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SKILLING UP THE WESTERN BALKANS AGRI-FOOD SECTOR

Final report

THE EU AGENCY SUPPORTING COUNTRIES TO DEVELOP THROUGH LEARNING

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EXECUTIVE SUMMARY

The ETF "Skilling-up the West Balkans Agri-food Sector" project

In 2022, the European Training Foundation (ETF) launched the *Skilling-up the Western Balkans Agri-food Sector* project. It was designed to strengthen cooperation and enhance joined-up action among stakeholders in the region's agri-food sector.

More specifically, the project sought to:

- identify opportunities to enhance regional cooperation among Western Balkan economies (WB6)[1] as well as collaboration with European Union (EU) member states; and
- strengthen skills development for innovation, productivity, competitiveness, and convergence with agri-food advances in the EU.

As part of the project, a participatory foresight study was conducted using a combination of desk research, natural language processing techniques, and a series of workshops with regional stakeholders. The foresight exercise aimed to identify key drivers of change, emerging skill needs in the selected agri-food sub-sectors sector, and the actions required across the region to enhance productivity and competitiveness – in support to smart specialisation.

A diverse group of stakeholders from the WB6 economies participated in the foresight exercise, including: innovative SMEs involved in digital transformation, sustainability in the agri-food sector, and organic and functional food production; business associations; industry and regional clusters supporting SMEs; vocational education and training (VET) and higher education (HE) institutions involved in skills development and innovation; public authorities (e.g., government bodies and agencies). In addition, peer learning partners from EU Member States provided insights into approaches taken to overcome skills challenges similar to those faced in the WB6 region.

This report presents the results of the cross-country skills foresight exercise. It emphasises the current and emerging technological changes as well as the evolving skills needs of SMEs operating within the agri-food value chain in the WB6 economies.

More specifically, the study focused on two agri-food value chain **sub-sectors** identified by the ETF.

1. **Agri-tech** – covering the application of new technologies and digital tools in agriculture to improve yields. It encompasses a wide range of technologies, including automation, Internet of Things (IoT), biotechnology (e.g., technology that utilises biological systems, living organisms or parts of this to develop or create different products), information monitoring and data analysis.
2. **Organic and functional food** – consisting of two components. First, organic food production that respects natural life cycles without using specific practices or additives (e.g., ionising radiation, artificial fertilisers, herbicides and pesticides, hormones and antibiotics for animal health). Second, the production of functional foods that are highly nutritious foods or food supplements associated with health benefits, such as disease prevention, nutrient deficiency mitigation, or the promotion of proper growth and development.

The main questions explored in this report are the following.

- What are the technological and non-technological drivers of change transforming the agri-food and, in particular, the agri-tech and organic and functional foods sub-sectors?

[1] Albania, Bosnia and Herzegovina, Kosovo*, Montenegro, North-Macedonia and Serbia. *This designation is without prejudice to positions on status and is in line with UNSCR 1244/1944 and the ICJ Opinion on the Kosovo declaration of independence.

- What are the main characteristics and technology trends in agri-food and the two selected sub-sectors in the WB6 economies?
- What are the emerging skills' demand in agri-food and the specific market sub-sectors?
- How well does existing education and training provision – including formal and non-formal training, support to companies and other activities – respond to current and emerging skills needs?

In addition, the report provides a series of recommendations for the two sub-sectors based on the discussions with stakeholders during the foresight workshops.

Opportunities and challenges of the agri-food sector

The twin digital and green transitions have the potential to reshape both the agri-food sector as a whole and, in particular, the agri-tech and organic and functional food sub-sectors. Enhancing the ability to adopt and use new technologies in the WB6 region, such as those associated with Agriculture 4.0, has the potential to transform agri-food into a hi-tech industry where employment is increasingly concentrated in professional and technician roles.

The agri-food sector holds significant potential for future growth, but it faces several challenges. Companies in the agri-tech subsector have reported low demand for agri-tech solutions in the WB6 region as a major obstacle to development. Many companies, farmers, and producers show resistance to adopting new technology, favour traditional farming methods, and require convincing that investment in technology will yield returns. The focus is on investing not only in new machinery and software but also in human resources – developing technicians, engineers, food scientists, and farmers who can advance the agri-tech, organic, and functional food sub-sectors.

A failure to enhance the diffusion of technology may well amplify the scale of future challenges. What might seem manageable today, may well be overwhelming in the future if actions are not taken now. There is a need to avert a future where WB6 producers fail to capture new, higher-value markets while its existing domestic markets come under increasing pressure from imports. Such a future might well mean that the WB6 agri-food sector is poorly placed to address any exigencies posed by climate change.

The findings summarised below outline how the potential of the WB6 agri-tech and organic and functional food sub-sectors could be secured through coordinated actions across the region.

Technological and non-technological drivers of change

Technology is a key driver of change in the agri-food sector. The evidence points to technological advances linked to digital and biotechnologies bringing about change in both products, production processes, and services. Some, such as those related to cell structure and genetic engineering in agri-tech, as well as bioactive agents and probiotics in organic and functional foods, are viewed as particularly significant for the future of the worldwide agri-food sector.

Scientific technological advances are not the only drivers of change reshaping the sector. Agri-food in the WB6 is directly influenced by **climatic events**, affecting the quantity and quality of production, including crops, livestock, and fisheries. Producers are also under pressure to minimise **environmental impacts**, such as those associated with water use, soil degradation due to overuse of chemical fertilisers, and biodiversity loss. The sector's ability to respond to these changes is hindered by limited **public and private investment in research and development** (R&D), leading to missed opportunities for innovation.

In addition, market dynamics are shifting. **Consumer preferences** for healthier, environmentally friendly food products (especially organic and functional food) result in the market being in a state of flux. Producers need to adapt if they are to capture higher-value, sometimes niche markets. Furthermore, **regulatory pressures are increasing as the region prepares for EU membership**, requiring compliance with EU food safety, veterinary, and phytosanitary standards. Lastly, **political instability and international relationship trends**, particularly following the invasion of Ukraine, have had a negative impact on food prices, trade and output across the WB6 region, further complicating the sector's challenges.

Characteristics of technology trends in the two sub-sectors

Digital technologies have the potential to increase agricultural performance by building resilience, raising productivity, and enhancing sustainability. Precision agriculture and optimised processing systems are achievable through the adoption and use of technology such as sensors, IoT, AI-based data analytics, and decision support systems.

Natural language processing (NLP) techniques used in the current research identified a variety of technologies relevant to the **agri-tech sub-sector**. These include **digital technologies** such as wireless network communication, robotics, autonomous vehicles, image capturing devices, global positioning systems (GPS), irrigation control systems, predictive analytics, databases, satellite monitoring, crop monitoring systems, image analytics, energy-saving systems and drones. Various **bio-technologies** were also identified as important to the sub-sector's future. These include: the increased use of cell culture technologies, genetic engineering, biological fertilisers, bactericides, fermentation process, pesticides and plant growth regulators was observed. **Food processing technologies**, such as sensors, food drying, food cutting, vacuum packaging, pasteurisation, food storage and conservation, sterilisation, food cleaning and traceability systems, were also identified as ones central to the sub-sector's future.

For the **organic and functional foods** sub-sector, relevant technologies that are likely to influence its medium-term development included bioactive agents, probiotics, agrochemicals, biological fertilisers, antioxidant agents, biopesticides, biomass production and biological fermentation.

Emerging skill needs

Research has identified several horizontal skills that are essential across the entire agri-food sector. These skill sets are crucial for overcoming existing barriers to the diffusion of new technologies within the agri-food industry, thereby improving its productivity and competitiveness. The key emerging skill needs for the agri-food sector relate to the following: **basic digital and data analytics** (e.g., computer literacy skills; undertaking basic analysis of data) to support the adoption and utilisation of technologies by companies and farmers; **advanced digital skills** (e.g., those related to software and programming, use of AI, analysis of big data, cybersecurity, and mobile computing); **updated agricultural and agronomy skills** to enhance adaptation to climate change; *green skills* to strengthen sustainability and circularity in the sector; **business development skills** (e.g., project management; knowledge of EU and international standards for organic products, packaging, etc.) to increase the long-term viability of companies; and **soft skills or personal attributes** (e.g., communication and presentation skills, foreign languages taking responsibility, being able to work independently, and self-efficacy) to support entry to foreign markets and collaboration with external partners.

The **agri-tech** sub-sector is dependent upon the digital skills mentioned above in relation to the agri-food sector as a whole. Advanced digital skills will need to be allied to those needed to promote plant protection and plant nutrition, the use of biotechnologies, the reduction of plant disease, the adoption of industrial microbiology techniques, and the use of industrial bio-reactors, if the sector is to embody smart agriculture.

In the **organic and functional foods** sector, the key skill needs include those related to: organic agriculture, including aspects related to agronomy and smart agriculture; knowledge of legal standards for organic farming and products; plant growth management; technological know-how; skills to facilitate technology licensing and transfer; and business and project management skills.

Most of these skills are currently in short-supply across the WB6, limiting the sector's ability to capture new, higher-value markets.

Skills supply

The analyses of supply of skills emphasised multiple areas for improvement, especially the need for educational and training systems to meet better the skill demands of businesses. There is significant room for strengthening cooperation between educational and training institutions (both at VET and higher education levels) with businesses to provide a combination of theoretical knowledge and practical skills that learners require when entering the labour market. Co-operation also needs to address how training programmes will combine digital skills with agricultural or food processing ones. It is not just a question of addressing the skill needs of those transitioning from education to work. There is a need to expand the provision of adult training with the support of business intermediary bodies (e.g., chambers of commerce, industry associations, trade organisations, and innovation hubs). If the VET sector is to deliver these types of programmes, there is a need to increase the opportunities for VET teachers to update their skills in line with technological developments outlined.

The importance of strengthening networking activities to persuade employers, on the one side, to invest in skills (and the delivery of those skills) and, on the other, to better understand the returns from investing in upskilling and reskilling, was mentioned by many stakeholders.

The path for the future

Both the agri-tech and the organic and functional food sub-sectors will face competition from other sectors and countries for the skills it will increasingly need in the future. The foresight exercise provided a series of recommendations designed to improve the supply of skills relevant to each sub-sector (see Error! Reference source not found.). In summary, these addressed the following.

1. Building a strong skills ecosystem that promotes collaborative efforts among the stakeholders in relation to both skills development and the diffusion of new technologies.
2. Improving the alignment between education and training systems with the needs of producers by developing multi-disciplinary programmes and updating existing curricula. In doing so, the scale of skill mismatches and skills gaps should be reduced.
3. Incentivising producers' involvement in education and training initiatives to improve the supply of practical skills of new entrants to the sector (e.g. through apprenticeship-type training) and re-skilling / upskilling the existing workforce.

Implementation of the recommendations can benefit from what is seen to work well elsewhere. The report highlights examples of good practices that provide a basis for developing those applicable in the WB6 region. The ETF's *Skilling-up the Western Balkans Agri-food Sector* project has established a strong network of cooperation in the region. This provides a basis for taking forward many of its recommendations.

CHAPTER 1. INTRODUCTION

1.1. Agri-food in the Western Balkans: opportunities and challenges

Western Balkan economies (WB6) have identified agri-food as a priority domain for smart specialisation. The agri-food sector is essential to regional economic stability and social structure. However, agri-food had failed to reach its full potential. Transforming agriculture can drive economic growth, create jobs, and improve rural livelihoods. To achieve this, WB6 must boost agricultural productivity and competitiveness, and enhance conditions for farmers (Joint Research Centre, 2023).

The twin digital and green transitions will have a transformative impact on the agri-food sector, increasing productivity, reducing carbon emissions, and providing healthier, nutritious and more affordable food products. While the adoption of sustainable and advanced farming methods presents significant opportunities, it also poses challenges. On the one hand, these methods could create new employment opportunities and attract labour that might otherwise seek work in other sectors or abroad. On the other hand, farmers and producers, typically small and medium-sized enterprises (SMEs), are often unaware of the market opportunities potentially available to them and, even where they are aware, face difficulties accessing investment capital and lack technological know-how. Additionally, companies working on developing new technologies for the sector experience low demand for them. These issues are not unique to either the WB6 or the agri-food sector.

International commitments to reduce greenhouse gas emissions will have a significant impact on the agri-food sector. Simultaneously, climate change poses an existential threat to traditional farming practices, as changing weather patterns affect crop yields and animal farming. Technological solutions, however, to mitigate these risks also provide opportunities to increase production efficiency and access higher-value segments of the global or European food markets. This creates a potential win-win situation, provided investments are made on a sufficient scale – especially in workforce skills.

1.2. Policy context and objectives of the skills foresight

Policy context

The *Growth Plan for the Western Balkans*, adopted by the European Commission (EC) 2023, aims to boost economic growth and accelerate the socio-economic convergence of WB6 economies with the EU (European Commission, 2023a). It also supports economic integration and alignment with the EU single market, including in the agri-food sector.

Sustainable food systems are at the core of the **European Green Deal (EGD)**. To this end, EC initiatives from July 2023 have sought to encourage resilient and resource-efficient farming and food systems. It includes strategies and regulations to improve soil quality, plants produced by certain new genomic techniques, and measures to reduce food waste. These efforts complement the EGD's "natural resources" pillar and support the path to achieving the EU's long-term objectives of sustainable and inclusive growth. There is also a focus on: food security given climate change, geopolitical challenges, and biodiversity loss; reducing the environmental and climate impact of the EU's food systems; and leading the global transition towards sustainable farming practices (European Commission, 2023b).

The "**Farm to Fork**" strategy, a key part of the EGD, strives to make food systems fair, healthy, and environmentally friendly. It aims to reduce the use of pesticides, fertilisers, and antibiotics, promote organic farming, and ensure food safety while encouraging sustainable practices across the entire food supply chain, from production to consumption (European Commission, 2020).

Achieving the goals of the EGD and the Farm-to-Fork strategy will require those working in the agri-food sector to be suitably skilled. There are various EU-wide initiatives which potentially support the sector to improve its skills base. The **Pact for Skills**, for example, supports public and private organisations to maximise the impact of their investments in upskilling and reskilling. This calls on national, regional and local authorities, companies, social partners, cross-industry and sectoral organisations, education and training providers to enhance collaboration and investment in training for all people of working age in the EU. More specifically, the **Agri-food Pact for Skills Partnership,** established in 2022 by the EC and co-ordinated by Copa-Cogeca (representing agriculture and agro-cooperatives) and FoodDrinkEurope (representing the food industry), addresses the specific skills challenges and opportunities facing the agri-food ecosystem (European Commission, 2024a).

ETF project "Skilling up the Western Balkans agri-food sector: digitalising, greening"

To facilitate skills development, which is essential for implementing smart specialisation strategies in the WB6 region, the European Training Foundation (ETF) initiated the "**Skilling up the Western Balkans agri-food sector: digitalising, greening**" project in 2022.

The initiative focuses on skills development from the perspective of agri-food SMEs. It encourages networking among companies and other stakeholders who work on skills development, supporting innovation, productivity and competitiveness in the sector. Launched to enhance collaborative skills development, it involves a wide range of Western Balkan stakeholders and their European counterparts. The aim is to strengthen joined-up skills development, contribute to the regional ecosystem's development, and to prepare the ecosystem to make the most of the opportunities offered by the EU's sectoral, business support frameworks.

Special attention is given to two sub-sectors: (i) agri-tech, and (ii) organic and functional foods.

Stakeholders from the six WB6 economies – Albania, Bosnia and Herzegovina, Kosovo[2], Montenegro, North Macedonia, and Serbia – have participated in the initiative, including:

- innovative SMEs involved in digital transformation, sustainability in the agri-food sector, and organic and functional food production;
- business associations, industry and regional clusters supporting SMEs;
- VET and Higher Education Institutions (HEIs) involved in skills development and innovation;
- public authorities (e.g., government authorities and agencies).

Launched in 2022, the ETF network 'Skilling up the Western Balkan agri-food sector: digitalising, greening' aims to:

- Enhance skills for innovation, growth, and competitiveness in the agri-food sector.
- Facilitate sector convergence with EU agri-food advancements.
- Identify opportunities for regional and EU cooperation using existing financial instruments like Horizon Europe, Erasmus+, and the Pre-accession Assistance Instrument.

An important contribution to the project was provided by **peer learning partners** from EU Member States, who provided insights into a various approaches taken to overcome similar skills challenges to the ones faced by the WB6 stakeholders, as well as sharing their experience on working with EU funding instruments.

The project facilitated cooperation by providing research on technological changes and corresponding skills needs in three niches: digitalisation solutions, biochemical and microbial products, and organic and functional foods. The research findings are compiled in EU, regional, and country reports. It also

[2] This designation is without prejudice to positions on status and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence.

examined systems of technology transfer, support services for company skills development, and identified gaps and improvement actions, with findings presented in regional and country reports[3].

As part of this initiative, the ETF commissioned a skills foresight study to explore how the twin digital and green transitions will affect skill demand in the WB6 agri-food sector by 2035.

Objectives of the skills foresight study

The foresight study had two main objectives: (i) to carry out a skills foresight exercise focused on the agri-food sector in the WB6 and (ii) to use this foresight process to enhance cooperation between WB6 stakeholders and their EU counterparts. In doing so, the study builds upon two previous ETF reports:

- Identifying technological changes and skills needs in the agri-food sector: Cross-country Western Balkan report (ETF, 2022).
- Analysing the skills dimension of technology transfer in the Western Balkans (ETF, 2023).

The specific objectives of the foresight study are as follows.

- To formulate a vision for skills development in the agri-food sector, with a focus on the agri-tech and organic and functional foods sub-sectors by 2035, identifying:
  - the skills necessary for the development of these sub-sectors;
  - the skills needed for adopting new technologies in the agri-food sector;
  - the actions required to ensure an adequate supply of these skills.
- To facilitate networking among WB6 agri-food stakeholders and with EU member states to:
  - strengthen cooperation among ecosystem actors in the WB6,
  - promote collaboration with EU member state stakeholders.
- To formulate a set of recommendations for stakeholders, including:
  - recommendations addressing current and future skills shortages for various stakeholders, particularly VET and adult learning systems;
  - elaboration of proposals for joint initiatives and projects addressing identified skills gaps in the agri-food sector.

ANNEX 1 **Methodological approach** provides further details on all aspects of the research methodology.

Definition of the sub-sectors considered in the analysis

The study explores the WB6 agri-food sector with a focus on two sub-sectors: (a) agri-tech; and (b) organic and functional foods. The Statistical Classification of Economic Activities in the European Community (NACE rev.2) was used to define the sector. This provides the basis for collating various statistics relating to employment and skills. According to NACE, agri-food consists of:

- NACE Division A: Agriculture, forestry and fishing
  - A.01 – Crop and animal production, hunting and related service activities;
  - A.02 – Forestry and logging;
  - A.03 – Fishing and aquaculture.
- NACE Division C: Manufacturing

[3] All reports developed under the project are available here

- C.10 – Manufacture of food products;
- C.11 – Manufacture of beverages.

Th agri-tech sub-sector includes:

- Manufacture of agricultural and forestry machinery (C28.3);
- Manufacture of machinery for food, beverage, and tobacco processing (C28.9.3);
- Computer programming, consultancy and related activities (J62);
- Information and service activities (J63);
- Research and experimental development on natural sciences and engineering (M72.1).

Unfortunately, it is not possible to define functional and organic foods with reference to NACE.

1.4. Structure of the report

The report summarises the results of the ETF's participative skills foresight exercise. It focuses on how the skill needs of the agri-food sector are likely to change over the period up to 2035, considering, amongst other factors, changes in production patterns and technology use. The report is structured to provide a comprehensive analysis of the sector, focusing on current challenges, emerging opportunities, and the future skills required to drive the sector forward.

CHAPTER 2. **EMERGING PATTERNS OF SKILL DEMAND IN AGRI-FOOD** summarises the current state of the sector, identifies the main drivers of change and highlights emerging skill needs. CHAPTER 3. **AGRI-TECH** and CHAPTER 4. **ORGANIC AND FUNCTIONAL FOOD** provide insights into technologies shaping the future, emerging skill needs, the supply of skills, and skill mismatches of, respectively, the (i) agri-tech and (ii) organic and functional foods sub-sectors. Error! Reference source not found. identifies specific areas requiring attention to stimulate the supply of, and demand for, skills and the recommendations for action to bring this about.

CHAPTER 2. EMERGING PATTERNS OF SKILL DEMAND IN AGRI-FOOD

2.1. Agri-food in the Western Balkans

As shown in Table 1 a **substantial share of the land in WB6 economies is dedicated to agriculture**, ranging from 50 per cent in North Macedonia to 19 per cent in Montenegro. In comparison, 41 per cent of the EU-27 landmass is used for agriculture. Notably, a relatively small share of land is allocated to organic farming. For example, the WB6 country with the largest share of land devoted to organic farming is Montenegro (almost 2 per cent in 2021), which is considerably lower than the 10 per cent found in the EU-27.

Table 1. Agriculture in the West Balkans – key statistics

Country	Agricultural land (% of land area)		Organic land (% of total agricultural land)*		Rural population (% of total population)		Agriculture, forestry, and fishing, value added (% of GDP)	
	2014	2021	2017	2021	2014	2023	2014	2023
Albania	42.9	41.5	0.05	0.1	43.6	35.4	20.0	18.3
Bosnia and Herzegovina	42.1	44.2	0.1	0.1	53.2	49.7	6.0	4.3
Kosovo	N/A	N/A	0.04	0.5	N/A	N/A	8.3	7.8
Montenegro	17.1	19.0	1.2	1.7	34.5	31.5	8.1	5.6
North Macedonia	50.0	50.0	0.2	0.6	42.7	40.5	10.2	7.0
Serbia	40.1	41.4	0.4	0.7	44.4	42.9	7.1	5.2
EU27	41.4	40.8	7.2	9.6	26.3	24.3	1.7	1.7

Source: World Bank database, 2024. * FiBL, 2023.The world of organic agriculture and FiBL 2019. The world of organic agriculture. N/A – Data Not Available

Agriculture, forestry and fishing contribute a significantly higher share of GDP in the WB6 region compared with the EU-27. In 2023, Albania had the highest share (18.3 per cent), followed by Kosovo (7.8 per cent), North Macedonia (7.0 per cent), Montenegro (5.6 per cent), Serbia (5.2 per cent) and Bosnia and Herzegovina (4.3 per cent). In the EU-27, agriculture's share of GDP was 1.7 per cent. The data in Table 1 refers to the agriculture sector. There is also a need to consider food manufacturing. Food manufacturing also accounts for a relatively high share of output in the WB6. In 2020, this was 3.8 per cent in Serbia, 3.2 per cent in North Macedonia, and 2.8 per cent in Bosnia Herzegovina, compared with 2.1 per cent in the EU-27.

In 2023, 24.3 per cent of the EU-27 **population lived in rural areas**, whereas the rural population was notably higher in the WB6: Albania (35.4 per cent), Bosnia and Herzegovina (49.7 per cent), Montenegro (31.5 per cent), North Macedonia (40.5 per cent), and Serbia (42.9 per cent).

The **agri-food sector accounts for a relatively high share of employment in the WB6** compared with the EU-27, as shown in Table 2. While its importance has declined over recent years, the sector remains an important source of employment, especially in rural areas. That said, there are significant labour challenges, not least an ageing workforce, and migration from rural areas to urban areas and other countries.

Table 2. Employment in the agri-food sector

Country	Employment in agriculture as % of Total Employment for 15+ years old[1]		Employment in agriculture of young people (15-24 years) as % of Total employment of young people[1]		Employment in the manufacture of food and beverages as % of total employment[2]	
	2014	2022	2014	2022	2013	2021
Albania	42.3	34.9	47.8	44.0	N/A	N/A
Bosnia and Herzegovina	17.1	16.9	18	10.9	N/A	N/A
Kosovo	5.9*	3.6*	2.6	1.2	N/A	N/A
Montenegro	5.7	7.2	5.8	1.1**	1.9+	2.0***+
North Macedonia	17.9	9.7	27.6	4.5	3.3	3.6**
Serbia	19.9	13.6	22.4	11.6	4.2	3.8
EU 27	5.3[2]	3.7[2]	4.6[2]	3.1[2]	2.4	2.2

Source: 1 ILO estimates 2024. 2 Eurostat database, 2024. * Data for Kosovo 2014 and 2021. Data for Montenegro 2021. *** Data for 2020. + Data only for the manufacturing of food products. N/A – Data Not Available.

The small scale of production for most companies in the region limits their competitiveness and ability to expand into new markets. Domestic markets are relatively small, and the demand for certain products, such as organic and functional foods, remains low. Limited demand for agri-tech products in local markets is influenced by factors such as farmers' awareness of technology benefits, farm size, and the gap in rural-urban digitalisation. More generally, the agri-food sector faces challenges resulting from an ageing workforce and the younger generation's lack of interest in agriculture, exacerbated by the depopulation of rural areas. These trends threaten the availability of skilled labour and the sector’s sustainability and growth.

As new farming and food production processes are introduced, the demand for skills will inevitably shift over the medium term. These changes will not occur in isolation, as WB6 economies will increasingly compete for labour with other sectors (Bartlett & Oruc, 2021). This draws attention to the need to improve and increase the skills supply to the sector. This is less than straightforward, not least because the sector proves to be a relatively unattractive one to younger generations. They perceive the sector as labour-intensive, offering relatively low wages, and limited career prospects (Ryan, 2023). It is not seen as a high-tech sector. The difficulties faced in attracting young people to enter the sector poses challenges to its sustainability and capacity to innovate.

The following sections provide an overview of the drivers of change affecting the agri-food sector over the next decade and the resulting impact on skills demand**. CHAPTER 3. AGRI-TECH** and **CHAPTER 4. ORGANIC AND FUNCTIONAL FOOD** provide more detailed results on the specific skill needs of the agri-tech and organic and functional foods sub-sectors.

2.2. Drivers of employment and skill change in agri-food

The analysis has identified several key drivers that will shape the future development of the sector, particularly in terms of employment and skill needs. There are manifold technological, economic, political, and environmental factors which are likely to shape the future of agriculture in Europe

(European Commission, 2023d). Here, the focus is on those factors that have a major bearing on the demand for skills.

Technology emerges as a transformative driver of change in agriculture, addressing many challenges the sector faces and having cross-cutting implications for other drivers, which are detailed below. The development and deployment of new technologies and digital tools in agriculture have played an essential role in enhancing productivity, reducing detrimental environmental impacts, and improving resource efficiency. Growth areas, such as precision agriculture, use technologies such as sensors, drones, and satellite data to optimise inputs (e.g. the use of water, fertilisers, and pesticides). Similarly, vertical farming enables controlled-environment agriculture, reducing reliance on traditional farmland and conserving water resources. It is apparent, however, that high technology and equipment costs, limited rural broadband connections, data ownership and legal compliance, and digital skill gaps are all challenges which need to be addressed if new technologies are to be widely adopted, particularly for smaller farms (EIT Digital, 2024; Ryan, 2023). Further details about the types of technological change affecting the (i) agri-tech and (b) organic and functional food sectors are provided in **CHAPTER 3. AGRI-TECH** and **CHAPTER 4. ORGANIC AND FUNCTIONAL FOOD**, respectively.

Climate change

Agriculture is both driving climate change and directly affected by it. Extreme weather events, such as droughts and floods, disrupt crop and livestock yields. According to Radovanović et al. (2023b), the WB6 are particularly vulnerable to these kinds of impacts. High temperatures, irregular precipitation, and water scarcity are expected to intensify, making it necessary to adopt resilient crop varieties and new agricultural practices. For example, a shift to crops that can be grown sustainably and the adoption of agricultural practices that can withstand changing weather patterns will be increasingly required in the future (European Union, 2023d). Similarly, consideration needs to be given to the introduction of farming practices to reduce the emissions from rearing livestock. There are indirect effects on employment and skills to consider in relation to the risks that climate change imposes on agriculture. Agricultural insurance, for instance, remains under-developed despite various efforts to improve the situation (World Bank, 2018). To date, WB6 economies have increased cooperation with development partners to mitigate the harmful effects of climate change, to manage water resource risks, to enhance energy efficiency, and to modernise farming infrastructures (Stričević et al., 2019). Increasingly, mitigation grows the demand for specific skills, particularly in project management, sustainability practices, and infrastructure development.

Environmental degradation

Institutions and consumers are increasingly concerned about environmental degradation. This includes finding the means to reduce the use of harmful pesticides and fertilisers, implementing crop rotation and regenerative farming, promoting organic farming, preserving biodiversity, developing sustainable food systems, reducing food waste, and enhancing the capabilities of local farmers (UNDP, 2023). Producers face growing pressure to minimise environmental impacts across the supply chain. In the WB6 region, soil degradation from overuse of chemical fertilisers (Pahalvi et al., 2021) and biodiversity loss, including the decline of pollinators, soil organisms, and natural pest predators (Županić et al., 2021) are some of the environmental changes causing concern. Activities to reduce levels of environmental degradation in the WB6 are supported by policies to promote the circular economy and, with it, the regeneration of nature. This includes awareness campaigns (Regional Cooperation Council, 2021).

Structural changes

The competitiveness of the agri-food sector is influenced by the prevalence of small and medium-sized farms, shaped by structural and historical factors. These farms often have low profitability. However, the number of these smaller farms is decreasing, with larger farms taking their place, which can better leverage economies of scale (Eurostat, 2022; European Commission, 2023d; 2023e). This shift contributes to employment declines in agriculture in some WB6 economies (Serbia, North Macedonia, Bosnia and Herzegovina, and Montenegro), mirroring trends seen in EU countries. Conversely, agricultural income in the EU has shown a steady increase from 2009 to 2022 (Eurostat, 2024). Additionally, advocacy for fair labour practices in agriculture is on the rise, potentially leading to higher wages for those in the sector.

Farm size is just one factor affecting competitiveness. Trade agreements with the EU and the Central European Free Trade Agreement have opened global supply chains, impacting the competitiveness of WB6 agri-food producers (Matkovski et al., 2022).

Investment, both local and foreign, is crucial in shaping the agri-food sector. It bolsters business growth and drives innovations towards greener production methods. However, the region's low levels of public and private research and development (R&D) funding limit its innovation potential (Radovanovic et al., 2022).

Consumer preferences

Market dynamics in the agri-food sector are increasingly influenced by evolving consumer behaviour, which affects both product demand and the methods of production. One prominent example is the growing demand for organic foods. Globally, the market value for organic products increased from 18 billion USD in 2000 to 177 billion in 2023 (Statista, 2024a) and is projected to reach 530 billion USD by 2032 (Fortune Business Insights, 2024a). Although currently, 2.8 per cent of global consumers eat mainly or exclusively organic food, the share is much higher in European countries. In Austria, for instance, 12 per cent of consumers eat mainly or exclusively organic food, with similar percentages in Austria and Switzerland (Statista, 2024b). The increase in demand has led to a growth in the amount of land farmed using organic-compliant methods. In Italy, for example, 19 per cent of agricultural land is dedicated to organic farming. And Italy's organic exports have grown by +866% over the past 15 years (Nomisma, 2023). An increase in farmland dedicated to organic farming has been also registered in the WB6 economies, as revealed in **Table 1**, though it remains below the levels recorded in the EU. The shift to organic farming brings with it specific skill needs, such as expertise in biological pest control, irrigation methods, and animal husbandry.

Ongoing shifts in consumer preferences are also creating new niche markets and job opportunities. In the EU, food consumption is shifting from animal to plant proteins. This reflects, in part, Europeans' interest in healthy eating (European Commission, 2024b). According to Radovanović et al. (2023b), the WB6 is transitioning from being an importer of agricultural products to becoming an exporter of high-value products, such as enriched or fortified nutraceutical foods. The global market for nutraceutical foods was estimated to be 420 billion USD in 2023, with an annual average percentage growth of nearly 10% a year projected over the period 2024 to 2032 (Fortune Business Insight, 2024b). Foods that satisfy special dietary needs are also expected to increase. For example, the market for gluten-free products is expected to double by 2032 across the globe (Statista 2024c). Locally sourced and traditional products are also gaining importance in the WB6 market.

In terms of production processes, increasing consumer awareness and demand for higher-quality, healthier, and safer food products are driving the need for transparent labelling and production techniques that ensure full traceability of food. This, in turn, requires the acquisition of new technologies and related skills.

Policies, regulations and EU integration

National policies and regulations play a significant role in transforming the agri-food sector. They serve as enablers, facilitating the implementation of various initiatives. Since 2013, all WB6 economies have adopted new strategies for agriculture and rural development. While the medium- and long-term agricultural policy objectives vary by country, they generally focus on three key areas: (1) enhancing farm viability and the competitiveness of the agri-food sector; (2) sustainable management of natural resources and mitigation of climate change effects; and (3) improving quality of life and fostering balanced territorial and economic development in rural areas.

In recent years, policy changes have included shifting from direct payment schemes to area-based payments and revising incentives and support strategies to strengthen rural development (JRC, 2017). More recently, attention has turned to increasing sustainability and promoting digitalisation (Stojcheska, 2024), aspects that might provide an impetus for the further development of agri-tech initiatives.

The European integration process has had a significant impact on the WB6 agri-food sector, with increasing trade of products and shifting trade orientations. The integration process requires also aligning national regulations with the EU standards and practices. For example, implementation of sanitary and phytosanitary measures (SPS) regulations helps modernise the WB6 agri-food sector and align it with EU legislation on food safety, veterinary practices, and phytosanitary standards (European Commission, 2019). Regulations for the organic agriculture set up new rules on organic production and labelling of organic products (European Commission, 2022a) and standards governing the approval of biological pesticides (European Commission, 2022b).

However, companies in the WB6 need support to improve their competitiveness, adapt their processes and adopt innovative practices, as well as upskill their workforce to comply with EU rules and standards. The EU-supported IPARD programme aids agri-food sector development in the Western Balkans and provides over 500 million euros for rural development in WB6 for the period 2021-2027.

Its objectives are to:

- Enhance competitiveness by aligning with EU standards and improving farm efficiency and sustainability.
- Promote business growth, employment in rural areas, and attract young farmers.
- Mitigate climate change, manage resources sustainably, and protect the environment.
- Boost community development, social capital, and modern public administration in rural areas.

Although the EU's IPARD III includes 13 measures, none of the countries opted for enhancing occupational skills in agriculture (European Commission, 2024).

National policies adopted also approaches examined in the EU countries, such as smart specialisation strategies (JRC, 2023) and the LEADER approach[4] (SWG, 2018). Both methodologies highlight the growing need for a skilled workforce, reflecting the broader transformation of the agri-food sector as it adopts technological innovations and environmentally friendly practices (World Bank Group, 2020).

Political tensions and international relationships trends

Global geopolitical dynamics and relationships with neighbouring countries have an important impact on the economies in the WB6. An example of such interconnection is related to Russia's invasion of Ukraine: while the long-term effects remain uncertain, this event significantly influences the agri-food sector, both worldwide and at the regional level, given that Ukraine is one of the world's major producers of wheat. In the WB6, the immediate effects have included food shortages and rising prices (Brankov et al., 2022), as well as trade disruptions resulting in higher prices and reduced market access (Glauben, 2022). Inflation peaked in all WB6 economies in 2022, but governmental interventions and EU support improved the situation in 2023 (OECD, 2024). While disruptions in agricultural supply were critical, the longer-term challenges arise from rising in energy costs (in particular, of natural gas), disruptions in fertiliser supplies (previously sourced from Russia), and trade restrictions, all of which have placed further pressures on the sector (Smart Balkans Project, 2024). Indirect consequences also resulted from the EU's sizable economic slowdown in 2023, with

[4] The LEADER approach was developed to address the challenges faced by rural regions in Europe that were inadequately solved by traditional top-down policies. This is based on seven specific features: bottom-up approach, area-based approach, local partnership, an integrated and multi-sectoral strategy, networking, innovation and cooperation. More details: https://ec.europa.eu/enrd/leader-clld/leader-toolkit/leaderclld-explained_en.html

economic growth falling from 3.6 per cent in 2022 to an estimated 0.6 per cent in 2023. The ripple effects of this were felt in the WB6, where trade, investment, and business confidence fell. In particular, the trade implications are particularly important for the WB6, given the openness of their markets (World Bank Group, 2024a). Despite these challenges, the WB6 economies continued to grow, albeit at a slower pace than in the past. Growth rates dropped from 7.9 per cent in 2021 to 3.4 per cent in 2022, and 2.6 per cent 2023 (OECD, 2024).

Another consequence that may have long lasting effects on the labour market is that the conflict has prompted many Russians and Ukrainians to migrate to the Western Balkans. For instance, in Serbia, the war has contributed to the three-fold increase observed in temporary foreign workers, with the economy hosting an estimated 150,000 Russian migrants as of February 2024 (OECD, 2024). At the same time, the war in Ukraine has intensified the EU's focus on food security, leading to broader engagement and collaboration with the WB6 on agricultural issues, including the EGD and other sustainability initiatives (ARC2020, 2023). These developments are likely to have enduring consequences beyond the current crisis.

2.3. Emerging skill needs in the agri-food sector

The research identified several horizontal skills clusters that are applicable across the entire agri-food sector. These skill sets are crucial for overcoming existing barriers to the diffusion of new technologies within the agri-food industry, thereby improving its productivity and competitiveness. The identified skill clusters are:

- digital and data analytics skills
- agriculture skills,
- smart agriculture and skills to facilitate technology adoption,
- green skills
- business development and soft skills.

Each of the skills clusters is describe briefly below.

The report provides also more detailed analysis of skills specific to two subsectors in sections **3.3. Emerging skills needs and skill gaps** (agri-tech) and section **4.3. Emerging skills needs and skill gaps** (and organic and functional food).

Digital and data analytics skills

Digital and data analytics are predicted to be of increasing importance. Basic digital and data analysis skills (e.g., computer literacy skills related with undertaking relatively basic analysis of data data) are required to adopt new technologies by companies and farmers. More complex skills (e.g., software and programming skills, AI, big data, cybersecurity, and mobile computing) are becoming increasingly relevant for emerging agri-tech businesses supplying digital solutions in the WB6 region.

It is important to consider the varying levels at which training is required. For instance, while individuals with lower levels of educational attainment will require support for acquiring basic digital skills, proficiency in skills supporting digital transformation and the development of new technologies will be more relevant for those with higher levels of attainment. Therefore, skills supply will be needed both at VET and HE levels.

Agriculture skills

Agriculture skills encompass a wide range of abilities needed to effectively manage and operate a farm. Example of agriculture skills include crop management, soil science, animal husbandry, irrigation management, pest and disease control, farm machinery operations. The content of agriculture skills may change in time. For example, climate modifications may trigger the emergence of new diseases and growing of crops that are more resilient to them. It will require also updated plant protection and plant nutrition knowledge and skills. The need to update agricultural and agronomy skill sets are seen as particularly important.

Smart agriculture and skills to facilitate technology adoption and use

The increasing need for smart agriculture skills was observed throughout the research process. This is relevant for improving productivity by understanding changes and variations in the performance of production and farming processes. It requires the integration of traditional agricultural and agronomy skills, along with food science ones, with the digital and analytical skills discussed above, which will lead to more efficient, sustainable and productive agricultural outcomes. In this context, persuading farmers and food companies about the benefits of smart agriculture (and the need to obtain the associated skills) is all important for the WB6 region.

To fully harness agri-food potential across the WB6 region, there is a need to enhance knowledge about technology transfer to companies by improving access to technological advances, smart-tech and biotech solutions, and sustainable farming practices. Farmers and companies will increasingly need skills to use and improve outputs with the support of new technological tools. To this end, increased cooperation between research and development centres and companies /farmers is required to ensure positive spillovers of technological transfer and equip the workforce with the skills needed to adopt and use innovations and new technologies. To some extent, the issues identified are not unique to the WB6 ’s agri-food sector. Therefore, strengthening the knowledge-sharing mechanism and facilitating the exchange of practices and mutual learning with peer partners in the EU should be pursued.

Green skills (comprising sustainability and circularity)

The green transition and the structural changes accompanying it emphasise the need to acquire skills related to sustainability. These skills are important for promoting awareness and implementing practices that support sustainable production processes (Ribeiro et al., 2023). Equipping the workforce with such skills plays an essential role in mitigating the impacts of climate change, facilitating the reuse and recycling of resources and materials, and promoting the adoption of renewable sources. Sustainability skills encompass a broad spectrum of knowledge and competencies required to address environmental challenges effectively – these include agricultural and agronomy skills along with food science ones. Skills related to food science are also becoming increasingly necessary for the design of novel food products that are aligned with the need to enhance sustainability. These are often high-level skills that one might expect to be provided primarily in the higher education system.

Business development and soft skills

Business development skills are relevant to enhance the competitiveness and productivity in agri-food and to increase the long-term viability of agribusinesses (i.e. businesses in to the entire agriculture value chain) in the sector across the WB6, but also to ensure their access to new markets. This includes aspects such as business and management skills (e.g. financial literacy, marketing, and planning), as well as enhanced knowledge regarding various standards and legal frameworks both in the EU and nationally. A further set of soft skills emerged as essential for the workforce in the WB6. This includes communication and presentation skills, as well as knowledge of foreign languages (to support entrance into foreign markets and collaboration with foreign partners). Soft skills or personal attributes, such as taking responsibility, being able to work independently, and self-efficacy, were highlighted as important.

CHAPTER 3. AGRI-TECH

Agri-tech includes manufacturing, biotech and digital-based technology companies creating novel solutions for the agriculture sector to improve yield, efficiency, profitability, sustainability, reliability, quality, or add value. This chapter provides insights into the technologies shaping the future of the agri-tech sub-sector, the skill needs they give rise, and the resulting skills mismatched. The section is based on a quantitative analysis of patent data to identify emerging technologies and the skills associated with the use of those technologies. Based on the workshop discussions with stakeholders in the region, consideration is given to how skill mismatches can be reduced so that the sector is better placed to introduce the new technologies that will ensure the agri-tech sector is a globally competitive one.

3.1. The strategic importance of agri-tech in the WB6

The agri-tech sub-sector comprises the application of new technologies to farming and encompasses the use of digital, biochemical, and microbial technologies for agri-food production and processing. Companies active in agri-tech focus on improving productivity /yields and sustainability of production by developing and applying advanced technological tools such as AI, IoT, sensors, agricultural robots, and digital platforms. It is a sector with substantial potential for growth given the importance attached to introducing more sustainable farming practices which depend heavily upon, for example, precision agriculture (EIT Digital, 2024; McKinsey, 2023).

At the EU level, the Farm to Fork Strategy has guided the transformation of European food systems towards the production of affordable, healthy and environmentally friendly foodstuffs (European Commission, 2020). The role of technology in realising this goal is evident from the levels of support provided through programmes such as Horizon Europe to develop new technologies linked to precision farming, sustainable agriculture, and efficient food production systems (European Commission, 2023c). Similarly, WB6 economies have placed a strategic importance on developing their agri-tech sector, as evidenced by their smart specialisation strategies and other national initiatives listed below.

- The Smart Specialisation Strategy of **Serbia** 2020-2027 recognises innovative food production practices as a priority for future economic growth and innovation[5].
- The draft Smart Specialisation Strategy of **North Macedonia** 2023-2027 identifies the development of smart agriculture and food with higher added value as a strategic priority for the country[6]. In addition, the Strategy for Agricultural and Rural Development 2021-2027 highlights the development of precision agriculture and the use of digital solutions to reduce administrative burdens and increase educational opportunities for agricultural workers[7].
- In **Kosovo**, the Strategy for Agriculture and Rural Development 2022-2028 recognises digitalisation in the agri-food sector as a means for increasing competitiveness and improving the efficiency and sustainability of farm production[8].

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[5] Government of the Republic of Serbia (2020). Smart Specialisation Strategy of the Republic of Serbia 2020-2027. Available at: https://pametnaspecijalizacija.mpn.gov.rs/wp-content/uploads/2021/06/Strategija-pametne-specijalizacije_EN_WEB.pdf.

[6] Draft Smart Specialisation Strategy of the Republic of North Macedonia S3 – MK 2023 – 2027, November 2023, Available at: https://mon.gov.mk/stored/document/Draft%20S3%20MK.pdf

[7] IPARD North Macedonia (2021). National Strategy for Agricultural and Rural Development 2021-2027. Available at: https://ipard.gov.mk/wp-content/uploads/2023/07/IPARD-PROGRAMME-2021_2027-I-st-modification-ENG.pdf

[8] Ministry of Agriculture, Forestry and Rural Development of Kosovo (2021). Strategy for Agriculture and Rural Development 2022-2028. Available at: https://kryeministri.rks-gov.net/wp-content/uploads/2023/01/STRATEGJIA-2022-2028-FINAL-ENG-Web-Noprint-final-PDF.pdf.

- The Economic Reform Programme 2024-2026 of **Bosnia and Herzegovina** envisages diverse actions to foster digitisation in agriculture, such as maintaining the Agricultural Market Information System and upgrading agricultural registers as well as a website for "disaster recovery"[9].
- The Smart Specialisation Strategy 2019 -2024 of **Montenegro** places sustainable agriculture and food value chain among its priorities[10].
- The agriculture sector was identified as a priority area in the process of developing the Smart Specialisation Strategy in **Albania**[11]**.**

Even if all WB6 economies recognise the potential and importance of agri-tech, this does not necessarily translate into economic activity. According to the ETF, the agri-tech sector in the WB6 is sparsely developed (ETF, 2022). There are, however, the seeds of growth. For example, there are companies producing advanced agricultural technologies in Serbia (e.g., providing services involving the Internet of Things, Machine Learning (ML) /Artificial Intelligence (AI), cloud technologies, data-driven management of farms, and robotic systems for agricultural tasks). In North Macedonia, there are companies working in drone construction and operation for agricultural purposes; in Montenegro, there are companies working on the IoT applied to farming; and in Kosovo, companies working on smart solutions for digital monitoring and control systems in farming. While there are examples of smart farming solutions in agriculture being applied in Albania and Bosnia and Herzegovina, there appear to be few, if any, companies specialising in the development and production of these technologies in these two countries.

3.2. Technologies shaping the agri-tech sector

Along with the various drivers of change mentioned in the previous chapter, there is a need to look at the specific technological changes pertinent to the agri-tech sub-sector.

Digital technologies can significantly enhance farm performance by improving sustainability, productivity, and resilience. The adoption and use of technologies such as sensors, the IoT, AI -based data analytics and decision support systems, facilitate more tailored and precise production and farming practices, leading to production optimisation, improved working conditions, strengthened animal welfare, and enhanced business competitiveness (European Commission, 2024c). Some of the challenges facing the introduction of digital and data technologies into agriculture are: (a) a lack of awareness of their potential benefits and a shortage of skills to adopt and use the technologies; (b) high costs of equipment; (c) digital divides resulting from unequal development of reliable and affordable internet coverage; (d) concerns about data privacy and ownership; and (e) a lack of interoperability among various technologies and systems (EIT Digital, 2024; European Commission, 2024c). These aspects are also valid for the food manufacturing sector and the use of new technologies designed to enhance processing capabilities.

In looking more closely analysis was undertaken based on patent data. This provides a privileged data source for studying technological change as they protect business innovations and anticipate market launches of specific products or processes years in advance. Agri-tech is a global industry where new technologies that provide a clear performance or economic advantage quickly capture worldwide interest, regardless of their country of origin. The overall temporal evolution of patent families[12] related

[9] BiH Directorate for Economic Planning (2024) Economic Reform Programme 2024-2026. Available at: http://www.dep.gov.ba/naslovna/Archive.aspx?pageIndex=1&langTag=en-US

[10] The Ministry of Science of Montenegro (2019). Smart Specialisation Strategy of Montenegro 2019-2024. Available at: https://wapi.gov.me/download/ea1d661e-922a-4d42-af8d-ae55bc53988e?version=1.0

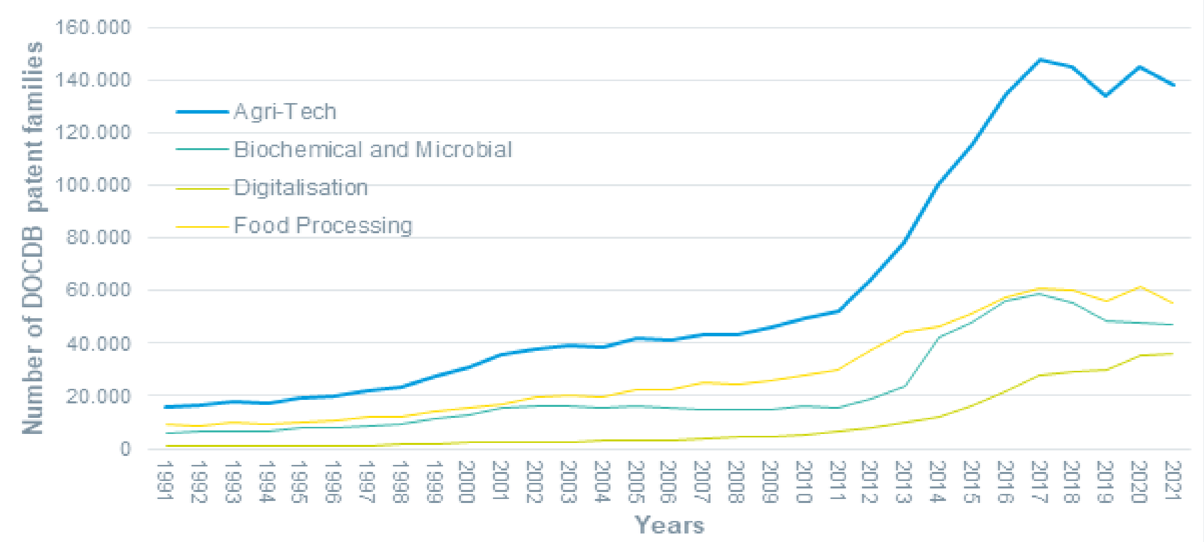
[11] The Smart Specialisation Strategy (S3) in Albania: A New Strategic Approach to Innovation. Available at: https://s3albania.org/about-s3/

[12] Companies usually file patent applications for the same invention in multiple countries to obtain the widest market protection; such a set of documents is called a Patent Family. The main standardised aggregation of worldwide patent families is provided by the European Patent Office in its DOCDB (DOCumentation DataBase) database. It is important to consider only one representative document for each Family in order to avoid duplicating the estimates of relevance for a

to the agri-tech sector, including sub-sectors such as biotech, digitalisation and food processing, are depicted in **Figure 1.** Time series of patent families' filings in the agri-tech sector.

Overall, inventive activity in the agri-tech sub-sector has grown steadily over the years, with a remarkably rapid expansion between 2010 and 2017. After peaking in 2017, the pace of innovation has stabilised globally, but still remains high at around 140,000 inventions every year (worldwide). Examining the individual trends for the three main sub-sectors, it can be seen that the inventive activity for biochemical and microbial production and for food processing are in line with the general trend. At the same time, the filing rate related to digitalisation has continued to grow.

Figure 1. Time series of patent families' filings in the agri-tech sector



Note: Patent applications are generally published no sooner than 18 months after the filing date, a timeframe often called secrecy period. Hence, the number of registered filings of the period 2022-2023 is necessarily under-estimated and was not plotted.
Source: Erre Quadro's own elaboration; raw data taken from the European Patent Office database of worldwide patents.

The key takeaway from the aforementioned trends is the significant global impact of technological advances in the sector. If WB6 economies want to remain competitive in international markets, they need to ensure that their workforce is prepared to adopt and use these new techniques. The patent data analysis identified a total of 66 technologies and technology-related topics that are likely to affect the sector in the future due to either the number of related innovations or their growth trends. The technologies belonging to each of the three sub-sectors (i.e., digitalisation, biotech, and food processing) are listed in the first columns of **Table 3.** Global score and national readiness level for technology-related topics in the Biotech sub-sector,

single innovation. International Patent Families are a reliable and neutral proxy for inventive activity because they provide a degree of control for patent quality and value by only representing inventions deemed important enough by the applicant to seek protection internationally.

Table 4. Global score and national readiness level for technology-related topics in the Digitalisation sub-sector and **Table 5.** Global score and national readiness level for technology-related topics in the Food Processing sub-sector.

The ordering of technologies within each table is based on the **global score indicator**, which is a combination of two factors indicating potential relevance: the number of worldwide inventions and their growth rate. The technologies with a higher global score are more likely to have an economic impact on the sector and on the demand for skills over the short and medium term. They are widely researched innovations with a rapidly growing trend resulting from significant investments in R&D, which will most likely translate into widespread adoption and use in the agri-tech sector. Technologies with a low score (say, lower than 0.5) are still relevant to consider because they could represent relevant technologies under the two possible scenarios.

1. Technologies with significant inventive activity but the level of that activity is slowing down, indicating a technology which is now mainstream but for which skills may still need to be updated (a relatively high number of inventions now, but the growth rate has recently slowed); or

2. Emerging technologies, with relatively few patents at present but which could become more important – possibly even game-changers – over the longer term (a relatively low number of inventions now, but a relatively high growth rate).

Innovation, while global, can vary in its adoption rate from one country to another due to many factors, from the availability of investment capital to the availability of qualified personnel to introduce, maintain and use the technologies. Previous research in the WB6 identified challenges in this regard, such as the limited support provided for technology transfer and the fragile ecosystem that can facilitate the transfer of innovative practices and technologies to companies. It also highlighted the need for long-term interventions to complement the project-based transfer of knowledge and the gap in training and consulting support services for all enterprises (ETF, 2023).

To estimate a country's readiness to introduce new technologies, one can combine patent filings from companies in that country with background information about the existing use of technologies. Non-sporadic inventive activity indicates the presence of companies actively investing in the development of new technologies, but it needs to be borne in mind that not all innovations are patented. Some technologies can be used in a country simply by importing them from abroad (especially in relatively small economies). The **readiness level indicator** gauges the potential impact of innovations relative to each country's specific situation and is calculated as a weighted sum of the number of national patents filed for a given technology, plus the fraction of companies already working with the same technology. The latter component is an estimate based on data collected from different sources[13], and therefore, the resulting value provides more of an indication rather than a quantitative assessment.

In **Table 3.** Global score and national readiness level for technology-related topics in the Biotech sub-sector,

[13] The following company databases have been consulted: Crunchbase (https://www.crunchbase.com/), OpenCorporates (https://opencorporates.com/), Dun & Bradstreet (https://www.dnb.com/); as available data were not always comprehensive, all results have been validated and integrated by national expert. The company component of the readiness level is then computed as the average for the various databases of the fraction of national companies specialized in a given technology over the total of agri-tech companies for the country. If data needed to be integrated by national expert estimates, conventional values have been used. The results for companies are then combined with those from national patents, and the resulting scores are finally divided into four groups: ready, growing, starting, and absent, according to suitable thresholds.

Table 4. Global score and national readiness level for technology-related topics in the Digitalisation sub-sector and **Table 5.** Global score and national readiness level for technology-related topics in the Food Processing sub-sector, the last six columns indicate the readiness level of each WB6 economy to adopt or leverage a given technology, parameterised using the following four qualitative values.

- Ready (°°°): The technology is already prevalent, with a high adoption rate in the country.
- Growing (°°): The technology's adoption rate within the country is steadily increasing.
- Starting (°): The technology's adoption rate within the country is beginning to rise.
- Absent ( ): The technology's adoption rate within the country is relatively low.

The information in **Table 3.** Global score and national readiness level for technology-related topics in the Biotech sub-sector to **Table 5.** Global score and national readiness level for technology-related topics in the Food Processing sub-sector serves two primary purposes. First, it provides a comprehensive overview of ongoing technological developments worldwide, and second, it assesses how the current situation in the WB6 aligns with these developments. For example, all WB6 economies seem to have already adopted most food processing-related technologies, particularly for common operations such as food cleaning, cutting, or pasteurisation. The readiness, however, varies in such areas as robotics, traceability, synthetic food and biodegradability, where they appear less prepared. In digitalisation, the readiness levels differ significantly among countries. For example, Serbia's overall readiness seems higher compared with countries such as Albania and Bosnia-Herzegovina. In the biochemicals and microbial production sub-sectors, the WB6 region appears less prepared, with several technologies, such as cell culture, genetic engineering, molecular biology, nanotechnology, and climate-resilient plants, assessed as nearly absent. Therefore, **Table 3.** Global score and national readiness level for technology-related topics in the Biotech sub-sector, and **Table 5.** Global score and national readiness level for technology-related topics in the Food Processing sub-sector provide a map of the technological gaps and differences between the WB6 and worldwide development, as well as a guide to support the smart specialisation strategies that characterise economies as the ones in the WB6.

The second purpose of the overview in **Table 3.** Global score and national readiness level for technology-related topics in the Biotech sub-sector to **Table 5.** Global score and national readiness level for technology-related topics in the Food Processing sub-sector is more strategic. The readiness level is partly based on the existence of national patents, which in turn imply the existence of professionals who are highly skilled in a certain technical field, so much so that they are able to invent new solutions. Similarly, if many companies have already adopted a given technology, their employees must possess at least a working knowledge of its use. This provides an indication of the extent to which skilled personnel familiar with the key agri-technologies are available in the WB6 region. This type of analysis can inform planning for development trajectories based on the current stock of human resources /skills. For example, if developing certain kind of agricultural production is considered strategically important for a country, the table helps identify technical competence gaps that need to be filled to introduce the most advanced innovations. Consequently, if a technology is already used, but a wider diffusion is desirable, the skilled professionals who already use that technology can be engaged in supporting the development of training programmes for upskilling and reskilling of the workforce. The comparisons revealed in **Table 3.** Global score and national readiness level for technology-related topics in the Biotech sub-sector to **Table 5.** Global score and national readiness level for technology-related topics in the Food Processing sub-sector provide a basis for discussions among the stakeholders in each country related to skill development.

Table 3. Global score and national readiness level for technology-related topics in the Biotech sub-sector

Technologies in Biochemical and Microbial production	Global score	Readiness level in					
		Albania	Bosnia-Herzegovina	Kosovo	Montenegro	North Macedonia	Serbia
Cell Culture	1.000						
Genetic Engineering	0.751					○	○
Biological Fertilisers	0.648			○	○	○	○
Bactericide	0.590	○○○	○○○	○○○	○○○	○○○	○○○
Fermentation Process	0.573	○○		○	○○○	○	○
Pesticides	0.527	○○○	○○○	○○○	○○○	○○○	○○○
Plant Growth Regulators	0.520					○	○
Agro-Bacterium	0.503					○	○
Synthetic Fertilisers	0.501	○○○	○○○	○○○	○○○	○○○	○○○
Bioreactors[14]	0.473						
Molecular Biology	0.471					○	○
Engineered Bacteria	0.465					○	○
Spectrometry	0.443	○○○	○○○	○○○	○○○	○○○	○○○
Fungicides	0.424	○○○	○○○	○○○	○○○	○○○	○○○
Plants Improvement	0.423	○○			○○		○○
Biostimulants	0.390	○○	○○	○○		○○	○○
Nanotechnology	0.387						○
Herbicides	0.373	○○○	○○○	○○○	○○○	○○○	○○○
Climate-Resilient Plants	0.366						
Synthetic Biology	0.359	○○○	○○○	○○○	○○○	○○○	○○○
Analytical Instrumentation	0.340	○○○	○○○	○○○	○○○	○○○	○○○
Bioinformatics	0.323	○	○	○○	○○	○○	○○
Microbial Bioprocessing	0.293					○	○
Data Mining	0.269	○○○	○○○	○○○	○○○	○○○	○○○

[14] There seem to be companies in WB6 working in this area, but no patents were identified with the text mining tools analysis.

Technologies in Biochemical and Microbial production	Global score	Readiness level in					
		Albania	Bosnia-Herzegovina	Kosovo	Montenegro	North Macedonia	Serbia
Phytobiomes	0.192						
Nanoagrochemicals	0.175						°°

Source: Erre Quadro’s own elaboration

Table 4. Global score and national readiness level for technology-related topics in the Digitalisation sub-sector

Technologies in Digitalisation	Global score	Readiness level in					
		Albania	Bosnia-Herzegovina	Kosovo	Montenegro	North Macedonia	Serbia
Wireless Network Communication	1.000	○○○	○○○	○○○	○○○	○○○	○○○
Robotics	0.963						○○
Autonomous Vehicles	0.947						
Image Capturing Devices	0.838	○○	○○	○○	○○	○○	○○○
Global Position System (GPS)	0.719	○○	○○	○○	○○	○○	○○○
Irrigation Control Systems	0.616	○	○	○○	○○	○○○	○○○
Predictive Analytics	0.588	○○○	○○○	○○○	○○○	○○○	○○○
Databases	0.573	○○○	○○○	○○○	○○○	○○○	○○○
Satellite Monitoring	0.566	○	○	○○	○○	○○	○○○
Crop Monitoring Systems	0.551	○	○	○○	○○	○○	○○○
Image Analytics	0.527	○○○	○○○	○○○	○○○	○○○	○○○
Energy Saving Systems	0.524	○	○	○○	○○	○○○	○○○
Drones	0.508	○○○	○○○	○○○	○○○	○○○	○○○
Weather Monitoring	0.491	○	○	○○	○○	○○	○○○
Artificial Intelligence	0.483	○	○	○○	○○	○○○	○○○
Sensors	0.447	○○○	○○○	○○○	○○○	○○○	○○○
Livestock Tracking Systems	0.388	○	○○	○○	○○	○○	○○
Food Traceability Systems	0.365			○	○	○	○
Cybersecurity	0.334	○○	○○	○○	○○	○○	○○○
Cloud Computing	0.239	○○○	○○○	○○○	○○○	○○○	○○○
Wildlife Repelling Systems	0.213	○	○	○	○	○	○

Source: Erre Quadro's own elaboration

Table 5. Global score and national readiness level for technology-related topics in the Food Processing sub-sector

Technologies in Food Processing	Global score	Readiness level in					
		Albania	Bosnia-Herzegovina	Kosovo	Montenegro	North Macedonia	Serbia
Sensors	1.000	○○○	○○○	○○○	○○○	○○○	○○○
Food Drying	0.888	○○○	○○○	○○○	○○○	○○○	○○○
Food Cutting	0.792	○○○	○○○	○○○	○○○	○○○	○○○
Vacuum Packaging	0.787	○○○	○○○	○○○	○○○	○○○	○○○
Pasteurisation	0.720	○○○	○○○	○○○	○○○	○○○	○○○
Food Storage And Conservation	0.718	○○○	○○○	○○○	○○○	○○○	○○○
Sterilisation	0.697	○○○	○○○	○○○	○○○	○○○	○○○
Food Cleaning	0.689	○○○	○○○	○○○	○○○	○○○	○○○
Food Traceability Systems	0.669			○	○	○	○
Robotics	0.642						○
Conveying Means	0.634	○○○	○○○	○○○	○○○	○○○	○○○
Food Waste Management	0.633						
Image Capturing Devices	0.628	○○	○○	○○	○○	○○	○○○
Food Freezing	0.625	○○○	○○○	○○○	○○○	○○○	○○○
Disinfection Treatments	0.553	○○○	○○○	○○○	○○○	○○○	○○○
Data Mining	0.535	○○○	○○○	○○○	○○○	○○○	○○○
Image Analytics	0.534	○○○	○○○	○○○	○○○	○○○	○○○
Food 3D Printing	0.532			○	○	○	○
Ultraviolet Light Treatment	0.480	○○○	○○○	○○○	○○○	○○○	○○○
Blockchain	0.479	○	○	○○	○○	○○	○○○
Biodegradable Packaging	0.419			○	○	○	○
Cultivated Meat	0.418						
Smart Packaging	0.371			○	○	○	○
Homogenisation	0.344	○○○	○○○	○○○	○○○	○○○	○○○
Predictive Maintenance	0.269	○	○	○○	○○	○○	○○

Source: Erre Quadro's own elaboration

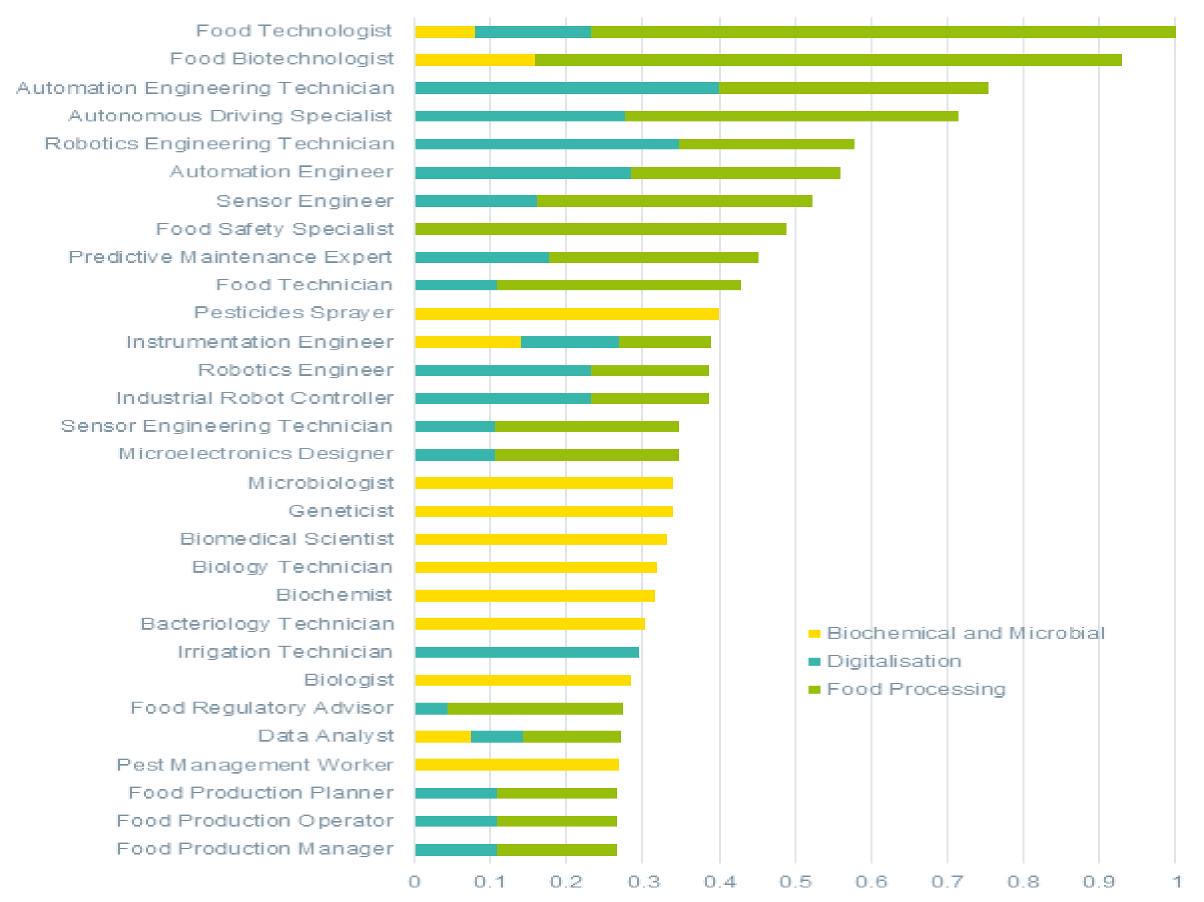
3.3. Emerging skills needs and skill gaps

Identifying emerging skills provides timely and relevant intelligence on priority skills needs and the direction of skills development and helps businesses and educational and training institutions strengthen collaboration with the aim of improving training offers and curricula to prepare workers and job seekers for future jobs, thereby minimising skill gaps. Furthermore, adequately addressing the skills shortages ensures preparedness and continuous functioning at an efficient level, consolidates innovation, and maintains productivity.

In this report, a list of relevant technologies extracted from patent literature was compared using semantic matching algorithms with standardised competencies and occupational profiles listed in the ESCO database. Each occupation in ESCO includes competencies, skills and knowledge considered relevant – either essential or optional – for that occupation. The result is a network where each relevant technology is linked to one or more skills and occupational profiles from ESCO. It is important to underline that the search approach starts with the technology identification, identifies the skills associated with that technology, and finishes with the identification of the occupations where these skills are required. This order makes it possible to maximise the occupation identification recall, enabling the extraction of the occupations related to the technology of interest and the occupations linked to the skills typically associated with the technology of interest.

By applying text mining and ranking procedures, it is possible to rank occupations connected to new technologies and related skills, as shown in Figure 2, resulting in a ranking based on their anticipated future demand. This gives a general idea of which occupations are likely to see increased demand in the near future. Ranking takes into account occupation-skill matches and occupation-technology matches. The ranking values are calculated as the weighted sum of the occupation matches where the weights are derived from the global score of each technology in the different sub-sectors within agri-tech. **Figure 2** ranks the top 30 occupations associated with skills and technologies likely to impact the agri-tech sector in the future. The connections between the food processing and digitalisation sub-sectors appear strong, both in terms of skills and occupations. Many occupations correlate with both sub-sectors, such as food technician, food safety specialist, and sensor engineer. Biochemical and microbial production is identified as a more specialised sub-sector, requiring domain-specific occupations such as bacteriology technician, biochemist, biomedical scientist, geneticist, and microbiologist. Some profiles, such as data analyst or instrumentation engineer, are fully transversal, evident across all sub-sectors, correlating with technologies such as data analysis used in all three areas of agri-tech. The increased demand for people to work in these types of jobs stems from specific technological requirements and from the fact that these needs are shared across multiple parts of the value chain (i.e., food production and processing).

Figure 2. Top 30 ESCO occupations which are likely to see an increase in demand due to technological inputs



Source: Erre Quadro's own elaboration

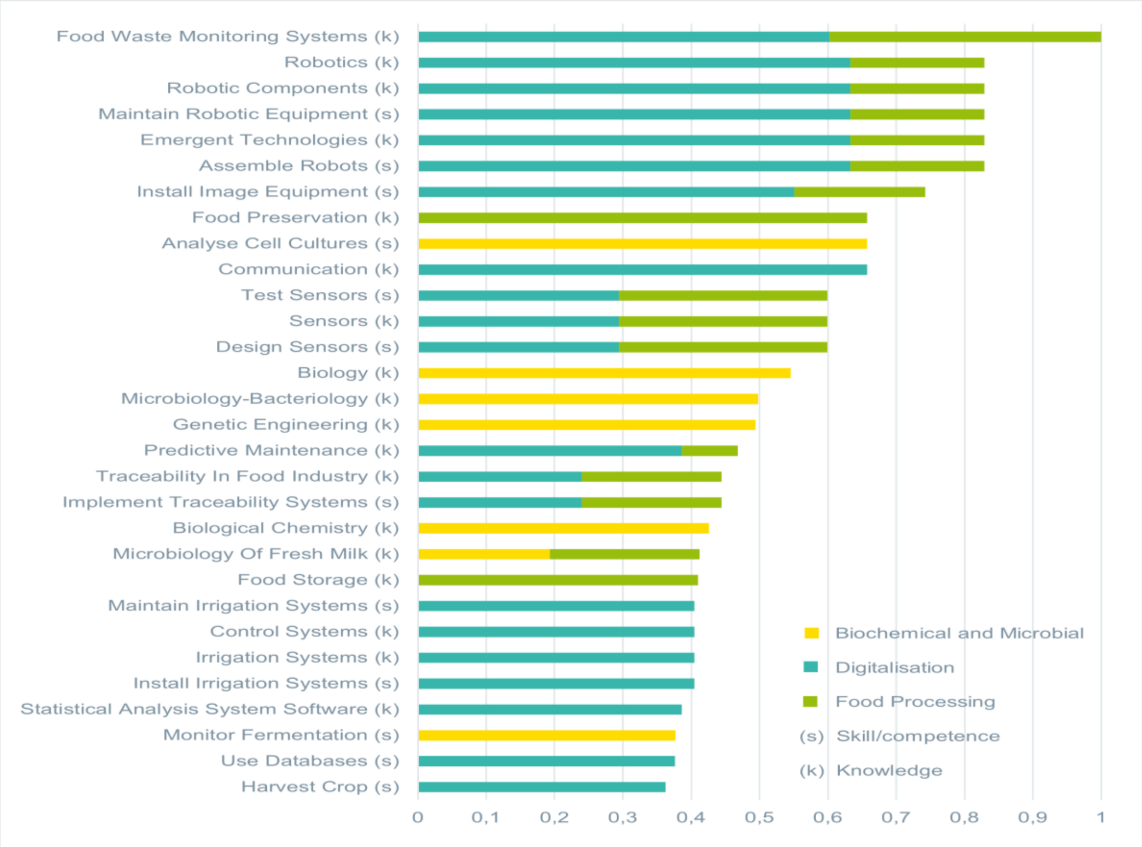
Using a similar method to the previous analysis, it is possible to correlate new technologies with the required skills and rank the identified skills as shown in **Figure 3**.

This ranking indicates which skills are and will be potentially significant for the agri-tech sub-sector based on the technological developments discussed above. Each bar in the chart represents the cumulative relevance levels of the various skills across the three agri-tech sub-sectors. The ranking values are calculated as the weighted sum of the skill-technology matches, where the weights are derived from the global score of each technology in the different sub-sectors. The ranking should be seen not as a quantitative measure but as a qualitative indicator of increasing demand resulting from the introduction of new technologies.

Skills related to robotics and automation are prominent, implying that the demand for such skills will grow in the future. Further, in Figure 3 additional skills clusters related to sensors (e.g., designing sensors, testing sensors, etc.) and irrigation system management (e.g., installing irrigation systems, etc) are evident. In between, a variety of skills are noted, ranging from image detection (installing image equipment) and biology (i.e., biology, microbiology-bacteriology) to maintenance (e.g., maintaining robotic equipment, predictive maintenance, etc.).

Figure 3 also shows that certain skills and competencies are needed in various processes, making them more general and transversal. For example, knowledge of sensors is relevant both for the digitalisation of production and for food processing. The relative importance of such competencies is derived from their applications across multiple sub-sectors.

Figure 3. Top 30 ESCO skills, competencies and knowledge associated with technologies likely to impact upon the agri-tech sector in the future[15].



Source: Erre Quadro's own elaboration

It is important to highlight that for some technologies listed in **Table 3.** Global score and national readiness level for technology-related topics in the Biotech sub-sector, and **Table 5.** Global score and national readiness level for technology-related topics in the Food Processing sub-sector, no corresponding skills were found in the ESCO database (see **Table 6.** List of Agri-Tech technologies for which no correspondent skill was found in ESCO for example). This lack of correlation does not diminish the technology's significance within the sector. Instead, it may result from a delay in ESCO being updated to take into account the latest technological developments. This pattern is particularly evident in the bio-chemical sector, which is underrepresented in ESCO, whereas the digitalisation area appears less affected.

Table 6. List of Agri-Tech technologies for which no correspondent skill was found in ESCO

Sub-sectors	Technologies	ESCO Skills
Biochemical and Microbial production	Bactericide	No match
Biochemical and Microbial production	Bioinformatics	No match
Biochemical and Microbial production	Biostimulants	No match
Biochemical and Microbial production	Nanoagrochemicals	No match

[15] As explained in the main text, the score for each competence /skill /knowledge provided in **Error! Reference source not found.** should not be interpreted as a quantitative measure but as a qualitative indicator of the increasing demand for the same skills due to the introduction of new technologies.

Sub-sectors	Technologies	ESCO Skills
Biochemical and Microbial production	Phytobiomes	No match
Food Processing	Cultivated meat	No match

Source: Erre Quadro's own elaboration

Some technologies relevant to the development of the agri-tech sector are matched with corresponding skills in ESCO, which, at first glance, seem far removed from agri-tech. Some of these skills are typically associated with other sectors. For instance, **Table 7.** Examples of agri-tech technological skill needs belonging to other sectors in ESCO shows an example of the image analytics technology relevant to both food processing and digitalisation in agri-tech. These skills are classified under the visual arts domain. Notwithstanding any limitations related to ESCO, this may suggest the potential for cross-fertilisation between sectors to improve the supply of these skills.

Table 7. Examples of agri-tech technological skill needs belonging to other sectors in ESCO

Technologies (Sub-sectors)	ESCO Skills (Sub-sectors)	ESCO Occupations	Connected to Agri-Tech
Image Analytics (Food Processing, Digitalisation)	Digital image processing (Arts - Audiovisual techniques and media production)	Computer Vision Engineer	Maybe
	Perform image editing (Working with computers)	Picture Editor	No
		Digital media designer	No
		Vlogger	No
		Online Marketer	No
	Analyse Image (Transversal Skills)	Automated Optical Inspection Operator (for printed circuits)	No

Source: Erre Quadro's own elaboration

New technologies are changing the skill sets required by traditional occupations. For example, according to ESCO, an agronomist's role is typically defined narrowly. As indicated in

Table 4. Global score and national readiness level for technology-related topics in the Digitalisation sub-sector and confirmed in previous ETF studies (ETF, 2020; 2021), the future agronomist will need a broader range of knowledge, including that of precision agriculture techniques, such as sensor deployment and data interpretation. These are skills which agronomists will increasingly need to acquire in the future. Similarly, existing skills can be repurposed for new job openings created by the introduction of new technologies in agri-tech (as the example of the image analysis provided above in **Table 7.** Examples of agri-tech technological skill needs belonging to other sectors in ESCO). Additionally, new technologies can create new occupational profiles, such as those required to manage nano agrichemicals or cultivated meat.

3.4. Skills supply to the agri-tech sub-sector

The analyses conducted by ETF in the WB6 region revealed the limited capacity of educational and training institutions to meet the skill demands of agri-tech companies (ETF, 2022). Integrating and using digital technologies in the sector requires education and training programmes and equipment to provide the specialist skills required to introduce, maintain, and use the new technologies. Stakeholders in the WB6 are of the view that there needs to be cooperation between educational and training institutions and companies to provide the combination of theoretical knowledge and practical skills the sector needs. Strengthening skills provisions is also seen as essential to bring about technology transfer.

Vocational education and training

All economies in the WB6 region provide agriculture, food production and ICT study programmes at the VET level. Nevertheless, concerns remain about the effectiveness of these programmes in supplying the practical skills needed to support the growth of companies active in agri-tech. Some of the challenges highlighted in relation to VET provision across the region include:

- slow and limited adaptation of programmes to labour market needs;
- lack of training programmes combining digital skills with agricultural or food processing practices;
- use of outdated technologies that hamper teaching and delivery of practical skills;
- insufficient practical learning opportunities in VET, the emphasis being on providing theoretical knowledge and less on supporting the acquisition of practical skills;
- limited opportunities for VET teachers to update their skills in line with technological innovations in the sector, which, in turn, hampers the delivery of knowledge and information to learners.

Initiatives to overcome these challenges in some of the WB6 economies focus on developing work-based learning at the secondary level to strengthen the provision of skills in line with the agri-food companies' needs. Both Serbia and North Macedonia have adopted work based learning approach at the secondary level, which increases the provision of work-based learning (ETF, 2022). For the most part, collaboration between VET schools and companies in the agri-tech sector is rare. Promising initiatives include some limited cooperation between digitally focused companies and VET institutions (e.g. in Albania and North Macedonia), though these tend to be informal arrangements (ETF, 2022). These collaborations concentrate on areas such as drone use, software for high-precision mapping, and pesticide application robots. These are key areas where the VET system will need to develop capabilities in the future to support the agri-tech sector and its workforce to adapt to technological change.

There is a consensus that tailored, multidisciplinary programmes offering hands-on learning experiences are necessary. These programmes should equip individuals with practical skills and knowledge for utilising a wide range of new technologies.

Higher education

Many of the jobs and skills in the agri-tech sector which are likely to emerge in the future are ones typically associated with higher education. However, it should be noted those skills are usually provided by practically oriented higher education institutions, such as universities of applied science, for example Department of Food Technology at Fulda University of Applied Sciences – Hochschule Fulda, and in many cases require bachelor degree. In WB this type of higher education is underdeveloped.

This is evident from the information provided in **Figure 2** with many occupations in demand requiring higher education level attainment and **Figure 3** which reveals levels of skills and knowledge usually associated with university education. Higher education institutions across the region provide academic programmes in fields such as programming, electronics engineering, mechanical engineering, agriculture, food technology, and agronomy. Enrolment data from some countries (e.g., North Macedonia and Serbia) indicate a decreasing interest in agriculture-related studies and an increase in ICT programmes (ETF, 2022). Enhancing agri-tech development could benefit from a more multidisciplinary approach and increased integration of agricultural and ICT programmes. Currently, agricultural subjects are not integrated into specialised ICT programmes, and agricultural faculties typically provide basic ICT skills, not the specialised ones, which the agri-tech sector will be increasingly dependent upon.

Agri-tech businesses highlighted gaps in the practical skills of university graduates. This was seen to result from curricula not being sufficiently focused on meeting labour market demand (i.e. delivering the types of skills listed in **Figure 3**). By offering specialised degrees and research programmes focused on agri-tech, there is the potential for higher education institutions to develop a critical mass of experts proficient in digital, biochemical, and microbial technologies. The development of these skills, along with the facilitation of technology transfer, is likely to be facilitated through collaboration between higher education institutions, businesses, and research and centres of excellence (e.g., BioSense). It should be also noted that companies often refer to higher education because it is familiar to them. However, in the EU, the profiles they seek are typically developed by universities of applied sciences and higher levels of vocational education and training (VET). In the Western Balkans (WB6), this level of education does not exist. Despite this, the required profiles are those with vocational skills. Here, these skills are sourced from higher education (HE) rather than VET. This was the view of stakeholders participating in the study.

Up- and re-skilling of the existing workforce in the agri-tech sector

Adult learning plays an essential role in facilitating jobseekers' integration and meeting employers' needs. There are, however, few adult learning programmes specific to the skills required in the agri-tech sector (ETF, 2022). To address this, and the shortcomings in VET and higher education, companies, especially start-ups, provide on-the-job training and informal training to enhance the skill levels of new employees. This approach aims to bridge the gap between the specialist skills the sector requires and those available in the labour market. But not all companies are able to provide this support to new recruits or existing employees whose skills need updating.

Nevertheless, informal and non-formal learning and skills development are essential for the agri-tech sector in the WB6 region. Provision of these types of learning opportunities and initiatives creates a dynamic learning environment (ETF, 2022). There is scope to expand the provision of adult training with the support of business intermediary bodies (e.g., chambers of commerce, industry associations, trade organisations, innovation hubs). The example of the Agri-Tech cluster based approach in Ireland, and the BioSense Accelerator Programme in Serbia demonstrate how adult learning opportunities can be effectively delivered (see **Box 3.1**).

Box 3.1. Examples from peer learning partners and WB6 region initiatives

AgriTech Cluster in Ireland

This cluster was developed based on an initiative promoted by the Munster Technological University (MTU). It was funded through Enterprise Ireland's Regional Technology Cluster Fund (RTCF). The AgriTech cluster is part of a growing network of clusters that focus on developing collaboration ecosystems in various industrial sectors and regions of Ireland. It brings together stakeholders representing companies, academic and research organisations, government institutions and community-level organisations. Some of the activities implemented by the AgriTech cluster focus on tackling the skills shortage in the sector, enhancing the attractiveness of jobs in the sector, improving productivity and innovation in agri-food, reducing fragmentation and supporting internationalisation and access to new markets. As part of the cluster, the AgriTech Centre of Excellence helps companies expand their capacities by delivering cutting-edge immersive reality technology and training services.

BioSense Accelerator Programme

In Serbia, the BioSense Institute offers tailored, continuous training in agri-tech, focusing on the IoT, geospatial and remote sensing, mechatronics, drones and robotics, data and software. The BioSense Accelerator, a three-month programme, supports agri-tech start-ups, offering training in business model development, business strategy definition, and comprehensive market and competition analyses.

Source: Foresight workshops

The current foresight study was able to provide networking opportunities – as part of its research design – to explore how reskilling and upskilling can be increased in the WB6. Networking can be a vital preparatory step in persuading employers, and other stakeholders, by providing information on the effective delivery of adult skills learning and the returns from doing so and for building the ecosystems for companies.

3.5. Relevant skills cluster for agri-tech and sources of skill mismatches

The text-mining analysis conducted as part of the current study identified several skill clusters pertinent to the agri-tech sub-sector:

- biotechnology,
- agronomy,
- digital and analytical skills,
- robotics and machinery,
- food processing,
- business, supporting and soft skills.

These skills clusters were further investigated with stakeholders during the foresight workshops. Table 8 provides details on the top three skills clusters identified as most important to the sub-sector's future development (i.e., **digital and analytical skills, agronomy, and biotechnology**). It also provides details about the key, critical skills within the clusters and whether or not these prove difficult to acquire. Further details are provided in ANNEX 2 **Agri-tech skills clusters**.

Table 8. Skills most critical for the agri-tech sub-sector

Skills cluster	Critical skills	Skills considered difficult to acquire	Why skills are difficult to acquire?

Digital and analytical skills	Computer literacy Skills and knowledge to support the adoption of digital technology AI-based data analysis	Skills and knowledge to support the adoption of digital technology	Low awareness: a) that workers need to upskill; and b) the net benefits which adopting certain technologies confer on business
Agronomy skills	Smart agriculture Plant protection and plant nutrition skills Ecology	Prevention of diseases	Need to constantly update knowledge and skills as plant and animal diseases develop rapidly due to climate change and other factors.
Biotechnology skills	Detection of plant diseases Smart technologies for plant disease and protection Industrial microbiology for agrobacterial technologies	Industrial bioreactors	In some WB6 economies, few companies have access to industrial bioreactor technologies.

Source: Background report and discussion in the second foresight workshop

For the **digital and analytical skills cluster**, the critical skills identified were computer literacy skills, the skills and knowledge to support the adoption of digital technology and AI-based data analysis. The skills and knowledge to support the adoption of digital technology were also highlighted as challenging to acquire. This point was emphasised in relation to the skills required to strengthen the diffusion of new technologies in the sector. The challenge was attributed to farmers' limited awareness of the need to enhance their digital knowledge and skills, which was, in turn, linked to their lack of understanding of the benefits that new technologies might confer on their farms. Matters were further complicated by limited information being available on the costs of accessing specific technologies and the improvements these could bring to production processes.

In the case of the **agronomy cluster**, smart agriculture, plant protection and plant nutrition skills, and ecology were identified as critical skills. Smart agriculture skills were seen as essential for improving productivity. Acquiring such skills enables the understanding of data collected from sensors to reveal where there were variations in performance across a range of measures in the production /farming system. The combination of traditional farming integrated with innovative new practices will lead to more efficient, sustainable and productive agricultural outcomes. Persuading farmers of the benefits of smart agriculture (and the need to obtain the associated skills) might be facilitated by hosting workshops where farmers learn to apply smart farming tools or by establishing mentorship programmes. Mobile apps would allow farmers to access agricultural advice, thereby integrating technology into their daily decision-making processes. Additionally, the criticality of plant protection and plant nutrition skills was highlighted as a means of assisting farmers in their activities. Ecology skills were seen as critical in supporting farmers to maintain biodiversity and build resilience given the various environmental changes. Skills related to the prevention of diseases would be challenging to acquire as it requires those working in the sector to constantly update their knowledge, especially so given the impact of climate change and the emergence of new diseases.

For the **biotechnology cluster**, detection of plant diseases, Smart technologies for plant disease and protection, and industrial microbiology for agrobacterial technologies were identified as critical skills for the future. These skills were particularly relevant for enhancing resilience and supporting adaptation to new environmental realities determined by climate change. Skills and knowledge related to industrial bio-reactors were highlighted as difficult to acquire in some WB6 economies, given that only a few companies have access to such technologies.

Previous analyses (ETF, 2022; 2023) conducted in the WB6 region and the discussions during the foresight workshops revealed growing skills mismatches. Some of the key factors highlighted as impeding the supply side from responding to emerging needs and leading to skills shortages were as follows.

- Few opportunities to gain the practical skills required as the curricula and training programmes are not aligned with current and emerging technologies and with the needs of businesses. Also, most educational programmes are not linked with learning experiences in companies and farms. Stakeholders from the WB6 economies indicated that cooperation between educational and training institutions and the private sector remains limited. Additionally, in some WB6 economies the regulatory framework further impedes the capacity of skills providers to respond to changes in the labour market.
- Limited development of multidisciplinary programmes combining knowledge of agriculture with specialised digital and engineering skills such as robotics, IoT, and geospatial technologies, as well as with skills related to business development. It leads companies to perceive graduates as under-qualified in relation to the employment opportunities available. Companies need to compensate for this deficit by providing training, which in turn adds to the cost of doing business and, eroding the competitive advantage of businesses.
- Insufficient number of local experts who can provide specific knowledge and skills related to agri-tech companies. Under-developed IT infrastructures (e.g., limited broadband connection in some areas) limits the capacity of companies to offer smart solutions to gain access to expert knowledge, or develop smart solutions to meet the needs of the agri-tech sector.
- Limited technology uptake and scarcity of support actions to help farmers and companies adopt new technologies. Since the skills needed for the use of new technologies in agricultural holdings are also lacking, this accentuates a vicious cycle that further limits the demand for advanced technological products and skills.

CHAPTER 4. ORGANIC AND FUNCTIONAL FOODS

Organic and functional foods include companies from the entire organic food production process, whereas functional food companies focus on specific health-related benefits, often achieved through added nutrients or modifications. This section provides insights into technologies shaping the future of the **organic and functional foods** sub-sector, emerging skill needs, and details on the supply of skills, and the degree of skills mismatch.

4.1. The strategic importance of organic and functional foods in the WB6 economies

Organic farming, which respects natural biological processes, strictly limits or forbids synthetic enhancers such as artificial fertilisers and various chemical pesticides and insecticides. The processing of organic products adheres to stringent regulations, notably the ban on certain food additives. **Functional foods** (i.e., nutraceuticals) are foods or dietary supplements specifically designed to offer health benefits, including disease prevention, development support, and overall well-being.

The sector is **experiencing significant growth within the EU and globally**, driven by consumer preferences for healthier products, environmental conservation, and sustainability practices (FiBL, 2023).

Key EU initiatives in organic and functional foods, such as the Organic Action Plan part of the Farm to Fork Strategy, are paving the way for the future expansion of the sector. The plan aligns with the EGD's ambition of converting 25 per cent of agricultural land to organic farming by 2030. The EU's initiatives in this area focus on increasing demand and trust in organic products, promoting the transition to organic agriculture, strengthening the organic food value chain, and enhancing the sector's environmental sustainability contributions (European Commission, 2021).

Analysis undertaken by ETF reveals **growing interest across the WB6 in organic and functional foods** (ETF, 2022; 2023). It is not just about fruits and vegetables but also about a wide range of products such as medicinal and aromatic plants, microgreens, and various functional food products. Several SMEs in the region are engaged in producing items such as dried fruits, spelt-based products such as juice, cereals, grits, pasta, and herbal detoxifying powders.

The organic and functional food sub-sector has been identified as strategically important one by policy makers. In Serbia, for instance, the focus is on enhancing the food production chain and facilitating the development of processed organic products and functional foods.[16] In North Macedonia, the aim is to support the expansion of organic farming and the production of fresh and processed organic products.[17] Montenegro is strengthening the value chain of organic production,[18]; and in Kosovo the expansion of organic farming and the establishment of a functional accreditation system for organic farming inspections and certification are prioritised.[19]

While the outlook for the sector is optimistic, not least given consumer preferences, **there are challenges ahead**. Organic food production generally has lower yields per hectare than standard cultivation, which increases the cost to the consumer. There are also concerns that climate change and the diseases and pests that flourish may pose a particular risk to organic farming. Functional foods require substantial R&D investments, which may not always be forthcoming. Notwithstanding

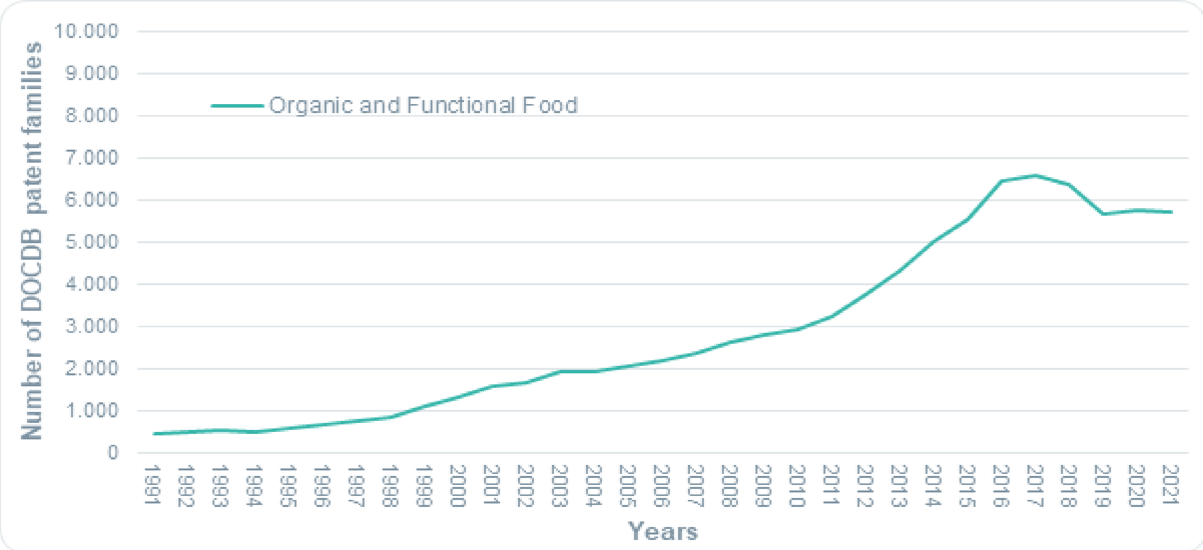
[16] Smart Specialisation Strategy of Serbia 2020-2027
[17] Draft Smart Specialisation Strategy of the Republic of North Macedonia 2023-2027
[18] Smart Specialisation Strategy of Montenegro 2019 – 2024
[19] Strategy for Agriculture and Rural Development 2022 - 2028

these concerns, there is increasing interest in health and wellness, leading to consumers expressing a preference for foods with functional benefits and fewer synthetic additives. This trend is driving the adoption of innovative farming techniques and technologies to enhance the production, including precision farming and sustainable agriculture practices.

4.2. Technologies shaping the organic and functional food sub-sector

Technological innovation remains an important driver of change. This section presents the analysis of patent documentation related to the field of organic and functional food. When compared to the trends shown in the agri-tech sector (see the previous chapter), the organic and functional food sub-sector reveals a lower level of innovative activity, at least in terms of patent filings. **Figure 4.** Time series of patent families' filings in the organic and functional foods, for example, shows the peak of activity of around 6.500 patent families in a year for organic and functional food, while in the agri-tech case, the chart peaks well above 140,000 families in a single year. That said, the sub-sector shows a modest yet meaningful patent production. Overall, innovative activity has increased in recent years, with a notable surge in the number of patent families filed annually between 2010 and 2016. After reaching a peak in 2016, there has since been a slight decline.

Figure 4. Time series of patent families' filings in the organic and functional foods



Note: Patent applications are generally published no sooner than18 months after the filing date, a timeframe often called secrecy period. Hence, the number of registered filings of the period 2022-2023 is necessarily under-estimated and was not plotted.
Source: Erre Quadro's own elaboration; raw data taken from the European Patent Office database of worldwide patents.

The patent analysis identified 18 technologies and technology-related developments likely to affect organic and functional foods over the medium term. These are shown in Table 9.

Global and national rankings of technologies in the Organic and Functional Foods sub-sector the last six columns indicate the readiness level of each WB6 economy to adopt or leverage a specific technology in the organic and functional foods sub-sector. This is parameterised using the following four qualitative values:

Ready (°°°): The technology is already prevalent, with a high adoption rate in the country

Growing (°°): The technology's adoption rate within the country is steadily increasing

Starting (°): The technology's adoption rate within the country is beginning to rise.

Absent ( ): The technology's adoption rate within the country is relatively low.

Table 9. Global and national rankings of technologies in the Organic and Functional Foods sub-sector, which provides comparable information for organic and functional food, as Table 3. Global score and national readiness level for technology-related topics in the Biotech sub-sector provides for agri-tech. The WB6 economies do not encompass all the technologies related to organic and functional food.

While more traditional topics such as agro-chemicals, fermentation, and irrigation control systems are widely adopted, particularly in Serbia and North Macedonia, other more specific technologies (e.g., bioactive agents, probiotics, and antioxidant agents) are still in the early stages of development across the WB6 region.

Table 9. Global and national rankings of technologies in the Organic and Functional Foods sub-sector

Technologies in Organic and Functional Food subsector	Global score[20]	Readiness level in					
		Albania	Bosnia-Herzegovina	Kosovo	Montenegro	North Macedonia	Serbia
Bioactive agents	1.000					○	○
Probiotics	0.983					○	○
Agrochemicals	0.903	○○○	○○○	○○○	○○○	○○○	○○○
Biological Fertilisers	0.867	○	○	○	○	○	○
Antioxidant agents	0.577					○	○
Biopesticides	0.532	○	○	○	○	○	○
Biomass production	0.525	○	○	○	○	○	○
Biological Fermentation	0.518	○○		○	○○○		
Proteomics	0.497					○	○
Phytochemicals	0.479					○	○
Organic solvents	0.443	○	○	○	○	○	○
Plant growth regulators	0.388					○	○
Metabolic Engineering	0.370					○	○
Dietetic products	0.340					○	○
Enzymes	0.328					○	○
Irrigation control systems	0.299	○○	○○	○○	○○	○○○	○○○
Bacteria culture	0.288					○	○
Molecular biology	0.278					○	○

Source: Erre Quadro's own elaboration

[20] Global score indicates the level of innovation production within the considered subsector at a worldwide level.

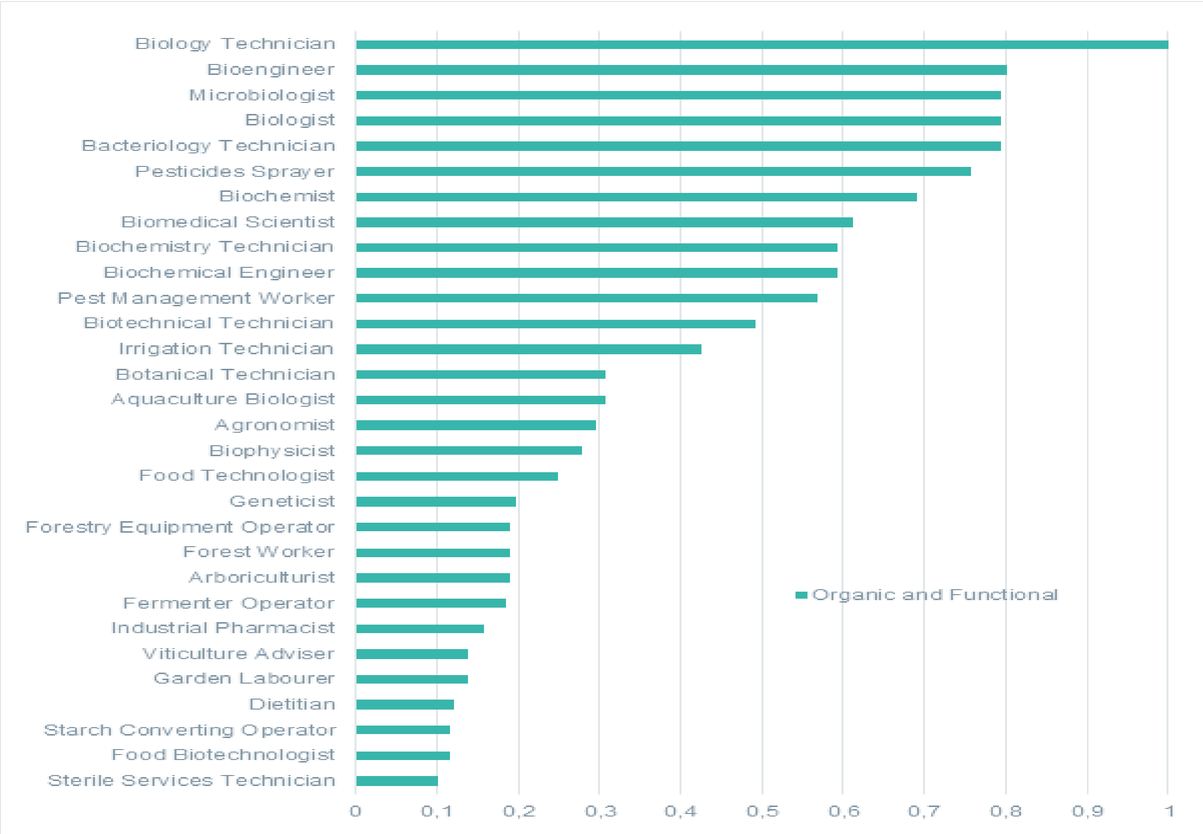
4.3. Emerging skills needs and skill gaps

By employing semantic matching, it is possible to correlate emerging technologies with job profiles, leading to a ranking of these profiles based on their anticipated demand in the future. This provides a general perspective on which occupations are likely to see an increase in demand based on their association with specific technologies or topics. **Figure 5**Error! Reference source not found. ranks the top 30 occupations linked to skills and technologies that are expected to significantly influence the organic and functional food sub-sector in the near future. These occupations fall into two main groups:

- generally applied professions common to all types of cultivation, such as agronomist or pest management workers, which will require a unique skill set tailored to the specificities of organic and functional foods; and
- job profiles that are either related to the scientific aspects of the sub-sector (e.g., geneticists or bioengineers) or production processes particularly relevant to it, such as fermenter operator or starch converting operator.

There are also indications of broader applications for the competencies of professionals beyond their initial domain. For example, an aquaculture biologist might be primarily engaged in organic or functional fish production, but their expertise could also extend to the aquaponics production of vegetables. **Figure 5** also shows examples of cross-sectoral crossovers, as roles typically associated with the health sector, such as dietitians and pharmacists, will be required in organic and functional foods to evaluate or design health benefits and /or their application in medicine.

Figure 5. Top 30 ESCO occupations which are likely to see an increase in demand due to technological inputs in the future.

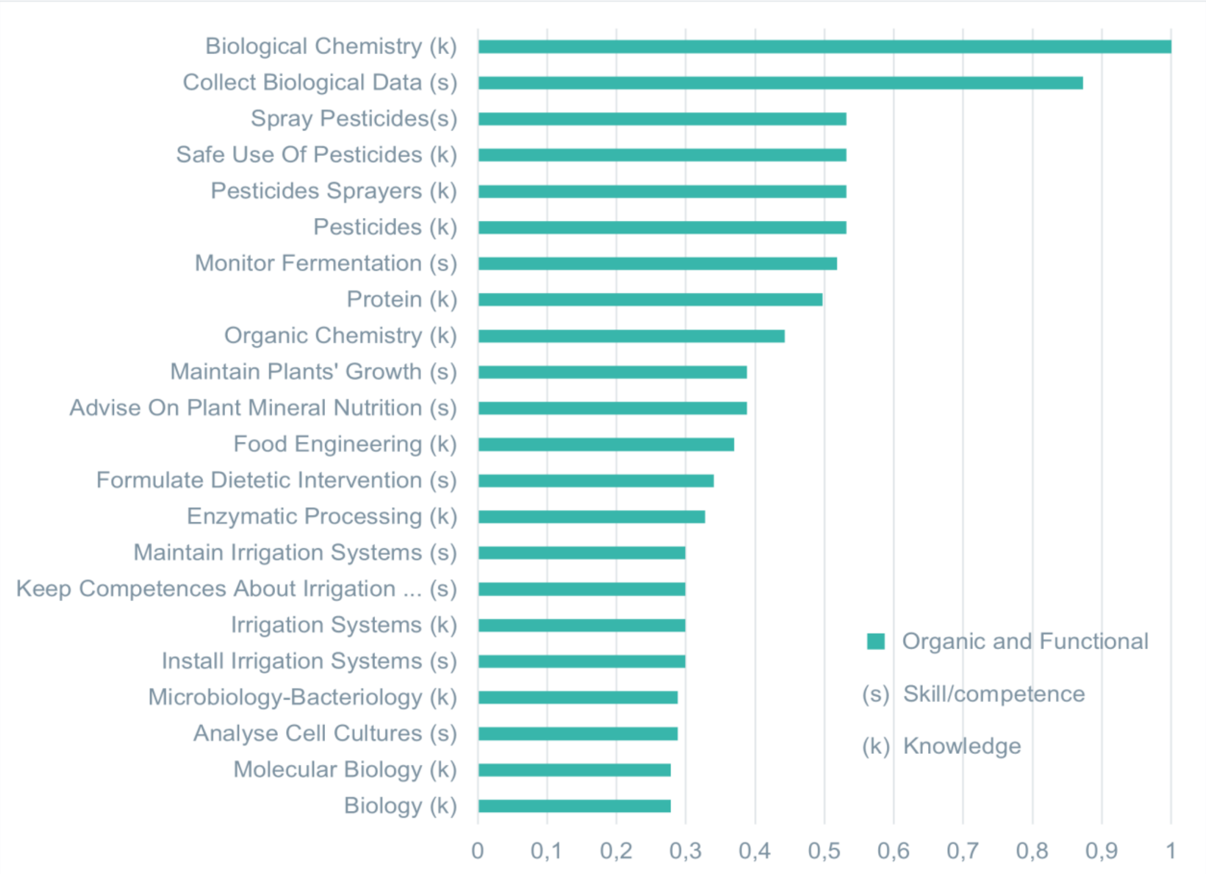


Source: Erre Quadro's own elaboration

Through the application of text mining and ranking procedures, it is possible to construct a list of skills associated with technologies shown in **Table 9.** Global and national rankings of technologies in the Organic and Functional Foods sub-sector. This ranking, presented in **Figure 6.** The top 22 ESCO skills, competencies and knowledge associated with technologies likely to have an impact on Organic and Functional Foods in the future., identifies the skills that are currently important and are likely to remain relevant in this area over the medium term. The competencies are grouped into clusters using the same method used for the agri-tech sub-sector (see **Figure 3** in the previous chapter).

Some of the skills /competencies are the same as the ones associated with standard cultivation practices, such as those related to irrigation systems. There is a distinction, though not explicitly outlined in the ESCO definition, which lies in the specific areas of expertise required. For example, in organic farming, synthetic pesticides are prohibited; therefore, knowledge about permitted alternatives such as biopesticides or phytochemicals is required, or the use of predator insects for crop protection. This necessitates an update in the corresponding competencies to align with these practices. Additionally, many other skills listed are associated with more advanced competencies in the scientific fields of biology, microbiology, and chemistry.

Figure 6. The top 22 ESCO skills, competencies and knowledge associated with technologies likely to have an impact on Organic and Functional Foods in the future.



Source: Erre Quadro's own elaboration

It is essential to highlight that for certain technologies listed in **Table 9.** Global and national rankings of technologies in the Organic and Functional Foods sub-sector, there are some which do not match with the skills documented in ESCO such as *agrochemicals, antioxidant agents, bioactive agents, phytochemicals, probiotics,* and *proteomics*. The absence of a match does not diminish the technology's significance within the sector. Instead, the lack of alignment arises from the ESCO database's potential lag in capturing the skills required by new novel technologies or the specificity of the skill requirement.

4.4. Skills supply to the organic and functional food sub-sector

Previous analyses among stakeholders and companies in the organic and functional food sub-sector indicated that current university and vocational training programmes are not fully aligned with the needs of the sector (ETF, 2022). This section explores in more detail the views of stakeholders who participated in the various workshops about the extent to which vocational education and training (VET) and higher education meet the skill needs of the sector and how skills supply might be improved in the future.

Vocational education and training

The VET education provides fundamental knowledge about agriculture but falls short in delivering specific skills, such as those related to the processing of organic and functional food products as indicated by some of the businesses active in the WB6 economies. Additionally, low cooperation between VET institutions and organic farms or producers leads to a lack of practical skills and first-hand experiences for students.

The expansion of organic and functional food production and processing activities in the WB6 region will increase the need to develop and enhance the offer of specialised courses on organic and functional food activities at the VET level. These will need to complement basic agriculture knowledge with information on organic certification processes, processing methods for organic products, soil health management in organic farming, pest and disease control without synthetic chemicals, and sustainable farming practices. There have been some positive developments with North Macedonia and Serbia developing VET curricula with options to study in courses on organic production. In Albania, VET providers collaborate with companies to provide opportunities for practical training.

The example of Albania draws attention to the need for training that can provide practical skills through companies and VET providers co-operating with one another. The examples of Provincial Technical Institute in Belgium and the Krems Wine School in Austria demonstrate how this has been successfully developed within the EU (see **Box 4.1**).

Box 4.1 Examples of practices from peer learning partners

Provincial Technical Institute (PTI) in Belgium

The Provincial Technical Institute provides a combination of practical and theoretical learning opportunities for students**.** The school emphasises blended learning methodologies for its courses, such as the Bio-STEM course within the science-mathematics track, which equips students with theoretical knowledge alongside practical experiences in water quality testing based on collaboration with industry partners. Similarly, in the biotechnical and chemical sciences track, students receive comprehensive training in animal care techniques and animal husbandry along with theoretical knowledge. This integrated approach ensures that students develop both technical skills and practical experience relevant to their chosen field of study.

Krems Wine School in Austria

The Krems Wine School provides diversified ways of learning for students. This includes student participation in practical applications, such as independently conducting laboratory work on wine samples and providing analysis to winegrowers. Additionally, the development of ‘practice companies’ helps students acquire knowledge and skills in designing, marketing, and selling products, as well as gaining an understanding of legal requirements and management skills. Other methods include integrating data analysis into courses provided to ensure that students grasp both theoretical concepts and have opportunities to apply them practically.

Source: Foresight workshops

Higher education

Specialist university level courses related to organic and functional foods are not commonplace across the WB6, but there are examples where higher education institutions have developed programmes and courses. In Serbia, for example, a bachelor programme on organic agriculture has been available since 2010 at the University of Novi Sad. It also provides access to an elective course on functional foods. Additionally, multiple higher education institutions offer various master's degrees and courses relevant to the organic food sector (e.g., the University of Belgrade, Faculty for Biofarming in Bačka Topola, Megatrend University and Faculty of Ecological Agriculture in Sremska Kamenica, Educons University). In North Macedonia, the University of Ss Cyril and Methodious-Skopje provides access to a study module on organic production (ETF, 2022).

Just as in the case of the VET provision, a need for practical skills training was mentioned by stakeholders. The example from the LUT University in Finland provides an example of how this has been realised in the EU (see **Box 4.2**).

Box 4.2 Examples of initiatives at the higher education level in peer learning countries

LUT University in Kouvola region Finland

LUT University provides students with various learning programmes that combine sector-specific knowledge with business skills. The strong collaboration between its specialised agricultural and business programmes emphasises the acquisition of knowledge and skills related to the commercialisation of agricultural products and services, along with the development of analytical and modelling skills. The University also plays an important role at the regional level by collaborating with industry partners to adapt its offer and share knowledge and expertise within the Kouvola region. This stems from a larger mandate the Finnish universities to strengthen regional development, and to facilitate cooperation between companies and higher education institutions.

Source: Foresight workshops

Up- and re-skilling of the existing workforce in the organic and functional food

Providing opportunities for adults to re-skill and up-skill helps avoid skills obsolescence and reduces the level of skill mismatches that might otherwise arise. Previous analyses (ETF, 2022; ETF, 2023) of the region have identified few formal adult learning opportunities related to organic and functional food production area. Some municipalities in Serbia (e.g., Belgrade and Novi Sad) provide courses for potential organic producers. Additionally, Serbian organic certification bodies deliver training to companies regarding product certification requirements and processes. In North Macedonia, the course entitled "Producer of Organic Vegetables and Fruits" is provided by the Goce Delčev University of Štip, delivers theoretical knowledge with practical skills acquired on farms.

Training offered by business support organisations enhances knowledge and skills in the organic and functional food sub-sector across the region. Examples include training delivered by the Italian Agency for Development Cooperation in Albania, by PePeKo in Kosovo, U.S. Agency for International Development (USAID) in Bosnia and Herzegovina, the Adult Education Centre in North Macedonia, Vojvodina Organic Agriculture Cluster; National Association Serbia Organica, and the National Alliance for Local Economic Development, Association Vitas and many others in Serbia (ETF, 2022).

4.5. Relevant skills cluster for organic and functional food and sources of skill mismatches

For the **organic and functional food sub-sector**, the skills clusters identified included digital and analytical skills, organic agriculture skills, food processing, business, supporting and soft skills, installation and maintenance, and chemistry and quality control. **Table 10.** Skills most critical for the organic and functional foods sub-sector provides details about the top three skills clusters (i.e**.,**

organic agriculture; digital and analytical skills; business, supporting and soft skills) for the organic and functional food sub-sector, along with the critical skills identified by stakeholders during foresight workshops along with the skills gaps they identified. The table also provides information on the factors which account for skill gaps. ANNEX 3 **Organic and functional food skills clusters**.

The skills gaps in most WB6 economies include specific knowledge related to organic farming and food processing, as well as knowledge of organic standards, labelling and certification processes, and understanding EU regulatory standards. The increase in the use of digital technologies in agri-food leads has led to increased demand for workers with at least basic user-level digital skills. It is anticipated that companies will increasingly require a workforce with skills related to the interpretation of complex data sets to optimise production processes, as well as skills that will facilitate the adoption and use of digital technologies.

Table 10. Skills most critical for the organic and functional foods sub-sector

Skills cluster	Critical Key skills	Skills considered difficult to acquire	Why skills are difficult to acquire?
Organic agriculture	Agronomy and smart agriculture Knowledge of legal standards related to organic farming and organic products Maintaining plant growth	Agronomy and smart agriculture	Limited funding; Restricted access to information; Lack of knowledge about available resources
		Knowledge of legal standards related to organic farming and organic products	Contradictory regulation and standards between the EU and Western Balkans context
Digital and analytical skills	Basic digital skills to use new technologies Skills to support the digital transformation of companies Skills in interpreting complex data sets to optimise agricultural processes Skills and knowledge to support the adoption of digital technology	Skills in interpreting complex data sets to optimise agricultural processes	Conservative mindset; varying levels of training and the customer's educational profile
Business, supporting, and soft skills	Technological know-how Skills to facilitate technology licensing and the transfer Business and project management skills	Communication Project Management Foreign languages	Reliance on ongoing practice Lack of business vision Lack of information Lack of cooperation between the sector and business schools Lack of trainers with sector-specific knowledge and business skills

Source: Background report and discussion in the second foresight workshop

For the **organic agriculture cluster**, the skills related to agronomy and smart agriculture, knowledge of legal standards related to organic farming and organic products, and maintaining plant growth emerged as critical ones. Agronomy and smart agriculture, along with knowledge of legal standards related to organic farming and organic products, were regarded as difficult to acquire but essential for business development in the future. Although the workforce in the sector already has some of these skills, the knowledge base changes rapidly (especially in relation to climate change and plant growth), so upskilling is of critical importance. Knowledge of legal standards also needs to be enhanced, considering the different and sometimes contradictory regulations and standards between the EU and WB6 economies. Understanding legal procedures is essential to facilitate market entry for specific products.

In the **digital and analytical cluster**, basic digital skills to use new technologies, supporting the digital transformation of companies, skills for interpreting complex data sets to optimise agricultural processes, and supporting the adoption of digital technology emerged as critical skills for the future. It is important to consider the varying levels at which training is required. For instance, while individuals with lower education levels may require basic digital skills, proficiency in skills supporting digital transformation may be more relevant for those with higher levels of education. Skills for interpreting complex data sets to optimise agricultural processes represent some of the skills difficult to acquire, which are essential for innovation and create shifts in mindsets. For example, while some companies possess the skills to support the digital transformation of the sector, they often lack knowledge about how to use them effectively or adopt a transformative mindset.

In the case of **business support and soft skills** were identified as being of critical importance to the future of the sector. This included business support skills related to technological know-how, facilitating technology licensing and transfer, business economics, and project management. In addition, there were soft skills related to (a) communication and presentation and (b) foreign languages, which were considered to be especially important for the future of the sector. Acquisition of business support and soft skills was impeded by a lack of co-operation between the sector and business schools and the limited number of trainers with both sector-specific knowledge and business skills.

Most of the factors leading to skills mismatches and shortages, emphasised in the section **3.5.** Relevant skills cluster for agri-tech and sources of skill mismatches for the agri-tech, are also relevant for the organic and functional food sub-sector. This includes reduced opportunities for students and learners to acquire practical skills in a workplace environment and the limited integration of programmes that provide skills for organic and functional food production and business related to marketing, certification of products, and soft skills (e.g., foreign languages, communication, teamwork, critical thinking, etc.).

CHAPTER 5. CONCLUSIONS AND RECOMMENDATIONS

The challenges facing the agri-food sector in the WB6 are similar to those confronting the sector across Europe and other parts of the world. These include navigating food safety and provenance regulations, responding to climate change, producing more with fewer resources in a sustainable manner, and harnessing the benefits of digital technologies. Like other agri-food sectors in Europe, the WB6 one faces intense competition for labour and skills, both from other sectors and other countries. Demographic change has reduced labour supply and will continue to do so, exacerbating the reluctance of workers, especially younger ones, to work in agri-food perceived as offering low-paid, precarious employment and manual labour, when other opportunities are available.

Technological change provides the sector with an opportunity to transform its fortunes. It provides technological solutions to some of the problems the sector currently faces and will continue to face over the medium-term. It can help redress some of the challenges posed by climate change. And it will be an essential element in any strategy which looks to improve yields or productivity and, in doing so, grant access to higher-value segments of the global market, not least that in the EU. It also has the potential to make the sector more attractive to would-be employees. The agri-food sector in 2030 and beyond has the potential to be a relatively high-tech employment destination if employers /farmers harness the productive capabilities new technologies potentially deliver. This means, in practice and to varying degrees, adopting the concepts associated with Agriculture 4.0, smart specialisation, precision and vertical farming, production of new forms of protein, use of hydroponics, organic farming, etc. This is as true for producers in the WB6 as it is for those elsewhere in the world. This implies that those who can bring about this kind of change will strengthen their position in the global market, possibly at the expense of those who are unable to embrace change.

Keeping pace with change rests in large part on being able to develop the skills required to ensure that existing market positions can be protected and new markets captured. This study has set out the skills the agri-food sector will increasingly need to acquire over the medium-term. In the future, skill requirements will be characterised by a growing demand for people to work in professional and associate professional jobs linked to the application of new farming techniques. Some of these jobs will have a specific agri-food focus, such as those in plant microbiology and developing pest /disease-resistant crops. Other jobs are common to many, if not all, sectors, such as those related to energy use /conservation, the use of sensors, data collection and analysis, and business regulation. Except that in agri-food sector these jobs will require hybrid skills – i.e. a mix of skills required across many sectors combined with agri-food sector specific knowledge. The acquisition of these skills might prove to be challenging.

The participative foresight element of this study, which engaged a range of sector stakeholders in thinking about the future of the WB6 agri-food sector, revealed two key findings. First, there is a general lack of awareness across the WB6 agri-food sector about the need to invest in both new technologies and new skills. Second, even when there is awareness of the benefits that these new technologies and associated skills might confer on a business, stakeholders agreed that the required skills are difficult to obtain due to: (a) limited supply; and (b) the agri-food sector's lack of appeal to individuals who possess the in-demand skills.

There are signs that the sector is in a low-skill equilibrium. Employers /farmers have limited demand for skills, which leads education and training providers to deliver a commensurately low level of skills supply. Employers are reluctant to make investments in new technologies if they lack the skills necessary to generate a return from them, and education and training providers are resistant to providing courses and programmes for which they see little or no demand. The policy challenge is to find the means of breaking out of this potentially vicious spiral because, without change, WB6 agri-food producers run the risk of being locked into serving local markets, which may well face increased competition from imports in the future.

Discussions in the foresight workshops pointed to several prescriptions to improve the performance of the agri-food sector over the medium term in the WB6. Demand-side recommendations focused on making the case for simultaneous investments in new technologies and skills. Peer-to-peer learning was considered a particularly important means of sharing information because farmers are more likely to listen to other farmers. Supply-side interventions concentrated on curricula development and ensuring that it is adapted in a timely manner to changes in the demand for skills. This required representatives from the agri-food sector to be actively involved in curricula design and programme design. While there was recognition that the demand and supply sides needed to act together, this was, in effect, easier said than done. Building the kind of agri-food ecosystem at national, regional or local levels, which can both increase the demand for skills and, at the same time, make sure that the supply side responds in a timely manner, might be regarded as a formidably daunting task given the current state of play.

All of the above points to the need to find catalysts which might develop an agri-food ecosystem capable of driving the kinds of change for which stakeholders clearly see a need. Existing initiatives, such as those cited throughout the report, provide a basis for further development. But there needs to be a degree of organisational agency in place which can take the initiative, at least over the short-term, to work out what an agri-food ecosystem in the WB6 might look like in practice: who is involved, how they are involved, and what they are expected to do.

The agri-food sector needs to find its own solutions to the challenges it will face over the medium term. Without the sector having ownership of any solutions, it is unlikely that they will be enacted in practice. Developing those solutions requires an institutional infrastructure which provides the basis for bringing stakeholders together through, for example, sector skills councils and /or innovation hubs to address the skill needs of the sector. There are existing examples of relatively good practices presented in this report that might provide the basis for developing the kind of ecosystem which stakeholders in the sector say they need.

The recommendations provided below reflect the analysis on agri-tech in **CHAPTER 4.** ORGANIC AND FUNCTIONAL FOOD and on organic and functional foods in **CHAPTER 4.** ORGANIC AND FUNCTIONAL FOOD. The recommendations represent the perspectives of stakeholders and participants in the foresight study regarding effective methods for acquiring the necessary skills for the sector. In general, both the agri-tech and organic and functional food subsectors will require similar broad types of skills in the future: relatively high-level STEM skills (in high demand across various sectors), integrated with knowledge of agriculture, agronomy, and related technologies. These skills are necessary due to the anticipated technological changes in the global agri-food sector over the medium-term.

Recommendation #1 - Business support should reflect the intentions of smart specialisation and respond to the need of agribusinesses to connect to networks and expertise.

Business support organisations need to adjust to their new enhanced role as industry facing hubs helping to unlock opportunities for competitiveness – and bridging the gap between the private and public sectors. Networking is critical in helping early and mid-stage agri-tech companies as well as organic and functional foods producers to connect with potential buyers, like-minded people, and open up new markets and opportunities.

Networking can help companies diversify their income streams and become more resilient to market fluctuations. Moreover, networking fosters knowledge flows and allows an exchange of ideas. It is key for companies to partner up, develop new solutions to agricultural challenges, and bring their ideas to fruition. Such a collaborative approach often allows for a rapid learning curve and more effective innovation than traditional research methods. Generally, the underlying reason for public and private actors to engage with each other relate to sharing costs, risks and resources. However, networking is also an opportunity for the authorities to increase the coherence and synergy of business support instruments that pursue commercial objectives, with those that have broader innovation, productivity and competitiveness objectives.

Recommendation #2 - Business support organisations should support real-world application and adoption of technology through more collaborative working opportunities.

Despite an increase in the number of technologies being developed, wider adoption or use of technology within primary food production is slow. Agricultural technologies are often perceived as expensive by smallholders (i.e. return on investment is not understood), difficult to learn how to use, or used too infrequently for farmers to think they can use them effectively (e.g. due to the seasonal nature of farming). Business support organisations (e.g. agriculture extension services and clusters) have an opportunity to provide training for farmers on latest technologies, support the uptake of new technologies and the development of new technologies. This would boost the domestic demand for companies developing agricultural technology (products, services or applications) and allow farmers to experiment and work with companies to adapt new technologies to their specific needs, driving innovation at a grassroots level. Targeted networking and peer learning would allow farmers to connect with technology developers and gain early access to new tools and technologies. Networks could also facilitate collective purchasing to leverage scale and acquire cost-effective equipment, thereby reducing production costs and improving their overall profitability.

Recommendation #3 - Through collaboration with business, authorities should seek to foster employers' investment in upskilling and reskilling to improve productivity.

Industry involvement in upskilling and reskilling is crucial for maintaining competitiveness. By investing in employee training and development, companies can improve retention, boost innovation, and address skills gaps, ultimately enhancing organisational agility and long-term sustainability. Although the involvement of businesses in upskilling and reskilling initiatives is low in the WB6 countries, the study found that innovative agri-food companies have understood the essential role they can play in this context and do invest in learning opportunities for their employees. Such learning can take the form of attending trainings or events abroad, as well as bringing in experts from abroad to the Western Balkans. Establishing Agricultural Knowledge and Innovation Systems (AKIS), i.e. self-sustained networks for exchange between research, industry, extension and the farming community), with financial support provided by IPARD III, was highlighted as an action that could be considered for increasing industry investment and collaboration on upskilling and reskilling to improve productivity.

Recommendation #4 - Through collaboration with business, policymakers and practitioners involved in the design and delivery of vocational programmes should codesign micro-credentials to equip the agriculture sector with cutting-edge skills.

Micro-credentials enable adult learners to acquire only the skills that are most relevant to their immediate goals or interests. As they are modular, they enable a precise adaptation to the needs of employers. They also make it possible to certify specific and often highly specialised skills in a rapid manner. In particular, they can be used to structure the provision of inter-disciplinary skills to address the increasing share of companies seeking for employees with expertise in more than one area. For example, companies raised the issue of consumers becoming increasingly concerned about the sources, safety, and welfare of their food. Micro-credentials on communication of agri-innovation would help companies enhance their communication skills and gain a better understanding of the importance of research, communication, and innovation in the agri-food sector today. Eventually, improved communication skills would also increase the uptake of new scientific solutions in the sector. Such micro-credentials would also provide valuable insights into the commercialisation of new ideas and the evolutionary process of solutions in the agri-food sector. Universities could also play a significant role, for example, by establishing summer schools.

Recommendation #5 - Through collaboration with business, policymakers and practitioners involved in the design and delivery of vocational programmes should foster work-based learning to facilitate learners' access to practical learning.

Workplace-based learning programmes are an important means to enhance both learners and teachers access to practical learning. Especially in organic agriculture, it is necessary to address foundational skill gaps of learners. Graduates often lack knowledge and practical skills for example on soil fertilisation. Addressing the demand for practical skills requires integrating experiential learning into educational programmes for example through practical modules, internships or apprenticeships on organic farms.

Lack of work-based learning is also limiting digital uptake among learners, and consequently agribusinesses. Primary food producers such as organic farmers in particular experience a shortage of workers with an understanding of agricultural technology and how it can be used as a tool to take their business forward. In agri-tech work-based learning is key to equipping learners with practical skills on the use of the latest technologies such as real-time monitoring networks and IoT systems applied to agriculture, advanced automation systems (e.g. such as drones, rovers, and autonomous vehicles), or optimising water resources in agriculture. However, despite its proven effectiveness, work-based learning programmes remain sparse, and the involvement of employers in developing programmes to facilitate learners' access to practical skills is limited. Tailor-made support services should be provided to facilitate work-based learning in startups and small agribusinesses. Without targeted intervention incentivising collaboration, the engagement between employers and education and training providers would occur but remain insufficient.

Recommendation #6 - Through collaboration with business, policymakers and practitioners involved in the design and delivery of educational and training programmes should encourage younger generations to see farming as a career choice.

The agricultural sector is undergoing a transformative shift due to the rapid advancement of agricultural technology, both in traditional and organic farming. Technological advances have created numerous new job opportunities, characterised by higher-than-average wages and better working conditions and made previously unattractive jobs more appealing. However, this change is not yet reflected in the image and attractiveness of vocational education and training, which has not kept pace with these developments. Today, the industry is facing a severe shortage of new workers.

Education and training providers play an important role in showcasing the diverse opportunities within agriculture and the transferable skills it offers. One of the most effective ways to engage young people with farming is through hands-on experience e.g. through school visits, farm internships, and summer work programs which give young people the chance to experience farming in action. To attract future-focused learners, education and training providers and agribusinesses should work together to show young people that from drones and automated machinery to precision farming techniques and sustainable practices, farming today is a sector rich in innovation and technology.

Recommendation #7 - Through collaboration with business, local authorities should mobilise local rural communities to prepare for the future of agri-tech.

The LEADER approach (comes from French Liaison Entre Actions de Développement de l'Économie Rurale) is a local development method used to engage local actors (i.e. Local Action Groups (LAGs)). It is used to co-design and deliver strategies, facilitate decision-making and resource allocation in the development of rural areas. The LEADER approach would be helpful in facilitating interaction between agribusinesses, education and training providers and other stakeholders. Such activities could fall under IPARD III Measure 5. LAGs would be responsible for preparing five-year Local Development Strategies (LDS) with a specific objective to strengthen the labour market and skills system. In the context of LDSs, various initiatives could be deployed, including projects that include investment in academic capacity and scouting of labour market demands.

Recommendation #8 - Through collaboration with business, authorities should identify and use skills intelligence to effectively transmit labour market signals to education and training systems.

Agribusinesses are undergoing significant transformations, driven by technological advancements, changing consumer preferences, and evolving economic landscapes. Having a strong labour market and skills intelligence system represent a vital step in enhancing for example business support to agribusinesses, evidence-based curricula improvements and updates to the labour market needs. Sector skills councils should regularly review and propose adjustments to the curriculum. Relevant and usable skills intelligence has strong stakeholder involvement to ensure that it effectively supports curricula development, the design of new programmes, and qualifications (e.g. micro-credentials).

Recommendation #9 - Business support organisations should build on the collaboration within the ecosystem to inform skills policies.

Skills development is a shared responsibility. By working together, companies, vocational education and training providers, higher education, research institutions, and business support organisations can advocate for policies that support relevant and timely skills development for innovation and sustainability in agri-tech and organic and functional foods. Focusing on a priority domain for smart specialisation means stakeholders can come together to address skills requirements based on shared needs. The greater the involvement of agribusinesses in skills development, the greater the opportunity to address skills shortages. Business support organisations must use this collective voice effectively to impact how the future of skills is being shaped at policy level. The key differentiating factor that networks bring to the policy discussion is the stakeholder collaboration and voice of the companies - and connecting it to policy dialogue.

Recommendation #10 - Business support organisations should provide information on European programs that support skills development and on how to apply for funding.

EU funding instruments such as Erasmus+, Horizon Europe and, in the future, the Competitiveness Fund, aim to foster competitiveness and create more and better jobs in Europe through the introduction of new skills, technologies and innovations. They mainly provide funding for collaborative projects. Companies find it difficult to navigate the different instruments, calls and deadlines. To boost WB6 participation in EU projects, business support institutions must provide timely information on relevant European programs and networks (e.g. website, newsletter), and on how to apply for funding. However, by far the biggest challenges companies, universities and research institutions face is identifying the right partners (EU member states and beyond) and writing project proposals. Writing a successful proposal for Erasmus+ and especially Horizon Europe, which offers higher funding, requires experience and skills. Business support organisations need to facilitate access to information on proposal writing, share good practices, organise training sessions, and provide contacts to consultancy services that accompany and support the application process for EU funding instruments.

ANNEX 1 METHODOLOGICAL APPROACH

Figure A.1 below summarises the methodological steps. A participative foresight approach was adopted, which involved the analysis of a range of background data and the obtaining of input from key stakeholders through a series of workshops. The workshops were incremental insofar as the discussions in one workshop shaped the agenda for the next one.

Figure A.1 Methodological steps

Source: own elaboration

The first step in the research process was to summarise the existing evidence on emerging skill needs in the agri-food sector. This background analysis is based on:

- a literature review of reports and statistics related to the agri-food sector in the WB6 region and publications issued by the ETF concerning future skills demand and the situation of the skills supply. This reviewed the drivers of change affecting the agri-food sector and the types of skills needs which were emerging as a consequence;
- collation of data on emerging technology use and related skill needs using text mining tools. This employs a methodology used in previous ETF studies addressing future skills needs related to agriculture and food production (e.g., ETF, 2020, 2021). Using text-mining techniques, data was collated from international patent and bibliographical databases to identify the types of technologies increasingly coming on stream in the global agri-food sector, together with information on other drivers of change. Links were then derived between technologies and other drivers of change, respectively, to emerging skill needs using the same databases plus ESCO (Classification of European Skills, Competences, and Occupations).

The background analysis was used to develop the agenda for the workshops (the participative part of the foresight exercise) described in greater detail in the following parts.

The role of text mining

The background analysis relies heavily upon text mining techniques. The advantage of these in studying emerging skill needs is threefold.

1. It allows a future-oriented perspective and possesses more predictive power than traditional approaches. Where change occurs rapidly, even experts may not be aware of all the changes at play, and extrapolating past trends may not be sufficient to capture emerging phenomena. Text mining, however, is able to capture emerging signals, even weak ones, and correlate pieces of information scattered across many sources into intelligible patterns of evolution.
2. It provides the opportunity to scan a huge corpora of data and provides a level of completeness and depth of analysis that is otherwise hard to obtain.

3. The results derived from desk research and those from text mining complement each other, providing reciprocal validation and allowing the capture of more comprehensive information.

Box A.1 below details the text mining-based approach utilised to identify the skill needs in the WB6 region agri-food sector.

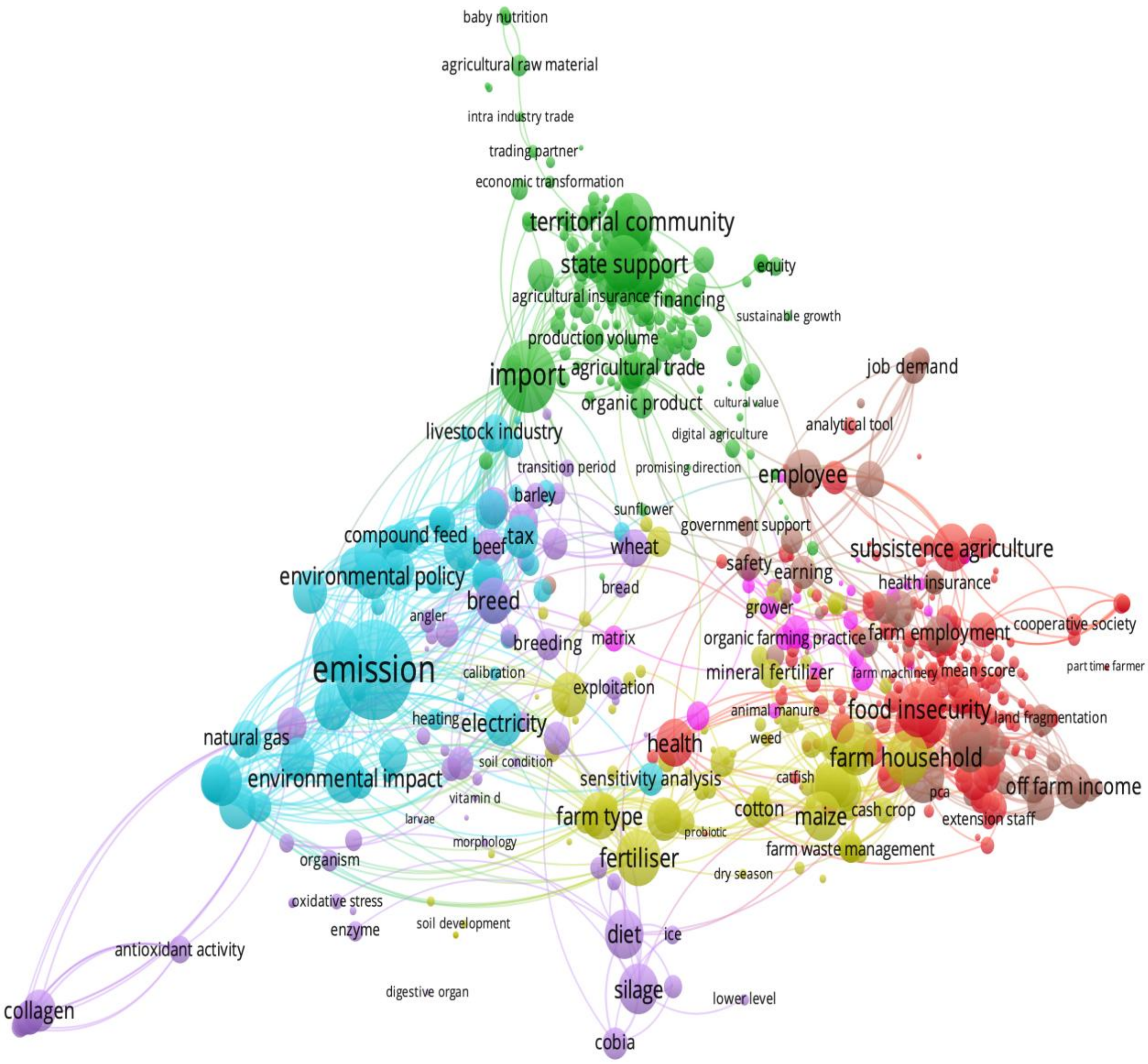
Box A.1 The text mining approach to identifying technologies and skills in the agri-food sector

The skill foresight analysis using text mining tools involved the following steps:

1. Sector definition and national context: The NACE classification was used as a basis for data collection and analysis. For the technology-focused analysis, sector definitions were tailored to each country's specific characteristics.
2. Drivers of change analysis: The OpenAire database, containing over 132 million journal and conference papers, was analysed using semantic and networking algorithms. Key concepts were identified to understand the societal and economic factors influencing the future of the agri-food sector in the WB6 region.
3. Technical innovation at a global scale: A global patent database of 130 million patents was analysed to identify relevant innovations in the agri-food sector. This analysis is mapped global innovation trends that will influence future skill and professional profile needs.
4. Correlation of national specificities to the global scenario: patents filed by national actors were analysed to compare national innovation focus with global trends. This helped assess the impact of innovations on each country's specific situation and informed discussions with stakeholders about the demand for skills and training.
5. Correlation of drivers of change to future need for skills. Socio-economic drivers and technological trends were linked to potential future skills and occupations using semantic matching with the ESCO database. Job profiles were ranked based on their anticipated demand in the future agri-food labour market.

Text mining techniques provide an opportunity to identify the major technological, societal, economic, or global forces that are currently shaping the agri-tech sector and are likely to continue to do so over the medium term. The initial step involved identifying key concepts from the literature and highlighting thematic clusters and their inter-relations. To this end, data from publications related to the agri-food sector in the WB6 region have been collated from three databases: (i) openAire (https://www.openaire.eu); (ii) Google Scholar (https://scholar.google.com); and (iii) ResearchGate (https://www.researchgate.net). The extracted data were analysed to identify recurring keywords, which were subsequently mapped using a network diagram, as depicted in **Figure A.2.** Each node in the diagram represents a topic found in publications, and arcs indicate the co-occurrence of topics within the same publication. The size of each node corresponds to the frequency of the concept's appearance in the literature.

Figure A.2 Network graph of the concepts from papers related to agri-food in the WB6 region



Source: Erre Quadro's own elaboration; raw data extracted from OpenAire, Google Scholar, and ResearchGate databases.

Figure A.2 is a visual representation of the intricate web of agri-food concepts. It showcases the clusters of concepts, providing a deep understanding of the complex relationships between them. For instance, the cyan cluster relates to the environmental consequences of agricultural production, spanning issues from emissions to waste and eutrophication, while the green cluster is comprised of concepts about governmental support and market regulations. **Figure A.2** also provides an indication of the interplay between different drivers of change. To this end, numerous connections can be observed between the concepts of the violet cluster, which is related to healthier food, and those of the cyan cluster, which focuses on sustainable production. Similarly, the green cluster, concerning governmental actions, shows multiple links with the brown cluster, which addresses labour dynamics. **Figure A.2**, however, is not a comprehensive representation of all the interlinkages, displaying only a segment of the overall network of relationships between various concepts relevant to the agri-food sector.

Workshops

The second step in the research process was to undertake a series of three workshops with key stakeholders to explore further the drivers of change, and the skill needs that are likely to rise to in the WB6 agri-food sector over the period up to 2035. Stakeholders discussed also various barriers to change, which will need to be surmounted to advance agri-food sector in the WB6 region.

- The first foresight workshop was a full-day event organised in Skopje on December 6th, 2023, and was dedicated to anticipating the future skill needs of the agri-food sector in WB6 economies. A summary of the results from the text-mining tools and previous analyses in the sector and region was used to guide the discussions.
- The second workshop, conducted online in two parts on February 21st and 28th, validated the clusters of specific skills identified in the background research and the first workshop. It also initiated the process of building a roadmap for future skills provision across the region.

The third workshop was held at the ETF headquarters in Turin on the 6th and 7th of June 2024 with a view to developing a set of recommendations and a roadmap to guide future skills provision to the agri-food sector in the WB6 region.

ANNEX 2 AGRI-TECH SKILLS CLUSTERS

Table A2.1. Skills clusters for the agri-tech sub-sector

Skills cluster	Specific skills identified
Digital and analytical skills	Computer literacy (e.g., data reading, data management, data sharing) Data analytics and data interpretation Big data, Cybersecurity and Mobile computing Digital measuring instruments Embedded software and automation Farm management information systems Software and programming skills, including development and simulation AI-based data analysis Distributed systems (needed for the adoption of all digital technologies: imaging, monitoring, robotics, agricultural extension) Prompt engineering (interacting with generative AI to obtain desired results) Skills and knowledge to support the adoption of digital technology Skills to support the digital transformation of companies Skills related to integrating different technologies (IoT + AI+ other tech).
Agronomy	Ecology (for correlation between crops) Plant Nutrition Plant physiology Smart agriculture Plant protection skills and knowledge Zootechnical skills and animal growing Skills related to circular economy Welfare of plants and animals Legislation and legal frameworks (both the EU and national provisions)
Biotechnology	Industrial microbiology, skills and knowledge needed for developing agrobacterial technologies Industrial bioreactors knowledge Chemical technology Detection of plant diseases Smart technologies for plant disease and protection Genetic engineering Physico-chemical and microbiological analysis skills Specialised Biology skills (for innovation in a range of technologies from biofertilisers to genetic engineering to new types of proteins)

Source: Own elaboration

ANNEX 3 ORGANIC AND FUNCTIONAL FOOD SKILLS CLUSTERS

Table A3.1 Skills clusters for the organic and functional food

Skills cluster	Specific skills identified
Organic agriculture skills	Maintain plant growth skills Organic plant nutrition and advice on plant mineral nutrition Agronomy and smart agriculture Agricultural engineering Enzymatic processing knowledge Horticulture Knowledge of legal standards related to organic farming and organic products Plant protection AI skills for production processes Knowledge of sensors and their applications Alternative techniques of production Management skills (planning, organising, and control) Responsibility, independence, and self-efficacy Communication skills Knowledge of foreign languages
Digital and analytical	Computer and technical skills to operate and manage new technological tools Sensor technology expertise Analytical and data processing abilities to interpret data from sensors, drones, and other digital sources Programming knowledge Statistical analysis Computer skills to operate advanced software and hardware systems (e.g. agricultural management software, data analysis tools, and precision farming technology) Analytical and data processing skills to use data for informed decision-making Advanced computing and technical skills Skills in interpreting complex data sets, including analysing crop yields, weather patterns, and market trends to optimise agricultural processes Skills and knowledge to support the adoption of digital technology. Skills to support the digital transformation of companies
Business, supporting and soft skills	Business and project management skills Business economics, including skills in budgeting and managing finances Skills and knowledge to enhance the understanding of intellectual property rights (IPR). Skills to facilitate technology licensing and the transfer of associated rights to a new owner. Modern methods and management procedures designed to improve competitiveness. Skills and knowledge regarding Freedom to Operate (FTO) services Teamwork Communication and presentation skills Marketing and sales skills Foreign languages skills Problem-solving skills Product market strategy development skills (i.e. developing the future goals of the business) Technological know-how (being able to identify key new technologies and understand how they can be introduced in a cost-effective manner into the business

Source: Own elaboration

ACRONYMS

AI	Artificial Intelligence
AKIS	Agricultural Knowledge and Innovation Systems
ARC2020	Agricultural and Rural Convention 2020
CIHEAM Bari	International Centre for Advanced Mediterranean Agronomic Studies
EC	European Commission
EEN	Enterprise Europe Network
EGD	European Green Deal
EISMEA	European Innovation Council and SMEs Executive Agency
EIT	European Institute of Innovation and Technology
ESCO	Classification of European Skills, Competences, and Occupations
ETF	European Training Foundation
EU	European Union
EU-27	European Union 27 countries
EUD	European Union Delegation
FiBL	Research Institute of Organic Agriculture
FITD	Fund for Innovation and Technological Development
GDP	Gross Domestic Product
FGB	Fondazione Giacomo Brodolini
GPS	Global Position System
HACCP	Hazard Analysis and Critical Control Points
HE	Higher education
HEI	Higher Education Institutions
ICT	Information and Communication Technologies
ILO	International Labour Organization
INTERREG IPA CBC Italy-Albania-Montenegro	The Interreg IPA South Adriatic is a cross-border cooperation Programme co-funded by the European Union through the Instrument for Pre-Accession (IPA III).

IoT	Internet of Things
IPARD III	EU pre-accession assistance for rural development
ISO	International Organization for Standardization
JRC	Joint Research Centre
LUT	Lappeenranta University of Technology
MAFWM	Ministry of Agriculture, Forestry and Water Management
MCG	Ministry of Agriculture, Forestry and Water Management
ML	Machine Learning
MCG	Ministry of Agriculture, Forestry and Water Management
MS	Member states
MTU	Munster Technological University
NACE	Statistical Classification of Economic Activities in the European Community
NLP	Natural Language Processing
OECD	Organisation for Economic Co-operation and Development
R&D	Research and Development
RTCF	Regional Technology Cluster Fund
SB	Società Benefit
SMEs	Small and Medium Size Enterprises
SPS	Sanitary and phytosanitary measures
SWG	Standing Working Group
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
VET	Vocational Education and Training
WB	Western Balkans
WB6	Western Balkan comprising Albania, Bosnia and Herzegovina, Kosovo, Montenegro, North Macedonia, and Serbia
WB6CIF	Western Balkans 6 Chamber Investment Forum

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