the use of conventional energy	Fuel consumption per unit of area	Expert estimates/ Average for the sector
		Cost of conventional electric energy per unit of gross output	Trend/ Average for the sector
Biodiversity	Maintaining or enhancing natural habitats	Change in the number of habitats	Trend/ Average for the sector
		Share of agricultural land in NATURA 2000 and other protected areas	Planed target/ Trend
	Preserving and improving the biodiversity	Number of cultivated plant species	Trend/ Average for the sector
Animal welfare	Compliance with the principles of animal welfare	Level of compliance with the principles of animal welfare	Official norms
Implementation of organic production	Increasing the organic production	Share of areas under conversion or certified for organic production	Expert estimates/ Trend
Adaptability to the environment	Sufficient adaptability to climate change	Variation in the yield of main crops	Average for the sector/ Trend
		Death rate in livestock farms	Average for the sector/ Trend

The approach behind the formulation and selection of principles, criteria and indicators for assessing agrarian sustainability in the contemporary conditions of development of Bulgaria is presented in other publications by the authors (Bachev, 2016, 2017a; Ivanov et. al., 2018).

In Bulgaria, like in many other countries, there are no official data for calculating the socio-economic and (some of the) ecological indicators at the agro-ecosystem level. In order to assess the level of sustainability of agro-ecosystems, in-depth interviews with the managers of 80 farms of different types and agro-ecological locations in 4 major regions of the country were held in 2017. Agro-ecosystems are the ecosystems associated with the farming activity and the individual farm (firm) is the first and lowest level of governing and assessment of agrarian sustainability (Bachev and Che, 2018; Bachev, 2018). The following criteria were used for the selection of the areas in which the farm surveys were conducted: major administrative and geographic regions of the country (North-Central, South-Eastern, South-Central and South-Western); main and specific types of agro-ecosystems in the country – mountainous, plain-mountainous, plain, riparian (Struma, Maritza, Yantra), southern Black Sea, mountainous area with natural constraints, non-mountainous area with natural constraints, protected areas and reserves, Western Thracian Plain, Middle Danube Plain, Dupnitsa and Sandansko-Petrich Valley, Sredna Gora mountains and Western Rila mountains. Farms which are "Typical" for each agro-ecosystem or the different regions of the country were selected with the assistance of the main associations of agricultural producers, state agencies, processing, bio-certification and service organizations, as well as the local authorities.

The interviews include questions related to primary information for calculating economic, social and ecological sustainability at the agro-ecosystem level. After that, the diverse quantitative and qualitative level estimates for each indicator are transformed into a unitless index of sustainability. Next, the integral index for a particular criterion, principle, and aspect of sustainability, and the integral sustainability index for each surveyed farm is calculated applying equal weight for each indicator in a particular criterion, for each criterion in a particular principle, and for each principle in every aspect of sustainability. The composite sustainability index of a particular agro-ecosystem is an arithmetic average of the indices of relevant farms belonging to that agro-ecosystem. In order to assess the level of sustainability of agro-ecosystems, the following scale for Index ranges, defined by experts, is used: 0.85-1 for a high level; 0.50-0.84 for a good level; 0.25-0.49 for a satisfactory level; 0.12-0.24 for an unsatisfactory level; 0-0.11 for non-sustainability.

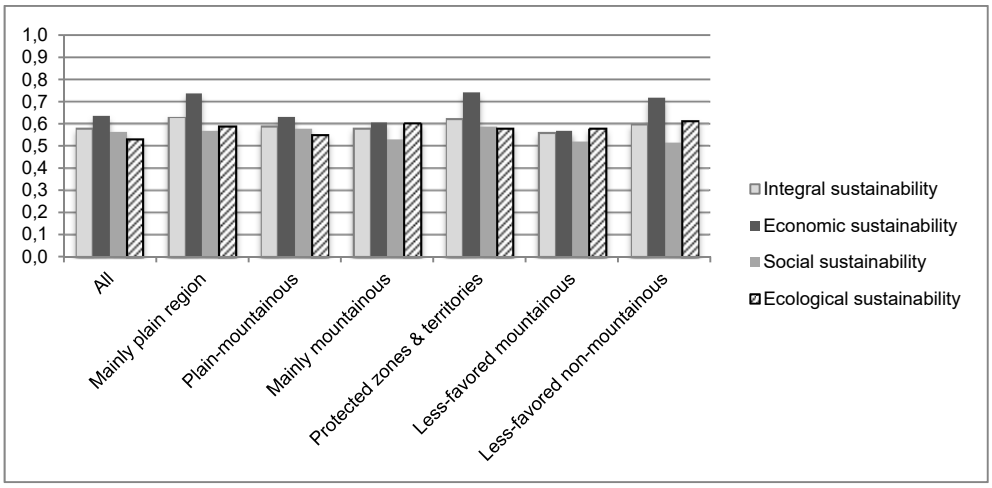
Level of sustainability in the main types of agro-ecosystems

There is a considerable differentiation in the level of integral and multi-aspect sustainability in the main types of agricultural ecosystems (see Figure 1). The agriculture in the plain regions has the highest level (0.63) of integral sustainability, in addition to having the highest level of economic sustainability, together with the ecosystems in the protected zones and territories (0.74). On the other hand, the integral sustainability in mountainous regions with natural restrictions is the lowest (0.56). This type of ecosystem also shows the lowest (bordering the limits of the satisfactory level) levels of social sustainability, together with the ecosystems in

non-mountainous regions with natural restrictions (0.52). Nevertheless, the ecological sustainability of agro-systems in mountainous areas with natural restrictions is relatively high (0.58).

Figure 1

Level of sustainability in the main types of agro-ecosystems in Bulgaria



Source: Survey held with the managers of farms in2017, and the author's own calculations.

The integral sustainability of mountainous ecosystems is on a medium level (0.58), but while its economic and social aspects are below the average for the country (at 0.61 and 0.53, respectively), the level of its ecological sustainability is among the highest (0.6). The agricultural sustainability in the protected zones and territories is above the average for the country (0.62) – these ecosystems have a relatively high level of economic sustainability (0.74), the highest level of social sustainability (0.59), and good levels for ecological sustainability (0.58). The ecological sustainability in the plain-mountainous regions is the lowest in the country (0.55), and it is highest in the non-mountainous regions with natural restrictions (0.61).

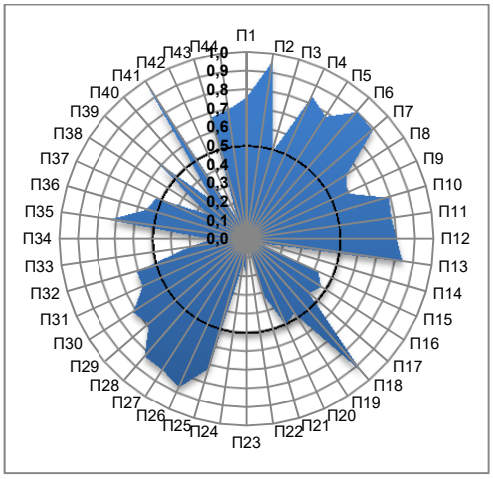
The agriculture of the ecosystems in the plain regions has a high significance for the economic sustainability in terms of the indicators: share of own capital in the total capital (0.96), labour productivity (0.84), livestock productivity (0.9) and share of sold production in the total output (0.89) (see Figure 2). The social sustainability of the sector in these regions is high in relation to the degree of correspondence to the normative labour conditions (0.84), the education level of the manager (0.94) and the share of unoccupied seasonal labour positions in the total number of employed (0.87). The agriculture in such regions shows ecologically strong sustainability

in terms of the dynamics of the utilised agricultural area (UAA) in the last 5 years (0.83), the dynamics of the raised livestock number in the last 5 years (0.83) and in keeping with the norms of animal welfare (1).

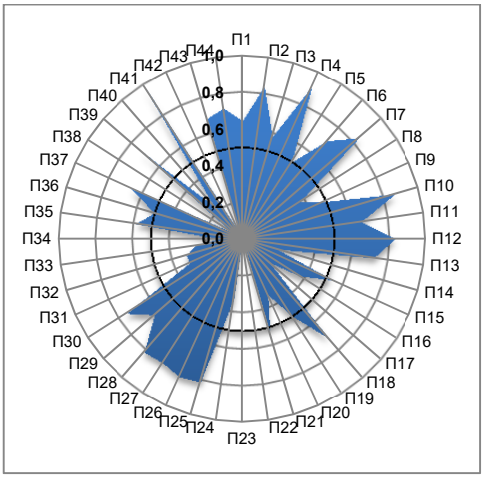
Figure 2

Indicators* of sustainability in the main types of agro-ecosystems in Bulgaria

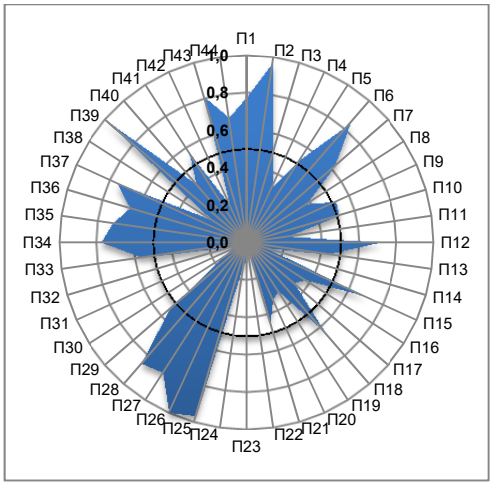
Predominantly plain regions



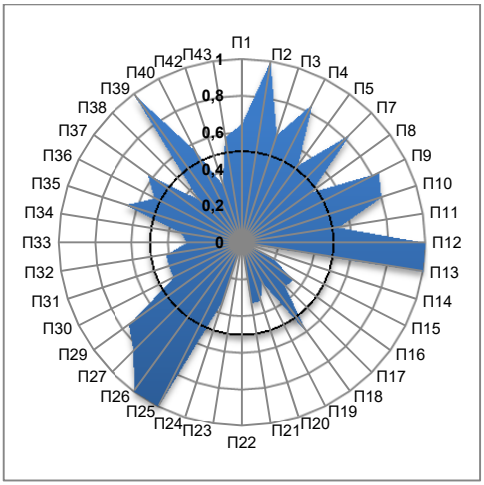
Plain-mountainous regions



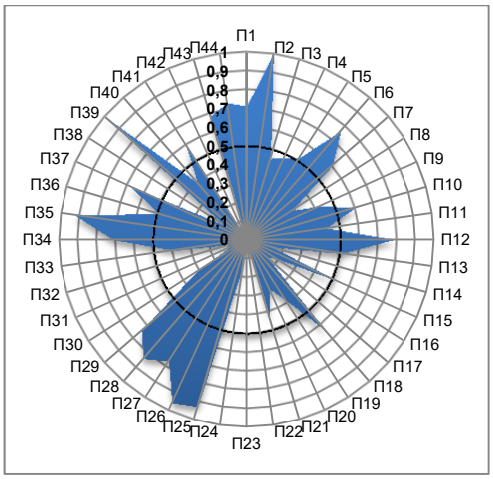
Predominantly mountainous regions



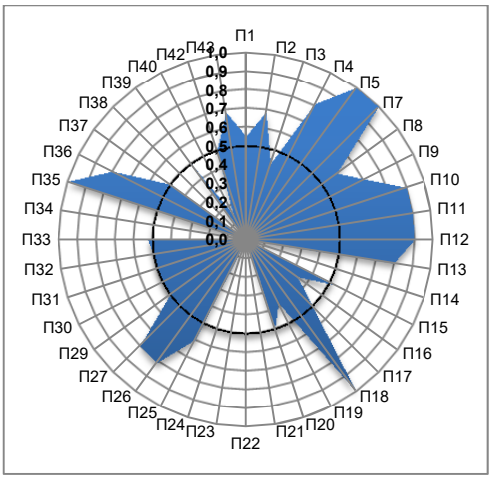
Protected zones and territories



Mountainous with natural restrictions



Non-mountainous with natural restrictions



* П1 - Share of direct payments in the net income; П2 - Share of own capital in the total capital; П3 – Profit / production costs; П4 - Labour productivity; П5 - Land productivity; П6 - Livestock productivity; П7 - Share of sold production in the total production; П8 - Sales growth in the last three years; П9 - Investment growth in last 5 years; П10 - Net farmer's income / average income in the region; П11 - Payment of hired labour/average income in the region; П12 - Degree of satisfaction from farmer's activity; П13 - Degree of compliance with normative labour conditions; П14 - Presence of a family member ready to take the farm; П15 - Number of family members working in the farm; П16 - Age of the manager; П17 - Participation in training programs in the last 3 years; П18 - Education level of the manager; П19 - Share of occupied persons with specialized agricultural education/ qualification; П20 - Degree of participation of women in the farm management; П21 - Number of participations in professional organizations and initiatives; П22 - Share of hired workers, who are members of trade unions; П23 - Public positions held by the farmer, manager and owner; П24 - Participation in local initiatives; П25 - Share of non-occupied permanent work positions in the total number of employed; П26 - Share of non-occupied seasonal work positions in the total number of employed; П27 - Changes in the UAA in last 5 years; П28 - Changes in the livestock number in the last 5 years; П29 - Soil erosion; П30 - Compliance of nitrate fertilization with the set norms; П31 - Compliance of potassium fertilization with the set norms; П32 - Compliance of phosphorus fertilization with the set norms; П33 - Share of arable land in the total UAA; П34 - Keeping with the practices of landscape maintenance; П35 - Degree of pollution of underground waters with nitrates; П36 - Level of fuel consumption; П37 - Level of electricity consumption; П38 - Presence of protected species on the territory of the farm; П39 - Natural biodiversity protection; П40 - Number of crop species; П41 - Keeping with animal welfare norms; П42 - Implementation of principles for organic production; П43 - Yield variation of the main crops over a period of 5 years; П44 - Percentage of mortality of livestock over a period of 5 years.

Source: Survey held with the managers of farms in 2017, and the author's own calculations.

Simultaneously, the levels of some indicators in the plain agro-ecosystems are low. While the economic sustainability is satisfactory only in terms of the profit/

production costs ratio, in the case of social sustainability, the satisfactory levels are those of the number of family members working in the farm, the manager's age, the participation in training programs in the last 3 years, the share of employed persons with special agricultural education/qualification, and the number of participations in professional organizations and initiatives. Along with that, the indicators public position of the farmer, manager or owner and participation in local initiatives show unsatisfactory levels, while the level of presence of family member ready to take the farm is no the verge of unsustainability. Moreover, in terms of the indicator share of hired workers, who are members of trade unions, the parameters are at the level of unsustainability. The ecological sustainability of the sector in these regions is satisfactory in relation to the share of arable land in the total agricultural land, the presence of protected species on the farm territory and the number of crop species; and it is unsatisfactory when it comes to keeping with the practices for landscape maintenance and the implementation of the principles for organic production.

The economic sustainability of the agriculture in the ecosystems in the plain-mountainous regions is high in terms of the: share of own capital in the total capital, the labour productivity, and the share of sold production in the total output (Figure 2). The highest levels of social sustainability in these regions are observed for the indicators: net farm income / average income in the region, degree of satisfaction from the farming activity, share of non-occupied permanent work positions in the total number of employed, and share of unoccupied seasonal work positions in the total number of employed. From an ecological point of view, the best levels in these ecosystems are observed only in the dynamics of the number of livestock in the last 5 years and the keeping with the norms of animal welfare.

At the same time, the agro-ecosystems in the plain-mountainous regions show satisfactory levels of economic sustainability in terms of the growth in sales over the last 3 years and the growth in investments over the last 5 years. The social sustainability in these regions is at a satisfactory level in terms of the manager's age, the degree of participation of women in the farm management, and the participation in local initiatives; however, it is unsatisfactory with regards to the presence of a family member, ready to take the farm, and the participation in training programs over the last 3 years; and it is socially unsustainable in terms of the share of hired workers, who are members of trade unions and the public positions held by the farmer, manager or owner. In the plain-mountainous ecosystems the ecological sustainability is satisfactory in terms of the compliance with the norms for the fertilization with potassium, the compliance with the norms for phosphorus fertilization, and the share of arable land in the total agricultural land; it is unsatisfactory with regard to the keeping with the practices for landscape maintenance, the presence of protected species on the farm territory, and the number of crop species; and it is unstable when it comes to the implementation of the principles of organic production.

The agricultural sustainability of the ecosystems in the mountainous regions has the highest values for the economic indicators: share of own capital in the total

capital and livestock productivity; for the social indicators: share of non-occupied permanent work positions in the total number of employed and the share of unoccupied seasonal work positions in the total number of employed; and for the ecological indicators: dynamics of UAA in the last 5 years, dynamics of the raised livestock in the last 5 years, natural biodiversity protection, and yield variation of the main crops over the span of 5 years (Figure 2). In the mountainous regions, the economic relation between profit / production costs, the labour productivity, and the sales' growth over last 3 years show a satisfactory level of sustainability. The social sustainability of this type of ecosystem is satisfactory in terms of many indicators: the degree of compliance with normative labour conditions, the manager's age, the participation in training programs over the last 3 years, the share of employed with special agricultural education/qualification, the degree of participation of women in the farm management, and the number of participations in professional organizations and initiatives. Furthermore, the social sustainability is unsatisfactory in relation to the payment of hired labour/average income in the region, the presence of a family member, ready to take the farm, the public position held by the farmer, manager or owner, and the participation in local initiatives. And as for the share of hired workers, who are members of trade unions, there is social unsustainability. In the mountainous agro-ecosystems the ecological sustainability is on a satisfactory level when it comes to the number of cultural species, and it is unsatisfactory in terms of the compliance with the norms for nitrate fertilization, the compliance with the norms for potassium fertilization, the compliance with the norms for phosphorus fertilization, the presence of protected species on the farm territory, and the implementation of principles for organic production.

The ecosystems' agricultural sustainability in the protected zones and territories is economically high in terms of the share of own capital in the total capital, the labour productivity, the share of sold production in the total output, and the growth in investments over the last 5 years (Figure 2). This ecosystem type has strong social stability with regards to the degree of satisfaction of the farming activity, the degree of compliance with the normative labour conditions, the share of unoccupied permanent work positions in the total number of employed, and the share of non-occupied seasonal work positions in the total number of employed. From an ecological point of view, the agricultural sustainability in the protected zones and territories is high only in terms of the dynamics of UAA over last 5 years, and the protection of the natural biodiversity. On the other hand, the economic sustainability of agro-ecosystems with protected zones and territories is satisfactory in terms of the growth in sales over the last 3 years, while the livestock productivity shows unsustainability. The social sustainability in these zones and territories is on a satisfactory level in regards to manager's age, participations in training programs over last 3 years, the degree of participation of women in the farm management, the number of participations in professional organizations and initiatives, and the participation in local initiatives. For the social indicators number of family members working in the farm, and share of employed with special agricultural education/qualification, the sustainability level is

unsatisfactory. Moreover, in terms of the indicators presence of family member ready to take the farm, share of hired workers, who are members in trade union and public position held by the farmer, manager or owner, the ecosystems are unsustainable. In protected zones and territories some ecological indicators are also at relatively low levels (unsatisfactory): compliance with the norms for the fertilization with potassium, compliance to the norms for the fertilization with phosphorus, the share of arable land in the total agricultural land, compliance with the practices for landscape maintenance, the presence of protected species on the territory of the farm, and implementation of the principles for organic production.

The agricultural sustainability of the ecosystems in the mountainous regions with natural restrictions are highly economically sustainable only in relation to the share of own capital in the total capital; they are strongly socially sustainable in terms of the share of unoccupied permanent work positions in the total number of employed, and the share of unoccupied seasonal work positions in the total number of employed; and they are highly ecologically sustainable according to the changes in the livestock number in the last 5 years, the degree of pollution of underground waters with nitrates, and the protection of the natural biodiversity (Figure 2). At the same time, some economic indicators of sustainability in these ecosystems are at a satisfactory level, such as: the profit/production costs ration, the labour productivity, the growth in sales over the last 3 years, and the growth in investments over the last 5 years. Similarly, the social sustainability of this type of ecosystems is satisfactory in terms of: the payment of hired labour / average income in the region, the share of employed with special agricultural education/qualification, the degree of participation of women in the farm management, and the number of participations in professional organizations and initiatives. The level of social sustainability in such regions is unsatisfactory when it comes to the presence of a family member, ready to take the farm, the manager's age, the participation in training programs over the last 3 years, and the participation in local initiatives. In terms of the share of hired workers, who are members of trade unions and the public position held by the manager, farmer and owner, the mountainous regions with natural restrictions are socially unsustainable. In these regions some indicators for ecological sustainability have satisfactory levels, such as the compliance with the norms for nitrate fertilization, the share of arable land in the total agricultural land, the level of fuel consumption, and the number of crop species. The ecological sustainability is unsatisfactory in terms of the compliance with the norms for potassium fertilization, the compliance with the norms for phosphorus fertilization, and the presence of protected species on the territory of the farm, while as far as the principles of organic production implementation are concerned, they are unsustainable.

The agricultural sustainability in the non-mountainous regions with natural restrictions is economically high when it comes to the labour productivity, the land productivity, and the share of sold production in the total output (Figure 2). In relation to the social sustainability, the indicators are high for: the net farm income / average income in the region, the payment of hired work in the region, the degree of satisfaction from the farming activity, the education level of the manager, and the share of

unoccupied seasonal work positions in the total number of employed. The ecological sustainability in these regions is high only in terms of the pollution of underground waters with nitrates. The agro-ecosystems in the non-mountainous regions with natural restrictions have satisfactory economic sustainability only as far as the profit/ production costs ratio is concerned. The social sustainability of these agro-ecosystems is satisfactory in regards to the age of manager, and the share of employed persons with special agricultural education/qualification. In terms of the presence of a family member ready to take the farm, the number of participations in professional organizations and initiatives, the share of hired workers, who are members of trade unions, the public positions held by the farmer, manager or owner and the participation in local initiatives, these ecosystems are unsustainable. Non-mountainous regions with natural restrictions have unsatisfactory level of ecological sustainability in relation to the indicator number of crop species, and they are ecologically unsustainable when it comes to the adherence to the landscape maintenance practices, and the presence of protected species on the territory of the farm.

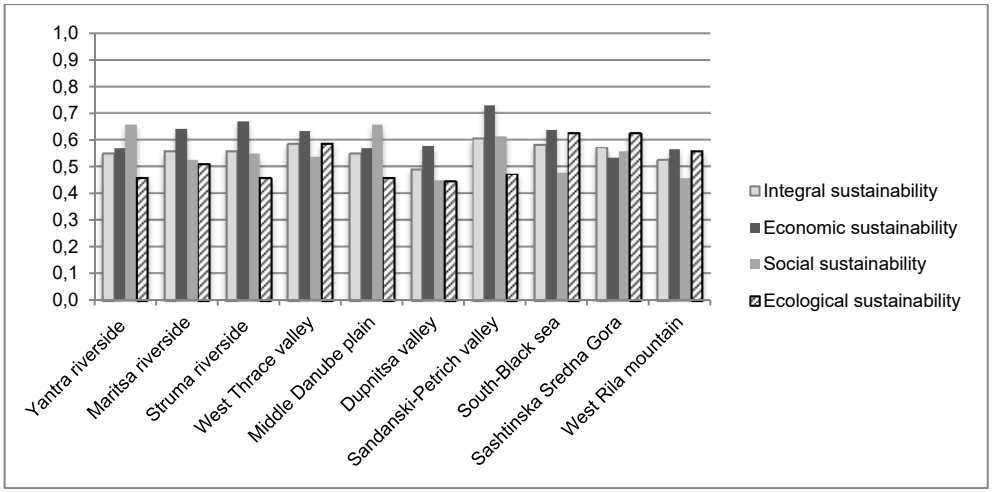
Level of sustainability in the specific agro-ecosystems

There is a big variation in the levels of the integral, economic, social and ecological sustainability of agriculture in the specific ecosystems. From the 10 analysed agro-ecosystems, the highest integral sustainability is that of the Sandanski-Petrich valley (0.61), where the economic sustainability shows the highest values (0.73), the social sustainability also has high values (0.61), while the ecological sustainability is among the lowest in the country and is at a satisfactory level (0.47) (Figure 3). On the other hand, the integral sustainability of the agriculture in the Dupnitsa valley is the one with the lowest level (0.49) and the only one with a satisfactory level among the analysed ecosystems. In this ecosystem the levels of social (0.45) and ecological (0.45) sustainability are satisfactory and are the lowest among the analysed ecosystems.

The integral sustainability of the agro-ecosystems in the areas alongside the rivers Yantra, Maritsa and Struma is at a relatively low (under the average) level – standing at 0.55, 0.56 and 0.56, respectively. However, there is a big differentiation among the different aspects of sustainability in these specific ecosystems. For the ecosystem alongside the Struma River, the economic sustainability is at a high level (0.67), while for the Yantra riverside it is slightly below the average for the country. On the other hand, the area alongside Yantra has the highest level of social sustainability (0.66), whereas the area alongside Maritsa has the lowest social sustainability and is close to the limit of the satisfactory level (0.52). For the three riverside ecosystems, the ecological sustainability of the sector is below the average values for the country, in that for the Maritsa riverside the value is on the border of the satisfactory level (0.51), and for the remaining two riverside ecosystems it is at a satisfactory level (by 0.46).

Figure 3

Levels of sustainability in the specific agro-ecosystems in Bulgaria



Source: Survey held with the managers of farms in 2017, and the author's own calculations.

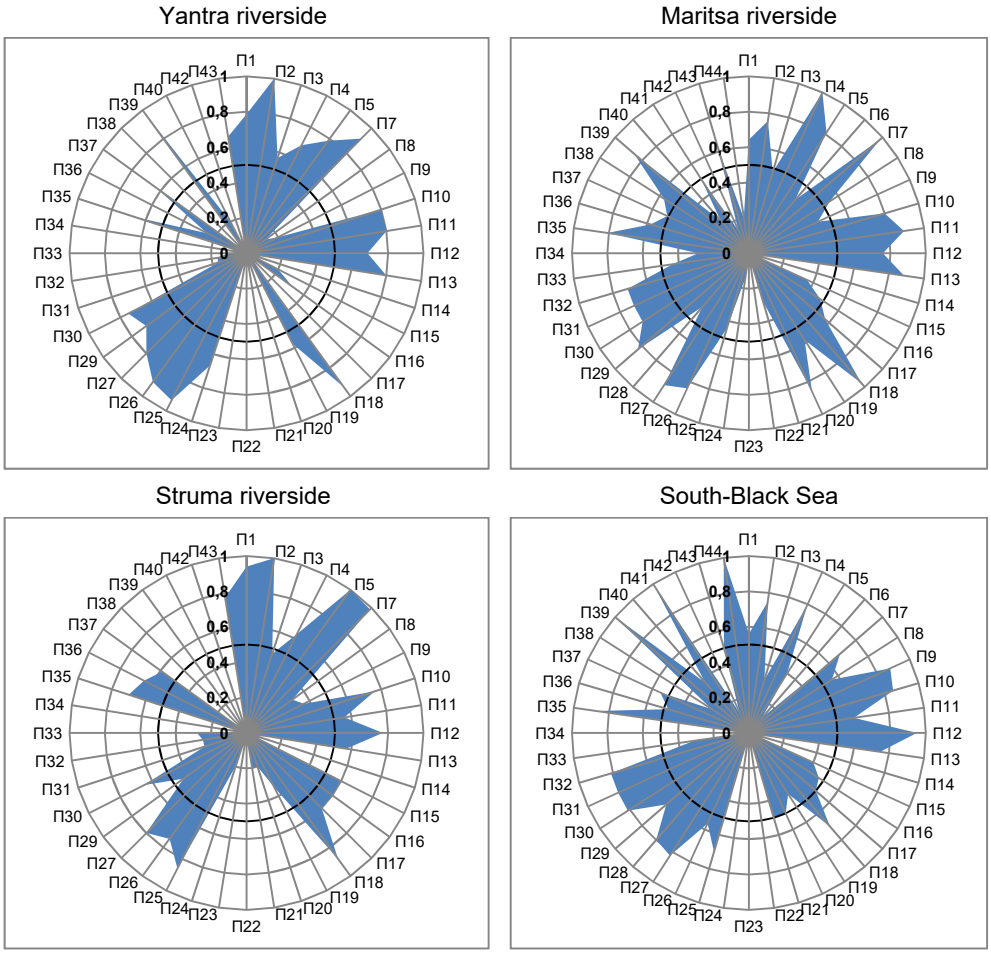
The agro-ecosystem of the Middle Danube plain has relatively low integral sustainability (0.55), with its levels of social sustainability being among the highest in the country (0.66), and those of its ecological sustainability standing at a satisfactory level (0.46) and being among the lowest for the country. The agriculture in the West Thrace valley has a relatively high level of integral sustainability, which is above the average for the country (0.59). This agro-ecosystem has good economic sustainability, above the average for the country (0.67), and shows one of the highest levels of ecological sustainability (0.59), but its level of social sustainability is relatively low and below the average (0.54).

Both of the analysed specific mountainous agro-ecosystems have a lower integral sustainability than the average –0.57 for Sashtinska Sredna Gora, and 0.53 for West Rila mountain, respectively. The social (0.56) and the ecological (0.63) sustainability of Sashtinska Sredna Gora are higher than the values of the West Rila mountain (standing at a satisfactory level of 0.46 and a good level of 0.56, respectively), whereas in terms of the economic sustainability, roles are reversed (at 0.53 and 0.57, respectively). The Sashtinska Sredna Gora and South Black Sea agro-ecosystems have the highest indicators for ecological sustainability among all the analysed specific ecosystems in the country. The integral sustainability of the agriculture in the South Black Sea ecosystem is at the average level for the country (0.58). While the economic sustainability is at a middling level (0.64), the social sustainability is satisfactory (0.48), and the ecological sustainability is the best of all the analysed specific ecosystems (0.63).

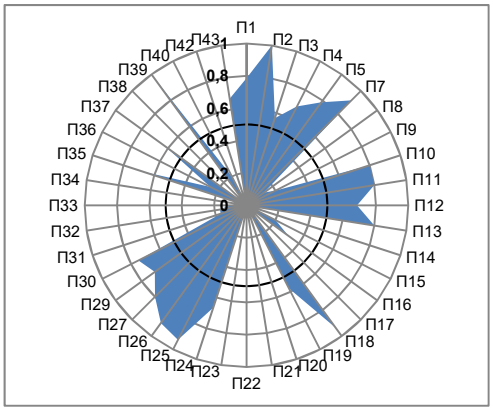
There is a considerable variation among the levels of the different indicators in the specific agro-ecosystems. In the agro-ecosystem of Yantra river, high levels are observed only for the indicators of economic sustainability share of own capital in the total capital and share of sold production in the total output; for the indicators of social sustainability – the level of education of the manager, the number of participations in professional organizations and initiatives, the share of unoccupied permanent work positions in the total number of employed, and the share of unoccupied seasonal work positions in the total number of employed; and for the indicator of ecological sustainability natural biodiversity protection (Figure 4).

Figure 4

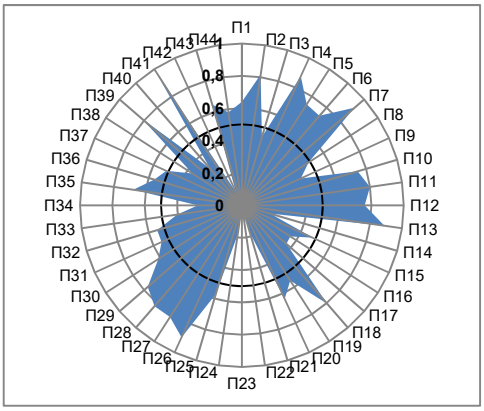
Indicators for sustainability in the specific agro-ecosystems in Bulgaria



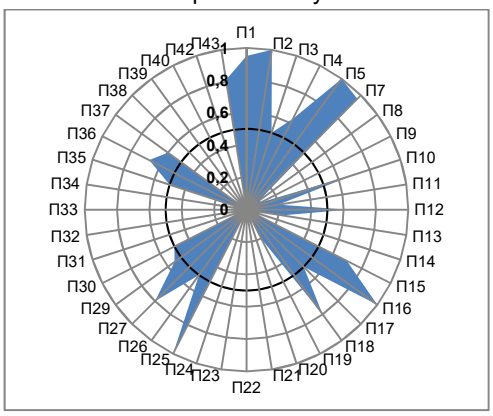
Middle Danube plain



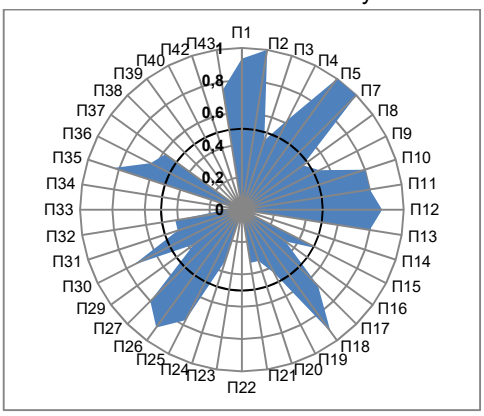
West Thrace valley



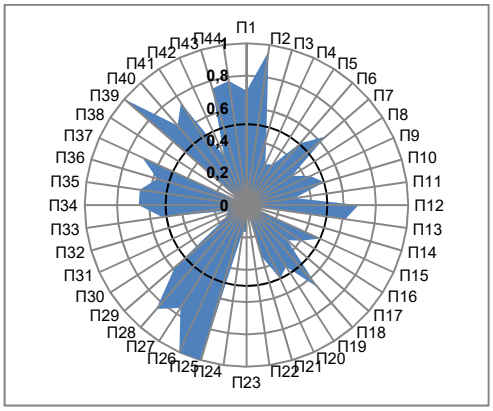
Dupnitsa valley



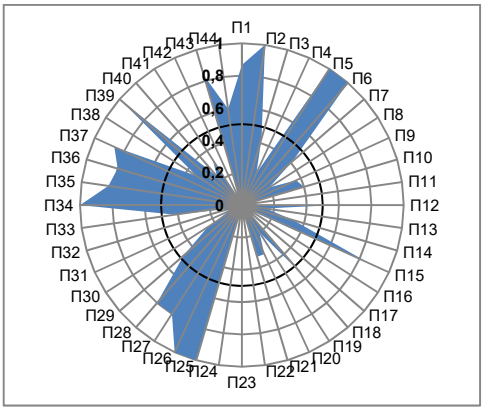
Sandanski-Petrich valley



Sashtinska Sredna Gora



West Rila mountain



Simultaneously, the agriculture of the Yantra riverside shows unsatisfactory levels of sustainability for lots of indicators: the economic indicators: growth of sales over the last 3 years, and growth in investments over the last 5 years; the social indicator: number of family members, working in the farm; and the ecological indicators: compliance with the norms for potassium fertilization, compliance with the norms for phosphorus fertilization, the level of fuel consumption, and the number of crop species. Moreover, this system is unsustainable due to a number of social and ecological indicators: the presence of a family member, ready to take the farm, the participation in training programs over the last 3 years, the degree of participation of women in the farm management, the share of hired workers, who are members of trade unions, the public position, held by the farmer, manager or owner, the share of arable land in the total agricultural land, the adherence to the practices for landscape maintenance, the presence of protected species on the territory of the farm, and the implementation of principles for organic production. In relation to the age of the manager, the social sustainability is satisfactory. The indicators for the sustainability of the Middle Danube plain are similar to the indicators of the agro-ecosystem along the Yantra riverside.

The agriculture in the other analysed riverside ecosystem (that of Maritsa) is characterized by several indicators with levels showing high sustainability: the economic indicators: labour productivity, land productivity, and share of sold production in the total output; the social indicators: payment of hired labour / average income in the region, degree of compliance to normative labour conditions, education level of the manager, degree of participation of women in the farm management, share of unoccupied seasonal work positions in the total number of employed; and the ecological indicators: dynamics of the UAA over the last 5 years, soil erosion, degree of pollution of underground waters with nitrates, and natural biodiversity protection (Figure 4).

The agro-ecosystems along the riverside of Maritsa have a satisfactory level of sustainability in terms of the economic indicators: profit/production costs, livestock productivity, and growth in investments over the last 5 years. The level of the social indicators is also satisfactory when it comes to: the number of family members, working in the farm, the manager's age, the number of participations in professional organizations and initiatives, and the share of unoccupied permanent work positions in the total number of employed. A similar level is observed for the ecological indicators: dynamics of the arable land in the last 5 years, and share of arable land in the total agricultural land. The agricultural sustainability alongside Maritsa river is at an unsatisfactory level in terms of the social and ecological indicators: participation in local initiatives, adherence to the practices for landscape maintenance, number of crop species, implementation of principles for organic production, and percentage of mortality of the livestock over a period of 5 years. When it comes to the social dimensions, a state of unsustainability is observed in regards to: the presence of a family member ready to take the farm, the share of hired workers, who are members in professional organizations and the public position held by the farmer, manager or owner.

Unlike the other two riverside agro-ecosystems that of Struma river has high economic levels of sustainability in regards to the share of direct payments in the net income, the share of own capital in the total capital, the land productivity, and share of sold production in the total output (Figure 4). The social sustainability in this agro-ecosystem is high only in terms of the education level of the manager, and the share of unoccupied work positions in the total number of employed. On the other hand, some indicators of economic sustainability in this agro-ecosystem show satisfactory levels, such as: the profit / production costs, the growth in sales over the last 3 years, and the growth in investments over the last 5 years. A similar level of sustainability is observed in terms of the social and ecological indicators: employed with special agricultural education/qualification, soil erosion, and share of arable land in the total agricultural land.

Moreover, the agricultural sustainability of the Struma riverside is unsustainable in relation to the social indicators: degree of participation of women in the farm management, number of participations in professional organizations and initiatives, and participation in local initiatives; and in terms of the ecological indicators: compliance to the norms of potassium fertilization, compliance to the norms of phosphorus fertilization and number of crop species. This agro-ecosystem is socially unsustainable when it comes to the participation of a family member, ready to take the farm, thy share of hired workers, who are members in trade unions and the public position held by the farmer, manager or owner. The ecosystem is also in a state of ecological unsustainability in regards to the indicators: adherence to the practices for landscape maintenance, presence of protected species on the territory of the farm, protection of the natural biodiversity and implementation of the principles of organic production.

The agricultural sustainability in the South-Black Sea ecosystem has high levels when it comes to the economic indicator growth in investments over the last 5 years; and the social indicators: net farm income /average income in the region, and degree of satisfaction from farming activity (Figure 4). The agro-ecosystem is also ecologically sustainable in terms of many indicators: dynamics in the UAA over the last 5 years, compliance with the norms for nitrate fertilization, compliance with the norms for potassium fertilization, compliance with the norms for the phosphorus fertilization, degree of pollution of underground waters with nitrates, natural biodiversity protection, keeping with the norms of animal welfare, and percentage of mortality of the livestock over a period of 5 years. The agro-ecosystem of the South-Black Sea has satisfactory sustainability when it comes to the economic indicator profit/production costs; and several social indicators, such as: the number of family members working in the farm, the manager's age, and the share of employed with special agricultural education/ qualification; as well as the ecological indicators: share of arable land in the total agricultural land, level of fuel consumption and number of crop species.

The agriculture in this specific ecosystem has unsatisfactory sustainability in terms of the economic indicator livestock productivity; the ecological indicators: presence of protected species on the territory of the farm, and implementation of organic production principles. The agriculture of South-Black Sea ecosystem is socially

unsustainable in regards to the presence of a family member ready to take the farm; the share of workers, who are members of trade unions, the public position held by the farmer, manager or owner, and the participation in local initiatives; and the ecological indicator adherence to the practices for landscape maintenance.

The agriculture in the West Thrace valley show a high level of economic sustainability in terms of the indicators: share of own capital in the total one, labour productivity, and share of sold production in the total; high social sustainability is observed in terms of the compliance to the normative labour conditions, and the share of unoccupied seasonal work places in the total number of employed; and high ecological sustainability can be seen in regards to the dynamics in the UAA over the last 5 years, the changes in the livestock number over the last 5 years, the natural biodiversity protection, and the adherence to the norms for animal welfare (Figure 4). The agriculture of this ecosystem shows satisfactory levels of economic sustainability in regards to: profit / production costs and growth in investments over the last 5 years; social sustainability is observed for the indicators: number of family members working in the farm, manager's age, and participation in training programs over the last 3 years; and ecological sustainability in relation to: the share of arable land in the total agricultural land (0.4), of the adherence to the practices for landscape maintenance, the presence of protected species on the territory of the farm, and the number of crop species.

The social sustainability is unsatisfactory in terms of the indicators: presence of a family member ready to take the farm, number of participations in professional organizations and initiatives, and participation in local initiatives, and it is unsustainable when it comes to the share of hired persons, who are members of trade unions, and the public position held by the farmer, manager or owner. The same can be said about the ecological sustainability in terms of the implementation of the principles for organic production.

The Dupnitsa valley has a high level of economic sustainability in regards to the indicators: share of direct payments in the net income, share of own capital in the total capital, land productivity, and share of sold production in the total output (see Figure 4). The agriculture in this ecosystem shows high social and ecological sustainability only in terms of the age of the manager, the share of unoccupied permanent work positions in the total number of employed, and the variation in the yields of the main crops over a period of 5 years.

The level of sustainability in this agro-ecosystem is unsatisfactory in terms of two economic indicators, several social indicators and one ecological indicator: sales growth over the last 3 years, growth in investments over the last 5 years, payment for hired labour / average income in the region, degree of compliance with the normative labour conditions, share of employed with specific agricultural education/qualification, and number of crop species. Many social and ecological indicators are at an unsatisfactory level: presence of a family member ready to take the farm, degree of participation of women in the farm management, number of participations in professional organizations and initiatives, share of hired workers, who are members of trade unions,

public position held by the farmer, manager or owner, participation in local initiatives, compliance with the norms for potassium fertilization; compliance with the norms for phosphorus fertilization; compliance with the practices for the landscape maintenance; presence of protected species on the territory of the farm; protection of the natural biodiversity and implementation of organic production principles.

The other analysed agro-ecosystem, the Sandanski-Petrich valley, is characterized by a high level of sustainability in terms of the economic indicators: share of direct payments in the net income, share of own capital in the total capital, land productivity, and share of sold production in the total output; the social measurers: degree of satisfaction from farm activity, education level of the manager, and share of unoccupied seasonal work positions in the total number of employed; and the ecological indicator: degree of pollution of underground waters with nitrates. In this ecosystem, the agricultural sustainability has a relatively low (satisfactory) level of economic sustainability in terms of two indicators: profit / production costs, and growth in sales over the last 3 years. Similarly, the social sustainability in the agro-ecosystem shows satisfactory levels in relation to: the manager's age; the share of employed with special agricultural education/qualification; the degree of participation of women in the farm management; the number of participations in professional organizations and initiatives and participation in local initiatives. The agriculture in this area is socially unsustainable in terms of the presence of a family member, ready to take the farm, the share of hired workers, who are members of trade unions and the public position held by the farmer, manager or owner.

Apart from this, the ecological sustainability of the Sandanski-Petrich valley is satisfactory in terms of soil erosion, compliance with the norms for potassium fertilization, and compliance with the norms for phosphorus fertilization; however, it is unsatisfactory in regards to the share of arable land in the total agricultural land, and the number of cultural species; and it is ecologically unsustainable when it comes to the adherence to the practices for landscape maintenance, the presence of protected species on the territory of the farm, the protection of the natural biodiversity and the implementation of organic production principles.

Two mountainous agro-ecosystems have been analysed – Sashtinska Sredna Gora and Western Rila mountain. The agriculture in Sashtinska Sredna Gora is economically sustainable in terms of the share of own capital in the total capital; it is strongly socially sustainable in regards to the share of unoccupied permanent work positions in the total number of employed, and the share of unoccupied seasonal work positions in the total number of employed; and it is highly ecologically sustainable when it comes to the changes in the livestock number over the last 5 years and the protection of the natural biodiversity (Figure 4). The agricultural production in this ecosystem shows satisfactory levels for many economic and social indicators: profit/production costs, labour productivity, land productivity, sales growth over the last 3 years, investments growth over the last 5 years, payment for hired labour/average income in the region, manager's age, participation in education

programs over the last 3 years, share of employed with special agricultural education/ qualification, and number of participations in professional organizations and initiatives. This agro-ecosystem has satisfactory levels of ecological sustainability in relation to the implementation of organic production principles.

Moreover, according several social and ecological indicators, the agriculture in Sashtinska Sredna Gora shows unsatisfactory levels of sustainability: public position held by the farmer, manager or owner, participation in local initiatives, compliance with the norms for nitrate fertilization, compliance with the norms for potassium fertilization, compliance with the norms for phosphorus fertilization. This agro-ecosystem is socially and ecologically unsustainable in terms of the presence of a family member, ready to take the farm, the share of hired workers, who are members of trade unions and the presence of protected species on the territory of the farm.

The other analysed mountainous agro-ecosystem – Western Rila mountain – has a high level of economic sustainability in relation to the share of direct payments in the net income, the share of own capital in the total capital, the land productivity, and the livestock productivity (see Figure 4). The social sustainability is strong in terms of the indicators: number of family members working in the farm, share of unoccupied permanent work positions in the total number of employed, and share of unoccupied seasonal work positions in the total number of employed. The agriculture in the Western Rila mountain is ecologically sustainable in regards to the adherence to the practices for landscape maintenance, the degree of pollution of underground waters with nitrates, the level of consumption of electricity, the protection of natural biodiversity, and the variation in the yields of the main crops over the span of 5 years. This agro-ecosystem shows satisfactory economic sustainability levels in relation to: the profit / production costs, the share of sold output in the total output, and the growth in investments over the last 5 years. The level of social sustainability is satisfactory in terms of the net farm income/average income in the region, the presence of a family member, ready to take the farm, the degree of participation of women in the farm management, and the number of participations in professional organizations and initiatives. The agricultural sustainability is unsatisfactory when it comes to the economic indicators labour productivity and sales growth over the last 3 years; and the social indicators: degree of compliance with the normative labour conditions and share of employed with special agricultural education/qualification. Furthermore, some social indicators in this agro-ecosystem show unsustainability levels: the payment for hired labour/average income in the region, the manager's age, the participation in education programs over the last 3 years, the share of hired workers, who are members in trade unions, the public positions held by the farmer, manager or owner, and the participation in local initiatives.

The agro-ecosystem Western Rila mountain has satisfying ecological sustainability for: soil erosion, share of arable land in the total agricultural land, presence of protected species on the farm territory, and respecting the norms for animal welfare. The ecological sustainability of the ecosystem is unsatisfying for:

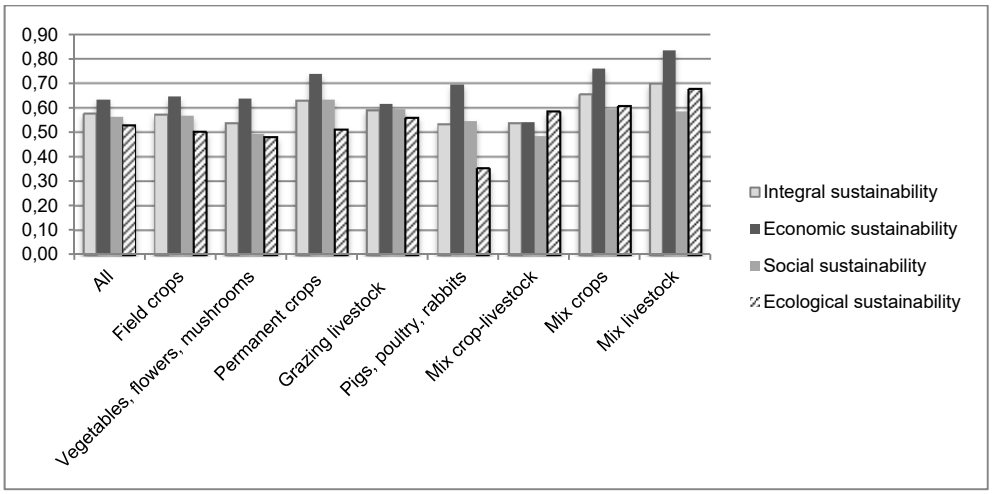
compliance to norms of nitrate fertilization, number of cultural species, compliance to norms of potassium fertilization, and compliance to norms of phosphorus fertilization. This ecosystem is ecologically unsustainable in relation to the principles of organic production.

Contribution of the different sub-sectors of agriculture and the different types of farms toward the sustainability of agro-ecosystems

The conducted survey makes it possible to assess the contribution of the different sub-sectors and the different types of agricultural farms to the sustainability of the agro-ecosystems in the country. The highest integral sustainability was observed in the case of the mixed livestock-breeding (0.7) and the mixed crop-growing (0.66) farms, followed by the perennial crops farms (0.63) (Figure 5).

Figure 5

Contribution of the different sub-sectors of agriculture toward the sustainability of agro-ecosystems in Bulgaria



Source: Survey held with the managers of farms in 2017, and the author's own calculations.

Therefore, the mixed livestock-breeding and crop-growing farms and the perennial crops farms contribute to the highest degree for improving the integral sustainability of Bulgarian agriculture. On the other hand, the farms specialized in pigs, poultry and rabbits (0.53), vegetables, flowers and mushrooms (0.54) and mixed livestock-crops (0.54), show the lowest levels of integral sustainability. This means that the latter types of farms are responsible to the greatest extent for the decrease in the total integral sustainability in the country.

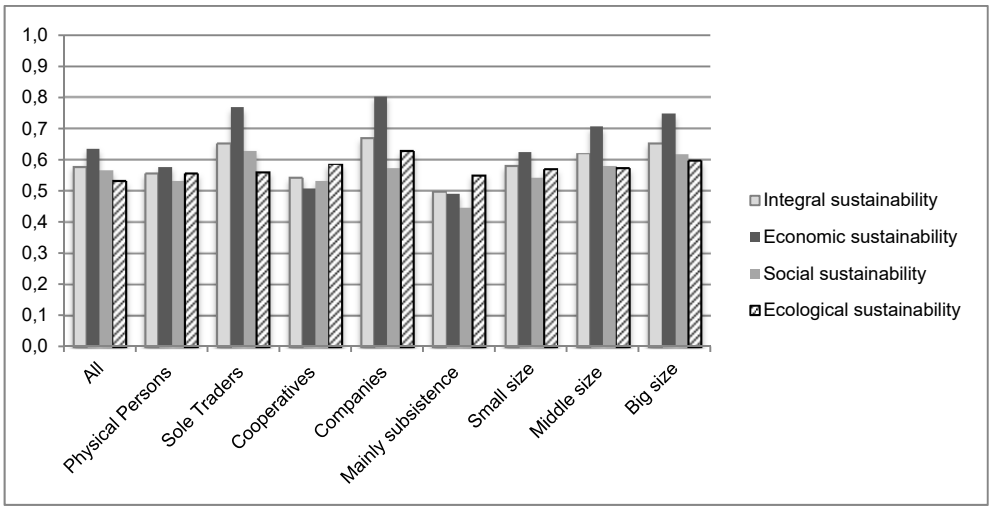
Similar to the case with the integral sustainability, the sub-sectors with the highest economic sustainability are: mixed livestock breeding, mixed crop growing and

perennial crops. The mixed crop-growing production has the highest ecological sustainability, and one of the best levels of social sustainability. The perennial crops sector has high social sustainability, but a lower than the average and almost satisfactory level of ecological sustainability. The social sustainability of farms specialized in grazing livestock is at a comparatively high level. The social sustainability in the mixed crop-livestock farms is at a satisfactory level. The farms for pigs, poultry and rabbits show the lowest satisfactory level, as do the farms for vegetables, flowers and mushrooms. The field crops farms have a good but relatively low level of ecological sustainability, which is close to the satisfactory level. The different agricultural sub-sectors are characterized by important variations in the levels of their sustainability indicators and therefore the type of contribution they make towards the overall and multi-aspect level of sustainability of agro-ecosystems in the country is also different.

The agrarian sustainability in the different types of agricultural farms stands at different levels, which is also an indicator of the specific contribution of the various types of farms for the formation of the existing level of sustainability of the agro-ecosystems in the country. Among the farms with different juridical status the trade associations show the highest agricultural sustainability (0.67), thus contributing to the greatest extent to the agricultural sustainability of the country. In these organizational and management structures the economic (0.8) and ecological (0.63) indicators of agricultural sustainability show the highest levels, while the social sustainability is at the average level for the country (Figure 6).

Figure 6

Contribution of the different types of farms toward the sustainability of agro-ecosystem in Bulgaria



Source: Survey held with the managers of farms in 2017, and the author's own calculations.

The social sustainability is highest when it comes to the sole traders (0.63), whose levels of integral (0.65) and economic (0.77) sustainability fall in the second place and are close to the values of the trade associations.

The agricultural production in cooperatives shows the lowest level of integral sustainability (0.54), its level of economic sustainability (0.51) is on a borderline satisfactory level, and its level of social sustainability is the lowest, standing at the same level as that of individuals (0.53). The ecological sustainability of the production in the cooperatives is at a relatively high level (0.59). The integral sustainability of the agricultural production of individuals falls below the average level (0.55), and its economic (0.58) and social (0.53) sustainability levels are lower than the average for the country.

The agricultural sustainability in farms with different market orientation and sizes is also characterized by different levels of contribution to the integral agricultural sustainability in the country (Figure 6). The highest level of integral sustainability is shown by the large farms (0.65), having the highest economic (0.75), social (0.62) and ecological (0.6) sustainability. Therefore, these farms contribute to the biggest degree for the increase of the integral level of agricultural sustainability in the country. In predominantly self-subsistence farms, the level of agricultural sustainability is low and is close to the satisfactory level (0.5). In these farms all the indicators of agricultural sustainability show low levels, in comparison to the large and market oriented farms, as their levels of economic (0.49) and social (0.45) sustainability are satisfactory. There is a trend towards a decrease in the levels of integral, economic and social sustainability that occurs alongside the decrease in the farms' size. The farms with small and medium sizes show the same levels of ecological sustainability, which are lower than those in the bigger farms, but are higher than the levels in the self-subsistence farms. The individual indicators for the level of sustainability of the farms of different juridical type, size and market orientation are also characterized with a great degree of variation.

Conclusion

This first-of-its-kind assessment of the sustainability of the agro-ecosystems in Bulgaria makes it possible to come to some important conclusions about the state of their sustainability and to make recommendations for the improvement of the managerial and assessment practices. Experimentation with the developed holistic framework improves the assessment of the integral and multi-aspect sustainability. This novel approach needs to be further discussed, experimented with, improved upon and adapted to the specific conditions and evolution of the different types of agro-ecosystems, as well as the needs of the decision-makers at the various levels.

There is a considerable differentiation in the levels of the integral and the multi-aspect sustainability in the different types of agricultural ecosystems. There are also substantial variations in the contribution toward the sustainability of agro-ecosystems from the individual sub-sectors of agriculture and the farms of different juridical types and sizes. The individual indicators with the highest and the lowest values show the

(critical) factors which enhance or deter partial or overall level of sustainability in the evaluated agro-ecosystem.

Having in mind the importance of holistic assessments of this kind for improving agrarian sustainability, farm management and agrarian policies, they are to be expanded upon and their precision and representation should increase. The latter requires a closer cooperation between and participation of all interested parties, as well as improvements of the assessment's precision through an expansion of the number of surveyed farms, and by incorporating more "objective" data from field tests and surveys, statistics, expertise of professionals, etc.

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