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About Agro-Ecosystems Sustainability – Case of in Bulgaria

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ABSTRACT

This study tries to fill the gap in theory and practice and assesses the sustainability level of agro-ecosystems using the case of Bulgaria. First a holistic hierarchical framework for assessing integral, economic, social and ecological sustainability of agro-ecosystems in Bulgaria is suggested including 17 principles, 35 criteria, and 46 indicators and reference values. After that, an assessment is made on overall and aspects sustainability of large (agro)ecosystems in North-Central, South-Eastern, South-Central and South-Western geographic regions, and particular main and specific types of agro-ecosystems of 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. The assessment is based on first-hand information collected though in-depth interviews with the managers of "typical" farms in the respective ago-ecosystems.

The study has found out that there is a considerable differentiation in the level of integral sustainability in agricultural ecosystems of different types. Furthermore, there are substantial variations in the levels of economic, social and ecological sustainability of agro-ecosystems of different type, and the critical indicators enhancing or deterring overall and particular sustainability of individual agro-ecosystems. Results of the integral agrarian sustainability level of this study, based on the micro agro-ecosystem (farm) data, are similar to the previous assessment based on the aggregate sectoral (statistical, etc.) data. There are large differences in the impact of socio-economic, institutional, behavioral, international, natural, etc. factors and individual public policy instruments on the sustainability of farming enterprises of different types and agro-ecosystems.

Keywords: *agro-ecosystem, sustainability, assessment, economic, social, ecological, Bulgaria*

INTRODUCTION

The issue of assessment of sustainability of agricultural systems of various type is among the most topical for last decades (Bachev, 2009, 2010, 2016, 2017, 2018; Bachev et. al., 2016, 2017; Candidoet al., 2018; FAO, 2013; Fuentes 2004; Hayati et. al., 2010; Ikerd, 2015; Ivanovo et al, 2009; Gliessman, 2016; Gemesi, 2007; Gitau et al., 2009; Jalilian, 2012; Irvin et. al., 2016; Lopez-Ridauira et. al. 2002;Rezear et. al, 2018; Sauvenier et al., 2005; Terziev et al., 2018; Todorova and Treziyska, 2018; Van Loon et al. 2005;Zvyatkova and Sarov, 2018).

Agro-ecosystems are ecosystems associated with agricultural (farming) activity and according to their specific characteristics and levels of analysis, the borders of an individual agro-ecosystem could be a part of a separate farm (e.g. a cultivated parcel, a meadow, a pond), located in numerous farms, or most commonly cover a larger region(s) of a country or beyond. Moreover, the individual agro-ecosystem could include, be a part, or overlap with other ecosystems – dry land, mountain, coastal, urban, etc.

In recent years an "ecosystem approach" has been increasingly incorporated in the management and evaluation of sustainability levels (Bachev and Treziev, 2017, 2018; Belcher, 1999; Bohlen and House, 2009; Hanna et.al., 2016; MEA, 2005;De Oliveira, 2018; Ramírez-Carrillo et.al., 2018;Oelbermann, 2014;Sidle et al. 2013).Despite enormous progress in the theory and practice of this new evolving area, still there is no consensus on how to assess the sustainability of agro-ecosystems due to diverse understandings, approaches, methods, employed data, etc.

In Bulgaria comprehensive sustainability assessments are mostly on sectoral (Bachev et.

al., 2017) or farm (Bachev, 2017; Bachev and Treziev, 2017) levels while there is practically no in-depth study on sustainability agro-ecosystems.

The goal of this paper is to assess the sustainability level of agro-ecosystems of different type in Bulgaria.

METHODOLOGY AND DATA

In order to assess sustainability level of agro-ecosystems in Bulgaria a hierarchical system is developed including 17principles, 35criteria, and 46indicators and reference values. Principles are the highest hierarchical level associated with the "universal" functions of agricultural system and represent the state of sustainability in 3 main pillars (aspects) of sustainability - economic, social, and ecological. Criteria represent a resultant state when the relevant principle is realized. Indicators are quantitative and qualitative variables of different types (behavior, activity, input, effect, impact), which can be assessed allowing the measurement of compliance with particular criteria. Reference Values are the desirable levels (absolute, relative, qualitative) for each indicator according to the specific conditions of each agro-ecosystem which assist the assessment giving guidance for achieving (maintaining, improving) sustainability.

We have examined the available academic research, official documents, and experience in Bulgaria and other countries, and have carried out numerous consultations with leading national and international experts in the area. On this basis, a system that includes principles, criteria, indicators, and reference values relevant to contemporary conditions in Bulgaria has been formulated. An expert panel was set up with ten leading experts in the country discussed and evaluated the importance of the proposed principles, criteria, indicators, and reference values, and selected most appropriate to the contemporary conditions in Bulgaria. A number of criteria were used in selecting indicators: relevance to reflecting aspects of sustainability; discriminatory power in time and space; analytical soundness; intelligibility and synonymy; measurability, governance and policy relevance; and practical applicability (Sauvenier et al., 2005).

In Bulgaria, such as in the most countries, there are no official data for calculating socio-economic and (some parts of) ecological indicators at agro-ecosystem level. Agro-ecosystems are the ecosystems associated with the farming activity and the individual farm is the first level for governing of agrarian sustainability (Bachev, 2018).

In order to assess the level of sustainability of agro-ecosystems in the country in-depth interviews with the managers of 80 farms of different types and locations in 4 major regions of Bulgaria were held in 2017. Following criteria were used for the selection of areas for farm surveys: major administrative and geographic regions - Eastern, Northern, Western and Southern Bulgaria respectively North-Central, South-Eastern, South-Central and South-Western administrative and geographic regions of the country representing distinctive large (agro)ecosystems; particular main types and specific (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.

In order to identify the "typical" for the different regions of the country farms, the co-operation of the main associations of farmers (National Association of Grain Producers, National Union of Gardeners, Union of Breeders, etc.), state agencies (National Agricultural Advisory Service, Executive Agency for Vine and Wine, etc.), processing, bio-certification and service organizations, and local government is used. Farmers of different types were surveyed covering the main types of farms in the regions concerned: different legal types of holdings - natural persons, sole traders, cooperatives, commercial companies, etc .;farms of different sizes - mainly for self-sufficiency, with small size for the sector, with average size for the sector, with large sizes for the sector; farms in different production specialization - arable crops, vegetables, flowers and mushrooms, perennials, grazing livestock, pigs, poultry and rabbits, mixed crops and mixed livestock breeding; farms in specific geographic and ecological locations. From farms originally identified for interviews only 5, 61% were not interviewed due to the extreme occupancy, unwillingness to participate or other reasons.

During the surveys, the managers of the farms were aware with the objectives of the survey, they replied to the questions prepared in

advance and discussed the main problems and challenges of sustainable agriculture in the farms and eco-systems. The duration of the interview with each participant was from several hours to a whole day, and in many cases additional meetings and phone calls were conducted to refine and supplement the answers.

The survey includes many questions in 5 major areas: general characteristic of farms; primary information for calculating economic indicators for agrarian sustainability at agro-eco-system level;primary information for calculating social indicators for agrarian sustainability at agro-eco-system level; primary information for calculating environmental indicators for agrarian sustainability at agro-eco-system level; impact of diverse socio-economic, policies, behavioral, personal, etc. factors on farmers actions for improving agrarian sustainability and its various aspects.

After that diverse quantitative and qualitative levels for each indicator are transformed into a unit less index of sustainability (ISi).After than the integral index for a particular criterion (SI(c)), principle (SI(p)), and aspect of sustainability (SI(a)), and the integral sustainability index (SI(o)) for each surveyed farm is calculate dapplying equal weight for each indicator in a particular criterion, of each criterion in a particular principle, and each principle in every aspect of sustainability.

The arithmetic averages of the indices of composite indicators, criteria and principles are calculated by the following formulas:

SI (c) = ∑SI (i)/n n - number of indicators in a particular criterion;

SI (p) = ∑SI (c)/n n - number of criteria in a particular principle;

SI (a) = ∑SI (p)/n n - number of principles in a particular aspect,

SI (o) = ∑S I (a)/3

The composite sustainability index of a particular agri-ecosystem is an arithmetic average of the indices of relevant farms belonging to that agro-ecosystem. For assessing the level of sustainability of agro-ecosystems the following scale defined by the experts is used:

Index range 0,85-1 for a high level of sustainability; Index range0.50-0,84 for a good level of sustainability; Index range 0,25-0,49 for a satisfactory level of sustainability; Index range 0,12-0,24 for an unsatisfactory level of sustainability; Index range 0-0,11 for non-sustainable.

General Characteristic of the Questionnaire Farms

The survey was conducted in the period April-November 2017 and covered 80 farmers from five administrative districts of the country - Pazardjik, Plovdiv, Kjustendil, Blagoevgrad, Bourgas and VelikoTarnovo.

The majorities of the surveyed holdings are unregistered farms of individuals, mostly small in size, and specialize in mixed plant-animal farms and perennial farms. Most of the studied farms are located in South Central and South-West geographical and administrative regions, and in mostly plane and plane-mountain areas of the country. One quarter of the farms surveyed is in the Thracian Lowland. Each fifth is located in valleys of different kind - Danube plain, Dupnitsa valley and Sandanski-Petrich valley. In riverside ecosystems of different types (Maritsa, Struma and Yantra) there are about 36% of the farms surveyed and in the seaside area - every tenth farm.

The owners or managers of the majority of farms surveyed are men and in active working age from 41 to 65 years. Such gender and age structure of managers (owners) will manage the majority of Bulgarian farms in the near 10-15 years and will contribute to one or other level of their sustainability. The majority of respondents are between age from 56 to 65, which is an indicator of both their life and professional experience and the worrying aging of the employed in our agriculture.

Most of the farms surveyed have a relatively long life - over 15 years and only 10% with a short development period from 2 to 5 years. This is an indicator that the majority of farms have sufficient effective management experience and sustainability. Most of the farmers surveyed indicate that the period they are taking care of improving the sustainability of the farm is over 6 years, the majority of them are in the group with long experience over 15 years. There is a correlation between the duration of the existence of the farms and the period during which the farms take care to improve their sustainability. Moreover, with the increase in the duration of the existence of the farm, the proportion of farms with an effective care to improve their sustainability increases. All this shows that the practical problem of

"agrarian sustainability" is not new. However, the question is whether farms know and to what extent they respect the principles of sustainable agriculture.

The kknowledge of the main socio-economic and environmental challenges and the basic principles of sustainable agriculture is the basis for effective management of agrarian sustainability. Our large-scale survey found that according to the majority of farms in the country, they are located in areas with "normal" economic, social and environmental problems. However, a significant part of them is in the areas with "big" or "extreme" economic, social and environmental challenges. One third of the managers say that their farm is located in an area with "small" or "no" ecological problems, while the share of farms with similar economic and social problems is smaller. The share of managers who are not familiar with the character or cannot assess the level of socio-economic and environmental problems in the area where their farm is located is not low. The greatest concern is farmers' competence with regard to the ecological problems in the area, followed by social and economic challenges.

Our study found that the majority of the managers of the surveyed farms know "well" and "very well" the principles of economic, social and environmental sustainability (.At the same time, a large proportion of farmers recognize that their knowledge of the principles of social and environmental sustainability is "satisfactory" or lacking at all. The low lack of competence concerns almost half of the holdings in terms of social sustainability principles, almost every third farm in terms of environmental sustainability and about one fifth of farms for economic sustainability.

Only a small proportion of the farms surveyed increase their sustainability management capacity by hiring a consultant and this is all about getting to know the principles of environmental and economic sustainability. The relatively high (internal) potential for managing the different aspects of sustainabilityare cooperative farms, where everyone knows "well" or "very well" the principles of economic and social sustainability, and a significant part of them know the principles of environmental sustainability (Figure6).At the same time, 16.67% of these farms "use a consultant" to improve their environmental sustainability competence.

All of the sole traders know well or very well the principles of economic sustainability and three-quarters of them - the principles of environmental sustainability. About 12% of these types of farms hire a consultant in order to improve the economic sustainability. The majority of sole traders also know well or very well the principles of social sustainability. However, 37.5% of them report that their knowledge about the principles of social sustainability is not good. The majority of commercial companies know well or very well the principles of economic and environmental sustainability, but only slightly more than half of them have a similar level of competence with respect to the principles of social sustainability. Every tenth of this type of farms also use an external consultant to enhance its environmental sustainability competence. Two thirds of individuals are highly competent in terms of economic sustainability principles, and 40% of them are also competent in terms of environmental sustainability. At the same time, nearly three quarters (73.33%) of this type of farms are not well aware of the principles of social sustainability.

Competence of sustainability principles grows together with farm size and, as a rule, larger farms are better acquainted with economic, social and environmental sustainability. At the same time, 7.69% of medium-sized farms hire a consultant to increase their knowledge of economic sustainability and 15.38%of environmental sustainability. At the same time, it is worrying that none of the farms that are primarily for self-sufficiencyknow well the principles of economic, social and environmental sustainability. This group of producers represents a significant part of all farms in the country and is an important factor in improving the socio-economic and environmental sustainability of agriculture. There is also a differentiation of competence with respect to the principles of sustainability and depending on the production specialization of farms. In all categories of farms, a high level of knowledge of the principles of economic sustainability is typical of all or a majority of them. Exceptions are only farms with plant breeding specialization, where each second farm is not well aware with the principles of economic sustainability. Half of pig, poultry and rabbit farms also have a consultant to improve their competence in terms of economic sustainability.

Knowledge of the principles of ecological sustainability is high in farms specializing in field plants, perennial crops, mixed crops, mixed crops and grazing livestock, while in farms with other specialization the share of those with low ecological competence is significant. Each fifth offield plants farms improves their ecological sustainability capacity by hiring a consultant, similar to 11.11% of those in perennial crops. Knowing the principles of social sustainability is good in most of the farms specializing infield plants, mixed plant growing and perennial crops. For farms in other production specialization, the share of highly competence in social sustainability is low, and for farms with vegetables, flowers and mushrooms, and those in mixed livestock farming, their share is zero.

Farms located in predominantly plain and plain-mountain areas and those in non-mountainous areas with natural constraints have a better knowledge of the principles of economic, social and environmental sustainability. On the other hand, farms located in predominantly mountainous areas, in mountainous areas with natural constraints and those with landscapes in protected areas and territories have a relatively small part highly competence in the principles of sustainability.

Some of the farms located in mountainous regions improve their economic and ecological sustainability by employing a consultant - respectively 6.67% and 13.33% of all farms in this group.

Finally, all the farms surveyed in the South-East region know well or very well the economic, social and ecological principles of agrarian sustainability. Competence for economic sustainability is high in most of the farms in the other studied regions of the country. Most of the farms in the North-Central region are well informed about environmental sustainability while in the South-West region they are a minority. Also, knowing the principles of social sustainability is not good at the majority of farms in the South-Central and South-West regions of the country. Consultants in order to improve the knowledge of sustainable agriculture use 13.5% and 6.25% of farms in the South-West and South-Central region in terms of ecological aspects and 6.25% of farms in the South Central Region in terms of economic sustainability. Therefore in the future, greater efforts should be made in order to improve the farmers' competence in low-culture groups with regard to the principles of agrarian sustainability through training, counselling, advices, exchange of positive experiences, etc.

Competence about the principles of agrarian sustainability is necessary but not a sufficient condition for its effective management. Due to incomplete knowledge and various other economic, technological, agronomic, behavioural, etc. reasons, and at different times, farmers do not always strictly apply the principles of sustainable agriculture. Our study found that, according to the majority of farm managers, they comply "strict" or "good" principles of economic, ecological and social sustainability (Bashev 2016).However, a significant part of the farms respect the principles of social, economic and environmental sustainability only "satisfactory". Moreover, some farms point that they do not "follow" such principles (which reach 6% of the total number of farms in terms of social sustainability), or "only follow if there are sanctions" (up to 8% ecological sustainability).

The principles of agrarian sustainabilityare applied to the greatest extent in the general management of farms in cooperatives and commercial companies. Around 8% of cooperatives apply the principles of environmental sustainability only if there are sanctions. A comparatively smaller proportion of sole traders and natural persons apply the principles of social sustainability to a high degree. Many natural persons follow the principles of sustainable agriculture only if there are sanctions - 9% for environmental sustainability, 5% for economic sustainability and 5% for social sustainability.

These data show that sanctions by the state, local authorities, owners, members, etc. generate economic behaviour to improve environmental sustainability in certain groups of farms such as cooperatives and natural persons.

The application of sustainability principles grows with farm sizes and as a rule, larger farms are better of economic, social and environmental sustainability. Compliance with the diversity of sustainability principles is the most common among farms specializing in field plants, grazing livestock and mixed plant breeding and mixed plant growing farms. However, the quoted study also found that for all groups of holdings, the proportion of those who respect well or strictly the principles of agrarian sustainability exceeds the proportion of those who know well or very well these principles. Therefore, the question is how much some of the farms apply effective principles that they themselves do not know well.

Overall Level of Sustainability in Analyzed Agro-Ecosystems

The multi-indicator assessment of agricultural sustainability level in the four analyzed regions shows that the integral indicator of overall sustainability is0,58, which expresses a good sustainability level of agriculture (Figure 1). The biggest value has the indicator of economic sustainability (0,64), the social sustainability shows lower value (0,57) and the ecological sustainability is close to the unsatisfying value level (0,53). Therefore, the improvement of the last two indicators is critical for maintaining the good agricultural sustainability of the country.

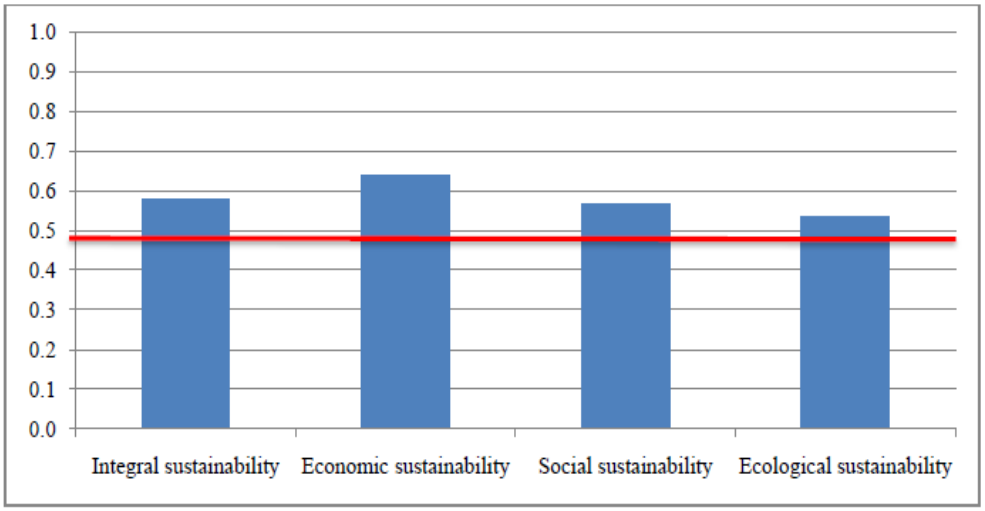


Figure1. *Indicators of integral, economic, social and ecological sustainability of analyzed agri-ecosystems in Bulgaria*

Source: *survey with managers of farms, 201 7 and author's calculations*

The analysis of private indexes on basic principles, criteria and indicators of the sustainability gives opportunity to identify components contributing for the levels of different aspects of agricultural sustainability in the country. The assessment ascertained that the ecological sustainability is relatively low due to the fact that the indicators for the principles "land quality" (0,44), "biodiversity" (0,38) and "organic production" (0,11) are low (Figure 2). Thus, the improvement of these low levels of above-mentioned principles is a factor for maintenance and raising of ecological and integral sustainability in the sector. Also it becomes clear that despite the relatively high integral economic sustainability, the indicator of adaptability to economic environment is relatively low (0, 54) and critical for maintaining the reached level. Analogically, for the social sustainability improvement would contribute mostly the increase of low levels of indicators for the principles "farming conservation" (0, 52), "gender equality" (0, 40) and "social capital" (0, 17).

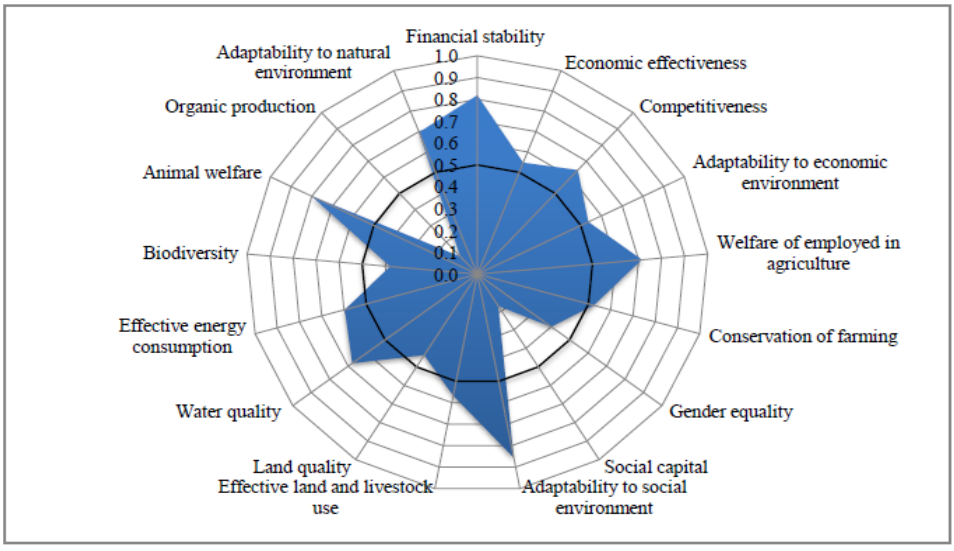


Figure2. *Sustainability index according the main sustainability principles in analyzed agri-ecosystems in Bulgaria*

Source: *survey with managers of farms, 201 7 and author's calculations*

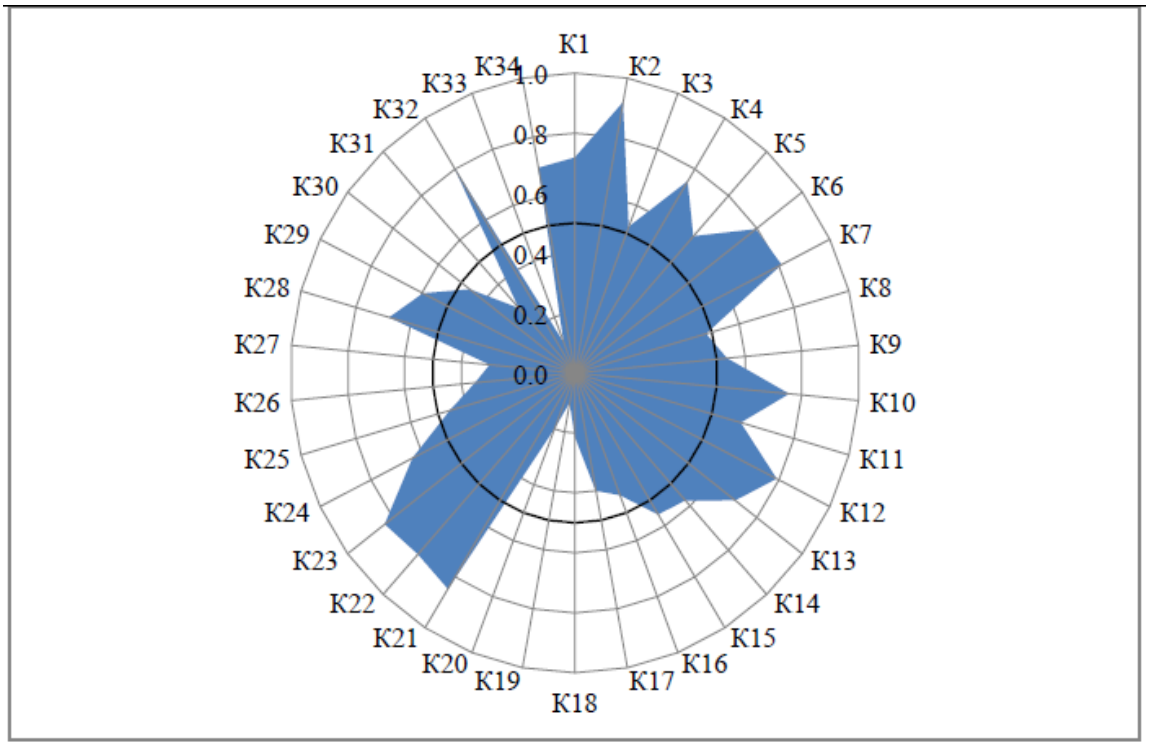


Figure3. *Sustainability index according the main criteria* in analyzed agri-ecosystems in Bulgaria*

** K1-Decrease of dependence on subsidies; K2-Minimization of dependence on exterior capital; K3-Positive or high profitability; K4-Maximal or increasing labour productivity; K5-Maximal or increasing land productivity; K6-Maximal or increasing livestock productivity; K7-Conservation or increase of sold output share ; K8-Conservation or increase of sales; K9-High investment activity; K10-Incomes parity with other sectors; K11-Equitable distribution of income in agriculture; K12-Sufficient satisfaction of farmer activity; K13-Satisfying labour conditions; K14-Keeping the number of family farms; K15-Knowledge and skills increase; K16-Conservation and improvement of agricultural education; K17-Equality of relations man-woman; K18-Participation in professional organizations and initiatives; K19-Participation in public management; K20-Contribution for the development of region and communities; K21-Sufficient potential for reaction to activity cession and to demographic crisis; K22-Keeping or increase of UAA size; K23-Keeping or increase of livestock number; K24-Minimization of soil losses; K25-Keeping and improvement of soil fertility; K26-Keeping of balanced land-use structure; K27-Protection of landscape elements; K28-Keeping and improvement of water quality; K29-Minimization of conventional energy use; K30-Keeping and improvement of natural biodiversity; K31-Keeping and improvement of cultural biodiversity; K32-Implementation of principles of animal welfare; K33-Organic production increase; K34-Sufficient adaptability to climatic changes.*

Source: *survey with managers of farms, 2017 and author's calculations*

The profound analysis according different criteria and indicators gives opportunity for detailed analysis of elements contributing for/or decrease the agricultural sustainability level. For example, the low levels of ecological sustainability are determined from the low criteria "conservation and improving of soil fertility" (0, 46); "balanced land use structure maintenance" (0,35; "landscape elements conservation" (0,30); "natural biodiversity maintenance and improvement" (0,46); "cultural biodiversity maintenance and improvement" (0,29) and "organic production increase" (0,11) (Figure 3). The unsatisfying levels according these criteria for ecological sustainability are (pre)determined of low levels of indicators for eco-sustainability, as: insufficient conformity of norms for fertilization with potassium (0,38) and phosphorus (0,38), high share of arable land in the total agricultural land (0,33), low degree of compliance with practices for landscape conservation (0,3), insufficient protected species on farms' territory (0,18), limited number of cultural species in farms (0,29) and low degree of application of organic production principles (0,11) (Figure 4).

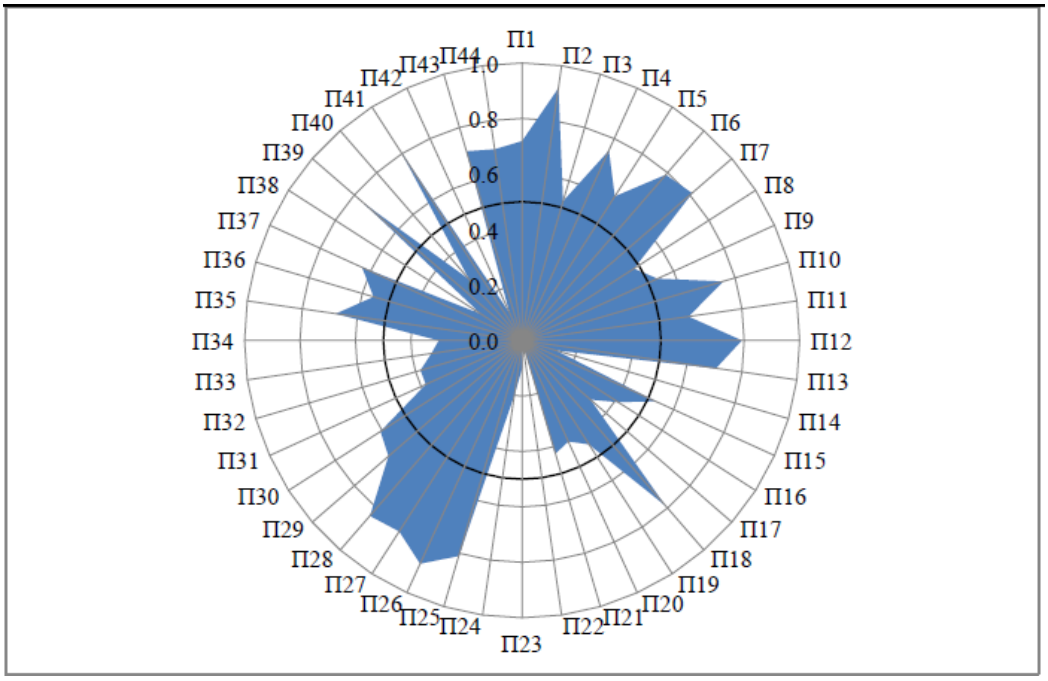


Figure4. *Indicators* for sustainability in analyzed agro-ecosystems in Bulgaria*

**П1-Direct payments in the net income; П2-Share of own capital in the total one; П3-Profit/production costs; П4-Labour productivity; П5-Land productivity; П6-Livestock productivity; П7-Share of sold production in the total one; П8-Sales growth in the last three years; П9-Investments 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 to 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 manager; П17-Participation of training programs in the last 3 years; П18-Education level of manager; П19-Share of occupied with special agricultural education / qualification; П20-Degree of participation of women in the farm management; П21-Number of participation in professional organizations and initiatives; П22-Share of hired workers, members of trade unions; П23-Public positions occupied from 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-Change of UAA in last 5 years; П28-Change of livestock number in last 5 years; П29-Soil erosion; П30-Compliance of nitrate fertilization to norms; П31-Compliance of potassium fertilization to norms; П32-Compliance of phosphorus fertilization to norms; П33-Share of arable land in the total UAA; П34-Keeping 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 farm territory; П39-Natural biodiversity protection; П40-Number of cultural species; П41-Respecting of animal welfare norms; П42-Implementation of principles for organic production; П43-Yield variation of main crops for 5 years; П44-Percentage of mortality of livestock for 5 years.*

Source: *survey with managers of farms, 2017 and author's calculations*

Social sustainability in agriculture is usually decreased almost by: lack of family member, ready to continue the farm work (for individual and family farms) (0,13), elderly age of managers and farm owners (0,41), insufficient participation in training programs in the last years (0,33), low share of employed with special agricultural education and qualification (0,44), insufficient participation of women in the farm management (0,4), low participation of farms in professional organizations and initiatives (0,43), lack of membership of hired workers in trade unions (0), weak participation in the public governance from the side of farmers, managers and owners (0,1), and insufficient involvement of farms in local initiatives (0,2).

Critical for the keeping and improvement of the sector's economic sustainability are the increase of production profitability (0,52) and the keeping and increase of sales (0,48).The low levels of indicators for sustainability show also the specialized areas for agricultural sustainability improvement through adequate change of farms strategies and/or of public policies in relation to the sustainable development of the sector, of different sub-

sectors, ecosystems and farms types. On the other hand, the high levels of some indicators express the absolute and relative advantages of Bulgarian agriculture regarding the sustainable development. On the actual stage they are expressed in: high share of own capital in the total capital of farms (0,92), high share of sold production in the total output (0,81), lower share of non-occupied permanent (0,81) and seasonal (0,88) work places in the total number of employed, increase of UAA (0,82) and livestock number (0,84) in the last years and respect of norms for animal welfare (for the livestock breeding farms) (0,8).

Level of Agricultural Sustainability in the Main Types of Agro-Ecosystems

Our assessment determined that there is a considerable differentiation of the levelof integral and aspect sustainability in agricultural ecosystems main types (Figure 5). The highest integral sustainability has the agriculture in the plane regions (0, 63), which have also the highest economic sustainability, with the ecosystems in protected zones and territories (0,74). On the other hand, the integral sustainability in mountain regions with natural restrictions is the lowest (0, 56).

These ecosystems' type has also the lowest (and close to the limits of satisfying level) levels for social sustainability, with the ecosystems in non-mountain regions with natural restrictions (0, 52). Nevertheless, the ecological sustainability of agro-systems in mountain areas with natural restrictions is relatively high (0, 58).

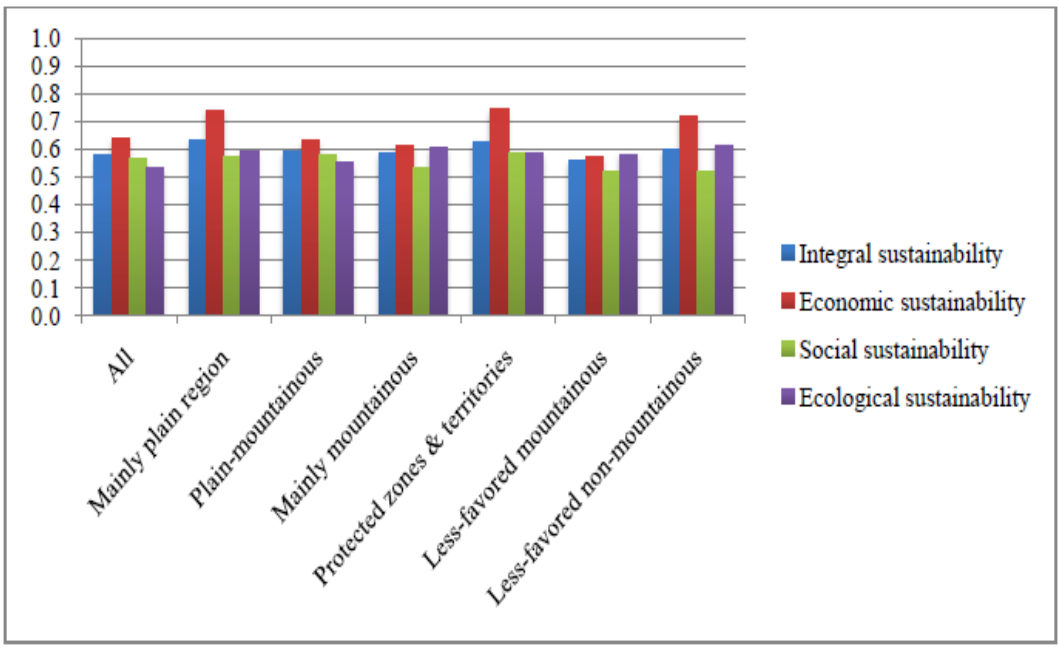


Figure5. *Level of sustainability in the main types of agro-ecosystems in Bulgaria*

Source: *survey with managers of farms, 2017 and author's calculations*

The integral sustainability of mountain ecosystems is on a medium level (0, 58), but while its economic and social aspects are below the average for the country (respectively 0, 61 and 0,53), the level of 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 having relatively high 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 plane-mountainous regions is the lowest in the country (0,55), and for the non-mountainous regions with natural restrictions it is the highest (0,61). The agriculture of ecosystems in the plane regions has high significances for economic sustainability for 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) (Figure 6). The social sustainability of the sector in these regions is high in relation to degree of correspondence to the normative labour conditions (0,84), education level of manager (0,94) and share of unoccupied seasonal labour positions in the total number of employed (0,87). Agriculture in such regions is with ecologically strong sustainability for the

dynamics of UAA in the last 5 years (0, 83), the dynamics of the raised livestock number In the last 5 years (0, 83) and keeping the norms of animal welfare (1).

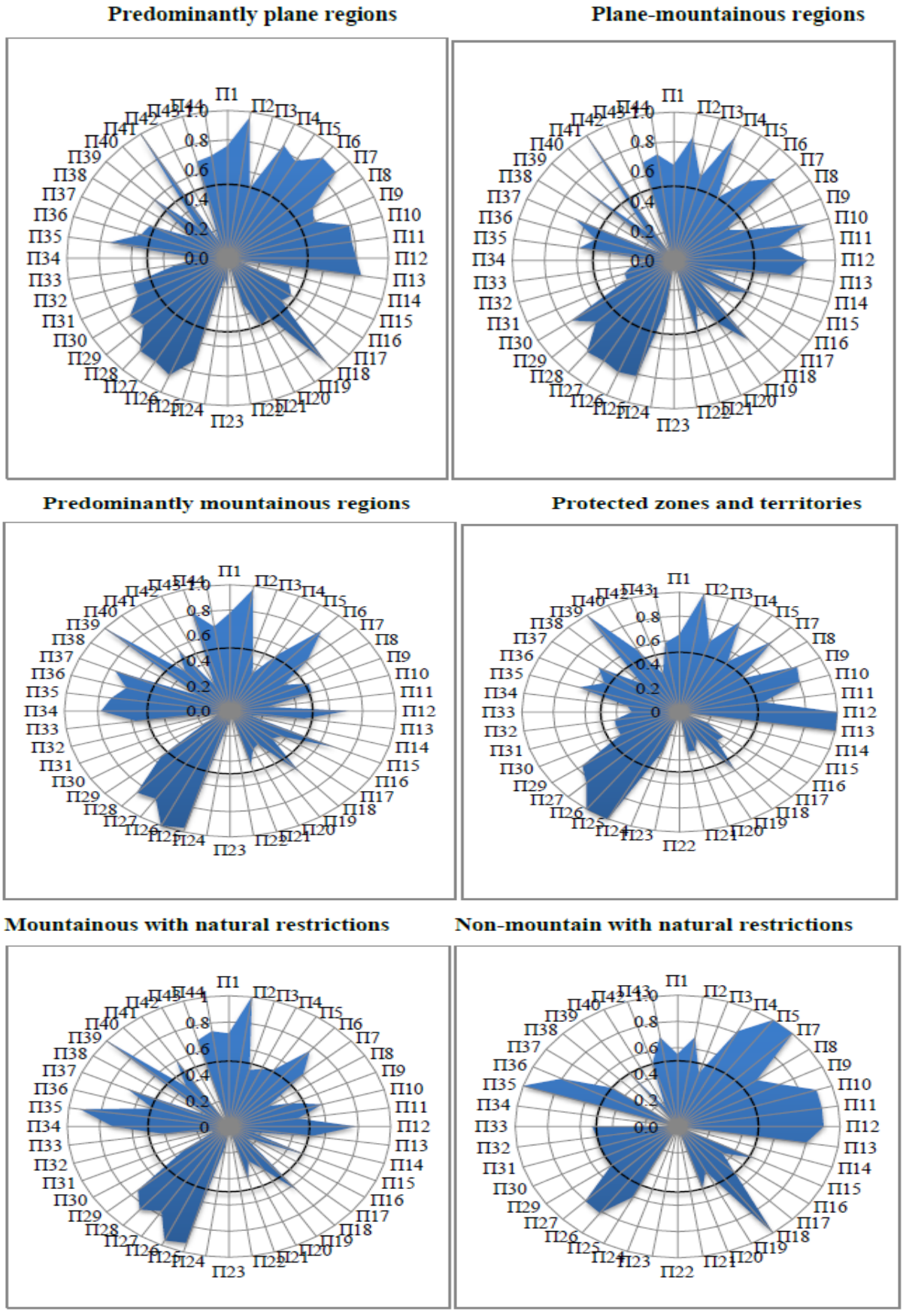


Figure6. *Indicators for in the main agro-ecosystems types in Bulgaria*

Source: *survey with managers of farms, 2017 and author's calculations*

Simultaneously, the levels of some indicators in the plane agro-ecosystems have low levels. While the economic sustainability is satisfying only regarding the relation profit/ production costs (0,49), for the social sustainability satisfying are the levels for number of family members working in the farm (0,42), manager's age (0,47), participation in training programs in the last 3 years (0,44), share of employed with special agricultural education/ qualification (0,47) and number of participation in professional organizations and initiatives (0,31). Along with that, regarding the public position of the farmer, manager or owner (0, 19) and participation in local initiatives (0, 13) the state is unsatisfying and for presence of family member ready to take the farm (0, 06), on the limit of the un sustainability. Moreover, according the indicator share of hired workers, members of trade unions, the state is un sustainability. The ecological sustainability of the sector in these regions is satisfying in relation to the share of arable land in the total agricultural land (0,32), presence of protected species on the farm territory (0,25) and number of cultural species (0,27); and unsatisfying for the keeping of practices for landscape maintenance (0,19) and implementation of principles for organic production (0,11).

In ecosystems of plane-mountain regions the economic sustainability of agriculture is high regarding the: share of own capital in the total (0, 84), labour productivity (0, 91) and share of sold production in the total output (0,84) (Figure 6). The highest in social aspect in these regions are the indicators: net farm income/ average income in the region(0, 87), degree of satisfaction from the farming activity (0, 83), share of non-occupied permanent work positions in the total number of employed (0,81) and share of unoccupied seasonal work positions in the total number of employed (0, 83). From ecological aspect, the best of these ecosystems are only the dynamics of the number of livestock in the last 5 years (0, 82) and the keeping of norms of animal welfare (1).

At the same time agro-ecosystems in the plain-mountainous regions have satisfying values of economic sustainability for the growth of sales in the last 3 years (0,38) and investments growth in the last 5 years (0, 49). The social sustainability in these regions is on satisfying levels in relation to manager's age (0, 37), degree of participation of women in the farm management (0,33) and participation in local initiatives (0,33); unsatisfying regarding the presence of family member, ready to take the farm (0, 2) and participation in training programs in last 3 years (0,2); and socially unstable for the share of hired workers, members of trade unions and public positions of the farmer, manager or owner. In the plane-mountain ecosystems the ecological sustainability is satisfying regarding the compliance with the norms of the fertilization with potassium (0,32), compliance with the norms of phosphorus fertilization (032) and share of arable land in the total agricultural land (0,26); unsatisfying for the keeping of practices for landscape maintenance (0,13), presence of protected species on the farm territory (0, 07), and number of cultural species (0, 24); and unstable for the implementation of principles for organic production.

The agricultural sustainability in ecosystems in mountain regions has the highest values for the economic indicators: share of own capital in the total capital (0,97)and livestock productivity (0,84); the social indicators of the share of non-occupied permanent work positions in the total number of employed (0, 97), and share of unoccupied seasonal work positions in the total number of employed (1); and ecological indicators: dynamics of UAA in last 5 years (0, 83), dynamics of raised livestock in last 5 years (0, 86), natural biodiversity protection (1), and yield variation of the main crops for 5 years (0, 81) (Figure 6).In mountain regions with satisfying values for sustainability are the economic relation profit/ production costs (0, 49), labour productivity (0,33), and sales' growth in last 3 years (0,38). The social sustainability of this type of ecosystems is satisfying in lots of indicators: degree of compliance with normative labour conditions (0, 44), manager's age (0, 37), participation in training programs in last 3 years (0,33), share of employed with special agricultural education/ qualification (0,31), degree of participation of women in the farm management (0,33), and number of participations in professional organizations and initiatives (0,44). Furthermore, the social sustainability is unsatisfying in relation to the payment of hired labour/ average income in the region (0, 22), presence of a family member, ready to take the farm (0,11), public position of the farmer, manager or owner (0,11), and participation in local initiatives (0,11). In relation to the share of hired workers, members of trade unions, there is a social instability. In the mountain agro-ecosystems the ecological sustainability is on a

satisfying level for the number of cultural species (0, 41), and unsatisfying for the compliance with the norms of nitrate fertilization (0,17), compliance with the norms for potassium fertilization (0,08), compliance of phosphorus fertilization with the norms (0,08), presence of protected species on the farm territory (0, 22), and implementation of principles for organic production (0, 22).

The ecosystems' agricultural sustainability in the protected zones and territories is economically high regarding the share of own capital in the total one (1), labour productivity (0, 85), share of sold production in the total output (0, 83), and investments' growth in the last 5 years (0, 84) (Figure 6). This ecosystem type has strong social stability for the degree of satisfaction of the farming activity (1), degree of compliance with the normative labour conditions (1), share of unoccupied permanent work positions in the total number of employed (1), and share of non-occupied seasonal work positions in the total number of employed (1). In ecological aspect the agricultural sustainability in the protected zones and territories is high only regarding the dynamic of UAA in last 5 years (0, 83), and natural biodiversity protection (1).On the other hand, the economic sustainability of agro-ecosystems with protected zones and territories is satisfying for the sales' growth in the last 3 years (0, 47), while for the livestock productivity there is an instability. The social sustainability in these zones and territories is on satisfying level in relation to manager's age (035), participations in training programs in last 3 years (0, 33), degree of participation of women in the farm management (0, 33), number of participations in professional organizations and initiatives (0,33), and participation in local initiatives (0, 33). For the social indicators the number of family members working in the farm (0, 2), and share of employed with special agricultural education/ qualification (0, 24) the sustainability level is unsatisfying. Moreover, regarding the presence of family member ready to take the farm, the share of hired workers, members in trade union and the public position of the farmer, manager or owner, the ecosystems are unsustainable. In protected zones and territories some ecological indicators are also relatively low (unsatisfying): compliance to norms of the fertilization with potassium (0, 42), compliance to norms of the fertilization with phosphorus (0, 42), share of arable land in the total agricultural land (0, 3), keeping of practices for landscape maintenance (0,33), presence of protected species on the farm territory (0,33) and implementation of principles for organic production (0, 33).

Agricultural sustainability in ecosystems of mountain regions with natural restrictions are highly economically sustainable just in relation to the share of own capital in the total (1); strongly socially sustainable for the share of unoccupied permanent work positions in the total number of employed (0, 93) and share of unoccupied seasonal work positions in the total number of employed (0, 96); and highly ecologically sustainable according the dynamics of livestock number in last 5 years (0, 84),degree of pollution of underground waters with nitrates (0, 93) and protection of natural biodiversity (1) (Figure 6).At the same time, some economic indicators of sustainability in these ecosystems are on satisfying level, as: profit/ production costs (0,45), labour productivity (0, 48), sales' growth in last 3 years (0, 29), and investments' growth in last 5 years (0, 43). Similarly, the social sustainability of this ecosystems' type is satisfying regarding: payment of hired labour/ average income in the region (0, 43), share of employed with special agricultural education/ qualification (0, 38), degree of participation of women in the farm management (0, 29) and number of participations in professional organizations and initiatives (0, 43). The level of social sustainability in such regions is unsatisfying for presence of family member, ready to take the farm (0,14), manager's age (0, 19), participation in training programs in last 3 years (0,14) and participation in local initiatives (0,14). In relation to the share of hired workers, members of trade unions and public position of manager, farmer and owner, the mountain regions with natural restrictions are socially unsustainable. In these regions some indicators for ecological sustainability have satisfying levels, as the compliance to norms of the nitrate fertilization (0, 32), share of arable land in the total agricultural land (0,4), level of fuel consumption (0, 49) and number of cultural species (0, 4). The ecological sustainability is unsatisfying for the compliance to the norms of potassium fertilization (0, 11), compliance to norms of phosphorus fertilization (0,11) and presence of protected species on the farm territory (0, 14), while for the principles of organic production implementation, they are unsustainable.

The agricultural sustainability in the non-mountain regions with natural restrictions is economically high regarding the labour

productivity (0, 81), land productivity (1) and share of sold output in the total one (1) (Figure 6). In relation to the social sustainability, the indicators are high for: net farm income/average income in the region (0, 9), payment of hired work in the region (0,9), degree of satisfaction from the farming activity (0,9), education level of manager (1) and share of unoccupied seasonal work positions in the total number of employed (0, 81).The ecological sustainability in these regions is high only for the pollution of underground waters with nitrates (1).The agro-ecosystems in the non-mountain regions with natural restrictions have satisfying economic sustainability only regarding the ratio profit/ production costs (0, 43). The social sustainability of these agro-ecosystems is satisfying for the age of manager (0, 34) and share of employed with special agricultural education/ qualification (0, 38). As regards to the presence of family member ready to take the farm; number of participation in professional organizations and initiatives; share of hired workers, members of trade unions; public position of farmer, manager or owner and participation in local initiatives, these ecosystems are unsustainable. Non-mountain regions with natural restrictions have unsatisfying level of ecological sustainability for the indicator number of cultural species (0, 15) and they are ecologically unsustainable as regards the keeping of landscape maintenance practices (0) and presence of protected species on the farm territory. (0).

Level of Agricultural Sustainability in the Specific Agro-Ecosystems

In the fourth geographical regions of the country have been identified and analyzed the following important for the respective region and for the country, as a whole, agro-ecosystems: the ecosystems alongside the rivers Yantra, Maritsa and Struma, West Thrace valley, Middle Danube plane, Doupnitsa and Sandanski-Petrich hollows, South- cost Black sea, Sashtinska Sredna Gora and West Rila mountain.

The assessment postulated that there is a big variation in the levels of integral, economic, social and ecological sustainability of agriculture in the specific ecosystems. From the analyzed 10 agro-ecosystems, the highest integral sustainability has Sandanski- Petrich hollow (0,61), with economic sustainability with highest values (0,73), social sustainability with also high values (0,61), while the ecological sustainability is among the lowest in the country and on satisfying level (0,47) (Figure 7).On the other hand, the integral sustainability of agriculture in Dupnitsa hollow is on the lowest level (0,49) and the only one with satisfying level among the analyzed ecosystems. In this ecosystems the levels of social (0, 45) and ecological (0, 45) sustainability are satisfying and the lowest among the analyzed.

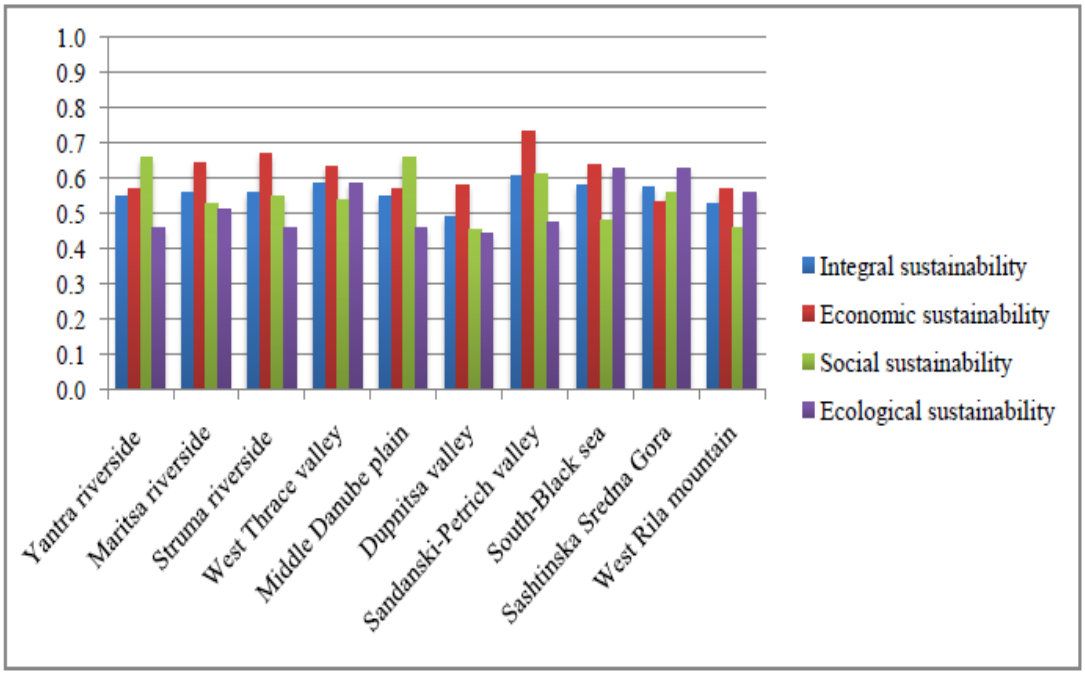


Figure7. *Levels of sustainability in the specific agro-ecosystems in Bulgaria*

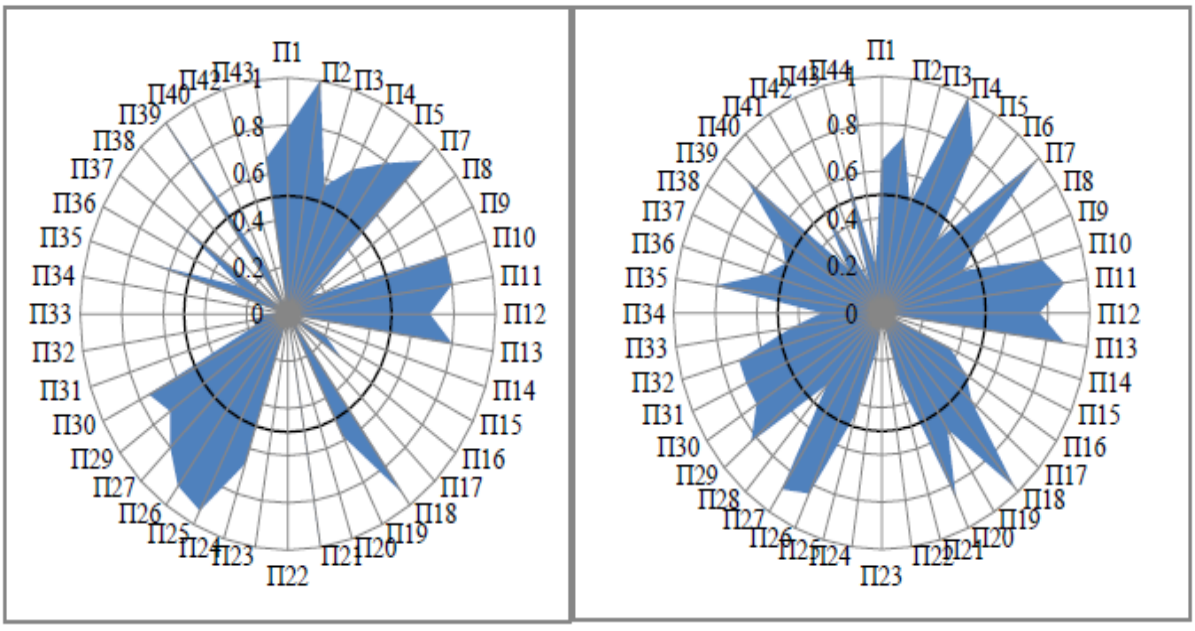
Source: *survey with managers of farms, 2017 and author's calculations*

The integral sustainability of agro-ecosystems in the areas alongside the rivers Yantra, Maritsa and Struma is on a relatively low (under the average) level – respectively 0,55, 0,56 и 0,56. However, there is a big differentiation of different aspects of sustainability in these specific ecosystems. For the eco-system alongside Struma river the economic sustainability is on a high level (0, 67), while for 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 close to the limit of the satisfying level (0,52). For the three riverside ecosystems the ecological sustainability of the sector is below the average values for the country, as for Maritsa riverside the value is on the border of the satisfying level (0,51), and for the other riverside ecosystems – on satisfying level (by 0,46).

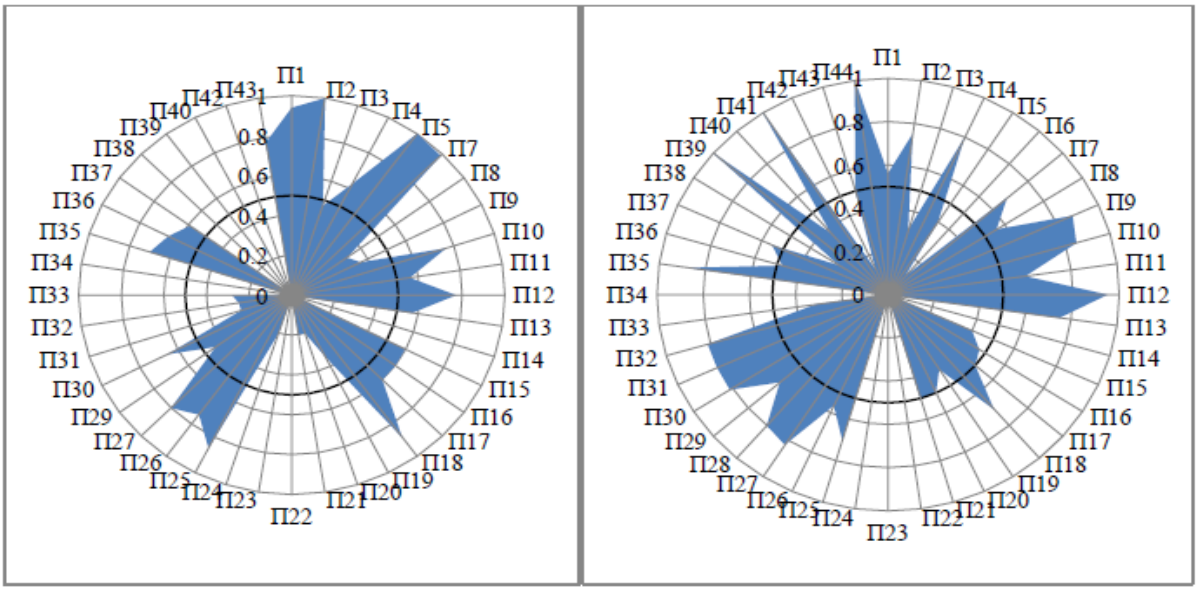
The agro-ecosystem Middle Danube plain has relatively low integral sustainability (0,55), with levels of social sustainability among the highest in the country (0,66), and from ecological aspect on the satisfying level (0,46) and among the lowest for the country. The agriculture in the West Thrace valley has integral sustainability on a relatively high level and over the average for the country (0,59). This agro-ecosystem has good economic sustainability, over the average (0,67), with one of the highest levels of ecological sustainability (0,59), but relatively low and under the average social sustainability (0,54). Both analyzed specific mountain agro-ecosystems have lower integral sustainability than the average – respectively 0,57for Sashtinska Sredna Gora, and 0, 53 for West Rila mountain. The social (0, 56) and the ecological (0, 63) sustainability of Sashtinska Sredna Gora are higher than the values of West Rila mountain (respectively on satisfying level 0,46 and good level 0,56), whereas for the economic sustainability is the opposite (0,53 and 0,57). Sashtinska Sredna Gora and South Black sea cost have the highest indicators for ecological sustainability among all analyzed specific ecosystems in the country. The integral sustainability of agriculture of South Black sea is on the average level for the country - 0,58, while the economic sustainability is on a middle level (0,64), the social sustainability is satisfying (0,48), and the ecological is the best of all analyzed (0,63).

There is a considerable variation of different indicators' levels in the specific agro-ecosystems. Three specific riverside ecosystems in North Central, South Central and South-West regions were analyzed. In the agro-ecosystem of Yantra river high levels have only the indicators for economic sustainability – share of own capital in the total one (1) and share of sold production in the total output (0,91); the indicators for social sustainability – level of education of the manager (0,93), number of participations in professional organizations and initiatives (1),share of unoccupied permanent work positions in the total number of employed (0,93), and share of unoccupied seasonal work positions in the total number of employed (0,9); and for the ecological sustainability – natural biodiversity protection (1) (Figure8).

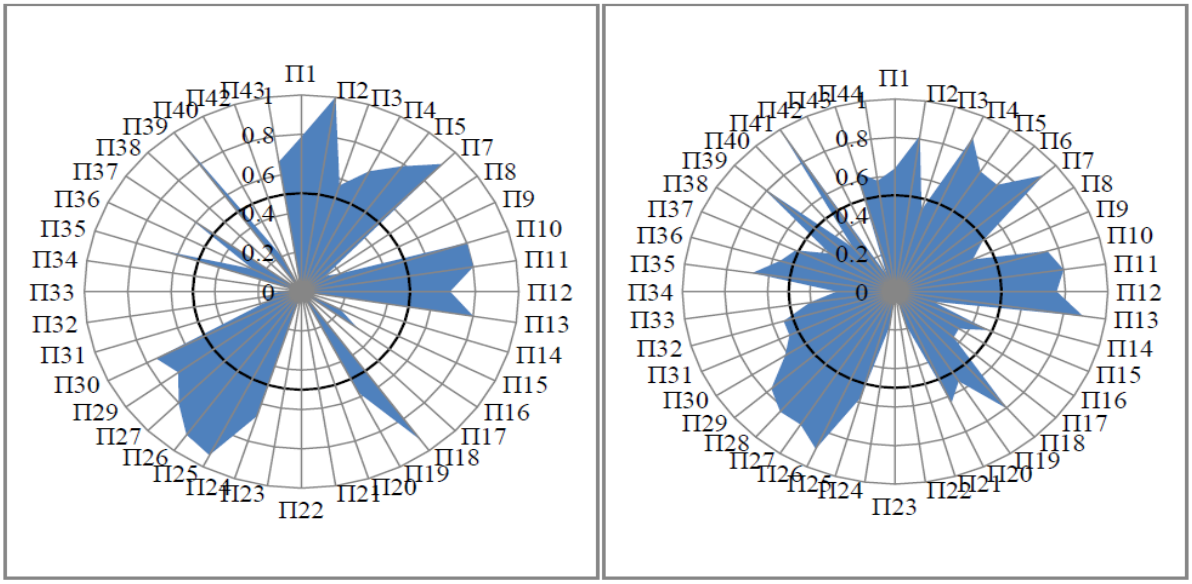
Yantra riverside **Maritsa riverside**



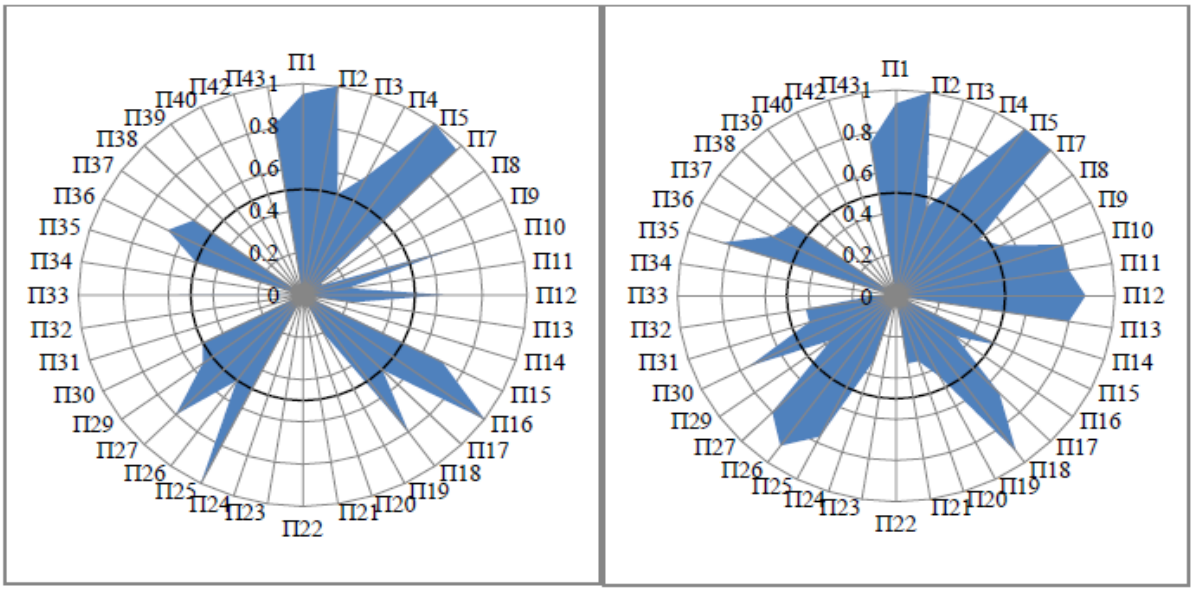
Struma riverside South-Black Sea



Middle Danube plain **West Thracevalley**



Dupnitsavalley **Sandanski-Petrichvalley**



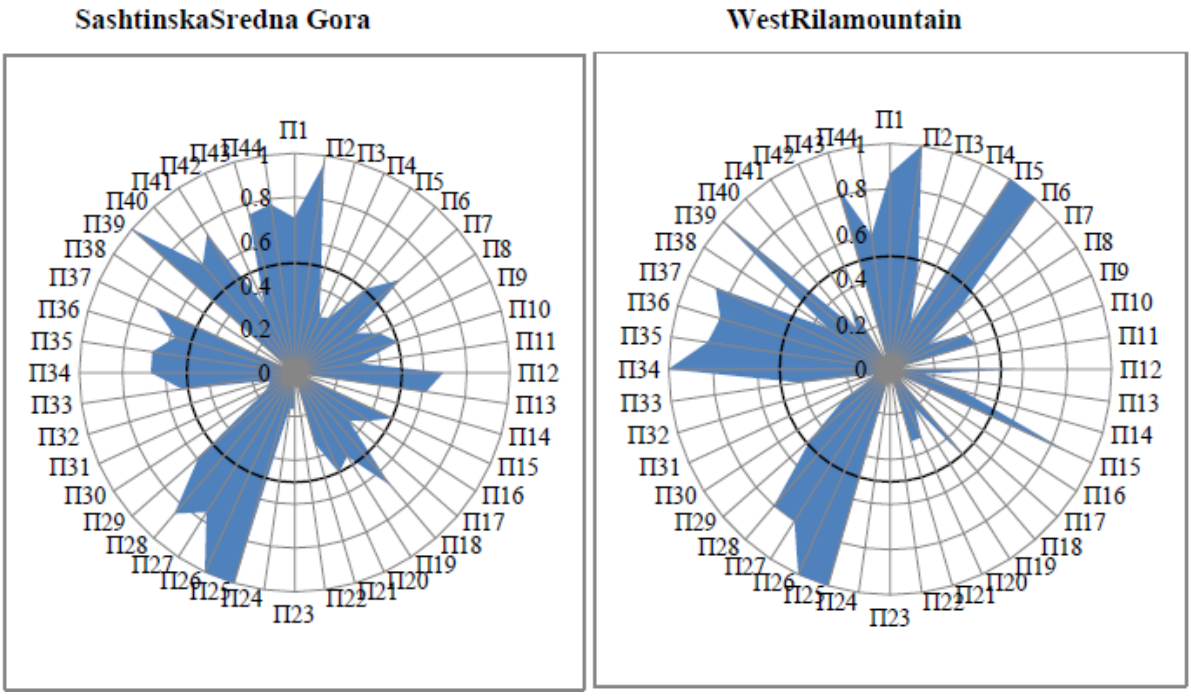


Figure8. *Indicators for sustainability in the specific agro-ecosystems in Bulgaria*

Source: *survey with managers of farms, 2017 and author's calculations*

The agriculture of Yantra riverside has unsatisfying sustainability for lots of indicators: economic growth of sales in the last 3 years (0,13) and investments' growth in the last 5 years (0, 2); social number of family members, working in the farm (0,2); and ecological: compliance of potassium fertilization to the norms (0,17), compliance to the norms of phosphorus fertilization (0,17), level of fuel consumption (0,25) and number of cultural species (0,2).Moreover, this system is unsustainable due to lots of social and ecological indicators: presence of a family member, ready to take the farm; participation in training programs in last 3 years; degree of participation of women in the farm management, share of hired workers, members of trade unions; public position, occupied by the farmer, manager or owner; share of arable land in the total agricultural land; keeping of practices for landscape maintenance; presence of protected species on the farm territory; implementation of principles for organic production. In relation to the age of manager, the social sustainability is satisfying (0, 32). Similar to indicators of the agro-ecosystem along Yantra riverside are the indicators for the sustainability of Middle Danube plain.

The agriculture in the other analyzed riverside ecosystem, of Maritsa, is characterized by several indicators for levels of high sustainability: economic – labour productivity(1), land productivity (0,81) and share of sold production in the total production (0,98); social – payment of hired labour/average income in the region (0,88), degree of compliance to normative labour conditions (0,88), education level of the manager (0,97), degree of participation of women in the farm management (0,86), share of unoccupied seasonal work positions in the total number of employed (0,84); and ecological – dynamics of UAA in the last 5 years (0,88), soil erosion (0,83), degree of pollution of underground waters with nitrates (0,81) and natural biodiversity protection (0,86) (Figure 8).

The agro-ecosystems from the riverside of Maritsa have satisfying sustainability of economic indicators: profit/ production costs (0,48), livestock productivity(0,4) and investments' growth in the last 5 years(0,43). The level of social indicators is also satisfying: number of family members, working in the farm (0,36), manager's age (0,48), number of participations in professional organizations and initiatives (0,29) and share of unoccupied permanent work positions in the total number of employed (0,44). Similar is the level of ecological indicators: dynamics of the arable land in the last 5 years (0,4) and share of arable land in the total agricultural land (0,44).The agricultural sustainability alongside Maritsa river is on unsatisfying level about the social and ecological indicators: participation in local initiatives (0,14), keeping of practices for landscape maintenance (0,29), number of

cultural species (0,24), implementation of principles for organic production (0,14) and percentage of mortality of the livestock for 5 years (0,2). In relation to social dimensions there is a state of un sustainability: presence of family member ready to take the farm, share of hired workers, members in professional organizations and public position of the farmer, manager or owner.

Unlikely the other two riverside agro-ecosystems, this of Struma river has high economic levels of sustainability for the share of direct payments in the net income (0,94), share of own capital in the total one (1), land productivity (1) and share of sold production in the total output (0,99) (Fig.16). The social sustainability in this agro-ecosystem is high only regarding the education level of the manager (0,88) and share of unoccupied work positions in the total number of employed (0,86).On the other hand, some indicators of economic sustainability in this agro-ecosystem have satisfying levels, as: profit/ production costs (0,47), growth of sales in the last 3 years (0,32) and investments' growth in the last 5 years (0,36). Similar is the level of sustainability regarding the social and ecological indicators for the employed with special agricultural education/qualification (0,34), soil erosion (0,44)and share of arable land in the total agricultural land (0,28).

Moreover, the agricultural sustainability of Struma riverside is unsustainable in relation to the social measurers: degree of participation of women in the farm management (0,2), number of participation in professional organizations and initiatives (0,2) and participation in local initiatives (0,2); and ecological indicators: compliance to the norms of potassium fertilization (0,25), compliance to the norms of phosphorus fertilization (0,25)and number of cultural species (0,12). This agro-ecosystem is socially unsustainable in relation to the participation of a family member, ready to take the farm; share of hired workers, members in trade unions and public position of the farmer, manager or owner. The ecosystem is also in state of ecological un sustainability regarding the keeping of practices for landscape maintenance, presence of protected species on the farm territory, protection of the natural biodiversity and implementation of principles of organic production.

The agricultural sustainability in the South-Black sea ecosystem has high levels for the economic indicator - investments' growth in the last 5 years (0,88) and for the social indicators: net farm income /average income in the region (0,85) and degree of satisfaction from farming activity (0,95) (Figure .10). The agro-ecosystem is also ecologically sustainable with lots of indicators: dynamics of UAA in the last 5 years (0,82), compliance to the norms of nitrate fertilization (0,81), compliance to the norms of the potassium fertilization (0,81),compliance to the norms of the phosphorus fertilization (0,81), degree of pollution of underground waters with nitrates (0,87), natural biodiversity protection (1), keeping the norms of animal welfare (1) and percentage of mortality for the livestock for 5 years (1). The agro-ecosystem South-Black sea has satisfying sustainability concerning the economic indicator profit/ production costs (0,31); several social indicators, as: number of family members working in the farm (0,4), manager's age (0,47) and share of employed with special agricultural education/ qualification (0,47); and ecological indicators for : share of arable land in total agricultural land (0,31), level of fuel consumption (0,47) and number of cultural species (0,37).

This specific ecosystem has unsatisfying sustainability of agriculture regarding the economic aspect for livestock productivity (0, 11) and from ecological aspect: for the presence of protected species on the farm territory (0,25) and implementation of organic production principles (0,12). The agriculture of South-Black sea is socially unsustainable regarding the presence of a family member ready to take the farm; share of workers, members of trade unions; public position of the farmer, manager or owner and participation in local initiatives, and in ecological aspect, for the keeping of practices for landscape maintenance.

The agriculture in the West Thrace valley has high economic sustainability regarding the indicators share of own capital in the total one (0,82), labour productivity (0,88) and share of sold production in the total (0,92); high social sustainability for compliance to the normative labour conditions (0,89) and share of unoccupied seasonal work places in the total number of employed (0,89); and high ecological sustainability for the dynamics of UAA in the last 5 years (0,82),dynamics of the livestock number in the last 5 years (0,82), natural biodiversity protection (0,82), and keeping of norms for animal welfare (1) (Figure 10).The agriculture of this ecosystem has satisfying levels of economic sustainability for: profit/

production costs (0,44)and investments' growth in the last 5 years (0,4); social sustainability for: number of family members working in the farm (0,48), manager's age (0,36), participation in training programs in last 3 years (0,36); and ecological sustainability for: share of arable land in the total agricultural land (0,4), keeping of practices for landscape maintenance (0,27), presence of protected species on the farm territory (0,36) and number of cultural species (0,3).

The social sustainability is unsatisfying for indicators: presence of family member ready to take the farm (0,18), number of participations in professional organizations and initiatives (0,18) and participation in local initiatives (0,18), and regarding the share of hired, members of trade unions, and public position of farmer, manager or owner the state is unsustainable. The same state has the ecological sustainability regarding the implementation of principles for organic production (0, 09).

In the South-West region of the country have been analyzed two specific agro-ecosystems of Dupnitsa valley and of Sandanski-Petrich valley. Dupnitsa valley has high economic sustainability of indicators: share of direct payments in the net income(0,95), share of own capital in the total one (1), land productivity (1) and share of sold output in the total (0,97) (Fig.16). The agriculture in this ecosystem has high social and ecological sustainability only regarding the age of the manager (1),share of unoccupied permanent work positions in the total number of employed (1) and variation of yields of the main crops for 5 years (0,81).

Under two economic, several social and one ecological indicator, the sustainability of this agro-ecosystem is unsatisfying: sales growth in last 3 years (0,1), investments' growth in last 5 years (0,1), payment of hired labour/average income in the region (0,2), degree of compliance to normative labour conditions (0,22), and share of employed with specific agricultural education/qualification (0,2), and number of cultural species (0,1). Under many social and ecological indicators the level is unsustainable: 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, members of trade unions; public position of the farmer, manager or owner; participation in local initiatives; compliance to the norms of potassium fertilization; compliance to the norms of phosphorus fertilization; respecting of practices for the landscape maintenance; presence of protected species on the farm territory; protection of natural biodiversity and implementation of organic production principles.

Other analyzed agro-ecosystem is Sandanski-Petrich valley, which is characterized by high sustainability of economic indicators: share of direct payments in the net income (0,93), share of own capital in the total (1), land productivity (1)and share of sold output in the total output (1); social measurers: degree of satisfaction from farm activity (0,86), education level of manager (0,93) and share of unoccupied seasonal work positions in the total number of employed (0,9); and ecological indicator: degree of pollution of underground waters with nitrates (0,83).In this ecosystem the agricultural sustainability has relatively low (satisfying) economic sustainability according two indicators: profit/ production costs (0,45) and growth of sales in the last 3 years (0,47). Similarly, the social sustainability in the agro-ecosystem has satisfying levels in relation to: manager's age (0,33);share of employed with special agricultural education/ qualification (0,44);degree of participation of women in the farm management (0,33); number of participation in professional organizations and initiatives (0,33) and participation in local initiatives (0,33). The agriculture in this area is socially unsustainable regarding the presence of a family member, ready to take the farm; share of hired workers, members of trade unions and public position of the farmer, manager or owner.

Apart this, the ecological sustainability of Sandanski-Petrich valley is satisfying for the soil erosion(0,37); compliance to norms of potassium fertilization(0,42) and compliance to norms of phosphorus fertilization (0,42); unsatisfying regarding the share of arable land in the total agricultural land (0,1) and number of cultural species (0,13); and ecologically unsustainable regarding the keeping of practices for landscape maintenance; presence of protected species on the farm territory; protection of natural biodiversity and implementation of organic production principles.

Two mountain agro-ecosystems have been analyzed – Sashtinska Sredna Gora and Western Rilamountain. The agriculture in Sashtinska Sredna Gorais economically sustainable regarding the share of own capital in the total

(0,96); strongly socially sustainable for the share of unoccupied permanent work positions in the total number of employed (1) and share of unoccupied seasonal work positions in the total number of employed (1); and highly ecologically sustainable for the dynamics of the livestock number in the last 5 years (0,85) and for the natural biodiversity protection (1) (Figure 8).The agricultural production in this ecosystem has satisfying levels of many economic and social indicators: profit/production costs (0,43), labour productivity (0,27), land productivity (0,3), sales growth in last 3 years (0,33), investments growth in last 5 years (0,43), payment of hired labour/average income in the region (0,3), manager's age (0,41), participation in education programs in last 3 years (0,33), share of employed with special agricultural education/qualification (0,45) and number of participations in professional organizations and initiatives (0,33).This agro-ecosystem has satisfying ecological sustainability in relation to the implementation of organic production principles(0,33).

Moreover, according several social and ecological indicators the agriculture in Sashtinska Sredna Gora is with unsatisfying sustainability: public position of the farmer, manager or owner (0,17), participation in local initiatives (0,17), compliance to norms of the nitrate fertilization (0,17), compliance to norms of the potassium fertilization (0,12), compliance to norms of the phosphorus fertilization (0,12). This agro-ecosystem is socially and ecologically unsustainable in relation to the presence of a family member, ready to take the farm; share of hired workers, members of trade unions and presence of protected species on the farm territory.

The other mountain agro-ecosystem Western Rila mountain has high economic sustainability in relation to the share of direct payments in the net income (0,87), share of own capital in the total (1), land productivity (1) and livestock productivity (1) (Figure 8). The social sustainability is strong regarding the indicators: number of family members working in the farm (0,86), share of unoccupied permanent work positions in the total number of employed (1) and share of unoccupied seasonal work positions in the total number of employed (1).The agriculture in Western Rils mountain is ecologically sustainable for the respecting of practices for landscape maintenance (1), degree of pollution of underground waters with nitrates (0,83), level of consumption of electricity (0,87), protection of natural biodiversity (1) and variation of yields of main crops for 5 years (0,83).This agro-ecosystem has satisfying economic sustainability in relation to profit/production costs (0,43), share of sold output in the total output(0,41)and investments growth in last 5 years (0,37). The level of social sustainability is satisfying for the net farm income/average income in the region (0,4), presence of a family member, ready to take the farm (0,33), degree of participation of women in the farm management (0,33) and number of participation in professional organizations and initiatives (0,33). The agricultural sustainability is unsatisfying regarding the economic indicators labour productivity (0,22) and sales growth in the last 3 years (0,2); and social indicators degree of compliance to normative labour conditions (0,15) and share of employed with special agricultural education/ qualification (0,2). Furthermore, some social indicators in this agro-ecosystem have un sustainability levels: payment of hired labour/average income in the region, manager's age, participation in education programs in the last 3 years, share of hired workers, members in trade unions, public positions of the farmer, manager or owner, participation in local initiatives.

The agro-ecosystem Western Rila mountain has satisfying ecological sustainability for: soil erosion (0,46), share of arable land in the total agricultural land (0,42), presence of protected species on the farm territory (0,33) and respecting the norms for animal welfare (0,33). The ecological sustainability of the ecosystem is unsatisfying for: compliance to norms of nitrate fertilization (0,25), number of cultural species (0,23), compliance to norms of potassium fertilization (0,08) and compliance to norms of phosphorus fertilization (0,08). This ecosystem is ecologically unsustainable in relation to the principles of organic production.

Sustainability Contribution of Different Sub-Sectors of Agriculture and Type of Farms

Our analysis allows to assess the contribution of different sub-sectors and farms with different specialization to the total agricultural sustainability and its main aspects. The highest integral sustainability has shown by the mixed livestock-breeding (0, 7) and mixed crop-growing (0, 66) farms, followed by the perennial crops farms (0,63). (Figure9). Therefore, the mixed livestock-breeding and crop-growing

farms and the farms with perennials contribute in highest degree for improving the integral sustainability of Bulgarian agriculture. From 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) have the lowest integral sustainability. This means that the last mentioned types of farms decrease in a biggest degree the integral sustainability in the country.

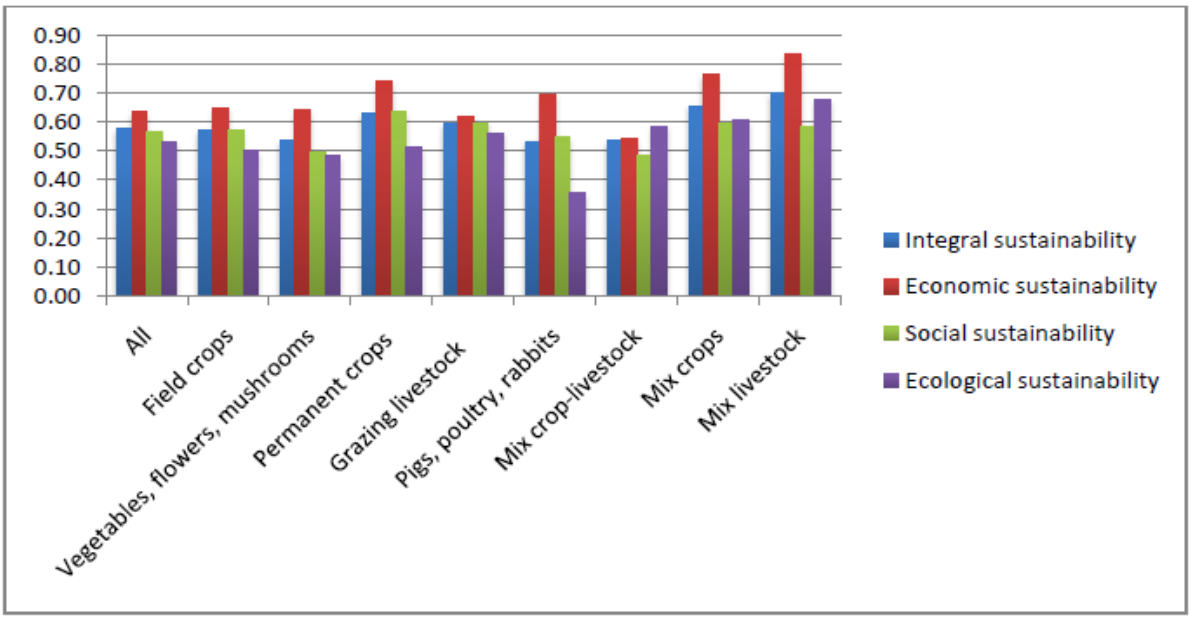


Figure9. *Sustainability contribution of different sub-sectors of agriculture in Bulgaria*

Source: *survey with managers of farms, 2017 and author's calculations*

Similar to integral sustainability, the sub-sectors with the highest economic sustainability are: mixed livestock breeding (0, 84), mixed crop growing (0,76) and perennial crops (0,74). The mixed crop-growing production has the highest ecological sustainability (0, 61) and one of the best social sustainability (0,6). The perennial crops sector has high social sustainability (0, 64), but lower than the average and almost satisfying ecological sustainability (0, 51). The social sustainability of farms specialized in grazing livestock has comparatively high level of social sustainability (0, 6). The social sustainability in mixed crop-livestock farms has satisfying level (0, 49). The pigs, poultry and rabbits' farms have lowest and satisfying level (0, 35), like the farms for vegetables, flowers and mushrooms (0,48). The field crops farms have good, but relatively low ecological sustainability (0,5), close to the satisfying level.

Furthermore, the different agricultural sub-sectors are characterized by important variation of levels of sustainability indicators and therefore type of contribution to overall and aspect level of sustainability of agri-ecosystems in the country.

Similarly, the agricultural sustainability in different farm types has different levels, which is determined by the specific contribution of different farms for the formation of the existing level of sustainability in the agri-ecosystems of country.

Among the farms with different juridical status the trade associations show the highest agricultural sustainability (0, 67), contribution the most for the agricultural sustainability of the country. In these organizational and management structures the economic (0,8) and ecological (0,63) aspects of agricultural sustainability have the highest levels, while the social sustainability is on average for the country level (Figure 10). The social sustainability is highest for sole traders (0, 63), whose integral (0,65) and economic (0,77) sustainability is on the second place and are close to the values of the trade associations.

The agricultural production in cooperatives has the lowest integral sustainability (0, 54), which economic sustainability (0, 51) is on the border with the satisfying level, and the social sustainability is the lowest, the same level as for individuals (0, 53). The cooperatives have ecological sustainability of the production on relatively high level (0, 59). The agricultural production of individuals has integral sustainability under the average level (0, 55) with lower than the average for the economic (0, 58) and social (0, 53) sustainability.

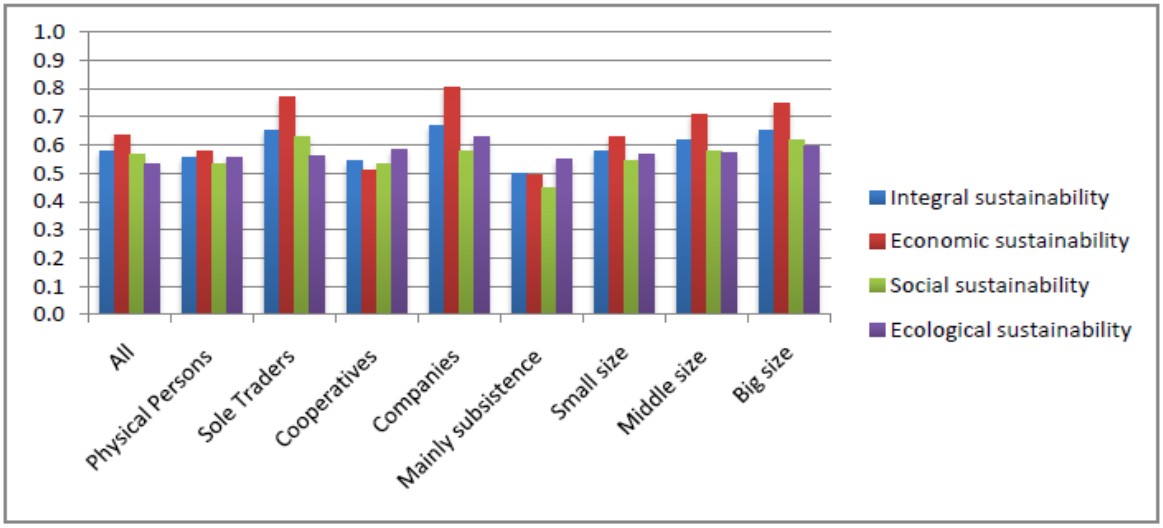


Figure10. *Sustainability contribution of farms of different types in Bulgaria*

Source: *survey with managers of farms, 2017 and author's calculations*

The agricultural sustainability in farms with different market orientation and sizes is also characterized by different levels and contribution to the integral agricultural sustainability in the country (Figure10). The highest 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 in biggest degree for the increase of the integral level of agricultural sustainability in the country. In predominantly self-subsistence farms the agricultural sustainability if low, close to the satisfying level (0,5). In these farms all the aspects of agricultural sustainability have low levels, in comparison to the large and market oriented farms, as the economic (0,49) and social (0,45) sustainability are satisfying. There is a trend to decrease of the levels of integral, economic and social sustainability with the decrease of the farm sizes. The ecological sustainability of farms with small and medium sizes has the same levels, which are lower than of the bigger farms, but higher than the levels of self-subsistence farms.

The individual indicators for sustainability of farms of different juridical kind, size and market orientation are very differentiated demonstrating different type of contribution of overall and aspect sustainability of respected agro-ecosystems.

Comparison of Assessment of Agrarian Sustainability with the Previous Studies in the Area

Finally, we compare the integral agrarian sustainability based on the assessment of sustainability of agro-ecosystems with the results of previous studies assessing agrarian sustainability with the aggregate sectoral (statistical, etc.) data in Bulgaria (Bachev et al., 2017).

According to the precious study based on aggregate data using the same methodological approach the integral sustainability index of the Bulgarian agriculture is 0.58 which correspond to a Good sustainability. That study has found out that the Economic sustainability of the Bulgarian agriculture is Good (index of sustainability 0.7), while the Social and the Environmental sustainability are also as Good but with a lower index (for both of them is 0.53) close to satisfactory level.

Therefore, integral assessment results based on the micro agro-ecosystems (farm) data are similar with the results based on aggregated sectoral (statistical, etc.) data. It means that both approaches are reliable and could be simultaneously used for assessing agrarian sustainability at various level – sector, subsector, region, agro-ecosystem, and farm.

Conclusion

This first in kind assessment on sustainability of agro-ecosystems in Bulgaria let make some important conclusions about the state of their sustainability, and recommendations for improvement of managerial and assessment practices. Elaborated and experimented holistic framework gives a possibility to improve general and aspects sustainability assessment. That novel approach has to be further discussed, experimented, improved and adapted to the specific conditions and evolution of agro-

ecosystems of different types as well as needs of decision-makers at various levels – farmers, interests groups, government officials, policy-makers, etc.

There is a considerable differentiation in the level of integral and aspects sustainability in agricultural ecosystems of analyzed main and specific types. With the highest integral sustainability are the agro-ecosystems plane regions and Sandanski- Petrichhollow while least sustainable are agro-ecosystems mountain regions with natural handicaps and Dupnitsa hollow. Furthermore, there are substantial variations in the levels of economic, social and ecological sustainability of agro-ecosystems of different type.What is more, individual indicators with the highest and lowest values show (critical) factors enhancing and deterring particular or overall sustainability of evaluated agro-ecosystem.

Results on the integral agrarian sustainability level of this study based on the micro agro-ecosystem (farm) data are similar to the previous assessment based on the aggregate sectoral (statistical, etc.) data.

Having in mind the importance of holistic assessments of this kind for improving agrarian sustainability, farm management and agrarian policies, they are to be expended and their precision and representation increased. The latter requires a closer cooperation between and participation of all interested parties as well as improvement of the precision through enlargement of surveyed farms, and incorporating more "objective" data from field tests and surveys, statistics, expertise of professionals in the area, etc.

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