SECTORAL INNOVATION SYSTEM OF AGRIBUSINESS IN BULGARIA – MAIN CHALLENGES AND PERSPECTIVES*

Sonia Mileva†, Teodora Georgieva‡

1, 2) Sofia university “St. Kliment Ohridski”, Sofia, Bulgaria

e-mails: †smileva@feb.uni-sofia.bg, ‡tmgeorgieva@feb.uni-sofia.bg

Received: 30 July 2022; Accepted: 07 September 2022 Online Published: 30 September 2022

ABSTRACT

This paper discusses the importance of public policy and current issues in the context of Agricultural Knowledge and Information System (AKIS) in Bulgaria. The goal is to outline the major challenges and perspectives as basis for analysis of the innovation potential within the sectoral innovation system of the agricultural sector in Bulgaria. Analysed is data about the major stakeholders, international and national programs supporting innovations in the sector, creation of new knowledge and technological solutions, scientific and research activity, state of transfer of technology in the context of agricultural ecosystem. A systematic approach with qualitative monitoring and quantitative assessment are applied for evaluation and definition of the types of effects in the innovation ecosystem. The results confirm, that despite the efforts and funds supporting AKIS, the public policy is not efficient, the stakeholder’s activity is limited, and the innovation and transfer of technology are not enough powerful to drive the economic growth and competitiveness in agriculture. The development of innovation potential should be based on the implementation of policies/addressing of measures that are relevant to the potential of the units of the innovation ecosystem and the priorities for their development.

Keywords: sectoral innovation system, science-business collaboration, innovation, potential, agriculture, Bulgaria

JEL classification: Q16, O30, O32

Paper type: Research article


INTRODUCTION

The developed research and innovation infrastructure, subject to regional characteristics is one of the key elements of the entrepreneurial and innovation ecosystem and a factor in turning the results of scientific activity into practical solutions to market needs. Research on entrepreneurial activity in the agricultural sector confirms the role of interaction and innovation networks (in the specific case in the form of value-added technological chains) for the success of newly created enterprises.

The EU policies in the field of the agricultural sector, the green transition and the digital transformation are the general framework for the development, the stimulation of the innovation potential and the increase of competitiveness in the agribusiness sector. Innovation and the transfer of technological knowledge are

* Part of research project “Innovation Potential of Sectoral Innovation Systems”, financed by the ”Scientific Research” Fund at Sofia University ”St. Kliment Ohridski”, 2022.
* Corresponding author, Sonia Mileva – smileva@feb.uni-sofia.bg
increasingly seen as drivers for the development of what are defined as low-tech or traditional sectors of the economy, including the agriculture. The existence of structural weaknesses - deficiencies of the institutional and infrastructural environment, along with the lack of capacity of the interested parties, can negatively affect the innovation processes. Addressing these challenges requires a systematic analysis of the sectoral innovation system and an assessment of the impact of the main factors and obstacles to innovation in agribusiness as a whole and as part of innovation ecosystems.

Innovation ecosystems include heterogeneous organizations that jointly grow in the creation of added value (Moore, Predators and prey: a new ecology of competition, 1993), (Moore, 1996) (Adner R., Kapoor R., 2010), (Thomas L., Autio E., 2014). Participants in the ecosystem can be with different status - objects, projects, clusters, organizations, with different ways and forms of financing, with different management models, network connectivity and built partnerships between them. Some of them can be purposefully created as a result of strategic policies, programs and interventions. The ecosystem is a dynamic structure, but at the same time all EU policies are supporting the active participants in the ecosystem.

The purpose of this article is to investigate the innovation potential of the sectoral innovation system of agribusiness as a basis for identification of major factors, responsible for innovation activity and the sources of competitive advantages at organizational, sectoral and national (regional) level. The focus will be placed on the role of different stakeholder groups and the interaction between them.

Innovation is one of the most recognizable factors of economic growth and competitiveness (Porter, 1990), (Fagerberg J., Srholec M., Verspagen, B., 2010). A number of studies from the end of the last century prove the need to apply the systematic approach in the analysis of the sources and factors of innovation activity substituting the prevalent linear model (Freeman, 1997), (Lundvall, 1992), (Nelson R. (Ed.), 1993), (OECD, 1996), (OECD, 1997). Further development of the theory of innovation systems leads to the identification of a number of features at the sectoral level that predetermine technological dynamics and are the basis for distinguishing high-tech from low-tech industries, sectors and activities (Pavitt, 1984), (Hatzichronoglou, 1997), (Carroll P., Pol E., Robertson P., 2000), (OECD, 1997), (OECD Reviews of Regional Innovation, 2011), (OECD Reviews of Regional Innovation, 2011).

Although the degree of penetration of innovations depends on such factors as farm size, benefits, productivity and business model, they will necessarily have to face the issues of climate change, new consumption patterns an at the same time meeting the needs (for food and resources) of the growing population (FAO, 2022). Innovations must be able to guarantee sustainable agriculture and the development of the agro-sector. On the other hand, innovation in the sector is moderate due to lack of investment and sufficient focus on sustainability (Berthet Elsa, Segrestin Blanche, Hickey Gordon , 2016). Additional constraint is the heritage of innovations in agriculture mainly focused on reducing labour and increasing production efficiency (Kirova, M., Montanari, F. et al., 2019).

The innovation system in the agricultural sector is highly dependent on a wide range of policies and in particular those, related to the creation and diffusion of innovations. The main challenges, on the one hand,
are the growing needs for growth in the efficiency and productivity of agricultural products with limited cultivated land, and on the other hand, responding to the priorities for sustainability, land protection, conservation of water resources and biodiversity. The OECD report (OECD, 2013) states that all reforms in the sector are primarily related to the improved integration of Agricultural Innovation Systems (AIS) into innovation systems, ongoing structural changes, governance structures, priority settings and funding mechanisms, the functioning of intellectual property markets and networking opportunities for partnership and cross-country cooperation. The public sector plays major role in the provision of knowledge infrastructure (databases, exchange platforms, centers of technology convergence) and financing scientific research in the agricultural sector. Key and decisive for sustainability is the integration, activity and participation of the various participants in the ecosystem, including of the private sector and public-private partnerships.

![Diagram of Agricultural Innovation System]

Figure 1. Agricultural innovation system

Source: adapted from (Aerni, P.; Nichterlein, K.; Rudgard, S.; Sonnino, A., 2015)

The key players in the innovation system in the agricultural sector (Tropical Agriculture Platform, 2016) are representatives of research and education, in the case of Bulgaria – mainly from the public sector; the bridging institutions – stakeholder platforms, agricultural extension organizations (public, private, civil), contractual agreements, contributing to the transfer, diffusion and application of innovations by business and
enterprises. The enabling environment is formed by innovation policies, investments and agricultural policies with the informal involvement of other stakeholders and their activity. The external environment at the macro level is constituted by science and technology policy, political system, science actors and technology from other sectors of the economy.

The development of research capacity within AIS is determined by the interaction and participation of individuals, organizations and an enabling institutional environment. This requires a focus on the level of support, synchronization of national and regional policies and interventions, both for existent and emerging initiatives e.g. individual initiatives (niche innovations), stimulating entrepreneurial discovery process (EDP), talent and creativity (Tropical Agriculture Platform, 2016). The understanding of the innovation system of the agricultural sector is a continuation of the concepts of Agricultural Knowledge System (AKS), Agricultural Knowledge and Information System (AKIS), Agricultural Innovation Systems (AIS), Learning innovation system for sustainable agriculture (Learning and Innovation Networks for Sustainable Agriculture, LINSA).

The present research is subordinated to the peculiarities of the sectoral innovation system of agribusiness. In fact, a number of scientific concepts in the field of innovation theory are launched for the first time and validated on the basis of data and analysis of the development of the agricultural sector. Such examples are the long economic cycles in the economy based on the accumulation and exploitation of new technological knowledge (Kondratieff, 1935) and the theory of innovation diffusion (Rogers E., 1995). Nowadays, in the conditions of exceptional growth opportunities arising from the dynamic development of new technologies and digital transformation processes on the one hand, and a number of global challenges on the other hand= The agribusiness is the intersection of significant changes in both political and regulatory mechanisms, changing business models and sources of entrepreneurial and innovation activity.

The linear model of the implementation of innovations by agricultural producers, as the final users of innovations, is responsible for the rapid industrialization and productivity in the agricultural sector, but it is strongly criticized for its negative environmental and social effects (Vanloqueren G., Baret P.V., 2017), (Knickel, K., Brunori, G., Rand, S., Proost, J., 2009). Among the main criticisms is the fact that the linear model excludes interaction and partnership between participants in the ecosystem and the possibility of generating innovations from other participants - part of the circular and bioeconomy (Berthet Elsa, Segrestin Blanche, Hickey Gordon , 2016), (Berthet Elsa, Hickey Gordon, Klerkx Laurens, 2018).


The model of open innovations defends the thesis that knowledge flows occur both from inside and outside enterprises, moving inside and outside them within various forms of interaction and partner networks,
including alliances, consortia, ecosystems, platforms, societies, etc. (Chesbrough H. W., 2003), (Vanherbeke, 2006), (Adner R., Kapoor R., 2010).

The EU policies for smart, sustainable and "green" growth require research on sustainability, environmental protection, biodiversity and, on the other hand, input resources, the quality and safe production with high added value. The application of innovations, the period of operation and the size of the farm are among the leading factors of competitiveness in the agricultural sector (Panteleeva I., Varamezov L., Kostadinova N., 2018). Other authors identify as the most limiting factors for innovations in agriculture the cost of investment for innovation and the lack of information about possible innovations (Harizanova-Bartos H, Dimitrova A., 2018). Research dedicated to logistics and added value chains in agribusiness (Linkova M., Lazarova E., 2021) finds effective utilization of available resources and generation of added value and a prerequisite for innovation and transfer of technological knowledge.

The innovations on a sectoral basis demand to go beyond the standard internationally accepted system of indicators for measuring innovation as a linear process and the result of scientific research only. The shift in emphasis to sectoral innovation systems and technology chains is more closely related to the concept of open innovation. This is why, besides the usual indicators, measuring intensity of scientific research activity, we attempt to define the factors-specific drivers of innovation activity on a sectoral basis and to characterize the mechanisms for implementation of innovation and the various forms of manifestation of the expected effect.

The current research aims to:

- Define the importance of the agricultural sector as a factor for increasing the competitiveness and growth of the Bulgarian economy;
- Outline the boundaries of the sectoral innovation ecosystem of agribusiness in Bulgaria on the basis of formal and informal interactions and knowledge flows;
- Evaluate the innovation potential of the agro-sector in Bulgaria to create and apply new knowledge in national and international context.

**ECONOMIC IMPORTANCE OF THE AGRICULTURAL SECTOR IN BULGARIA**

The agricultural sector has a serious potential to 1) support development of a competitive economy based on the principles of sustainable development and green innovations; 2) create of solutions of social, economic and environmental problems of modern society; 3) meet growing requirements regarding food safety and quality; 4) address policies for balanced development of rural areas.

The agricultural sector is very sensitive in terms of political decision-making and inhomogeneous in terms of activities, applied technologies and final products. The approach to its research from the positions of sectoral innovation systems makes an attempt to examine it in its entirety, subject to the high level of interdependence between the individual stages of the innovation process.

In Bulgarian agriculture, the sub-sectors with the greatest economic importance are plant breeding in the production of grain and oil crops, fruits and vegetables, and animal breeding (the production of milk, pork,
poultry, beef and lamb meat and eggs). The data for 2021 show that the gross value added (GVA) of the agricultural sector is under BGN 5 million, forming 4.3% of the total GVA for the country. There is a sustainable upward growth trend since 2018, achieving growth in real terms of 6.1% for 2021. The dynamics of GVA from agriculture shows that in 14 years it has grown from BGN 2,954 million (2007) to only BGN 4,950 million (2021), despite huge subsidies and financial intervention for increasing the sector's competitiveness. The public subsidies in the sector do not have the expected positive influence on the gross value added (GVA) produced by the agriculture. Regardless of the growth in the absolute amount of GDP, it is insignificant compared to the dynamics of GDP from other sectors of the country's economy (See Figure 2).

![Figure 2. Gross value added of the agricultural sector at current prices, in million BGN](image)

*Source: NSI*

Investments in the sector are between 1.3-1.5 billion BGN per year and are mainly in modernization of farms and support to meet food and feed safety standards; environmental protection; animal welfare; renovation of equipment and the introduction of new technologies; modernization in the processing industry, etc. Officially, the number of employed are 193,600 people or 6.3% of the total number of employed in the country. Bulgaria is the leader in the registered growth in labour productivity, and according to Eurostat data, there is a growth of 32.9% compared to 2020 with an average of 1.5% for the EU-27. The increase in productivity is mainly due to changes in production values and higher prices of raw materials, while maintaining the volume of agricultural labour.

The total value of agricultural exports for 2021 is over 6 billion euros, equivalent to 25.8% increase compared to the previous year. The increase in imports was weaker (10.5%), with the positive balance growing twice on an annual basis and reaching 1.6 billion euros. In 2021, the agricultural sector formed 14.1% of the
country’s total trade for the year, including 17.3% of total exports and 11.3% of total imports. In 2021, trade with the EU-27 represents 62.4% of Bulgaria’s total agricultural exports and 75.9% of total agricultural imports. The leading place in the export of Bulgarian agricultural goods is occupied by Greece and Romania (23.7% of the total export for 2021), followed by Spain (7.3%), Germany (6.2%), Italy (5.7%), The Netherlands (4.9%). In exports to third countries, with a share of 29.7% are countries like Turkey, China, the USA, Korea and Great Britain. With potential and huge growth compared to the previous 2020 are countries such as Vietnam (growth of 1969.1%), Korea (growth of 754.7%) and Pakistan (+337.5%). The war in Ukraine and political decisions related to grain production and trade are influencing the agriculture market. According to preliminary data of the Ministry of Agriculture, in 2022 there is an increase in the export of the main grain and oil crops.

Foreign direct investments (FDI) in the sector "Agriculture, forestry and fisheries" for the period 2008-2020 marked stable decline since 2014 (see Table 1)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Agriculture, forestry and fishing</th>
<th>Share %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>19185</td>
<td>0.56</td>
</tr>
<tr>
<td>2009</td>
<td>20442</td>
<td>0.37</td>
</tr>
<tr>
<td>2010</td>
<td>22114</td>
<td>0.38</td>
</tr>
<tr>
<td>2011</td>
<td>21645</td>
<td>0.42</td>
</tr>
<tr>
<td>2012</td>
<td>21951</td>
<td>0.48</td>
</tr>
<tr>
<td>2013</td>
<td>23340</td>
<td>0.55</td>
</tr>
<tr>
<td>2014</td>
<td>21582</td>
<td>0.79</td>
</tr>
<tr>
<td>2015</td>
<td>23163</td>
<td>0.49</td>
</tr>
<tr>
<td>2016</td>
<td>23509</td>
<td>0.36</td>
</tr>
<tr>
<td>2017</td>
<td>24475</td>
<td>0.28</td>
</tr>
<tr>
<td>2018</td>
<td>24920</td>
<td>0.22</td>
</tr>
<tr>
<td>2019</td>
<td>25342</td>
<td>0.26</td>
</tr>
<tr>
<td>2020</td>
<td>26884</td>
<td>0.22</td>
</tr>
<tr>
<td>2021</td>
<td>28137</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Source: NSI

Figure 3. Distribution of agricultural holdings by region, 2019

Source: Ministry of Agriculture, Bulgaria
There is permanent trend of reducing the number of farmers and from 493,100 in 2007 achieving 132,400 in 2020, cutting the numbers of smaller farms (Ministry of Agriculture, 2019). The distribution of agricultural holdings on the territory of the country is uneven, with the exception of districts of Plovdiv and Blagoevgrad. According to data from the last census (2020) the utilised agricultural area (UAA) in Bulgaria is 3957 thousand ha, which is an increase of 9% compared to 2010 and 36% increase compared to 2003. The family workforce and the permanently employed are 292 thousand people. The relative share of the family's unpaid hand is 79%. According to NSI data, there are 193.6 thousand people employed in the "Agriculture, Forestry and Fisheries" sector before 2021, which is 6.3% of those employed in all economic sectors.

**Figure 4. Employed in the "Agriculture, Forestry and Fisheries" sector**

*Source: NSI*

According to data from the Ministry of Agriculture (Ministry of Agriculture, 2019), the average values and distribution by size of agriculture holdings, UAA in Bulgaria for 2020 is presented as follows:

<table>
<thead>
<tr>
<th>Area, ha</th>
<th>Cattle and buffaloes</th>
<th>Ewes and goats</th>
<th>Number of agricultural holdings</th>
<th>Average UAA, ha</th>
<th>Average size of standard production, euro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very small agricultural holdings</td>
<td>0,5-1,0</td>
<td>&gt;10 young cows or buffaloes, &gt;5 beefs cows</td>
<td>&gt;10</td>
<td>44198</td>
<td>0,85</td>
</tr>
<tr>
<td>Small agricultural holdings</td>
<td>1,0-5,0</td>
<td>10-50</td>
<td>10-100</td>
<td>45617</td>
<td>3,66</td>
</tr>
<tr>
<td>Medium agricultural holdings</td>
<td>5,0-30</td>
<td>50-200</td>
<td>100-300</td>
<td>38915</td>
<td>38,30</td>
</tr>
<tr>
<td>Large agricultural holdings</td>
<td>30-650</td>
<td>200-500</td>
<td>300-1000</td>
<td>2361</td>
<td>541,14</td>
</tr>
<tr>
<td>Very large agricultural holdings</td>
<td>&lt;1500</td>
<td>&lt;500</td>
<td>&lt;1000</td>
<td>1071</td>
<td>1415,2</td>
</tr>
</tbody>
</table>

*Source: Ministry of Agriculture, Bulgaria*
The registered organizations of fruit and vegetable producers and their associations are 17, the organizations of milk producers, associations of producers’ organizations, organizations for milk and dairy are 3 in total, the organizations of producers of agricultural products, associations of organizations of producers groups of producers in the Republic of Bulgaria are 25. As conclusions, there is limited number of associations in the agriculture.

Despite the changes that have occurred in the direction of restructuring, industrialization, specialization, agriculture is dominated by individual or family small farms that are relatively independent, and thus remain difficult to influence by dynamically changing technological factors.

The analysis of the support of agricultural holdings with direct payments between 2007-2013 and 2014-2020 (Koteva N., Ivanov B., 2020) show that 1/3 of the agricultural holdings were financially supported. There is an uneven distribution between the beneficiaries in favour of the larger agricultural holdings, which has been preserved over the years. Direct payments in the researched period grew nearly 4.7 times (from 166.4 million in 2008 to 777.4 million before 2020), becoming an important tool and income for farmers, but without significant results.

A study funded by the Bulgarian National Science Fund to evaluate the competitiveness of farmers in Bulgaria shows that more than a third of all farms have a low level of competitiveness. Factors responsible for this include low productivity, profitability, financial security and adaptability to changes in the natural environment (Bashev H, Koteva N., 2021).

POLICIES AND STRATEGIES IN THE FIELD AT INTERNATIONAL, EUROPEAN AND NATIONAL LEVEL TO SUPPORT INNOVATION IN THE AGRICULTURAL SECTOR

The most important strategic document at international level is the Program for Sustainable Development until 2030 and the set of seventeen Sustainable Development Goals (SDGs), which at the national level is deployed in the National Program Bulgaria 2030.

The Food and Agriculture Organization of the United Nations (FAO) adopted the FAO Science and Innovation Strategy (FAO, 2022) which outlines the critical contribution of science and innovation to the transformation of food systems. It highlights the role of science and innovation as crucial to finding solutions to climate challenges, managing knowledge and spreading innovation, by promoting and adapting to local needs and reaching the smallest farmers and producers.

At the EU level, the strategic framework and the main instruments aimed at scientific research and innovation are part of the pan-European policy, in fulfilment of the UN Sustainable Development Goals 2030, the EC priorities (2019-2024), the Recovery and Development Plan, the European Green Deal, Europe fit for the digital age, an Economy that works for the people, the Strategic Plan 2020-2024 for Research and Innovation strategy and others. All of them emphasize the importance of innovation and scientific research as major drivers, empowering growth, smart specialization and competitiveness. The so-called innovation
principle, including all new EU policies or regulations support innovation. Directly related to R&D and innovation are also the European Research Area (ERA), the Pact for Research and Innovation in Europe and the Horizon Europe programme.

The Strategic Plan (2021-2024) for the Horizon Europe program includes four key strategic directions supported by 15 impact areas structured in 6 clusters that make up the second pillar of Horizon Europe, Global Challenges and European Industrial Competitiveness. Among the co-financed partnerships of particular interest to the agricultural sector are:

- European Clean Energy Transition Partnership
- European partnership to accelerate the transition of agricultural systems:
- European Partnership for Animal Health and Welfare
- European Data Farming Partnership
- European Partnership to Save Biodiversity to Protect Life on Earth
- European partnership for a climate-neutral, sustainable and productive blue economy, etc.

Europe's strategy for international cooperation in a changing world is a new EC strategy outlining the priorities for strengthening the EU's leading role in supporting multilateral research and innovation partnerships to deliver new solutions to environmental challenges, digital technologies, healthcare and innovation.

The new European Research and Innovation Area aims to build a common science and technology area for the EU, the creation of a single market for research and innovation that promotes the free movement of researchers, scientific knowledge and innovation and stimulates the creation of a more competitive European industry. This includes restructuring the European research environment to strengthen cross-border cooperation, continent-wide competition, achieving "critical mass" and cooperation, and improving national research policies and systems. The European Strategic Forum on Research Infrastructures (ESFRI) has developed plans for 55 European research infrastructures in all fields of science, 37 of which have already been implemented and have mobilized investments of €20 billion. Since 2004, national investments in joint research programs amounting to more than 7 billion euros have been made. The European Open Science Cloud, the Data Exchange Platform, the EURAXESS Platform (to support the mobility and career development of researchers) are launched.

The European Institute of Innovation & Technology (EIT) supports businesses, educational and research institutions to work together to create an environment conducive to innovation and entrepreneurship in Europe. The institute enhances Europe's innovation capacity and its ability to compete with foreign partners and thereby create jobs and wealth. It brings together three key drivers of innovation – business, education and research – to help form dynamic, multi-stakeholder partnerships known as Knowledge and Innovation Communities. Of particular interest is the community for innovations in the food system, in which Bulgaria also participates. EIT Food is the leading European food innovation initiative working for a more sustainable, healthy and reliable food system. It is a pan-European consortium that focuses on entrepreneurship and
innovation in the food sector. The members of the EIT Food community are leading organizations in the international food field: more than 50 partners from companies, research centres and universities in 13 countries.

The Access to Research for Development and Innovation (ARDI) program of the World Intellectual Property Organization (WIPO) aims to increase the availability of scientific and technical information in developing countries. The database is grouped into several main areas of science: HINARI (medical literature), AGORA (food and agriculture), GOALI (law and social sciences), OARE (environment).

The leading strategic document in the field of agriculture is the Common Agricultural Policy (CAP) aimed at supporting farmers and increasing agricultural productivity to ensure stable food supplies at affordable prices; protection of farmers' living standards; help to address climate change and sustainable management of natural resources; care for the state of rural areas and landscapes across the EU; maintaining the viability of the rural economy by promoting employment in agriculture, food processing and related sectors.

The New Common Agricultural Policy: 2023-2027 paves the way for a fairer, greener and results-oriented CAP. Among the main goals are, fair incomes for farmers; increasing competitiveness; improving the position of farmers in the food supply chain; action to combat climate change; as a serious emphasis is placed on care for the environment; landscape and biodiversity protection; supporting generational change; viable rural areas; preservation of food quality and health; stimulating knowledge and innovation.

During the period 2021-2027, within the framework of the CAP, 387 billion euros have been allocated through the two funds - the European Agricultural Guarantee Fund (EAGF) (direct aid and financing of market measures) and the European Agricultural Fund for Rural Development (EAFRD) (financing for rural development). More €8 billion from the EU’s Next Generation are planned to help rural areas make the structural changes needed to achieve the goals of the European Green Deal and the digital transition.

The new emphases are on knowledge, research and innovation for a smart and sustainable agricultural sector. Within the framework of the "Horizon Europe" program, 10 billion euros have been earmarked for projects related to food, agriculture, rural development and the bioeconomy. The new CAP strengthens the position of farmers in the supply chain. The Farm to Fork strategy is based on the European Green Deal, which aims to make food systems fair, healthy and environmentally friendly.

The long-term vision for EU rural areas 2040 aims to make rural areas stronger, connected, resilient and prosperous by harnessing the emerging opportunities resulting from the EU’s environmental and digital transition and the lessons learned from the COVID-19 pandemic such as the quality of life in rural areas has increased, balanced territorial development has been achieved and economic growth has been stimulated. A Pact for Rural Areas and an Action Plan for Promoting Sustainable, Coherent and Integrated Development of Rural Areas are to be adopted. Scientific research and innovation as well as the rural revitalization platform are essential tools to achieve the "stronger" part, to "connectivity" digitization and sustainable multimodal rural mobility, and to sustainability - the fight against climate change, carbon farming, deal for soil, social
sustainability and women in rural areas, and to "prosperous" - entrepreneurship and social economy in rural areas.

At the national level, within the National Development Program Bulgaria 2030 agriculture takes its place within the framework of priority 6 Sustainable agriculture. The focus is on the structural and sectoral balance of agriculture and the acceleration of restructuring processes in the sector - strengthening small family farms, achieving an appropriate balance between crop production and livestock production and their sub-sectors, the entry of young people into agricultural business. The areas of impact are crop production, livestock production, economic potential of small farms, age structure of farmers, areas with natural or other limitations.

In second place are incomes of agricultural producers, support for the sustainability of production structures and an increase in their market power and competitiveness. It relies on mechanisms for direct support and risk management in agriculture (adverse climatic events, spread of diseases and enemies of plants and animals, prevention and reduction of losses).

In third place is the competitiveness of agriculture based on the increased efficiency of production, the accelerated entry of innovations, the growth of productivity, the improvement of marketing and the market organization of supply, finding access to new markets. Investments are planned for modernization, innovation and digital technologies in agricultural holdings. Interventions aimed at implementing innovations and digital solutions, including those related to precision agriculture, will have a special focus. It is planned to build a complete electronic information system in agriculture, which will allow the digitalization of information flows from and for the implementation of administrative activities and, digitalization of the services provided to farmers. Strengthening the market positions of farmers will contribute to a fairer distribution of the added value created along the food chain by promoting the association of agricultural producers, stimulating vertical integration between producers and processors of agricultural products, shortening food supply chains. Qualification and knowledge of agricultural producers and in particular stimulating the transfer of knowledge and the provision of information concerning scientific research and innovation in the field of agriculture, including the bioeconomy.

In the fourth place, the role of the agricultural sector for environmental protection is defined, by encouraging the application of environmentally friendly practices in agricultural production, with a contribution to the protection of water, soil, air and biodiversity. The focus is on agro-ecological commitments and the implementation of agricultural practices aimed at adapting and strengthening ecosystems dependent on agriculture. Special attention is given to promoting organic production and increasing the production and consumption of clean and high quality food. In connection with the adaptation of climate changes, investments in irrigated agriculture and hydromelioration are planned for the improvement and sparing use of water resources.

In fifth place is the support of fisheries and aquaculture in order to reach the European level on the basis of improved competitiveness and sustainability.
Within the framework of the National Plan for Recovery and Sustainability under the priority Green Bulgaria - Sustainable Agriculture is set. Reforms related to updating the strategic framework of the agrarian sector in the context of the countries commitments resulting from the SDGs and the Green Deal are foreseen. Farmers should rapidly change their production methods, use nature-friendly, technological and digital solutions to ensure better climate and environmental results.

In the Innovation Strategy for Intelligent Specialization of the Republic of Bulgaria (2014-2020) as well as in the draft Innovation Strategy for Intelligent Specialization 2021-2027 of the Republic of Bulgaria, the thematic area "Industry for healthy living, bioeconomy and biotechnology" is preserved. "The vision for the development of the thematic area envisages that by 2030, Bulgaria will establish itself as a producer of bioproducts - food, cosmetics, medicines, produced from Bulgarian raw materials; to build an image of a destination offering safe high-quality medical, healing and rehabilitation services, including with high-tech products and devices using nanotechnology and meeting the highest global standards". The analysis for the period 2014-2020 shows that this thematic area is in second place (25.3%) of funds used and approved projects (60 projects). With the highest interest in "methods for clean production, storage, processing and reaching the end user of specific Bulgarian ingredients, means and products", and with the lowest "production of specialized foods and drinks (infant and children's, "cosmic" foods)". By types of innovations in the thematic area "Industry for healthy living, bioeconomy and biotechnologies are supported (Innovation Strategy for Intelligent Specialization (ISIS) Project, 2021-2027 of the Republic of Bulgaria, 2022):

- Supported enterprises that introduced new products for the enterprise - 21 in total
- Supported enterprises that introduced new products to the market - 24 in total
- Supported enterprises through Sofia Tech Park - 4 in total

The implemented procedures under Operational Programme “Science and Education for Smart Growth“ with a total value of 219.9 million euros display that 63.7 million euros or 28.97% of the total amount have been paid in the thematic area "Industry for a healthy life, bioeconomy and biotechnologies". The low degree of cooperation between enterprises and scientific structures and organizations is indicated among the barriers to the diffusion of innovations in the interim assessment of ISIS 2014-2020.

The national strategy for small and medium-sized enterprises in the part Measure 1.5 Support for crafts, entrepreneurship in rural areas and creative industries, incl. at the regional level (Action 3). By measure 4.1 Promoting the digitization of SMEs, support is provided for SMEs through the introduction of digital technologies and software products for automation and robotization of production processes, communication and distribution technologies, etc. in agriculture.

The update of the National Action Program to contribute to the implementation of the objectives of the "Farm to Fork“ Strategy until 2030 is aimed at promoting green investments, sustainable management of natural resources (water, soil, air), adaptation to climate change and mitigation of their consequences. The
program will outline a framework for the management and protection of the environment and natural resources in the field of agriculture. It includes a complex of tools and activities until 2030 related to the implementation of specific goals and commitments such as preparing an analysis of the opportunities for low-carbon agriculture and more efficient use of natural resources; increasing the awareness and knowledge of agricultural producers about the benefits and ways of introducing ecological practices and solutions based on nature, opportunities to apply the principles of the circular economy; investments related to the protection of environmental components, as well as the introduction of innovative production and digital technologies in work processes; investments in facilities and equipment to overcome the consequences of climate change for the agricultural sector, etc. Investments are planned for:

- Fund for promoting the technological and ecological transition of agriculture, provide supports to farmers for the realization of targeted investments, for the purchase of tangible and intangible assets for the implementation of activities ensuring the protection of environmental components and mitigating the consequences of climate changes introducing innovative production and digital technologies, technologies for production and organization in agriculture, to automate work processes, to shorten supply chains and protect genetic resources. The total planned resource is BGN 962.2 million (BGN 437.4 million at the expense of the Recovery and Sustainability Mechanism and BGN 524.9 million in national co-financing, including BGN 437.4 million in private co-financing) with an implementation period of 2022-2025.

- Digitization of processes from the farm to the table. It is planned to build a comprehensive electronic information system in agriculture, through which to achieve: digitalization of information flows from and for the implementation of administrative activities; digitalization of services provided to farmers, their centralization and their use by businesses in the course of fulfilling obligations and requirements depending on the type of agricultural activity; integration of the administration's information systems and creation of an opportunity for automated data exchange between the administration and farmers. The total planned resource is BGN 23.9 million (BGN 19.9 million at the expense of the Recovery and Sustainability Mechanism and BGN 3.9 million national co-financing) with an implementation period of 2022-2025.

The Strategy "Digital Transformation of Bulgaria for the period 2020-2030", in the part of the Strategy for Digitization of Agriculture and Rural Areas of the Republic of Bulgaria, foresees the following areas of activity to develop the potential of the Bulgarian agrarian economy: building and developing an appropriate digital infrastructure for communication and connectivity; investment in modernization and technologies for precision agriculture; development of digital networks and use of software applications in business management and decision-making; awareness, training and advisory services for the development of digital skills and qualifications, research and innovation, partnership for the exchange and transfer of innovations, development of infrastructure for experimentation and access to it. The main goal of the digitization of Bulgarian agriculture and the related agricultural business is to turn it into a highly technological, sustainable,
highly productive and attractive sphere of the Bulgarian economy, which not only improves the living conditions of farmers, but also of rural areas such as whole.

Agriculture and rural areas can benefit in larger degree of new technologies and knowledge, without in any way jeopardizing the functionality of farmers. Therefore, digitization is set as a major cross-sectoral priority in the European Commission's Proposal for a Regulation on Strategic Plans under the Common Agricultural Policy (CAP). The main institution at European level responsible for digitizing agriculture and promoting innovation is the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI).

Within the framework of the Strategy for Digitization of Agriculture and Rural Areas of the Republic of Bulgaria, the aim is the accelerated digitization of Bulgarian agriculture and rural areas, including the public administration, optimization of production processes, increase of farmers' incomes and yields, achievement of sustainable bio - industry, maintenance of food safety in conditions of increased industrialization and new unproven technologies, a drastic increase in competitiveness and increased demand for Bulgarian products on the single European and world markets. The specific objectives, outputs, effects and areas of interaction are summarized as follows:

Table 3. Objectives, results, effects, areas of impact of the Strategy for digitization of agriculture and rural areas in the Republic of Bulgaria

<table>
<thead>
<tr>
<th>Strategic goals of digitization</th>
<th>Specific goals in agriculture</th>
<th>Specific results of digitization</th>
<th>Expected effects</th>
<th>Areas of impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Increasing the productivity and sustainability of agricultural production; 2. Improving people's health through the production of quality food; 3. Protecting the environment and addressing the challenges of climate change; 4. Increasing/expanding the presence of Bulgarian products on the Single European Market and on world markets; 5. Stimulating interest and attracting young people to develop agriculture;</td>
<td>1. Increase in income of farmers; 2. Reduction of production costs; 3. Improving the traceability and quality of the manufactured products in view of the demand and requirements of the market/consumers; 4. New funding opportunities.</td>
<td>1. Improved access to information; 2. Improved access to counseling service; 3. Improved access to markets and distribution of production; 4. Improved access to financing and reduced dependence on CAP subsidies; 5. Significant acceleration of administrative activity and reduction of the administrative burden;</td>
<td>1. Higher selling prices for farmers' produce and production in volume to satisfy demand; 2. Better risk management, including the risk of natural disasters; 3. Higher yields; 4. Reduction of the harmful effects of agriculture on the environment; 5. Reduction of intermediaries in the agri-food chain and shortening of the supply chain; 6. More efficient channels of product distribution; 7. Increase efficiency and forecasting;</td>
<td>1. Building and developing an appropriate digital infrastructure for communications and connectivity; 2. Investments for modernization and technologies for precision agriculture; 3. Development of digital networks and use of software applications in activity management and decision-making; 4. Training and consulting to develop digital skills and qualifications 5. Research and innovation, partnership for exchange and transfer of innovations, development of infrastructure for</td>
</tr>
</tbody>
</table>
In the Concept for the development of artificial intelligence in Bulgaria until 2030, agriculture is defined as a consumer sector of AI. The strategy is expected to play an important role in the implementation of the development policies set out in "Bulgaria 2030" and, more specifically, sustainable agriculture.

In accordance with the objectives of the EU policy for the development of rural areas, the Program for the Development of Rural Areas for the period 2014-2020 is the main strategic document for the implementation of the Second Pillar of the CAP in Bulgaria in the period 2014-2020. Currently, a working group has been created and work is underway to adopt a Strategic Plan for the CAP in the period 2023-2030.

The following strategic documents also relate to innovations in the agricultural sector - National strategy for the development of scientific research in the Republic of Bulgaria 2017-2030 in the part "Better science for a better Bulgaria" and National Science and Research Fund as a secondary authority to the Ministry of Education and Science, is the main tool for funding of scientific research on a competitive basis in the country. It is written in the strategy that the Agricultural Academy (AA), some of the institutes of the Bulgaria Academy of Science (BAS) and Higher Education (HE) develop the various agrarian sciences, as a large part of these scientific fields correspond to the priority areas of ISIS.

For the implementation of the strategic documents in the field of research and innovation activity, the main sources of funding are laid down in the National Plan for Recovery and Sustainability, the national budget through the National Innovation Fund (Ministry of Economy), National Science and Research Fund, Ministry of Agriculture (CAP 2023-2027) and others.

**RESEARCH AND INNOVATION POTENTIAL OF THE AGRICULTURAL SECTOR (RESULTS)**

Bulgaria has a long history in the development of innovations in agriculture, both from the universities and from various scientific units and other institutions. The concept of the innovation system in the agricultural sector makes it possible to cover all participants in the processes of creation, transfer, dissemination and application of new knowledge and technologies both in the field of agriculture and in all related spheres, the
existing and potential interactions between them, the impacts of side of European and national politics, the influence of factors such as funding and quality of human resources. In this way it is achieved:

- Emphasis on factors promoting innovation activity originating outside the system, which can find a new application or stimulate the effective use of other internal factors;
- The generation of a critical mass is encouraged in terms of used resources and exchange of ideas at the expense of the isolated performance of individual functions in service of the innovation process;
- Innovations dictated by novelties in science and technological development, and to those originating from changes in the market and the behaviour of end users;
- Interaction within the sector on the individual units of the technological chain on the basis of coordination of activities, generation of knowledge, multiplication of results stands out;
- An opportunity to build the innovation capacity of the individual participants in the system and of the system as a whole through systematic and coordinated efforts dictated by the opportunities of the research units, the educational system and the business;
- Development of an innovation culture and an environment supporting innovation through approaches and measures that are adapted to the needs of the system and the goals for its development.

Ecosystem participants are many and varied in their structure, funding and capacity. It is important to point out that the ecosystem is dynamic and includes both already built and newly built research and innovation infrastructures, which requires additional monitoring. The different participants in the Agricultural Knowledge and Innovation System (AKIS) contribute differently to management and financing, for the initiation, creation, distribution and the implementation of knowledge and innovation in the industry.

In addition to the diverse types of farmers and farms, this complex system includes scientific institutes, universities and schools, agricultural advisory services, private consultants, specialized consulting, training and innovation companies, professional organizations of agricultural producers, non-governmental organizations, suppliers of technology, chemicals and innovation, food chains, processors and exporters of agricultural products, government agencies, local authorities, non-governmental organizations and interest groups, media of various kinds, international organizations, private individuals, etc. (Agricultural Academy, Institute for agrarian economy, 2020).

In the agricultural sector, R&D is mainly carried out by the state sector - scientific institutes and experimental stations of the Agricultural Academy, the Centre for Plant and System Biology and Biotechnology, part of the institutes of the BAS and HEIs. All accredited universities are state-owned, accredited as follows:

<table>
<thead>
<tr>
<th>HEIs</th>
<th>6.1 Plant breeding</th>
<th>6.2 Plant protection</th>
<th>6.3 Livestock breeding</th>
<th>6.4 Veterinary medicine</th>
<th>6.5 Forestry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural University - Plovdiv</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Trakia University - Stara Zagora</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>University of Forestry</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 4. Accredited universities in the field of higher education: 6. Agricultural sciences and veterinary medicine.
In addition to the above-mentioned HEIs, which are state-owned, other HEIs accredited in other professional areas (mainly in professional fields 3.8 Economics and 3.7 Administration and Management) should be considered as working at the sectoral level in the agricultural sector. Such HEIs are Higher School of Agribusiness and Development the regions - Plovdiv or all others with structural units or specialties - such as University of World and National Economy, "D. Tsenov" Svistov Academy, Sofia university “St. Kliment Ohridski” and others.

The digital innovation hub (AgroHub) and the European digital innovation hub (AgroDigiRise) are important stakeholders in AKIS. Among the more significant scientific research complexes and centers with a contribution to the economic growth of Bulgaria included in the National Roadmap for Scientific Infrastructure, developed by the Ministry of Education, three centers included in the pan-European infrastructures in the field of biomedicine, health and food; eleven centers, part of the national R&I complexes in the field of "Healthy Life Industry and Biotechnologies", directly and/or indirectly related to the agricultural sector.

From projects, part of the national science and innovation complexes of key importance for the development of the competitiveness of the Bulgarian economy and technological base, from the thematic area "Industry for a healthy life and biotechnologies", the following were financed:

- Center for Plant System Biology and Biotechnology;
- National Infrastructure for Research and Innovation in Agriculture and Food (RINA);
- Research infrastructure in the field of food, nutrition and health, tied to Bulgaria's participation in pan-European infrastructure;
- Competence center "Sustainable utilization of bio-resources and waste from medicinal and aromatic plants for innovative bioactive products" coordinated by the Institute of Organic Chemistry with the Center for Phytochemistry at the BAS, in partnership with the Agrobio-Institute at the Agricultural Academy and other organizations and a budget of 23.8 million BGN
- Plant Health Diagnostics and Technologies Center (PLANTHELIT), a consortium between the Forestry Institute at BAS, Agricultural University - Plovdiv and Trakia University - Stara Zagora.

The territorial coverage, the scientific infrastructure in the field of agro-bio science is throughout the country (via institutes of the Agricultural Academy). In the Southwestern region and mainly in the capital of Bulgaria, there are 8 scientific institutes, one university and Sofia Tech Park. Three institutes and three universities are located in Plovdiv - South Central region. There are 3 institutes and one university in the Southeast region. There are 2 institutes in the North-East region. In the North Central region we have 4 institutes, the exception is the North Western region, where there is no scientific infrastructure.
The main centers for making managerial decisions within the sectoral innovation ecosystem of agribusiness in Bulgaria are distributed between those responsible for policies in the field of scientific research and innovation, scientific organizations and HEIs creating new knowledge and technological solutions, organizations and structures for the dissemination of knowledge and information, as well as organizations applying new technologies.

The national research and innovation policy is implemented by the Ministry of Education, the Ministry of Innovation and Growth and the expected new Law for the Promotion of Scientific Research and Innovation. In the agrarian sector, the leading place is occupied by the Ministry of Agriculture and Food (new CAP 2023-2027) together with the National Plant Protection Service and the Agricultural Academy, as well as the Ministry of Economy (National Plan for Recovery and Sustainability, National Innovation Fund), Ministry of Education (National Scientific Research Fund) and others.

The creation of new knowledge and technological solutions is mainly carried out by scientific organizations and universities. The inherited fragmentation between institutions and units engaged in fundamental and applied research and training is in the process of transformation in the direction of reconciliation, sharing, multiplication of functions and activities in order to reflect the multidisciplinary nature of innovation processes, the need to search for complex solutions, shortening time and optimizing efforts in the process of creating and applying new technologies.

The data from the register of scientific activity in the Republic of Bulgaria, maintained by the Ministry of Education and Science through the National Center for Information and Documentation in professional field 6. Agricultural Sciences and Veterinary Medicine, a total of 36 organizations are registered. Of these, 23 are part of the Agricultural Academy (with experimental stations), BAS with 2 institutes (Institute of Reproductive Biology and Immunology "Acad. Kiril Bratanov", Institute of Organic Chemistry with a Phytochemistry Center), accredited universities with their affiliates/units: Agricultural university - Plovdiv, Trakia University - Stara Zagora (with 3 registered organizations), Konstantin Preslavski" University of Shumen, Higher School of Agribusiness and Regional Development - Plovdiv, Technical University - Varna, Forestry University. NGOs are included with two organizations Bulgaria association for biological plant protection, National Biomass Association, and from the business organizations only M-AGRO EOOD.

An important prerequisite for increasing the innovative activity of the sector is the new knowledge created by the scientific organizations and scientists included in it. The analysis of the dynamics and structure of this process reveals the potential of the units of the innovation system to successfully fit into global scientific networks, the country's comparative advantages in this area of knowledge and the ability to successfully compete on the market of intellectual products. Proof of this is the data on scientific publications in the field of the agricultural sector, indexed and referenced in the world databases compared to other Eastern European countries.
Table 5. Publications in Agriculture and Biological Sciences, Region Eastern European (April 2022)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Documents</th>
<th>Citable documents</th>
<th>Citations</th>
<th>Self-citations</th>
<th>Citations per document</th>
<th>H index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Russian Federation</td>
<td>75776</td>
<td>74785</td>
<td>692949</td>
<td>206201</td>
<td>9.14</td>
<td>214</td>
</tr>
<tr>
<td>2</td>
<td>Poland</td>
<td>68756</td>
<td>67922</td>
<td>915842</td>
<td>258252</td>
<td>13.32</td>
<td>208</td>
</tr>
<tr>
<td>3</td>
<td>Czech Republic</td>
<td>44677</td>
<td>43838</td>
<td>704294</td>
<td>166608</td>
<td>15.76</td>
<td>210</td>
</tr>
<tr>
<td>4</td>
<td>Hungary</td>
<td>22520</td>
<td>22009</td>
<td>381293</td>
<td>62058</td>
<td>16.93</td>
<td>191</td>
</tr>
<tr>
<td>5</td>
<td>Slovakia</td>
<td>14603</td>
<td>14433</td>
<td>169679</td>
<td>33615</td>
<td>11.62</td>
<td>129</td>
</tr>
<tr>
<td>6</td>
<td>Croatia</td>
<td>13198</td>
<td>13010</td>
<td>160781</td>
<td>32359</td>
<td>12.18</td>
<td>126</td>
</tr>
<tr>
<td>7</td>
<td>Serbia</td>
<td>12147</td>
<td>11929</td>
<td>131155</td>
<td>28508</td>
<td>10.8</td>
<td>108</td>
</tr>
<tr>
<td>8</td>
<td>Ukraine</td>
<td>10649</td>
<td>10542</td>
<td>82491</td>
<td>16073</td>
<td>7.75</td>
<td>99</td>
</tr>
<tr>
<td>9</td>
<td>Romania</td>
<td>10566</td>
<td>10433</td>
<td>113223</td>
<td>19706</td>
<td>10.72</td>
<td>110</td>
</tr>
<tr>
<td>10</td>
<td>Bulgaria</td>
<td>9305</td>
<td>9141</td>
<td>114082</td>
<td>14262</td>
<td>12.26</td>
<td>117</td>
</tr>
<tr>
<td>11</td>
<td>Slovenia</td>
<td>8856</td>
<td>8711</td>
<td>175398</td>
<td>23761</td>
<td>19.81</td>
<td>138</td>
</tr>
<tr>
<td>12</td>
<td>Estonia</td>
<td>7112</td>
<td>6940</td>
<td>194252</td>
<td>29751</td>
<td>27.31</td>
<td>162</td>
</tr>
<tr>
<td>13</td>
<td>Lithuania</td>
<td>5770</td>
<td>5680</td>
<td>70647</td>
<td>12459</td>
<td>12.24</td>
<td>97</td>
</tr>
<tr>
<td>14</td>
<td>Latvia</td>
<td>4760</td>
<td>4728</td>
<td>36463</td>
<td>6890</td>
<td>7.66</td>
<td>72</td>
</tr>
<tr>
<td>15</td>
<td>Belarus</td>
<td>1663</td>
<td>1653</td>
<td>17229</td>
<td>1425</td>
<td>10.36</td>
<td>57</td>
</tr>
</tbody>
</table>

Source: Scimago Journal and Country rank

The data for Bulgaria indicates a significant lag compared to the publications from the leaders Russia, Poland and the Czech Republic, with a relatively low degree of self-citation, but with a high number of citations per document and h-index levels.

Figure 5. Ratio of H-index to average number of citations per publication in Agricultural and Biological Sciences

Source: https://www.scimagojr.com/

The detailed analysis of the publication activity in Bulgaria indicates that with the highest degree of citation and h-index levels are publications in the field of plant breeding, ecology, food industry, and the authors are mainly from a limited number of state HEIs such as Medical University, University of Food Technologies – Plovdiv, Trakia University, Sofia university and the institutes from Bulgarian Academy of Science (BAS), where the Institute of Biodiversity and Ecosystem Studies - Sofia stands out. The publication activity is not
balanced among the accredited universities in the field of agricultural sciences, as there are also a large number of interdisciplinary scientific researches and publications.

The publications in SCOPUS of the Agricultural Academy with all its structural units in the period 2000-2022 are a total of 1464, distributed by year as follows:

![Figure 6. Scopus indexed publications of Agricultural Academy](source: Scopus)

By editions, the most publications are in the Bulgarian Journal of Agricultural Science (403), which is a edited by Agricultural Academy(AA), followed by those in Biotechnology and Biotechnological Equipment (191) of Tylor & Francis, Acta Horticulturae (38). The publications in the field of agricultural sciences - by affiliation stand out AA (991), Agrobioinstitute - Sofia (552), BAS (253), Institute of Animal Breeding Sciences - Kostinbrod (170), Sofia University (115), Institute "N. Pushkarov" (102), Institute of Biodiversity and Ecosystem Research (73), Institute of Agrarian Economics (67), Trakia University (63), Unoversity of Food Technology – Plovdiv (57), Agricultural University - Plovdiv (55), Institute of Plant Physiology and Genetics ( 53), Plovdiv University (49), Forestry University (33) and others.

![Figure 7. Scopus indexed publications by affiliation](source: Scopus)
In terms of funding sources, the majority is state-funded through the National Science Research Fund (125 publications), the Ministry of Education and Culture (158), followed by publications funded by the EU (40), supplemented by those under the Seventh Framework Program (26).

![Figure 8. Number of publications by funding source. Source: Scopus](image)

In terms of thematic content, the publications are mainly in three sub-fields: agricultural and biological sciences (37.4%), biochemistry, genetics and molecular biology (17.7%) and veterinary medicine (16.9%).

![Figure 9. Distribution of issued patents in Bulgaria by sections and technological areas up to class level of IPC, 2001-2022, number. Source: Bulletins of the Bulgarian Patent Office; own calculations](image)
Protected new technological knowledge is the result of the creative activity of various participants in the innovation process, has unique characteristics and economic significance that make it attractive as an object of transfer. The analysis of the applicant and patent activity, as well as the attitudes of Bulgarian and foreign persons in this field, allow to evaluate an essential aspect of the functioning of the innovation system and to look for ways to improve it.

Figure 10. The distribution of patents issued in Bulgaria to Bulgarian patent holders by sectors and sections of the Classification of Economic Activities, 2001-2021 (number)

Source: Bulletins of the Bulgarian Patent Office

The distribution of the issued patents of Bulgarian patent holders in Bulgaria, by sections and technological directions up to class level of the International Patent Classification (IPC) is shown in Figure 10, and the distribution of patents issued in Bulgaria to Bulgarian patent holders by sectors and sections of the Classification of Economic Activities in Figure 11. Most of the patents are A01- AGRICULTURE; FORESTRY; ANIMAL HUSBANDRY; HUNTING; TRAPPING; FISHING and in A23- FOODS OR FOODSTUFFS; TREATMENT THEREOF, NOT COVERED BY OTHER CLASSES Together, A01 and A23 represent 94% of all issued patents in the period 2001-2021. The dynamics during the research period outlines high levels during 2002-2011, followed by a period of almost zero activity (2011-2017) and gradually activation in the number of issued patents.

The trend of extremely low patent activity in the Higher Education sector in the period 2011-2022 is interesting, as from the accredited universities in professional field 6. Agricultural Sciences and Veterinary Medicine, only 1 patent was registered (2021) from the Agricultural University - Plovdiv, while in the period 1994-2001, nearly 10% of the total number of patents in the sector were owned by the Agricultural University, Plovdiv (17 out of a total of 136 patents). In the private sector, only 49 of the patents with possible application in the agri-food sector are owned by businesses.
A significant contribution to the innovation ecosystem is expected to be generated by a number of national scientific programs funded by the Ministry of Education, which are in the process of implementation, directly aimed at the agricultural sector:

![Figure 11. Patent activity of structures and units at the Agricultural Academy, 2001-2021.](image)

Source: Bulletins of the Bulgarian Patent Office

National scientific program "Healthy foods for a strong bioeconomy and quality of life", a consortium with leading partner Agricultural University - Plovdiv, together with the Agricultural Academy; Bulgarian Academy of Sciences; University of Food Technologies - Plovdiv; Sofia University "St. Kliment Ohridski"; Trakia University - Stara Zagora. The program addresses societal challenges for a more innovative, resource-efficient and competitive society. Indicative budget BGN 6.0 million.

National scientific program "Intelligent plant breeding" is implemented by a consortium with a leading partner Agricultural University - Plovdiv, together with the Agricultural Academy; Bulgarian Academy of Sciences; Trakia University - Stara Zagora, Ruse University "A. Kanchev", National Institute of Meteorology and Hydrology, Higher Naval School "N. Y. Vaptsarov" - Varna. The program aims to conduct fundamental and applied scientific research to create models for robotic technologies, digital methods for diagnosis and forecasting, as well as for digital management of agricultural holdings with a crop production direction to ensure a sustainable and efficient food system. Implementation period 2021-2024 and budget BGN 4.5 million.

National scientific program "Intelligent animal husbandry" is implemented by Trakia University - Stara Zagora, Agricultural University - Plovdiv, Sofia University "St. Kliment Ohridski", Technical University - Sofia, BAS (Institute of Information and Communication Technologies, Institute of Mechanics, Institute of Reproductive Biology and Immunology), AA and a number of associated partners. Implementation period 2021-2024 and budget BGN 4.5 million.

National scientific program "Reproductive biotechnology in animal husbandry in Bulgaria" (REPROBIOTECH) aims to optimize the reproductive process in animal husbandry through the implementation of innovative biotechnology and knowledge transfer. The specific objectives of the program are related to reproductive biotechnology in animal husbandry - use of fresh and cryopreserved genetic material; improving the reproductive potential by using non-hormonal bioactive supplements during periods important for reproduction; knowledge transfer and reproductive biotechnologies.
The National Infrastructure for Research and Innovation in Agriculture and Food - (RINA, Research, Innovation, Agriculture) is a consortium of scientific institutes that will upgrade existing scientific and service units and unite them in 5 research complexes in the main thematic directions of the agrarian science - sustainable management of soil resources, efficient use of water and definition of environmental risks and threats; genetic research and plant selection; food and beverage research; livestock, fisheries and aquaculture research; agro-information, agro-management and rural development. The goal is to create a modern national research infrastructure for achieving significant scientific and applied results, transfer of knowledge and technology in the field of agriculture, food and natural resource protection and an active partner in the creation of clusters between science, agrarian and processing business.

The national infrastructure also includes the Center for Plant System Biology and Biotechnology including 10 research departments in the field of plant system biology and biotechnology, plant breeding, genomics, molecular biology, metabolomics, bioinformatics.

Bulgaria is participated in European infrastructure under the project "STRENGTHEN RESEARCH AND INNOVATION CAPACITY FOR GRAZING LIVESTOCK MEAT PRODUCTION IN BULGARIA THROUGH ADVANCED KNOWLEDGE TRANSFER” - "GREENANIMO", financed by the National Program "European Scientific Networks” with participation of the Faculty of Agriculture and Veterinary Medicine of Trakia University, the French National Institute of Agrarian Sciences and Ecology (INRAE) and the Scottish Agricultural College (SRUC).

Dissemination of information and knowledge and provision of consulting services are carried out primarily by the units of the Ministry of Agriculture and Food. Within the education system, there are specialized units for knowledge transfer, but the services provided are not of a systematic nature. Greater independence in the performance of these functions was achieved through the launch of the LEADER-initiative, although in this case the funding was public. Among the main reasons for this are a) the large number of small farms with severely limited financial resources, resp. opportunities to use similar services on a market basis; and b) the government's desire to maintain its influence on the development of the sector by implementing specific policy measures. The representatives of the private sector with relevant functions are depleted with rather sporadic appearances of large companies that provide services in addition to new and improved products; small independent consulting firms and consultants oriented towards the provision of specialized assistance; non-governmental organizations whose portfolio depends on donor organizations at a certain point and in this sense cannot claim sustainability.

European Digital Innovation Hubs (EDIH) and Digital Innovation Hubs (DIH) are expected to make a significant contribution to the dissemination of information and knowledge. At the national level, out of a total of 17 ECIH applicants, only one is targeted in the agricultural sector - AgroHub. BG "Developing the innovative potential of the agricultural sector in the perspective of "precision agriculture” and supporting the overall digital transformation and development of the South Central Region". Of the remaining Bulgarian candidates for EDIH, although they are directed to other thematic areas than ISIS, they have indicated that they are related to the agricultural sector, a total of 4 hubs of which 2 have been approved, 2 are in the process of approval. These are European Digital Innovation Hub Zagore (candidate), Next-Gen-BioTech Digital Innovation, RIC Digital Future, Trakia Digital Innovation Hub (candidate).

At the European level, following the Strategy for the digitalization of the European economy within the Horizon 2020 program, the SmartAgriHubs project has been selected in agriculture, in which the Bulgarian AgroHub.BG also participates.

In 2022, AgroDigiRise was created, which builds on the existing AgroHub.BG and was approved for the EDIH of the South Central Region of Bulgaria. Its main objective is to support the region - SMEs and in particular the food industry.
sector - in its digital and green transformation by providing an integrated portfolio of services targeting the identified needs; connecting fragmented ecosystems of various digital solution providers and end-users with academia and the public sector with increasing competitiveness and the green transition. To better support the ecosystem, AgroDigiRise aims to expand its services and capacity by building a National Demonstration Center (NDC) and a network of Demo Points (DP) in other agriculturally relevant regions across the country as the needs are similar. This, combined with the laboratories and technology provided by partners, will provide the necessary infrastructure to support precision agriculture. The ultimate goal is to create a network of an active and complex ecosystem of stakeholders interacting with each other to achieve common goals.

EIT Food is the leading European food innovation initiative working for a more sustainable, healthy and reliable food system. EIT Food is a pan-European consortium focusing on entrepreneurship and innovation in the food sector. The members of the EIT Food community are leading organizations in the international food field: more than 50 partners from companies, research centers and universities in 13 countries. This is the largest public-private innovation partnership focused on the agricultural and food sector, to create an EIT Food Hub in Bulgaria, through participation in the EIT Regional Innovation Scheme (EIT RIS). The EIT RIS is a structured scheme to support the integration of the knowledge triangle (education, research, business) and increase innovation capacity in regions in Europe that do not yet directly benefit from the EIT and its programmes.

At the beginning of 2021, with the aim of supporting business creation activities and the start-up ecosystem in the agri-food sector, a consortium was created between the Agricultural University-Plovdiv and Cleantech Bulgaria OOD with the support of the Sofia University "St. Kliment Ohridski". The consortium was established within the framework of an international project of the European Institute for Innovation and Technology in Food (EIT Food) to act as the EIT Food Hub for Bulgaria in the period 2021-2023. The consortium will act as an innovation network supporting activities to create business and the start-up ecosystem in the agri-food sector, representing different actors in the knowledge triangle (education, research, business). The hub is envisioned to act as a catalyst for partnerships to increase uptake of knowledge and skills by players and stakeholders in the food industry sector, facilitate the participation of students, researchers, entrepreneurs, start-ups, industry representatives and experts in the programmes of EIT Food and initiatives at the European level, creating conditions to support the development of start-up companies in the food industry, transfer of scientific knowledge and innovative technologies and joint participation in national and international programs and projects.

The application of new technologies is determined by the end-users of innovative technologies in agriculture, family farms that produce products primarily to satisfy their own needs, making up about 80-90% of all structures in the sector; family farms, whose production is mainly market-oriented while also satisfying their own needs, about 15-20%; large farms (no more than 3-5%) with significant resources (cultivable area, machinery, finance, technology), specialized in the production of certain final products and fully integrated with national/international markets. Within Horizon Europe, according to the priority "Food, bioeconomy, natural resources, agriculture and environment", only 5 Bulgarian MPS participate - Pensoft Publishers (3), Denkstatt Bulgaria OOD, Okis OOD, Association of local initiative groups Troyan, Apriltsi, Ugarchin, Tech Tour Global, but this activity is extremely low for the sector as a whole.

Although the food industry sector is a major economic force, many farmers face difficulties in starting modernization due to insufficient information about digital technologies and their possibilities, lack of digital skills and knowledge necessary for the implementation process, difficult access to technological expertise and investments (Agricultural Academy, Institute for agrarian economy, 2020) to contribute to the preparation of the CAP Strategic Plan 2021-2027).
This leads to low investment activity, followed by difficult penetration of modernization and weak implementation of modern technologies and innovations.

As a result of the slow and difficult modernization in the sector, problems related to inefficient production efficiency and the quality of human potential are clearly emerging. This reduces the competitiveness of farmers and limits their opportunities for sustainable business development, which has a serious impact on the entire agri-food chain and the local economy. However, the need for digitization in the country - and in particular in the agricultural sector - is recognized and benefits are seen in increasing the efficiency of processes and services, reducing costs, better planning and management, increasing productivity, collecting and analysing data. But there is still a lack of a unified state policy for modernization, as well as overall support in this process.

The unmodernised agricultural sector also has a negative impact on nature and the environment, in particular in terms of resource wastage (water due to an unmodernised irrigation system), excessive use of fertilizers, groundwater pollution with nitrates, and high average nitrogen rate per unit area (Popov A., Stoilov I., Vodenska M. and team, 2020).

CONCLUSION

A comprehensive assessment of the innovation ecosystem at the national and regional level in the agricultural sector has not been done due to a lack of sufficient official information and statistical data on its state and development, as well as due to the difficult to measure relationships between the participants, which are dynamic and the system itself open.

The analysis of the state, the potential for development and the intra-systemic interaction between the units of the sectoral innovation ecosystem of the agricultural sector contrasts the following potential opportunities and challenges.

In the agricultural sector, there is a large fragmentation of cultivated land. The country is dominated by small producers (Mishev P., Atanasov A. et al., 2009), a large number of small fragmented farms without sufficient capacity, are characterized by low-skilled personnel, low innovation culture, lack of interaction. Uneven development of agricultural sub-sectors, leading to deterioration of production results, weak interaction between sub-sectors and inefficient use of land and other resources.

In terms of the level of interaction, including: institutional (AA is a secondary allocator of budget credits within the Ministry of Agriculture and Food); functionally (AA offers training for PhD students, training and consulting services in relation to business; universities carry out fundamental research) there is a formal basis of interaction, which, however, does not lead to acceleration and facilitation of the process of implementation of new technological solutions along the chain of production of final products agribusiness products. The connections between universities and scientific institutes, scientific institutes – National Agricultural Advisory Service (NAAS), NAAS and agricultural producers and NGOs, private companies and consultants have been assessed as highly effective. The connections between individual universities, universities - agricultural producers, private companies and consulates are low efficiency; scientific institutes with agricultural producers, private companies and consultants; NAAS with private companies and consultants; of the
associations of producers between them and with private companies and consulates as well as between the agricultural producers themselves.

A high degree of geographical decentralization of research and university units located in the areas of application of the relevant knowledge/services. The decentralization of the research activity of the AA in 25 regional units allows scientific coverage of the territory of the entire country.

Practical-applied oriented research activity, both within the framework of AA and HEIs research projects and service activities bring the results of scientific activity as close as possible to the problems of agricultural holdings, solved on their basis. However, the implementers are the least ready in terms of financial capabilities, scale and competences to implement the results of scientific developments.

Effective mechanisms for the rapid application of scientific achievements in practice - highly productive varieties and new breeds of animals, complex technologies for soil treatment and production of agricultural products - have not been created. Medium and small farms are not informed about the possibilities for joint activity with the institutes of the AA. Low levels of engagement/cooperation/interaction between farmers and public intermediary structures, largely due to lack of vision and strategy in service delivery; lack of resources (financial and administrative capacity); a standard approach to the provision of services, inconsistent with the specific needs of the persons/farms to which they are directed. A large number of industry associations. Absent or weakly developed cluster structure.

Lack of strategic vision, understanding of the importance and ineffective use of intellectual property. Lack of up-to-date, detailed and systematized information. Data on registered patents, on the one hand, show relatively high activity among AA and BAS, limited by HEIs and highly selective by the private sector.

Limited investment in new technology, innovation and research. Scarcity and low quality of raw materials. Lack of cost-effective technologies and equipment. A study from 2019 dedicated to the effectiveness and development factors of the system for sharing knowledge, innovation and digitalization in agriculture (AKIS) (Bashev H., Mihailova M., 2019) confirms empirically, identified the main features of the Bulgarian innovation ecosystem in the agricultural sector. Low level of public costs and investments for digitization in the agrarian sphere, for agrarian research and for the implementation of agrarian innovations and for agrarian education and training. Scientific institutes and universities stand out as the most active and significant for the development of new products, methods, technologies, varieties and information. Agricultural advisory services lead for consultation and advice, while digital services stand out for universities, media and the internet.

The private companies and organizations, producers' organizations and NGOs are defined as having the highest financial security. The assessment of financial security mainly of scientific institutes and stations and to a lesser extent of universities is unsatisfactory. There is a high potential for agrarian research and consultation in the main participants in the AKIS - especially in the universities and scientific institutes.

There is an imbalance and a different degree of efficiency regarding the degree of use of advice and implementation of innovations in the sector. The biggest innovators are legal entities of various types, followed
by commercial companies. There is also a large imbalance in terms of the size of farms and holdings, as innovative, applying new technologies and digital solutions, precision agriculture and automation mainly large farms and farms. Among the factors for improving the spread of knowledge, innovation and digitalization, consumer demand, product prices, competition and subsidies for new investments, as well as the activity of the National Agricultural Advisory Service (NAAS) stand out.

Need for direct interaction between farmers and hands-on observation of good practices/results and profitability to foster motivation and willingness to expand and transfer knowledge into practice. Studies show that most farmers self-identify as innovative, but practice shows other results. This includes the stimulation of an integrated approach - face-to-face contacts on the farm and digital solutions, with web-based information exchange. The participation and commitment of agricultural producers is also a prerequisite for faster dissemination of information. Joining or creating an online knowledge network will help farmers quickly connect with a wide range of partners.

The development of the agricultural sector and the food industry and the creation of their basis of national competitive advantages depends on the innovation activity of the units of the sectoral innovation system. Innovation is the most important factor in increasing productivity and overcoming the sources of social inequality. The development of innovation potential should be based on the implementation of policies/addressing of measures that are relevant to the potential of the units of the innovation ecosystem and the priorities for their development; the orientation of innovation processes to the needs of practice and the possibilities of application, at the same time under conditions of high return and conversely positive impact on the innovation ecosystem as a whole; the creation of intermediate units to act as a natural bridge between the participants in the innovation process, to orientate/translate the newly created knowledge into the language of those who will apply it.


All authors have read and agreed to the published version of the manuscript.


Institutional Review Board Statement: not applicable

Informed Consent Statement: Informed consent was obtained from all the participants involved in the study.
Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgement
The paper was supported by research project "Innovation Potential of Sectoral Innovation Systems", financed by the "Scientific Research" Fund at Sofia University "St. Kliment Ohridski", 2022

Conflict of interests
The authors declare no conflict of interest.

References


Agricultural Academy, Institute for agrarian economy. (2020).


About the authors

Sonia Mileva

Full Professor at Sofia University “St. Kliment Ohridski”- Faculty of Economics and Business Administration. She holds Doctor of Science in Economics and Business Administration. She holds Doctor of Science in Economics from Sofia University “St. Kliment Ohridski” and PhD degree in Marketing from University of National and World Economy – Sofia.

Her major research interests include sectoral economy, tourism, marketing, strategic development etc. Vice chairman of Bulgarian Chamber for Education, Science and Culture, Editor-in-chief of the journal “Science & Research”. Chair of Scientific committee for Social science at Bulgarian National Science Fund.

ORCID ID: https://orcid.org/0000-0002-5636-874X

Teodora Georgieva

Professor in the field of strategic management of science, technology and innovation at the Faculty of Economics and Business Administration at Sofia University "St. Kliment Ohridski". Senior fellow at the Applied Research and Communications Fund since 2008. As part of the ARC Fund's team, Teodora Georgieva advises on the development and implementation of strategic and program documents at the national, regional and business levels in the field of innovation and technology transfer.

Member of Expert Council on Innovation and the National Innovation Award Jury at ARC Fund. She is the editor and coordinator of the annual report Innovation.bg.

ORCID ID: https://orcid.org/0000-0002-8031-6405