Current state of agricultural ecosystems and plant resources, as a basis for the balance of food in Bulgaria

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Abstract
The publication is an overview of the complex of socio-economic, environmental and agro-climatic factors influencing the state of ecosystems and agricultural production in Bulgaria. The aim of the study is based on the available official analyzes and publications in order to summarize the trends in the cultivation of agricultural crops and to outline the main challenges to ensuring a sustainable plant resource base for food systems. Results of a study found that the environmental risks to the development of agricultural production systems in the country are associated with a very low level of protection against climate anomalies, the dominance of commercial crop rotations and the low relevance between public support and improvement of agri-environmental indicators. To preserve the balance of agroecosystems requires targeted selection of forms with high ecological plasticity, expansion and modernization of existing hydro-ameliorative infrastructure and land-differentiated approach to regulate growth factors through the accessible agro-technological methods.

Key words: climate change; agroecosystems; food systems

INTRODUCTION

The industrialized food system is dependent on natural resources that degrade as a result of economic activity. According to the eco-economic theories of the last century, the economic deficit is rooted in physical reality and the world economy is heading for an inevitable collapse. Social evolution in our time is changing the way humanity is meeting the challenges and leading to the understanding that the economy can create growth and prosperity by changing the resource base. Bioeconomy as a modern paradigm is based on the use of renewable biological resources in all sectors of the economic system with the ultimate goal of achieving a closed production cycle. Mathematical models show that species-rich agroecosystems are more productive. For this reason, the conservation of biodiversity is a key factor in the efficiency of the biodiversity-based economy. Wild species and local populations are used as sources of genes to increase the resistance to abiotic and biotic stress, the quantity and quality of yields of domesticate varieties. The long-term dynamics of relations between regional economic sectors in a global environment are impacted by climate change (Miernyk, 1999; Capon and Mollov, 2003).

In Bulgaria there are conditions for environmentally sustainable agriculture and producers of food and beverages unique for the country by authentic methods. The added value of the activities of small and medium-sized enterprises using local resources are socio-economic and environmental benefits for the regions. Possibilities for clustering in organic production are being studied (Georgieva, 2018; Zlateva, 2019). To implement the strategy for development of the bioeconomy in the country, certain tasks should be solved: preparation of a regional map with classification of organic producers, defining competitive advantages of organic products and their positioning through a platform for marketing, liaising with representatives of HoReCa business as users of organic products and development of basic criteria for quality of raw materials and analyzes ensuring product safety (Nikolova et al., 2014; Toskov et al., 2018). As a result of field work and analyzes at national level, the main risks in the areas of sustainability, adaptability and transformativity of crop production systems are classified: 1. Socio-demographic - a trend of depopulation of rural areas, leading to lack of skilled labor and management staff in the farm structure; weak demand for local production and home-grown food. 2. Economic - uneven distribution of power in the agri-food system; weak skills of producers for planning in the short and medium term /15-20 years /. 3. Environmental - high levels of investment, monoculture agriculture and unprofitability due to a very low level of protection against climate risks. 4. Institutional - ineffective communication between national and regional authorities; property problems as a result of a complicated process of land restitution. Based on the SWOT analysis, the following recommendations have been formulated by organic producers: Increasing the volume of production; Cooperation, association and co-operation between producers; Raising awareness among adolescents about the importance of organic products for health and the environment; Establishment of a regional center for management of organic producers; Creating an agricultural market for organic products; Preparation of new strategy for development of the sector at national level; Diversity of cultures (Peneva and Valchovska, 2018; Georgiev et al., 2020).

The purpose of this study is based on the available official analyzes and publications to review the complex of socio-economic, environmental and agroclimatic factors influencing the state of ecosystems and agricultural production in Bulgaria, to summarize the trends in crop production and to outline the main risks and challenges for providing a sustainable plant resource base for food systems.

CLIMATE CHANGE AND ECOSYSTEMS

The territory of Bulgaria is located in the transition zone of the temperate climate between three vast bioclimatic regions - the Central European continental, the Eurasian steppe and the Mediterranean, which overlap. The border between the district with annual snow cover of the temperate climate and the area with snow cover once in 5-10 years of the Mediterranean climate crosses the territory of the country. Apart from the change in the values of the climatic indicators in the north-south and east-west directions, there is a great variety in the climatic conditions due to the influence of the heavily rugged terrain of the mountains and the large water masses of the Black Sea and Aegean Sea. The analysis of multi-year meteorological data shows a significant negative trend for the average annual rainfall in the regions with transitional-continental climate (Figure 1) and a significant positive trend for the average maximum annual temperatures in all regions of the country - temperate-continental, transitional-continental, transitional-Mediterranean and North Black Sea climate (Figure 2). According to satellite data, the sea level in the Black Sea has been rising by about 3 mm/year since 1993. A trend of warming of surface sea waters by 0.05°C/year has been reported since the 1990s. Local and medium-scale disasters related to weather have doubled in the last twenty years, and their appearance has changed. There are more and more atypical disasters - unusual weather for the season, more storms, strong winds, heavier rainfall, alternating with heat waves and droughts, forest fires and landslides. The most climate models simulate that by the end of the XXI century, annual rainfall on the Balkan Peninsula will decrease by 5-10%. A study by NIMH[1] predicts an increase in the annual air temperature in Bulgaria by 1.6÷3.1°C by 2050 and 2.9÷4.1°C by 2080. The forecasts are for a gradual increase in the average annual temperatures by 3.3-4.3°C and reduction of the average annual precipitation by 8-18% by 2100. The forecast data for the warming of the Black Sea up to 2100 at the maximum amount of RCP8.5 emissions show an increase in surface water temperature of the order of 2.6°C/century. The available scenarios for climate change in Bulgaria predict a tendency

[1] NIMH - National Institute of Meteorology and Hydrology

to increase the frequency of extreme events such as drought, heavy snowfall, snowstorms, icing and hail (Alexandrov, 2005; BAS, 2011; Popova et al., 2013; Kubryakov et al., 2017; Miladinova, 2017; Banov, 2020; BRC, 2020; Kazandjiev & Georgieva, 2020).

Nine types of ecosystems have been identified on the territory of Bulgaria: Grass, Forest, Ericoid, Marine, Freshwater, Wet, Vegetation-free, Urbanized and Agroecosystems (Figure 3). The geographical location of the country on the border between the temperate and subtropical physical-geographical zone determines its natural conditions - climate, water regime and soil and vegetation cover. Another factor is the nature of the relief, due to the geological structure and various morphotectonic structures: the platform Lower Danube Lowland, parts of the young folded Alpo-Himalayan mountain system and the old land of the Macedonian-Thracian massif. The complex topography of mountain massifs, foothills, plains and lowlands determines the vertical distribution of living areas. There are five hypsometric belts: lowland (0 ÷ 200 m above sea level - 31.4%), hilly (200 ÷ 600 m above sea level - 41%), low mountains (600 ÷ 1000 m above sea level - 15, 3%), medium mountain (1000 ÷ 1600 m above sea level - 9.8%) and high mountain (above 1600 m above sea level - 2.5%). The diversity of microhabitats depends on the complex spatial structure of rock and soil substrates. Bulgaria belongs to two European soil-geographical areas: the Carpathian-Danube and the Mediterranean. Eight higher soil taxa have been identified under FAO taxonomy. The complex of highly varying abiotic factors - climatic, geological, topographic and hydrological, determines the rich diversity of plant communities, including Unique and Representative phytocenoses and ecosystems (karst areas, gorges, dunes, seasonal flood islands, etc.), and contains almost all major habitat types known in Europe. Phytogeographical and geobotanical zoning refers the country to three regions - Alpine, Continental and Black Sea. The Bulgarian biota includes over 3500 species of higher plants, including 498 Bulgarian and Balkan endemic species and subspecies of 43 families, constituting a total of 12.8% of the flora. The influences of Tertiary and Quaternary are manifested in the presence of relict cenoses of steppe species (*Amygdalus nana, Artemisia lerchiana, Stipa lessingiana, Paeonia tenuifolia*, etc.). There are two World Natural Heritage Sites on the territory of the country - Pirin National Park and Srebarna Reserve; 17 biosphere reserves under the MAB[2] program of UNESCO and four protected

[2] MAB - Man and Biosphere Program

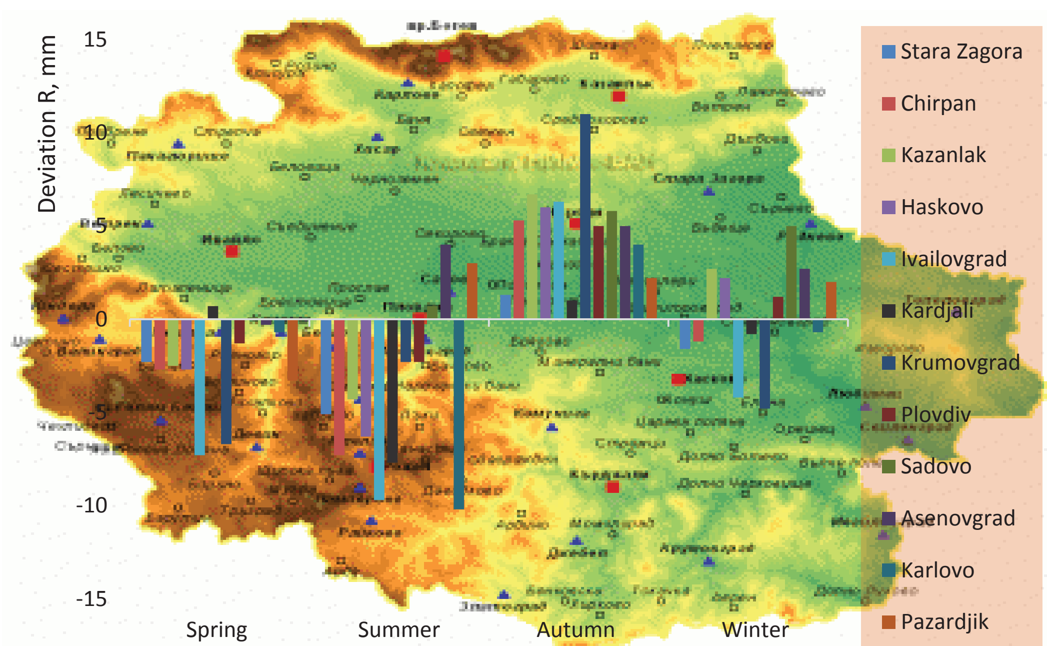

Figure 1. Deviations of the average long-term amounts of precipitation in the South-Central region of Bulgaria for a 30-year period compared to the climatic norm (Kazandjiev, V. & Georgieva, V., 2020)

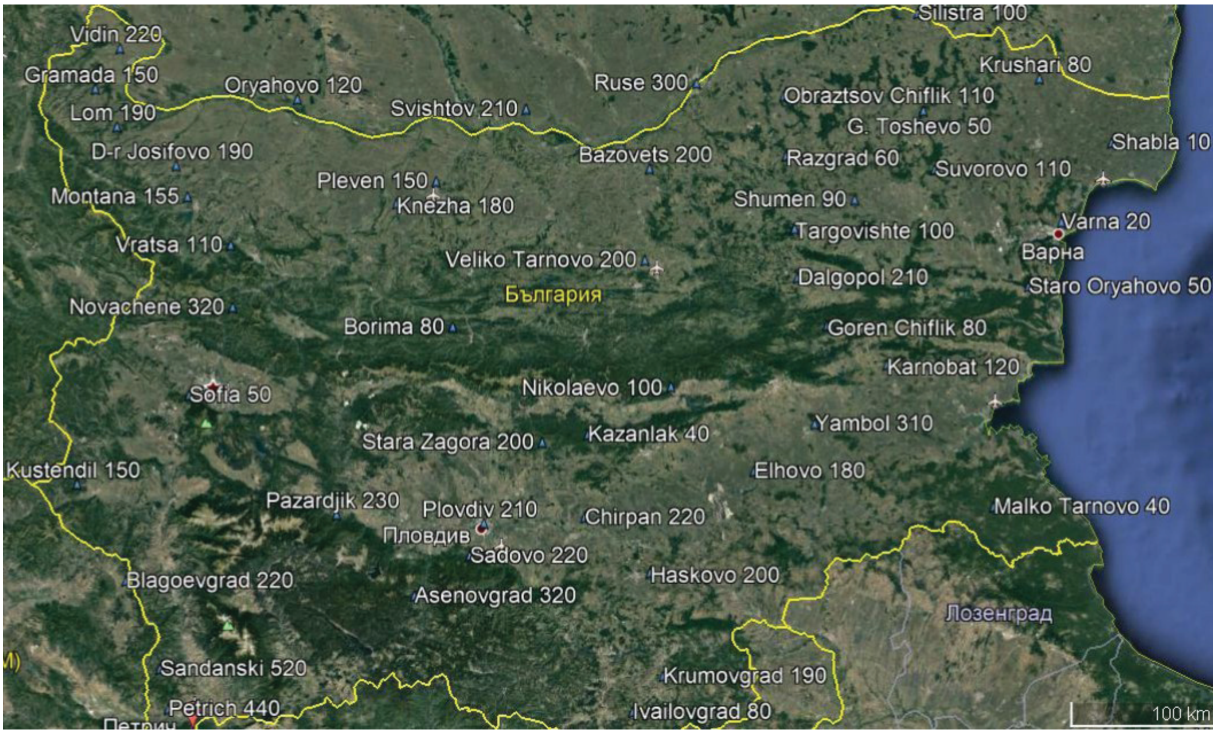

Figure 2. Deviations of the number of days with maximum temperatures above 25°C (Tmax ≥ 25°C, days) in Bulgaria for a 30-year period compared to the climatic norm for 1961-1990. (Kazandjiev, V. & Georgieva, V., 2020)

sites under the RAMSAR[3] convention. NATURA 2000 covers over 30% of the country's area (BAS, 2011; Meine & Hessmiller, 2013; Bachev, 2020; Bachev et al., 2020).

The physico-geographical conditions and the historical development of Bulgaria have been a prerequisite for the establishment of a wide variety of plant genetic resources that are used for commercial and non-commercial purposes. The autochthonous economic valuable species (*Triticum durum, Triticum aestivum, Secale cereale, Avena sativa, Hordéum vulgáre, Sorghum, Zea mays; Solanum lycopersicum, Capsicum annuum, Allium cepa, Brassica oleracea, Cucumis satitaus, Cucumis satitaus*; horticultural and field, cereals and fodder, annual and perennial legumes; *Vitis vinifera*, seed, stone and walnut fruit; *Nicotiana tabacum*, spices and 250 species of traditional medicinal plants) provide products for local consumption, domestic trade and export. Fruit trees and shrubs - *Rubus, Fragaria, Prunus, Pyrus, Malus* and *Juglans* - have a wide variety of wild and semi-wild relatives. Biodiversity faces many anthropogenic threats. In the Bulgarian landscape are found all forms and sources of point and non-point pollution - domestic, agricultural, petrochemical, industrial and radioactive. Habitat degradation affects all ecosystems. Direct overuse, such as the excessive collection and export of medicinal plants, affects many individual taxa. The unique gene pool has also decreased as a result of the periodic changes in the regime and the way of land use and land management (collectivization, restitution, consolidation). As a result of anthropogenic pressure, 31 species of higher plants have become extinct in the last 50 years. Due to the location of the country at the gathering place of three main bioclimatic regions, even insignificant changes in climatic conditions can have significant effects on meteorological characteristics, especially on the distribution and seasonality of precipitation, and thus on biodiversity (BAS, 2011; Meine & Hessmiller, 2013; EEA[4], 2017 a; Bachev, 2020; Bachev et al., 2020; EUROSTAT, 2020).

[3] RAMSAR – Convention on Wetlands of International Importance

[4] EEA - Executive Environment Agency

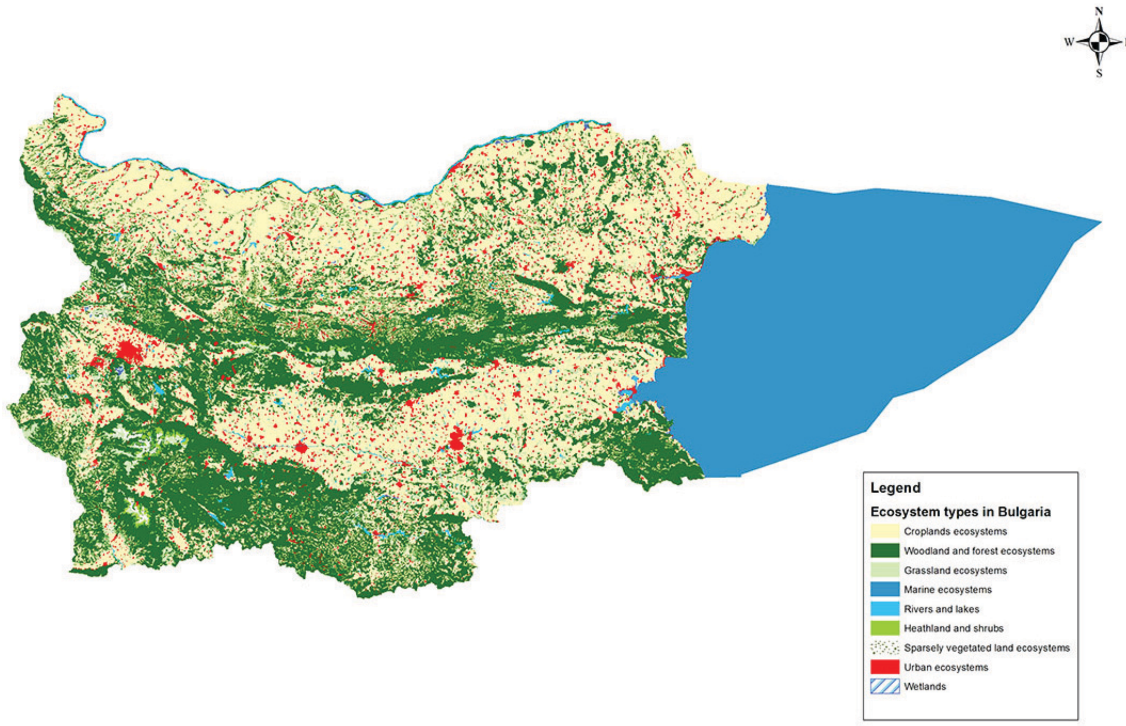

Figure 3. Types of ecosystems in Bulgaria. Source: EEA 2020 b

Agricultural ecosystems of different types and their specific services are one of the most widespread in Bulgaria. The hierarchy of agroecosystems includes an agricultural plot (barn, greenhouse, beehive, room for mushroom production), land (set of plots), micro-region (characterized by specific and joint services such as Melnik wine, Samokov potatoes, Kazanlak rose; recreation and tourism , conservation of endangered species) and macro-region (Thracian lowland, Struma river valley, Western Stara Planina, Central Stara Planina, Strandzha mountain, Danube river basin). There is a tendency, as everywhere in the world, for ecosystems to degrade as a result of human activity, which requires public intervention in the form of monitoring, regulation, support, assessment, etc. The impact of climate change on agro-ecosystems varies depending on the geographical area and the crop production system, and is expressed in changes in productivity in terms of quantity and quality of production, in the processes of carbon and nitrogen mineralization in the soil, leaching and erosion, in the enzymatic activity, structure and functionality of bacterial communities, reduction of crop diversity and changes in agricultural practices. The challenges for agriculture arising from changes in the environment are related to increased stress for plants from high temperatures and drought or moisture; increased frequency of extreme weather events, leading to crop damage and crop compromise; greenhouse gas emissions; increasing attacks by diseases, pests and weeds; reduced effectiveness of pesticides; biodiversity loss in pollinating insects and soil microorganisms; rapidly decreasing gene pool and strong dependence on a decreasing number of varieties; soil degradation, including salinization and acidification; water pollution with nitrates, pesticides and heavy metals; negative effects on human health and changes in market conditions. Among the forecasted changes, the possibility for growing new crops, the extension of the potential vegetation period and the increase of productivity due to the increased CO_2 content in the atmosphere are considered as positive (EEA, 2017 b; Prakash et al., 2017; Moreno-Espíndola et al., 2018; Bachev, 2020; Bachev et al., 2020; Banov, 2020).

The mapping and assessment of the state of Ecosystem Services in Bulgaria is based on the National Methodology for Assessment and Mapping of Ecosystems and Ecosystem Services Provided by

Them. The monitoring of agricultural ecosystems is carried out through terrain-field, landscape-ecological, cartographic and GIS-based methods. Sources of monitoring data are LPIS[5], IACS, BANCIK, NSI EEA - CORINE, EUROSTAT - LUCAS, GMES, National Spatial Development Concept 2013-2025, JRC - ESTIMAP, MetEcoSMap NINA, MI, MPD, SF Agriculture, real data in situ by private companies and NGOs. Research on the management of agro-ecosystem services is at an initial, mostly conceptual, stage. Theoretical-methodological and methodological issues on the application of a holistic approach to improve the management system have been developed. Regional interdisciplinary studies of the ecological potential of the landscape have been carried out mainly after 2007, and in recent years the relevance of the issues of ecosystems disservices has been growing. The developments are initiated by leading international programs or the result of projects related to the country's commitments to European agreements and cover the diverse services of certain large ecosystems, including their agricultural component. Alpine ecosystems are used as an indicator of climate change on a regional scale due to their vulnerability to changes in environmental factors. Determination of the current state of ecosystems is performed on the basis of multispectral satellite data through a combined methodological approach of terrestrial and remote sensing methods, and analysis of climatic components. Tracking the dynamic relationships between climate components and the spatial distribution of indices (NDVI[6], NDWI, NDGI) to determine the state of ecosystems allows for the development of policies and the implementation of good management practices that help adapt to the changing environment. The obtained results for the current state of ecosystems are suitable for detailed assessment of ecosystem services, which are closely related to the concept of sustainable development. The information is used for monitoring research, development of NGOs and for special micro-studies of specific ecosystems. The natural components are assessed as services according to economic and managerial criteria, taking into account the investments for conservation, restoration and maintenance of ecosystems. The existence of a standardized information base for material resources by regions allows its use as a database for monetary valuation of material services (Yaneva, 2016; Chipev et al., 2017; EEA, 2017 b; Nikolov & Drenovski, 2017; Katrandzhiev, 2018; Bachev et al., 2020).

The analysis of the *agri-environmental indicators* in Bulgarian agriculture and the assessment of the pressure of agricultural production on the environment using the DPSIR[7] model shows an unfavorable trend in terms of *GHG emissions* compared to the period since the beginning of Bulgaria's EU membership. Agriculture is a source of 10% of GHG in the country, which is the average for EU countries. The country has the largest reduction in ammonia emissions from agriculture (-74%) in the EU, and emissions of PM[8] precursors have decreased by 69% compared to the base period. *Water abstraction* for agriculture in Bulgaria accounts for 17% of total water consumption (compared to the EU average of 24%). There is a slight improvement in the pollution of groundwater with nitrates and phosphates. Control of the *risk of pesticide contamination* by plant analyzes showed positive samples most often in lettuce (60%), apples (55%) and wheat (45%). Bulgaria's share in *RES[9] energy production* in total EU production is 0.15%. The change in biodiversity indicators shows a slight deterioration. *Ex situ genetic diversity* is maintained in 19 research institutes at the Agricultural Academy, as the national gene bank is located in IPGR "K. Malkov" - Sadovo. A total of over 160,000 plant forms are maintained in various collections - over 100,000 field crops, over 5,000 vegetable crops, over 40,000 perennials and over 130 essential oil crops. *Agricultural lands with HNV[10]* (mainly meadows and pastures) represent 35% of the land and include 198 species of plants of supranational conservation importance. The soil indicators show preservation of the levels of nitrogen

[5] LPIS - Information system for lands and plots; IACS - Integrated system for administration and control; BANCIK - Bulgarian survey for monitoring the agricultural and economic situation; NSI - National Statistical Institute; CORINE - ground cover project; LUCAS - Land Use/Cover Area frame statistical Survey; GMES - Global Monitoring for Environment and Security; JRC - ESTIMAP - Model of pollination services; NINA - Norwegian Institute for Nature Research; MetEcoSMap - project Methodological support for assessment of ecosystem services and biophysical assessment; SF - state fund

[6] NDVI - Normalized Difference Vegetation Index; NDWI - Normalized Difference Water Index; NDGI - Normalized Difference Greenness Index

[7] DPSIR – Drivers – Pressures – State – Impact – Response – framework

[8] PM - fine dust particles

[9] RES - renewable energy sources

[10] HNV - high natural value

and phosphorus content, pollution with heavy metals, vulnerability to water and wind erosion. *Gross nitrogen balance* increased by 47% and *gross phosphorus balance* decreased twice. According to both indicators, Bulgaria is in one of the last places in the EU. In some districts (Ruse, Dobrich, Pleven, Veliko Tarnovo) the humus content has decreased from 4-5% to 1.7 - 2.3%. As a result of deteriorating physical and mechanical properties, compaction and reduced microbiological activity, during the next 20-25 years, some areas will not be able to grow trench crops. The production of more food in Bulgaria is accompanied by a reduction in the total area of agricultural land from which quality production can be obtained: an average of 5.2 da/capita. About 20% of the agricultural lands have a slope of more than 2˚ and most of the arable lands are not surrounded by windbreaks, which is why they are susceptible to *water and wind erosion*. Affected by water erosion are 65% of the managed lands (mainly in the Fore-Balkan, Western Stara Planina and the southernmost parts of the country), and 24% - by wind erosion. Some technological processes are carried out outside the optimal time due to climate change. There is an application of inappropriately justified KTL[11] and TCM[12], which are not resource-saving and environmentally friendly. There is a reduction of irrigated areas by about 100 times and transition to commercial crop rotations. RELV[13] between public support and the values of trends by indicators is very low - 0.06-0.09. The implemented activities do not contribute enough to the improvement of the agri-environmental indicators. It is necessary to encourage the use of non-chemical alternatives to pesticides, more efficient use of the potential of Bulgarian agriculture for bioenergy production and rehabilitation of the hydro-ameliorative infrastructure, which is currently in unsatisfactory condition (Nikolov & Drenovski, 2017; EEA 2018; Kirechev, 2018; Mitev & Beloev, 2018; Bachev et al., 2020; EEA, 2020 a; EUROSTAT, 2020) .

The challenges for the introduction of the ES concept concern the methodological, institutional, legislative and administrative-territorial aspects of the process. Ecosystem services have an anthropocentric focus and this predetermines the limitations in the interpretation of the usefulness of natural functions. The biophysical assessment, providing information on the potential for providing this type of services, proves a strong dependence on specific data and expert analysis at all stages of the procedure. The economic assessment adapts the established approaches to valuation and relies on the factors of supply and consumption and the experts can use the results of the biophysical assessments only within specific administrative-territorial boundaries. A limitation in the economic evaluation of the ES is the lack of data regarding social aspects such as the number of tourists, period of residence, etc. In the conditions of high natural heterogeneity of the Bulgarian landscapes, the question of the ways of integration in the assessments of the effects of synergy and dissersion in the consumption of ES is important. Bulgaria is working on the introduction of a market mechanism for PES[14] at the national level. So far, PES is carried out by individual companies in some regions of the country on a voluntary basis and on the company's own initiative. Through MOEW[15] and BAS, projects are implemented to assess the quality of services and develop methodologies for their evaluation. From 2021, the mechanism is expected to work at the national level. Pilot areas with grass, forest and freshwater ecosystems, providing 17 types of ecosystem services, are Bulgarka and Vratsa Balkan Nature Parks, Central Balkan National Park and Western Stara Planina. A special project implemented by WWF in Bulgaria and Romania includes the pilot areas Rusenski Lom and Persina Nature Park (Jibreel et al., 2014; WWF, 2014; Borisova et al., 2015; Kazakova-Mateva & Peneva, 2015; Koulov et al., 2017; Koulov & Borisova, 2018; Georgiev et al., 2020).

PLANT RESOURCES FOR FOOD SYSTEMS

There have been no significant changes in the functional use of land in the agricultural sector and the structural employment of the territory in the last 20 years. The pan-European institutional framework and the open market have expanded crop production with a fused surface and led to the domi-

[11] KTL - complex technological lines

[12] TCM - technological complexes of machines

[13] RELV - coefficient of relevance

[14] PES - payment for ecosystem services

[15] MOEW - Ministry of Environment and Water

nance of extensive over intensive production and a bipolar model in agricultural holdings. Cereals occupy about 56% of agricultural land, followed by industrial crops by 34%. Cereals are concentrated in Northeastern Bulgaria, technical crops - in the Northwestern part of the country, vegetable crops - in the South Central region, and perennials - in the Southeastern part and North Central region. The irrigated areas make up 2% of the arable land and include rice fields, corn, potatoes, vegetables, strawberries and 20% of the plantations with cherries, plums, apples, peaches and walnuts. There is a change in the structure of agricultural production. The biggest changes are the introduction of rapeseed in mass production and the permanent reduction of tobacco production. For the main crops, an increase in production of about 40% was reported for wheat, 170% for maize and almost 200% for sunflower. An upward trend was reported in triticale and perennials (apples, pears, cherries, walnuts, raspberries and wine grapes) at the expense of a decline in barley, oats, beans, potatoes, tomatoes, peppers, cabbage, watermelons, melons and strawberries. Yields from most field crops and main vegetable crops in open areas are increasing as a result of the use of certified seeds by farmers and the observance of cultivation technologies with an emphasis on the application of environmentally friendly techniques. The trend for modernization of the cultivation facilities, in which about 1/7 of the vegetable production is obtained, continues. Varieties grown in greenhouses are diversified - in addition to the main tomatoes and cucumbers, potatoes, onions, garlic, zucchini, eggplant, melons and strawberries are also produced (MAFF, 2016; MAFF, 2019 c; MAFF, 2020 j).

The trend of continuing changes in the global climate in our country and the dynamics of local meteorological phenomena raise the question of growing appropriate, well-adapted to different regions crops and optimal combination of different varieties on farms. The results of extreme years with the addition of a large number of stressors show that the regional selection purposefully develops varieties that combine high productive potential, adaptability to environmental conditions, cold hardiness and drought tolerance. The yields of wheat varieties selected in DAI[16] and IPGR (with both high levels of cold resistance and drought tolerance such as Katarzyna, Lazarka, Fani, Nikibo, Ginra, Nadita) are up to 250% higher than the average for the respective regions. A series of barley varieties, selected at the Institute of Agriculture - Karnobat, with combined resistance to abiotic stress (Orfey, Odisey, Kuber, Saira, Daria), which give up to 39% higher yields than foreign ones, have been introduced into production. The trend of increasing the number of varieties of field and vegetable crops entered in the national variety list, protected by a certificate of legal protection, continues. Both Bulgarian and foreign varieties are included in the varietal composition of the production. Durum wheat, spelt, triticale, rye, oats, beans, peas, peanuts, sugar beets, tomatoes, cucumbers, melons, pumpkins, radishes, leeks, broccoli, raspberries, vines, roses, lavender and tobacco are mainly or entirely with Bulgarian origin. The cultivation of rice, maize, rapeseed, sunflower, lettuce, eggplant, garlic, cauliflower, chicory, fennel, strawberries, chokeberry and walnuts is mainly based on introduced varieties. In other crops, both Bulgarian and introduced varieties are equally represented. In vegetables there are Bulgarian varieties developed for growing under particular conditions - onion (Asenovgradska 5, Ispanska 482), white cabbage (Kyosse 17), red cabbage (Pazardzhishko cherveno), pepper (Bulgarski ratund, Byala shipka, Chorbadgiiski, Djulynska shipka, Kurtovska kapiya , Sivriya), watermelon (Mramorna 17), melon (Medena rosa, Vidinski koravci), tomato (Edar rozov, Ideal), egg plant (Bulgarian 12), pumpkin (Plovdivska 48/4) (EAVTASC, 2020 a; EAVTASC, 2020 b; MAFF, 2020 i).

The sale of the produced vegetable products (including mushrooms and potatoes) for fresh packaging for the trade network is 80%, direct sales are 10% and the rest is distributed for household consumption and processing - freezing, drying, canning, concentrates/purees and juices. In the processing enterprises 86% of the delivered products are from the Bulgarian producers, 3% are from the enterprises' own production, 7% - imports from the EU, 3% - imports from third countries and 1% - for hire. Of the processed vegetables with the largest share are tomatoes - 38%, peppers - 22%, potatoes - 11% and eggplant - 7%. About 50% of the finished production of processed vegetables is sold on the local market, exports to the EU are 15%, and to third countries - 7%. About 48% of the total fruit yield is intended for the trade network, 34% for the

[16] DAI - Dobrudzha Agricultural Institute

processing industry (jams, compotes, frozen fruits and juices), and 1.6% for household consumption. In the processing enterprises 45% of the fruits are delivered from Bulgarian producers, 5% - from the enterprises' own production, 17% - from the EU, 31% - from third countries and 2% - for hire. The largest share of processed fruits are apples - 39%, cherries - 26%, peaches - 13% and plums - 8%. Between 50 and 80% of the finished processed products are sold as exports to the EU. Of the total grape yield, 8% is for direct consumption, and the rest - for vinification and processing into other products. Of the industrial wine production, regional wines with a protected geographical indication account for 39%. Throughout the food chain from the farm-to-table principle, food safety is monitored by MAFF through the Agricultural Chain Policies Directorate under the methodological guidance of BFSA[17] and the independent scientific evaluation by CRAFC[18] (MAFF, 2019 b; MAFF, 2020 a-f).

Bulgaria is a traditional producer of quality agricultural products. Organic production is still weak in the country, but the market for organic products is developing rapidly. The prerequisites for the development of this type of production and the factors motivating farmers in this direction are the natural resources, ecologically preserved areas, the perceived benefits for rural development, the growing demand for healthy food from consumers and the existence of a legal framework that makes Bulgarian organic products legitimate on the common market of the EU. The number of operators in a control system in organic production (producers, processors and traders) is about 7% of the total number of registered farmers. The areas on which organic production methods are applied (areas in transition and organic areas) make up about 1% of the areas with cereals (mainly wheat, maize, barley and oats); 3% of the areas with industrial crops (including aromatic crops, medicinal plants and spices; mainly lavender, fennel, coriander and oil-bearing rose); 50% of perennials and 13% of the area with vegetables, melons, strawberries and cultivated mushrooms. The main production of organic products is from perennial crops - apples, raspberries, plums, hazelnuts, rose oil and strawberries, and the most common organic wild products are mushrooms, herbs and nuts. The most competitive results are shown by traditional organic beekeeping. Over 90% of currently produced certified organic produce of fruits, vegetables, honey, herbs and nuts is exported to Western Europe, the United States and Canada. Bulgarian organic jams, lutenitsas and dried fruits have excellent taste and are highly valued on the European and world market. Direct sales exceed 50% of the sales of agricultural products in about 20% of organic farms and at the same time in about 60% of organic farms household consumption exceeds 50% of production. About 1.8% of farms close the production cycle or diversify their activities with rural tourism (hotel and restaurant services), craftsmanship (pottery, weaving, cutlery), processing of farm products and production of renewable energy for the market (from wind, hydropower and biogas) (MAFF, 2016; MAFF, 2017; NAAS, 2017; MAFF, 2019 a).

Climate change is a major external driver of conventional and organic food systems. The effect of the impact of abnormal agrometeorological factors during the most important phases of plant development is sometimes expressed in serious deviations from the national average and the average long-term yields (in the current harvest 2020, for example, wheat yields vary by ± 68% , and from barley - by ± 48% compared to the average 5-year yields). Increasingly, the main limiting factor for autumn crops is the lack of moisture during the autumn-winter period due to the unusually low soil moisture and lack of snowfall in combination with high average daily and absolute maximum temperatures. The deficit of precipitation in January reaches 81%, and the average temperatures exceed 15˚C, as a result of which morphological changes and unusual for this period damages such as yellowing of the leaf mass are observed in the winter crops. This requires replanting part of the areas with autumn crops (especially rapeseed) with maize and sunflower. At the same time, the precipitation in the spring acquires a spontaneous character and in some places exceeds the normal amounts by over 200%, which is combined with return frosts, hail, strong wind and frost formation. This slows down the sowing and development of spring crops. Critically low temperatures cause frostbite of fruit buttons, flowers and knots in a number of fruit species (apricot, peach, cherry, sour cherry, plum, apple) and vines. Intense or combined with hail rains damages crops and hydro-ameliorative infrastructure, which is already in un-

[17] BFSA - Bulgarian Food Safety Agency

[18] CRAFC - Center for Risk Assessment in the Food Chain

satisfactory condition. The subsequent early onset of heat and high indices of soil drought shorten the interphase periods of plant vegetation and hinder the passing of flowering and fertilization (MAFF, 2016; GAIN[19], 2020; Georgiev et al., 2020).

The increase in the number of hot days (by 5-17 in different regions) with temperatures up to 39˚C and the drastic reduction of precipitation in summer (≤15mm for July and August) made it difficult to prepare the areas for autumn sowing and closed the year-round cycle of adverse effects for 2020. The expectations are that agriculture in Bulgaria will be affected by the current changes in the next 20-30 years. According to the vulnerability analyzes and the risk assessment in the simulation agroclimatic models (CERES, ROIMPEL CROPGRO, WOFOST; ECHAM5 / MPI-OM) with different emission scenarios (HadCM2, ECHAM4 and GFDL - R15; SRES - A2 and SRES - potential potential) vegetation period - Growing Degree Days, calculated at temperatures above 5˚C will increase in the middle of the century by 30-40, and at the end of the century by more than 40 days. Scenarios with projected future changes provide for a reduction in Average Number Of Frost Days by about 5-10 days by 2030 and by 10-15 days by 2050, by 2065 they will decrease to 55 days, and at the end of the century - to 40 days . The results show a reduction in the vegetative and reproductive period in wheat and maize in the XXI century. Wheat vegetation is expected to end one to two weeks earlier in 2050 and two to three weeks earlier in 2080, and in maize 11-30 days in 2050 and 17-39 days in 2080. The change in the natural cycles of plants is also expressed in changes in the dates of phenological phases, such as earlier flowering and ripening of fruit trees, shortening the period of grain filling in oilseeds and extending the growing season on the vines (Alexandrov, 1999; Alexandrov, 2011; MoEW, 2013).

The scenarios for the development of agricultural production for the period 2040-2050 show a decrease in the growth rate of winter crop yields (by no more than 12-25%), a decrease in the sunflower harvest by 10-20% in the eastern regions of the country and lowering the harvest in the main cereal areas with low altitude. From the change of temperature and water resources in the coming years in our country the most vulnerable will be the spring agricultural crops grown on non-irrigated areas. By 2070-2080, growing maize under non-irrigated conditions will be inefficient. Warmer winters can prevent the vernalization of winter crops and reduce the yields of stone fruit species, which need a certain amount of cold units for their normal development. There is a danger of increasing populations of weeds, diseases and pests and of increasing the number of generations of plant pests. Major crops grown under high CO_2 conditions are likely to have reduced protein, iron and zinc content. The quality of the vegetable production will be affected - texture, color, ripeness and nutritional value. Contamination of wheat, maize, rice and peanuts with microtoxinogenic fungi will be facilitated (World Bank, 2012; Smith & Myers, 2018; Miltenova, 2019).

Increasing the heat potential is a prerequisite for expanding the suitable conditions for agricultural crops to the north and at higher altitudes. The chronological review of the changes in the agroclimatic conditions shows that from the end of the XX century the territories of the Rila valley extension, the Gotse Delchev valley and the valley of the river Struma pass from the warm to the very warm zone of the subzone of moderately high heat tolerance crops; The Skopje field passes from the subzone of moderately high heat tolerance crops to the subzone of thermophilic crops; The upper reaches of the Mesta River pass from the moderately cool to the moderately warm zone of the subzone of low heat tolerance crops; The Gevgelija valley and the Sandansko-Petrich field fall entirely in the very hot zone of the subzone of thermophilic crops, with temperature sums above 4100°C. Changes in agrometeorological resources can allow the cultivation of new high heat tolerance species, varieties and second crops in case of irrigation. As a measure for the adaptation of spring crops, changes in the calendar of agricultural activities, such as earlier sowing, can be applied. The cultivation of early spring crops can be moved from cultivation facilities to open areas. The cultivation of some crops can go from summer to winter. In recent years, regular observations of the occurrence of phenophases in winter cereals, trench, technical, essential oil, fruit crops, vineyards and wild phenological indicators have been conducted to establish stable transitions of air temperature at 0°C, 5°C, 10°C and 15°C, in order to forecast the terms for carrying out the main agrotechnical activities. Bioresources must be cultivat-

[19] GAIN - Global Alliance for Improved Nutrition

ed and reproduced or their *in situ* self-reproduction must be ensured. In the long run, it is important to create genetic maps and preserve species in *ex situ* conditions. Agriculture needs to use water resources more efficiently and introduce new, more drought-resistant varieties (Capon & Mollov, 2003; Moldovanski, 2003; Shopova, 2008; Popov, 2018).

CONCLUSIONS

As a result of the review analysis it can be summarized that the environmental risks to the development of agricultural production systems in Bulgaria are associated with a very low level of protection against climatic anomalies, the dominant commercial crop rotations and monoculture with fused surface and with the low relevance between public support and the improvement of agri-environmental indicators. Over the last 20 years, there has been a tendency to increase the frequency of atypical and extreme meteorological phenomena, which according to the available modeled scenarios will continue to have a strong impact on agricultural development in the next 2-3 decades. The rich natural diversity of plant genetic resources as sources of genes to increase the resistance to abiotic and biotic stress in cultivated varieties in the last few decades has been exposed to anthropogenic pressure in the form of overuse, urban sprawl, pollution (from all types of point and non-point sources) and successive changes in the land management regime (collectivization, restitution and consolidation).

The challenges for maintaining the balance of agroecosystems proceed from changes in the environment, affecting the carbon and nitrogen cycle, the structure of the soil microbiome, the activity of pollinating insects, increased stress for plants from direct exposure to inappropriate external growth factors and excessive multiplication of native and invasive pest species. The dynamics of local meteorological phenomena raise the question of growing suitable varieties with high ecological plasticity. The results of extreme years with the addition of a large number of stressors show that the regional selection of cereals and vegetables has developed varieties with good adaptability to environmental conditions. It is desirable to use the potential of the varieties of rice, corn and sunflower created in our country, which are competitive with foreign ones, but for commercial reasons are not widespread in production. Targeted selection work is needed in this direction in crops such as rapeseed, garlic, lettuce and other leafy vegetables, as well as in some fruit species such as strawberries, chokeberries and walnuts.

Taking into account the simulated agroclimatic models, it is imperative that by the middle of the century the hydro-ameliorative infrastructure covers a significant part of the arable land, including winter cereals, where the vegetation period is shortened with an impact on yields. A differentiated approach is needed in the implementation of agricultural practices and the technological processes for each specific land in order to optimize the plant regime through affordable methods - use of antitranspirants, seed hydrophobization, soil drainage and mulching, construction of protective and buffer zones, evaporative cooling of fruit trees by supracrown micro-sprinkling or mist irrigation to avoid freezing of fruit buds from the frequent recurrent spring frosts, etc. Due to lower yields in areas with lower altitudes, the zoning of the respective crops may be changed to the north or at higher altitudes. The cultivation of early spring crops can be moved from cultivation facilities to open areas. If the photoperiodic reaction of the varieties allows, a shift in the calendar of agricultural activities, including a change in the growing seasons, is applicable.

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