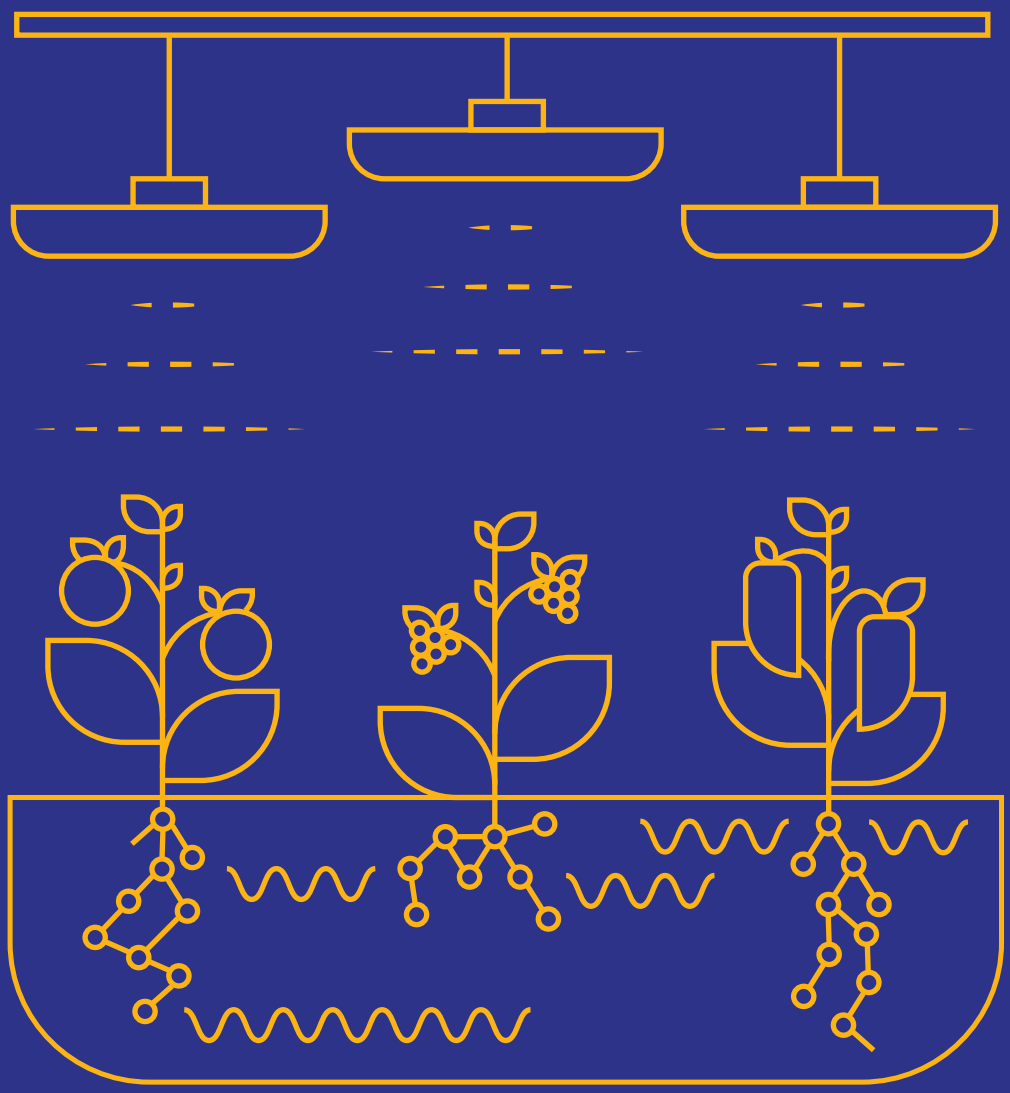
SMART**LABOR**

Strengthening Alliances for Policy Development and Testing in the domain of Innovation, Digitalization, and the Labour Market in the Western Balkans

Twin (Green Digital) Transformation in WB Agri-Food Sector



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1. EXECUTIVE SUMMARY

The agri-food system is a vivid, multi-actor and multifaceted system, constantly changing and evolving in response to a plethora of exogenous and endogenous drivers, ranging from demographic shifts, economic growth, changing lifestyles and demand patterns, trade patterns, new technology, environmental changes, etc. For policymakers, this presents a challenge, particularly now, when scale, volume, and intensity of the challenges associated with sustainability and viability of the agri-food system are at their peak, calling for system transformation. In that sense, business as usual is not an option; therefore, the policy narrative must aim to support actionable steps in the right direction.

This brief result from a foresight-based approach, presenting points to a visionary future of the **WB agri-food sector in selected countries, Bosnia and Herzegovina, Serbia, and North Macedonia**, while considering technical and technological advancements, political feasibility, and social and economic acceptance. By implementing a **foresight approach**, this brief supports policymakers in creating an enabling environment for a set of policies (mainly research and innovation policies) to decide on priorities for the future.

The report relies on a series of online surveys which were completed by stakeholders from all six Western Balkan countries, aimed to “screen” the most pressing challenges as well as opportunities, identified by the stakeholders from the Western Balkan region, followed by a series of face-to-face workshops with stakeholders to validate developed scenarios. Through this process, **three plausible scenarios of the agri-food sector were co-created with particular focus on digital and green transition** in selected countries. The scenarios of the future presented in this report are created based on the most relevant and pressing trends and drivers.

Furthermore, roadmaps and policy implications are tailored to respective countries. Three scenarios were developed:

Scenario 1: Asymmetric market power and participation centred around the idea of investing in the large, often vertically integrated companies and farms, characterized by rapid technological advancements and innovations, a surge in skills demand, particularly green and digital, new product development, an increase in food quality and safety requirements.

Scenario 2: Technology-enriched food systems focus on a transparent and traceable system, strongly supported by technology. Like scenario 1, it is characterized by new markets, products, or business models/initiatives built on new technology utilization (Industry 4.0), but with particular benefits associated with quality of life in rural areas.

Finally, **Scenario 3: Integrated participatory approach** is centred around the idea of a system that promotes environmental, social, economic, and nutritional values tailored to the needs and values of the local community. The scenario is anchored in sustainable agricultural practices, supports local farmers and communities/economies, while providing fresh and nutritious food to the community and the region. It fosters highly exploratory activities that involve investing in next-generation innovations, such as social innovations driven by technology.

An overview of all three scenarios and their potential impact on traditional and emerging drivers/ trends can be found in the following figure.

Figure 1: Framework for scenario description

Major drivers/trends		Contribution of scenarios to traditional and emerging drivers		
		Scenario 1: Asymmetric market power and participation	**Scenario 2:** Technology-enriched food system	**Scenario 3:** Integrated participatory approach
Traditional drivers/trends	Climate change			
	Quality of life in rural areas			
	Technological innovations			
	Food quality and safety			
Emerging drivers/ trends	Changing lifestyle			
	Emerging citizenship/ awareness			
	New business models			
	Skills requirements			
	New policy governance			
	New production systems			
Constraints/barriers		Infrastructure	Digital transformation	Trust /social innovation /social capital

Note: Blue - scenario contributes significantly and positively, red - scenario contributes negatively, yellow - moderate and positive effect.

These scenarios serve as a foundation for the comprehensive analysis presented in this report, offering actionable insights and policy recommendations for shaping the future of the agri-food sector in the Western Balkans. The following sections provide a deeper exploration of the challenges, opportunities, and strategic pathways for achieving a sustainable and innovative agri-food system in the region.

2. CONTEXT AND RATIONALE

The current agri-food system is seen as a major driver of environmental issues, particularly climate change (Mazhar & Zilahy, 2025), and is associated with loss of biodiversity, GHG emissions, high energy and water consumption, poor diet, increasing undernourishment, food waste, and many other socio-economic problems (Nikolić et al., 2025). Such unsustainable practices ***call for system-wide transformation*** (Kennedy et al., 2021; EC, 2023) to progress the Sustainable Development Goals, while boosting a low-carbon economy and climate-friendly

society. The agri-food system is complex, multifaceted in nature, and is reflected in vivid and constantly evolving behaviour, responsible not only for providing safe and nutritious food, but also for responding to wider societal needs.

While these global challenges are pressing, they are particularly relevant to the Western Balkans, where the agri-food sector faces additional challenges rooted in economic transition, limited technological adoption, and the need for structural reforms. Countries like Bosnia and Herzegovina, North Macedonia, and Serbia, with their evolving agricultural landscapes and varying levels of technological infrastructure, must address these global trends within the context of their own unique socio-economic conditions and development stages.

To reconcile economic, environmental, and social aspects of the agri-food system, innovative and modern solutions are needed, and the focus of this report is on digital and green transformation, which is seen as critical to providing such desired outcomes in Western Balkan economies and particularly in selected countries Bosnia and Herzegovina, North Macedonia, and Serbia. For several decades, the agrifood system has been active in rapid automatization, digitalization, and digital innovation (Akyazi et al., 2020; Lezoche et al., 2020; Tian et al., 2020), still the agrifood system has been recognized as a slow adopter of technology (Braun et al., 2018). Now, more than ever, digital[1] and green[2] agri-food transformation has transformative potential to deal with ongoing challenges, overturn such challenges into new business opportunities through communication, information and intelligence (Bai et al., 2020; Leng et al., 2020) enhancing data-driven processes making it more informed, efficient, profitable, secure, safer, environmentally friendly, sustainable and resilient (Lezoche et al., 2020). Additionally, **Twin (Green Digital) Transformation in Agri-Food** represents the integration of digital and green transformations, which means using digital tools to accelerate and enhance sustainability in agri-food systems. For example: *Precision agriculture* uses digital data to apply water and fertilizers only where needed, reducing waste and environmental harm, *IoT and sensor networks* monitor soil and crop health in real time, enabling targeted interventions that save resources and protect ecosystems, *Blockchain* ensures traceability for sustainably produced food, giving consumers confidence and incentivizing green practices; *Digital platforms* facilitate the adoption of green technologies by making information and products more accessible to farmers. Such transformation can contribute to ***(i) economic dimension*** (reduced set-up times, shorter lead times, reduced labour and material costs, decreasing logistics effort, such as order delay, damage to goods, errors, and multiple data entries (Tijan et al., 2019), while increasing production flexibility, productivity, customization and transparency and traceability); ***(ii) environmental dimension*** (managing system to work smarter minimising waste (Sestino et al.,

[1] **Digital transformation in agri-food** refers to the adoption of digital technologies such as *Precision farming:* Use of sensors, drones, GPS, and data analytics to optimize planting, irrigation, fertilization, and harvesting, reducing waste and increasing yields; *Mobile applications and ICT platforms:* Providing farmers with real-time information on weather, market prices, pest outbreaks, and best practices, empowering them to make informed decisions; *Data analytics and AI:* Leveraging big data and machine learning to improve crop predictions, resource allocation, and supply chain management; *Blockchain and traceability:* Ensuring transparency and food safety by tracking produce from farm to consumer, building trust and enabling secure transactions; *Digital platforms for market access:* Connecting farmers directly with buyers, reducing intermediaries, and opening up new economic opportunities (list of most promising technologies and detailed overview on this topic is provided here Nikolić et al., 2021).

[2] **Green transformation in agri-food** is the shift toward environmentally sustainable farming and food production practices. It involves: *Reducing chemical inputs:* Lowering the use of synthetic fertilizers and pesticides, and increasing organic alternatives; *Resource efficiency:* Optimizing water, energy, and land use to minimize environmental impact and preserve biodiversity; *Climate resilience:* Adopting practices and technologies that help agriculture adapt to and mitigate climate change, such as drought-resistant crops or sustainable soil management; *Circular economy:* Promoting waste reduction, recycling, and the reuse of agricultural by-products; *Sustainable value chains:* Ensuring that processing, packaging, and distribution are also environmentally friendly.

2020), allowing reuse, recycling, or remanufacturing and reducing energy and resource consumption through detection and data analysis across production and supply chain processes, decreasing the environmental footprint, (Lioutasa & Cha-ratsar, 2020); ***(iii) social dimension*** offering attractive jobs, while intelligent and autonomous production systems can support employee health and safety, by taking over monotonous and repetitive tasks; resulting in higher employee satisfaction and motivation (Bai et al., 2020), and contributing to public health and quality of life. Different policies have been developed because of complex, multiplayer, and multilevel characteristics, and long-term coevolutionary processes (Vivien et al., 2019; Giuntoli & Mubareka, 2023). Policy support includes, i.e., the European Green Deal, the EU Bioeconomy strategy, the Farm to Fork Strategy, and the Circular Economy Action Plan. Such a complex set of public interventions supports the transition to sustainable agricultural practices and efforts to mitigate climate change (European Parliament, 2023), but with different levels of success (Ferreira Gregorio et al., 2018; Imbert et al., 2017).

Traditional drivers such as impact of climate change, technology advancements, market requirements in terms of safety and security/demand, demography changes (i.e. more elderly people, "blooming" of fast-food and home delivery), are well recognized, on contrary, ***emerging drivers***—including new policy and governance narrative (i.e. food policy councils), consumer behaviour and changing lifestyle (i.e. demand for local, seasonal, organic, health concern), and social values (i.e. environmental concern)—are gaining prominence but are not yet systematically integrated into foresight processes. This study integrates such emerging drivers into the possible scenarios, which is particularly important for transitional and "emerging innovation" economies in which diffusion of innovation is slow due to different reasons, among which the weakness of the innovation ecosystem, especially the innovation infrastructure, stands out.

3. METHODOLOGY

This report is based on the foresight approach, which provides a valuable method to drive transformational change toward a better and more advanced system, a system capable of dealing with challenges in the 21st century. The foresight approach is a process of visioning alternative, possible, probable, and preferable futures (OECD, 2025; Kuosa, 2012; Bell, 2003), and is seen as a valuable method that brings together diverse food system stakeholders such as farmers, agri-food businesses, and governments to drive transformational change (Gupta et al., 2025).

By exploring future scenarios, participants can better understand and address possible risks and vulnerabilities while also identifying and seizing opportunities – emerging drivers (so-called weak signals) for positive transformation within the food system. In this process, stakeholder engagement and careful selection of the type of stakeholders involved are needed to ensure diversity and inclusion, different expertise, interests, and power, and it is of crucial importance for scenario development and planning (Paddeu & Lyons, 2024).

The foresight approach draws on a wide range of methods and practices, and their use depends on context and the objectives of the studies/projects. Regardless of the approach, they are based on exploring alternative futures, fostering collaboration, collective ownership, and shared vision from inclusive dialogue. For this project, Horizon scanning and visioning methods were applied to systematically collect insights on emerging trends and weak signals of change and identify potential threats, risks, and opportunities. This methodological approach was implemented to highlight areas where policies and strategies change may be needed and alternative futures (scenarios) developed. Additionally, the advantages of using such an

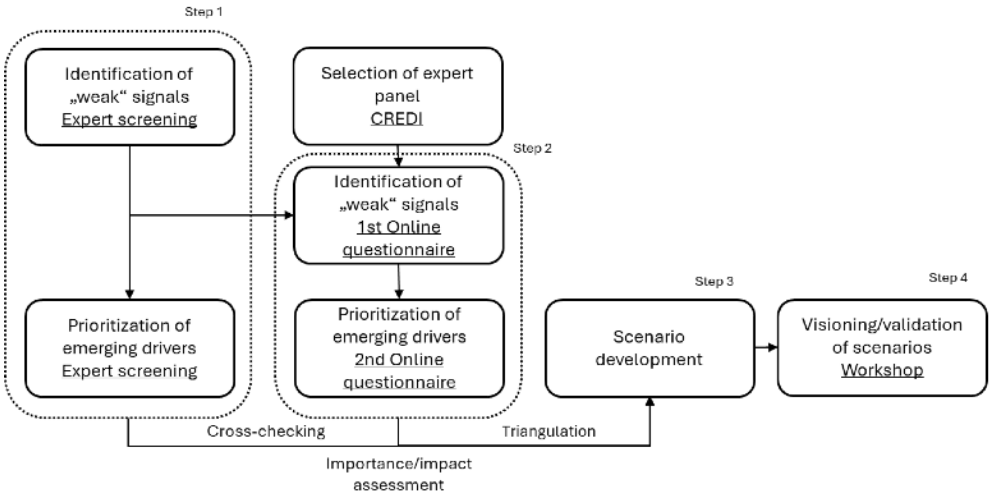
approach are seen in its holistic and comprehensive view, integrating diverse sources to build a broad understanding of potential future scenarios, which is important in highly complex food system changes. Furthermore, the process is inclusive and provides a collaborative framework for defining alternative futures and guiding transformative actions in the food system (WEF, 2018; Antonelli et al., 2019; Global Panel on Agriculture and Food Systems for Nutrition, 2020; FAO, 2022a; 2022b; FAO & CIRAD, 2025; Gupta et al., 2025).

Our methodology comprised standard and accepted elements of the future studies, complementing horizon screening with a visioning process including: i) defining the scope of the question for the "screening" phase, ii) identifying relevant stakeholders, iii) recognising fundamental trends and uncertainties, iv) developing preliminary scenario narratives, and vi) checking for completeness and clarity/validation of scenarios.

A stakeholder mapping exercise non-randomly identified a diverse range of organisations working in the agri-food sector or complementary sectors from the Western Balkans to participate in this study. Secondly, for further validation of plausible scenarios, representatives from organizations, businesses (small, medium, and large) were invited to participate in surveys and workshop(s) to provide diverse and contrasting expertise and experiences. This approach ensures understanding of wider economic, social, and environmental systems, facilitating holistic insight into a multifaceted agri-food system.

The steps of the methodology are illustrated in the following figure and are further described below.

Figure 2: Methodology framework



Step 1: Expert assessment of weak and strong signals, and emerging drivers was done by identifying and reviewing existing literature, from academic journals, and project reports, to relevant professional and industry journals, headlines from magazines, and particularly focusing on previous foresight studies (WEF, 2018; Global Panel on Agriculture and Food Systems for Nutrition, 2020; FAO, 2022; FAO & CIRAD, 2025). This phase was important to develop scoping questions for the 1st online questionnaire (Annex 1), as well as 2nd online questionnaire (Annex 2).

Step 2: Screening phase: The selection of the expert panel was done by CREDI, and the expert panel consists of SmartLabor network partners and other stakeholders mapped within the

project. A pool of experts with a range of disciplines (different sectors), but with experience in the agri-food sector, ensures different and contrasting views. After the first round of questionnaires was distributed, responses were analysed, and according to the findings, the questionnaire for the 2nd round was adjusted. Two rounds of questionnaires were distributed to collect feedback from a wide range of stakeholders to highlight drivers and barriers within the agri-food sector, particularly important was to look for “weak” signals. Because of the project's need, scoping questions were centred around workforce and skills shortages, but all the time, there were open questions to allow experts to express their concerns and “visions” about the future of the agri-food sector. First round was designed to identify: (i) most pressing general challenges, workforce shortages, and skills shortages in the agri-food sector in next ten years, (ii) how digital technologies can support agri-food sector development, (iii) what are key national strategies or policies that can influence sector development, finally (iv) how they see sector development in next ten years.

Step 3. Scenario development, based on the screening phase and participants' feedback, initial scenarios were developed. During this process, signals of change were evaluated for their importance and impact. Each signal was assessed by an expert, positioned on the impact matrix, and later integrated into the developed scenarios. The results of this assessment are presented in the Results section (Figure 6), where the impact matrix provides a clear overview of the signals' potential influence. The matrix plays a crucial role in prioritizing and categorizing potential future outcomes by examining both their impact and certainty. This distinction allows for the identification of expected developments that require planning (high-impact, high-certainty) and emerging, uncertain outcomes that could indicate potential surprises or disruptions. This structured methodology facilitates the systematic analysis of how different trends and events may interact, providing valuable insights for identifying risks, opportunities, and strategies, which ultimately enhances preparedness for complex, interconnected futures.

Step 4. Visioning – validation of scenario. The final stage of methodology includes validation of scenarios. This was done in a face-to-face workshop held in Belgrade on 19.09.2025., organized as part of the conference “Farming the Future: Smart Agriculture in the Western Balkans,”. Participants were divided into four groups, each comprising up to 10 participants. Three groups participated in person, with each group working on one specific scenario, while the fourth group joined online and could choose which scenario to work on, ultimately focusing on the first scenario. Each group was moderated by a member of the research team to ensure structured discussions.

Each scenario was presented in the form of a one-pager, focusing on the most important characteristics. Based on stakeholders’ feedback and group discussions, scenarios were further refined and upgraded to better reflect their perspectives and priorities. (Annex 3 – summary of stakeholders’ feedback). This structured approach ensured active engagement, validation of assumptions, and alignment of scenarios with real-world expectations, strengthening the relevance and applicability of the final outputs.

The following section provides an overview of why these countries were selected for the study and highlights key characteristics of their agri-food sectors.

4.COMPARATIVE OVERVIEW – COUNTRY SNAPSHOTS

The agri-food sector in selected countries, Bosnia and Herzegovina (BA), Serbia (RS), and North Macedonia (MK), always plays a vital role in the socio-economic development, especially in terms of the number of people engaged in agricultural activity, favourable geo-climatic

conditions, and market position. This is recognized, and policies are designed to prioritize the agri-food sector (i.e., strategies for agricultural development and strategies for economic development), but implementation is rather weak. Such a „traditional "environment is facing numerous challenges in terms of climate change adaptation and rapid technological innovation, all of which require a higher level of knowledge and more active information sharing (participation) among all the value chain actors. Usually, farmers and SME entities lack this ability, resulting in poor networking capacities (low access to information), poor development, weak exchange of information, knowledge, and know-how, weak (and questionable quality) production inputs, and a lack of specialized business services and skilled workforce. The importance of the agricultural sector and its development patterns can be seen from the presented indicators below.

Table 1. Sectoral indicators – gross agricultural output and employment (adapted from Martinovska Stojcheska et al., 2021)

Indicator	Period	BA	MK	RS
GVA of agriculture (million EUR)	2010–2012	871	705	2 296
	2017–2019	985	899	2 635
	Index 2017–2019/2010–2012 (%)	113.1	127.5	114.8
Proportion of agricultural GVA out of GVA of all activities (%)	2010–2012	8.2	11.0	8.1
	2017–2019	6.8	9.7	7.4
	Index 2017–2019/2010–2012 (%)	83.2	87.4	91.6
Employment in agriculture and forestry (thousand persons)	2010–2012	164.3	118.3	492.7
	2017–2019	144.1	116.9	461.7
	Index 2017–2019/2010–2012 (%)	87.7	98.8	93.7
Proportion of those employed in agriculture and forestry out of total employment (%)	2010–2012	19.9	21.5	22.9
	2017–2019	17.5	16.2	18.6
	Index 2017–2019/2010–2012 (%)	87.9	75.6	81.4

The necessity to spur digital and green transformation in Bosnia and Herzegovina, North Macedonia, and Serbia is more than evident to successfully deal with agri-food sector challenges and impact sustainability and resilience of the sector, but also the region. Generally, the Western Balkan region ***demonstrates increased efforts for regional cooperation in the domains of economic and innovation potential***. Particularly, the Economic and Investment Plan for the Western Balkans aims to support the region by sustained ***economic recovery, ecological and digital advancement, and strengthened regional bonds*** within the Western Balkans and with the European Union. Initiatives such as the Common Regional Market (CRM) Action Plan for 2021-2024, Regional Trade Area, Regional Investment Area, Regional Digital Area, and Regional Industrial and Innovation Area are all aimed at spurring ***transition, improving competitiveness, driving economic growth, and job creation***. Additionally, Smart Specialization Strategy (S3) is in different stages of development (i.e., Serbia is fully developed and accepted, North Macedonia is developed – still pending, while Bosnia and Herzegovina is in

the initial phase) (Radovanovic & Stevanovic Carapina, 2024). Within S3, all Western Balkan economies prioritise sustainable agriculture (food processing) and ICT, while also highlighting the growing need for a skilled workforce and the necessity to adopt technological innovations and environmentally friendly practices (JRC, 2023; World Bank, 2025).

The Western Balkan economies are committed to Sustainable Development Goals, the European Green Deal, and the Green Agenda for the Western Balkans (GAWB). However, the Green Agenda's implementation lags due to incomplete legal documents and necessary reforms. Governments perceive the green transition mainly as an obligation imposed by the European Union (Radovanovic & Stevanovic Carapina, 2024). GAWB is structured around five pillars: (1) climate action, including decarbonisation, energy and mobility, (2) circular economy, addressing in particular waste, recycling, sustainable production and efficient use of resources, (3) biodiversity, aiming to protect and restore the natural wealth of the region, (4) fighting pollution of air, water and soil, and (5) sustainable food systems and rural areas and as highlighted in line with the idea of the dual green and digital transformation, the focus is placed on ***digitalization as a crucial enabler*** for the aforementioned five pillars (Radovanovic, & Stevanovic Carapina, 2024). Furthermore, ***WB economies recognise the potential and importance of agri-tech***, but this does not necessarily translate into economic activity (ETF, 2022; 2024; Stojcheska, 2024).

All three countries have adopted national strategies for agriculture and rural development, as long-term documents defining the future development of the sector. North Macedonia and Serbia have adopted the third IPARD programme for the period 2021-2027. Strategic objectives are strongly related to the EU CAP objectives, including competitiveness, environmental protection and development of rural areas (see Table 2). Still, direct producer support to farmers is predominantly used as an agricultural policy instrument; thus, increasing producers' income is the priority objective, compared to the other respective objectives (Radovanovic & Stevanovic Carapina, 2024; Martinovska-Stojcheska et al., 2021; JRC, 2017). The proportion of measures currently linked to greener policy and particularly for research and development in the Western Balkan countries/territories remains very modest, limiting its innovation potential, albeit with a slight upward trend in recent years (Radovanovic et al., 2022; Radovanovic & Stevanovic Carapina, 2024). Particularly, the IPARD programme 2021-2027 assists rural development in the WB and can be seen as a positive example of an increase in funding for agri-food sector development (Radovanović et al., 2023b; European Commission, 2024).

Table 2: Comparison of the EU key objectives with strategic objectives of selected countries (adapted from Radovanovic & Stevanovic Carapina, 2024)

CAP 2023-2027 objectives	Objectives in selected countries' agricultural and RD policy strategies (2023-2027)
To ensure fair income for farmers.	Stability of producers' income (BA, RS). Sustainable income.
To increase competitiveness.	Increasing competitiveness (all countries) plus, marketability (BA).
To improve the position of farmers in the food value chain.	Improve the position of farmers in the food value chain (MK).
Climate change actions.	To mitigate and adapt to climate change (MK).

Environmental care.	Environmental protection (RS). Efficient management of natural resources (MK). Sustainable management of natural resources (BA, RS).
To preserve landscapes and biodiversity.	Preservation of landscapes and biodiversity (MK).
To support generational renewal.	To attract young farmers (MK).
Vibrant rural areas.	Improved and better quality of life in rural areas (BA, RS). Local development of rural areas (MK).
To protect food and health quality.	-
To foster knowledge and innovation.	Enhancing and sharing knowledge, innovation, and digitalization in agriculture and rural areas (MK).
Other.	To improve institutional capacity (BA, RS) and effective management of public policies, and improve the institutional framework (RS).

Because expected temperature increases of 1.7 – 4.0°C, or even over 5.0°C by 2100, followed by less rainfall and more frequent occurrence of natural hazards, such as floods, droughts, hail etc. (Radovanović et al., 2023b; RCC, 2018) that will consequently impact agriculture (e.g., decrease in quantity and quality of agricultural products); forestry (e.g., higher risk of widespread forest degradation, forest fires); and natural resources (e.g., deficiency in water for irrigation, land erosion and degradation) (Stričević et al., 2019; Radovanovic, & Stevanovic Carapina, 2024). In the WB region, these impacts are particularly related to water usage and scarcity (Regional Cooperation Council, 2021), 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). Such impacts are calling for a proper response in terms of the establishment of technological and technical infrastructure, particularly one associated with modern and efficient water management (i.e., smart irrigation systems), other natural resources (i.e., soil management and biodiversity protection), and digital transformation. Such infrastructural “upgrade” must be accompanied with soft infrastructural development in terms of development of efficient agricultural knowledge system (as a base for innovation), agricultural insurance system (which is underdeveloped despite various efforts to improve the situation (World Bank, 2025)), food quality and safety systems (there is increasing call for transparent and traceable food system, one that enable relevant, accurate, real-time information, thus enabling customer to react, to develop healthy eating habits and lifestyle choices).

From an environmental perspective, institutions and consumers are increasingly concerned about environmental issues, promoting sustainable agriculture practices. At the same time, there is stronger pressure on farmers to innovate, change production, and adopt different, usually sophisticated practices to minimise environmental impacts across the supply chain (Radovanovic & Stevanovic Carapina, 2024; Nikolić et al., 2025; Mujčinović et al., 2024). Somehow, farmers are left alone, with very scarce resources and underdeveloped “hard & soft” infrastructure. So, because of the lack of skills, particularly in project management, sustainability practices, and infrastructure development (Radovanovic & Stevanovic Carapina, 2024), farmers are struggling and have difficulties following such desired transformation. At the

same time, the policy framework is very complex and does not target the aforementioned problems, making the situation even more complex and more demanding to change.

5. KEY CHALLENGES IN THE AGRI-FOOD SECTOR

There is common agreement on complexity and interconnectedness of agri-food systems issues, the complex interactions between demographic, environmental, technological, and economic drivers impacting food production, processing, distribution, and consumption. Review of the literature identified wide range of trends shaping agri-food systems, but one that stood out are associated with climate change impacts (increasing temperature, extreme weather events, but also antimicrobial resistance, contamination, etc.), changing consumer preferences and lifestyle (i.e. towards healthier, sustainable and ethically produced food, dietary shifts towards plant-based diets, functional food, demand for greater transparency along the value chain, authenticity, food safety assurance), new food sources and production systems (alternative sources like plant-based alternatives, edible insects, urban agriculture methods, vertical, hydroponic, aquaponic production methods), new business model i.e. circular economy (waste reduction, resource reuse), technological innovations (intelligent packaging, nanotechnology, 3D/4D food printing, portable sensing devices, blockchain, IoT, AI, automation), food fraud (enhanced detection, regulatory strategies, stakeholder cooperation). Based on the literature review and expert screening phase, online questionnaires were developed, and after the first round of questionnaires (n=30), responses were analysed, similar responses were grouped, and findings are presented in the following table.

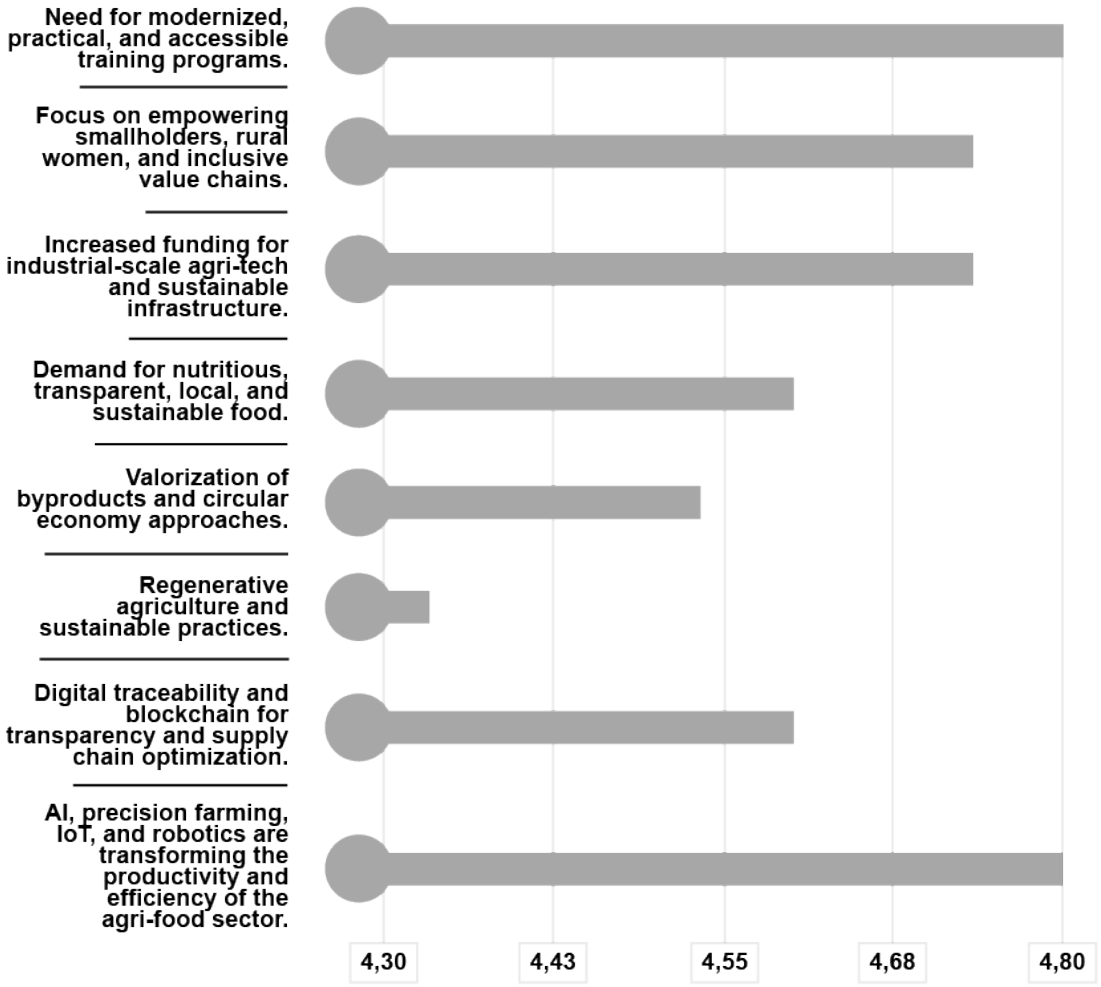
Table 3: Overview of results from first round of questionnaire

Challenges in the agri-food sector		Potential of digital technologies	Key strategies	Future development
General challenges	Workforce and skills shortages related			
Lack of workforce and aging rural population	Lack of digital skills	Application of precision agriculture and automation	National strategies for agriculture and rural development	Political obstacles
Low digitization and technological readiness	Lack of knowledge on sustainable practices	Use of IoT, sensors, drones, and big data analytics	EU integration programs (IPARD, Green agenda)	Lack of consistent support
Climate change and extreme weather conditions	Lack of training on new technologies	Automation, optimization	Climate change and environmental protection strategies	Workforce migration and its impact on the sector
Land fragmentation and small farms	Lack of lifelong learning and training programs	Online markets and digital platforms	Programs to encourage young farmers	Competition from imports and market imbalance
Lack of education and knowledge transfer	Farm succession and transfer of “local” knowledge	Education and knowledge sharing	Programs and policies for education	Weak connection between producers, processors, and markets

Food safety and quality standards issues	The gap between the education sector and the agri-food sector	Supply chain monitoring and food safety	Policies for improving standards and EU-aligned food safety	Lack of long-term vision and coordination in the sector

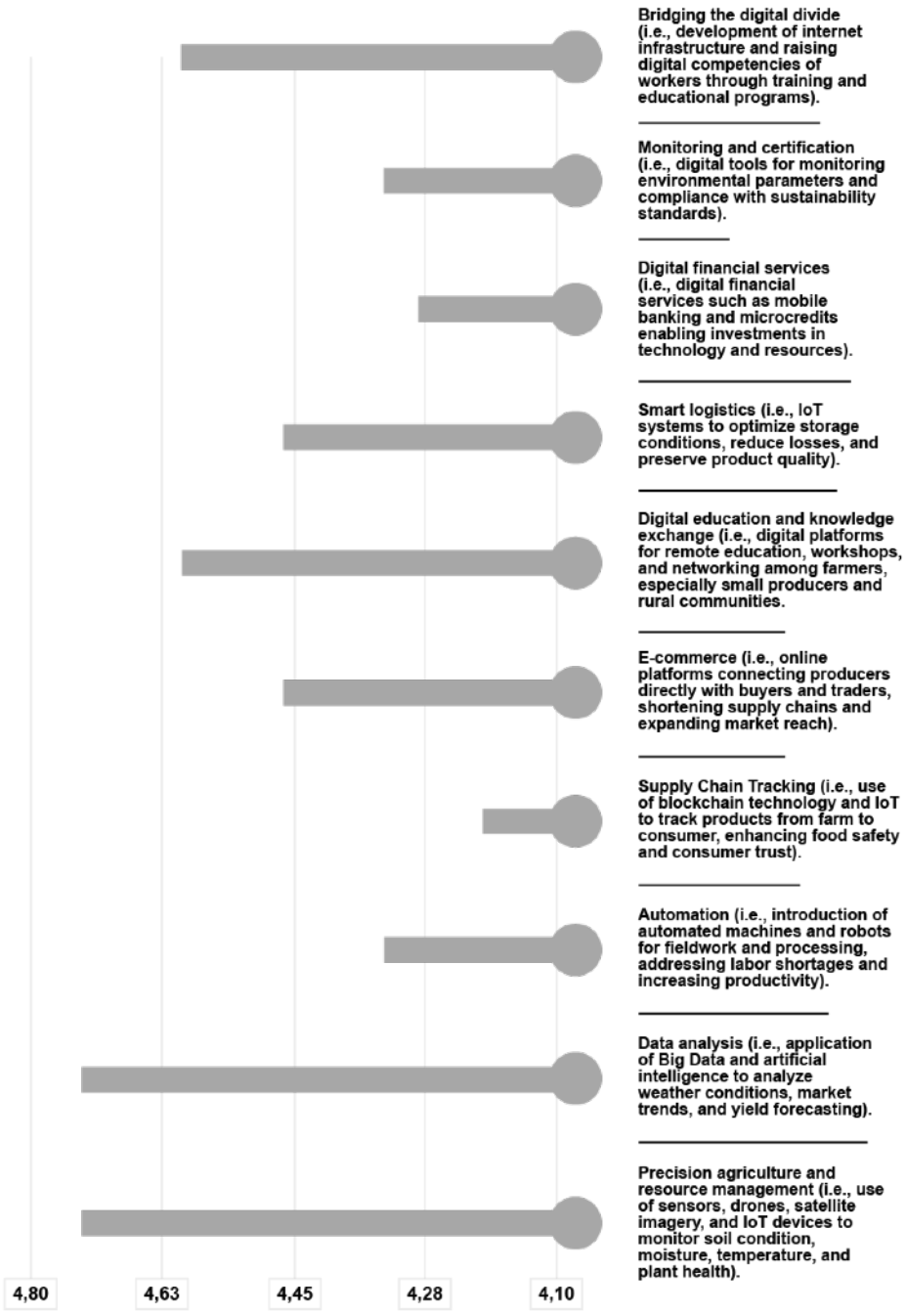
Results from the expert screening phase and first round of questionnaires were then used to develop a questionnaire for the second round, and the focus was on the importance of (i) emerging trends in the agri-food sector, (ii) opportunities to improve the situation in the sector, and (iii) skills mismatch. For the second round of the questionnaire, participants were asked to rate importance by using a Likert 5-point scale, from 1 – very unimportant, 2 – unimportant, 3 – neutral, 4 – important, 5 – very important. Findings from the second round of questionnaire (n=15) highlighted a high level of agreement with identified trends, particularly with the necessity for modern, practical, and accessible training and AI, precision farming that are transforming productivity and efficiency of the agri-food sector. Smaller importance was highlighted for regenerative agriculture and sustainable practices, and valorisation of by-products and circular economy, but again, those claims are also important (Figure 3).

Figure 3: Emerging trends in the agri-food sector



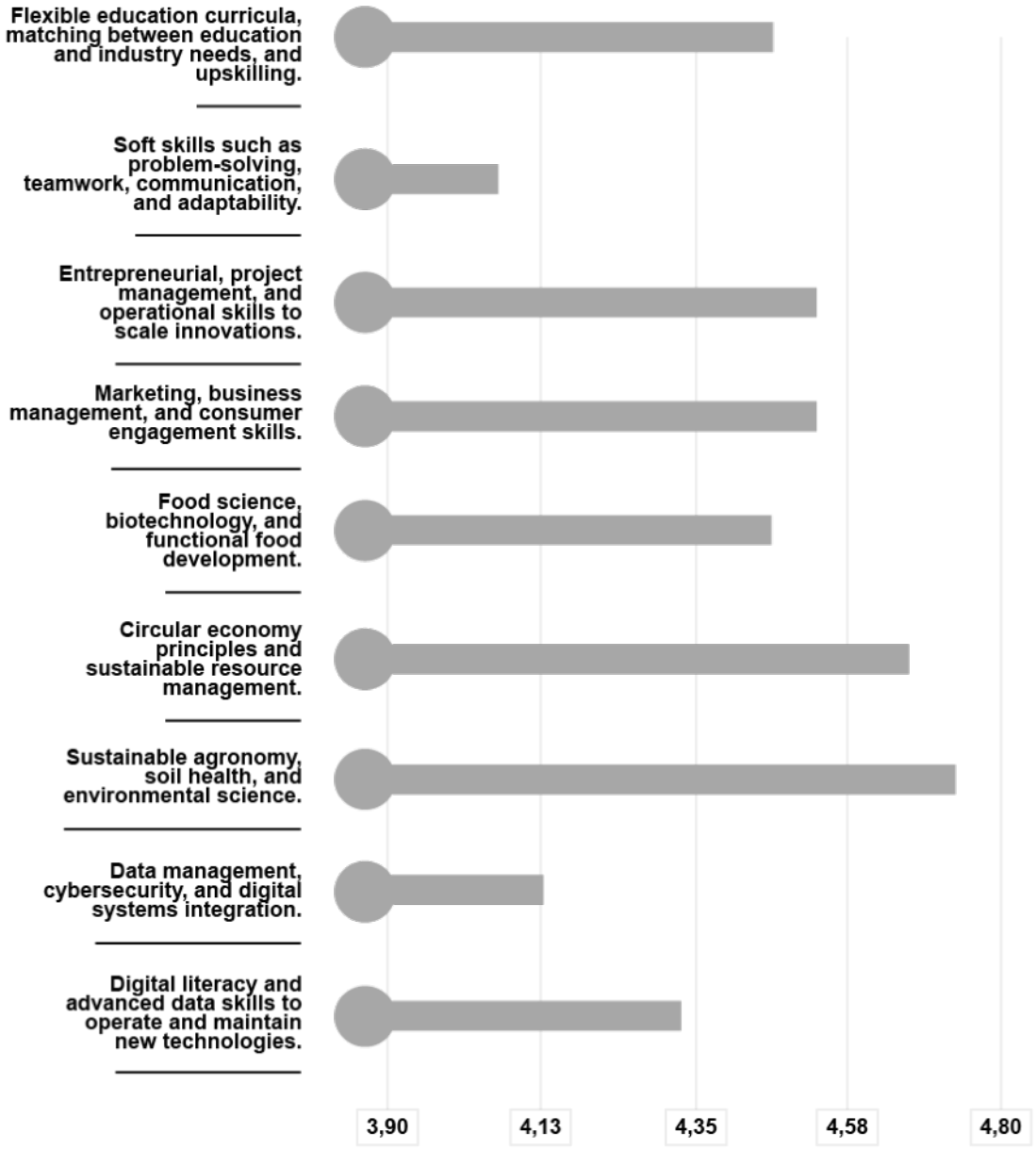
When it comes to the opportunities in the agri-food sector, stakeholders highlight emerging opportunities such as precision agriculture and resource management and data analysis, bridging the digital divide, while of less importance highlight supply chain tracking, automation, digital financial services, monitoring, and certification (Figure 4).

Figure 4: Emerging opportunities in the agri-food sector



Finally, when it comes to the skills mismatch, stakeholders address sustainable agronomy, soil health and environmental sciences, circular economy principles, and sustainable resources management as the most important missing skills, followed by entrepreneurial, project management, marketing, and business management skills. Less important are skills such as soft skills, i.e., problem-solving skills, data management, and cybersecurity skills (Figure 5).

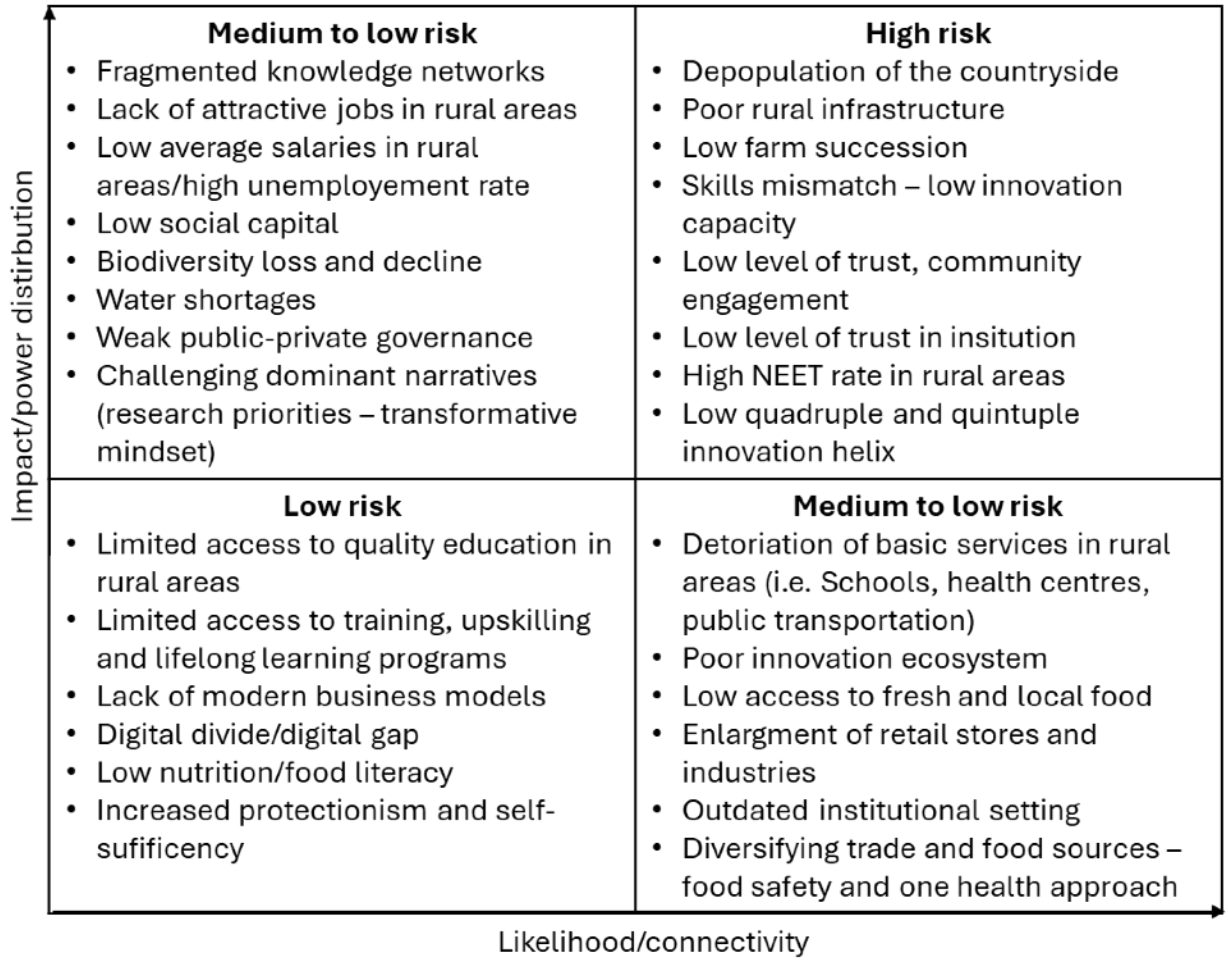
Figure 5: Skills mismatch



After the expert screening phase, two rounds of online questionnaires, the results were compared, cross-checking was done, and identified trends, signals, and opportunities were

positioned on the importance/impact matrix (Figure 6). This was the final step before proceeding to the scenario's development.

Figure 6: Importance/impact matrix



According to the results, both from expert screening and the prioritization process (secondary data) and two rounds of online questionnaires process (primary data), key challenges were identified and served as material for scenario development. The agri-food sector is undergoing a profound transformation driven by demographic shifts, technological innovation, climate change, and evolving consumer demands. However, workforce shortages and skills mismatches remain persistent bottlenecks that undermine the sector's capacity to adapt and thrive. The sector is facing significant and multifaceted challenges that threaten productivity, food security, and the long-term sustainability of the sector and region. Understanding these challenges is essential to designing effective policies and strategies for a resilient and sustainable food system in selected countries. However, it should be noted that deterioration of quality of life in those rural areas is the result of a ***complex interplay of social, economic and infrastructural factors***, and among them loss of ***(i)* b*asic services*** i.e. schools, healthcare centres, public transportation, shops often "triggers" a self-reinforcing cycle of decline, making rural areas less attractive and further depopulation trends. Rural areas are also dealing with many ***(ii) economic challenges***, mainly with the availability of jobs, lower average salaries, higher rates of underemployment or

unemployment, and higher rates of NEETs (young people not in education, employment, or training). Also, ***(iii) inadequate infrastructure*** is often found in rural areas, in terms of poor roads, lack of or unreliable public transportation, unreliable electricity, limited internet connectivity, and water shortages, which hinder daily activities but also economic development. Another critical challenge is associated with ***(iv) limited access to quality education*** as schools and kindergartens are often understaffed, under-resourced, limiting opportunities for personal development, limited access to training, upskilling, and lifelong learning programmes. Those challenges are particularly affecting women and marginalized groups. They are consequently resulting in the sector missing out on a significant portion of the potential labour force as well as diverse perspectives (i.e., avoiding masculinity trends that are well-documented all over Europe).

The most pressing issue is one associated with demographic shifts, an aging workforce, and declining labour availability. ***Depopulation of the countryside*** is happening not only because of an insufficient number of jobs but also because of an insufficient number of prestigious and well-paid jobs, and limited possibilities to make a career. Rural areas are less attractive for young farmer succession, limiting their capacity to generate social, economic, and environmental benefits, while also leading to the loss of traditional knowledge. Agriculture is often perceived as an outdated, physically demanding, and low-wage industry, which discourages young people and skilled professionals from pursuing careers in the sector. The sector relies heavily on seasonal and temporary workers, and there is often a decline in product quality and safety due to overworked staff and a lack of skilled labour. This is further exacerbated by urbanization and migration trends, shifts to service-oriented economies, making it challenging to ensure labour availability in rural areas.

Skills gaps and changing skill requirements - the sector is experiencing a high rate of skills misalignment, including both over- and under-qualification, making it difficult to match available workers to evolving job requirements. In terms of technological innovations (such as precision agriculture and automation) and sustainable practices, which are rapidly changing the skill set required, many potential candidates lack the necessary digital, technical, or management skills. There are acute shortages in social skills, teamwork, problem-solving, quality control systems, and equipment maintenance. Training and education systems are not keeping pace with sector demands.

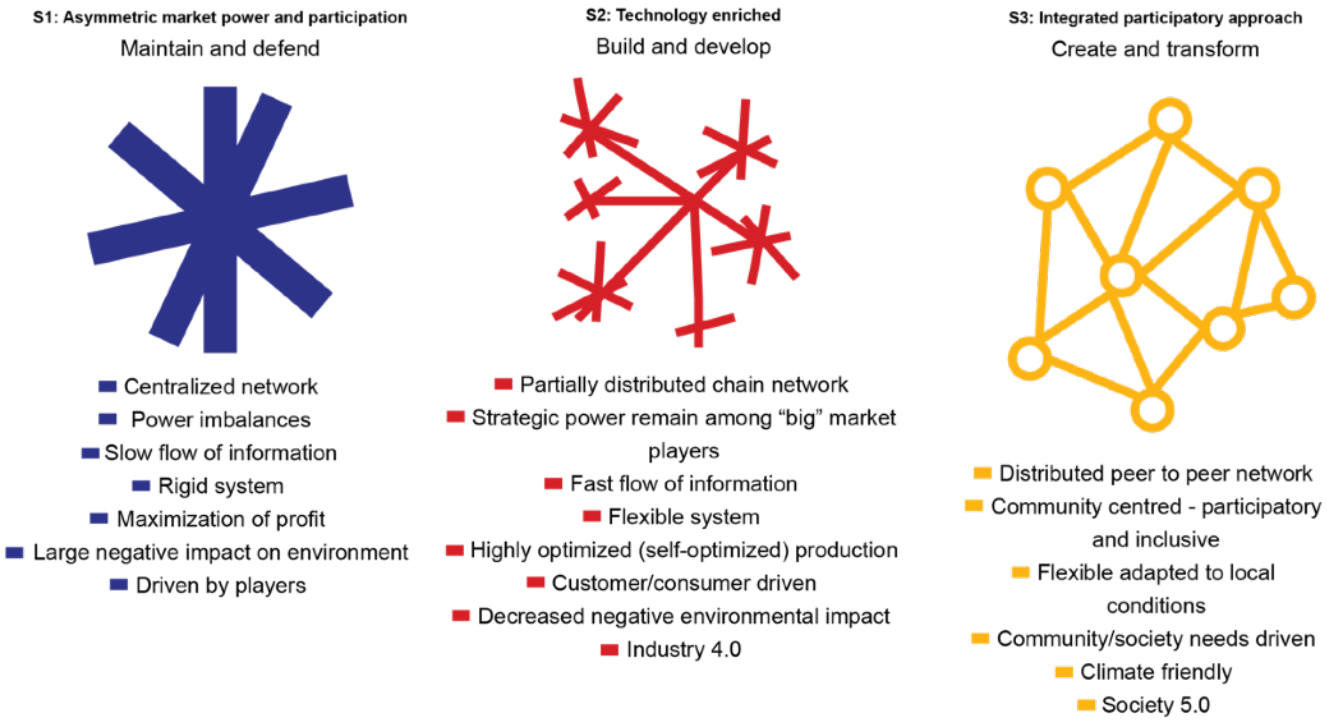
A weak innovation ecosystem that is reflected in a lack of integration in niche markets and regional food systems, or low diversification of farm activities, i.e., a lack of new business models such as agroforestry, care farms, and agrotourism. Additionally, there is ***fragmented knowledge networks***, poor connection (which is later reflected in poor collaboration and undeveloped social capital) between education system, economic system, natural environment, media-based and culture-based public (civil society) and political system, known as quintuple helix limiting sector's ability to generate, absorb and diffuse (transfer) new knowledge, technologies, practices, further limiting growth potential.

6. FUTURE SCENARIOS

The agri-food system transformation is underway, fostered by socio-economic, political, and environmental conditions and changes. The WB region is facing many challenges addressed above, but workforce shortages and skills mismatch are the ones that are currently preventing the desired agri-food system transformation. Based on collected primary and secondary data about strong and weak signals, identified uncertainties, three plausible scenarios were developed, each representing scenario associated with decent level of connectivity (extent and

quality of linkages and interactions among the various activities, actors, and stages involved in creating and delivering a product or service), distribution of power and responsibility (how decision-making authority, control, and accountability are shared among the actors and activities) across the chain. Therefore, scenarios range from a food system that is connected and where origin is known, food is fresh and seasonal, and there are strong ties between producers and consumers, to low low-connected system, where origin of food is not known, or questionable, and there are low or no ties between producers and consumers. Also, all three scenarios consider resource efficiency, ranging from efficient systems and systems that are inefficient in resource management, and therefore have enormous negative environmental impacts. Figure 7 describes the major characteristics of each scenario developed.

Figure 7: Major characteristics of designed future scenarios for agri-food systems



Scenario 1: Asymmetric market power and participation

This scenario is centered around the idea of investing in the large, often vertically integrated companies and farms, aiming to maximize yields and reduce the cost of production. This initiative focuses on developing the existing "core business" by enhancing efficiency and effectiveness, aiming to maintain and defend "successful practices".

Power distribution: Market power is asymmetrically distributed, with "big market players" (usually large farms/buyers holding) significant influence over pricing, input supply, and the value chain. Meanwhile, smaller farmers (small and medium-sized) often have limited market access, having low market/negotiation power, which increases their vulnerability. Such

concentration led to monoculture practices and industrial farming methods, focusing on maximizing yields and efficiency but potentially at the cost of environmental and social sustainability. Farms are operating in highly competitive and volatile markets; therefore, investment in the storage and cooling facilities must be made. Access to sophisticated knowledge, resources/infrastructure (including digital ones), equipment, and community support (including knowledge system) is low.

Role of actors: Dominant role of large farms and large buyers with high market power, with limited to no access to value chains for small and medium farmers, Strategic decisions are done by large farms, while others are not involved in such processes resulting in low diversity of the system, solution and focus is usually on technical solutions and not on mind setting all consequently leading to low level of resilience and sustainability of the system. Community is having limited engagement, particularly affecting local rural economies because of power imbalances (which further result in population leaving rural areas), the government provides subsidies that large farms and achieve food safety and environmental compliance.

Resource efficiency: Because of a strong focus on maximization of yields through intensive use of agricultural inputs, it consequently leads to environmental degradation (i.e., soil degradation, water pollution, water use shortages, etc.).

The connection between consumers and producers is low to non-existent, due to highly complex supply chains, resulting in limited access to product information for consumers.

Fostering regional cooperation: limited due to the competitive market dynamics, the policy framework may promote fair competition, or support for smaller farmers to co-exist alongside large farms.

Policy interventions are focused but not limited to:

- Support large input-intensive farms (monoculture), followed by support to obtain adequate machinery; support to obtain cooling and storage facilities to ensure product quality and better prices.
- Establishment of specific financial insurance lines for farmers because of reduced heterogeneity and intensification of farming activities, there is increased vulnerability to agricultural pests and diseases, as well as greater flood risk, climate change effects, etc.
- Support in the development of locally adapted and more resistant to climate change effects varieties – there is a necessity to form a public-private partnership to investigate into the locally adapted seeds and seedling materials, to ensure yield stability and quality of the products, as well as to reduce strong dependency on foreign inputs.
- Support for phytosanitary measures, as with the increase of monoculture, the emergence of new pathogens is evident.
- Support to diversify farm activities and introduce crop rotation to mitigate the potential for rapid disease spread.

Scenario 2: Technology-enriched food systems

This scenario focuses on a transparent and traceable system, strongly supported by technology. It is crucial to note that technology is not context-neutral; therefore, expected improvements and benefits will be achieved only if it is used to transform current agri-food systems. Still, this scenario fosters innovation/creation and development based on emerging opportunities that have the potential to become significant in the future. These are often related to new markets, products, or business models/initiatives built on new technology utilization (Industry 4.0).

Power distribution: This system is designed to have different layers of food nets. The lower layer consists of a usually distributed net of interconnected, interrelated short food supply chains, food hubs, and individual actors. In contrast, the higher food-net layer driving strategic transformation and development consists of a partly decentralized network of more powerful payers. Their power is based on either market power, innovation/technology strength, or better connections with the community. So, transfer of responsibility for improvement and dealing with global challenges is shared among all actors, but some asymmetry still exists. Such a food system connects better producers, consumers, and all other stakeholders, ensuring a high level of transparency and traceability, thus enabling smarter, more responsive, and environmentally responsible food production and consumption. Combined with a community-centred approach, it can accelerate transitions to resilient and sustainable local food systems that benefit farmers, consumers, and ecosystems.

Role of actors: Strategic power remains among large companies to implement procurements, logistics, and traceability. Tech-savvy companies/farms are gaining in importance, with the presence of large and medium-sized farms that might benefit from digital contracts and data sharing. Community engagement is facilitated through digital platforms and local innovation hubs, while the government supports innovation, equitable technology access, and data privacy.

Resource efficiency: high, with optimized input usage, reduced waste, and better monitoring. The system is capable of self-optimization, self-structuring, and self-nutrition, while striving to achieve sustainability and resilience, increased productivity and efficiency, optimising externalities, promoting inclusiveness, and enabling small farmers to have an equal position within the system, and finally, to achieve a high level of benefits and redistribution across and between all actors

Connection between consumers and producers: Variable, from medium to high, technology can increase transparency and direct interaction.

Fostering regional cooperation: Promote regional innovation clusters, public-private partnership, shared digital infrastructure.

Policy interventions are focused but not limited to:

- Establishment of pilot farms for knowledge and practice exchange – to foster peer-to-peer education, facilitate technology uptake – this approach is needed to provide “role model”, demonstration sites that are open for experimentation with adopting new, innovative, eco-friendly methods. Pilot farms are living examples where other farmers can directly observe the implementation of specific techniques or technologies, thus reducing the risks perceived by others in trying new approaches and spreading practices. Such farms create collaborative learning environments, peer-to-peer education platforms that can host different events, from meetings, workshops, to competitions. They also serve as an interface between research, extension, and practice, closing the loop of innovation and knowledge exchange.

- Public education campaigns and hackathons with the aim: to raise awareness and build trust and collaboration among the actors, which is seen as essential for technology adoption, to attract funding; to attract talents – farmers, researchers, technologists, entrepreneurs to jointly develop innovative solutions tailored to local food system challenges; to support community engagement, networking, etc.

- AI-driven platforms – provide actionable insights and recommendations, support less-experienced workers, and help bridge skills gaps in areas such as crop management, pest identification, and yield forecasting, accessible to all – not only in case of lack of advisory services but also all the time, 24/7.

- Automation: AI-powered robots, autonomous tractors, and drones can automate planting, weeding, spraying, and harvesting, significantly reducing dependence on manual labour while helping to improve quality and safety control. Given that automation is typically associated with large companies and is often hindered by high initial costs, the recommendation is to form alliances that jointly purchase such machinery.

- Big data management: data from satellites, sensors, weather forecast/climate patterns, soil data, historical records integrated to make more informed decisions about i.e. planting, crop stress, input management - nutrition deficiencies, irrigation, pest management, harvesting ensuring timely interventions, reducing waste and environmental impact and improving quality and quantity of the yields and quality of life in rural areas.

Scenario 3: Integrated participatory approach

This scenario is centered around the idea of a system that promotes environmental, social, economic, and nutritional values tailored to the needs and values of the local community. It integrates sustainable agricultural practices, supports local farmers and communities/ economies, while providing fresh and nutritious food to the community and the region. This scenario is based on a profound transformation of the role of each person, actor, and group that is driven by a changed “mindset”, not only technology. It fosters highly exploratory activities that involve investing in next-generation innovations, i.e., social innovations driven by technology. So, risks are higher, and the outcomes are more uncertain.

Power distribution: A distributed peer-to-peer network that relies on public/private interventions designed to activate individual and joint activities of actors across the community/food system, thereby building a rural-urban continuum. This multifaceted and community-centered approach aims to increase the quality of life, provide a clear investment activity plan to upgrade hard and soft infrastructure (building crucial hubs/living labs of the regional ecosystem), and decrease negative environmental externalities.

Role of actors: Community-centered, participatory, and inclusive, supporting local markets, local food hubs, cooperatives, and public procurements. Farmers are diversified and engaged in cooperative models, while the government provides support for local infrastructure.

Resource efficiency: High because of incentivized local resource recycling, diversifying cropping systems, and minimizing transport. Solutions are innovative and tailor-made, highly diversified, and foster an innovation culture within the whole community.

Connection between consumers and producers: High connection through direct sales, farmers' markets, community-supported agriculture, and participatory activities.

Fostering regional cooperation: Joint activities in building local food infrastructure, shared resource management, and facilitating knowledge exchange across the region. Individual interventions are not sufficient to achieve such a scenario; instead, a combination of different measures presented below (but not limited to) is essential to reach desired outcomes. The system is based on trust, cooperation, collaboration, exchange of information and knowledge, and it is strongly supported by consumer willingness to buy environmentally friendly products and to change food habits as well.

Policy interventions are focused but not limited to:

- Establish food policy councils or advisory groups to guide local food system development and help align goals and share resources among different actors, farmers, government, companies, non-profit organizations, and is reflected in social capital

increase, increase in trust, and driver aforementioned change; support value chain collaboration with chefs, retailers, institutional buyers – initiate green public procurements.

- Policy reforms – rural development – improving infrastructure and quality of life in rural areas; introduction of income Support for Young Farmers (CISYF); support for rural business start-ups, introduction of cooperation schemes, establishment of Biodistrict to promote and accelerate rural development processes, maximise the economic and sociocultural potential of the territory. At the same time, guarantee environmental protection and the quality of the products.

- Investment into the soft and hard infrastructure – opening up the attractiveness of rural areas (digital nomads), pushing new business opportunities based on social innovation, pilot initiatives for a wide range of innovative solutions to improve the quality of life in rural areas, i.e., sustainable energy cooperatives, mobility of people.

- Cooperation with scientific, education, business and agricultural holdings to facilitate transfer of simple-to-use innovative and environmentally friendly technologies and farming methods; adoption of such practices and technologies i.e. conservation agriculture need to be tailored to location with the support of extension services and combined training in agriculture with nutrition and health training, and market linkage support, all leading to increase in adoption of such practices

- Upskilling and reskilling strategies among local farmers/actors: targeted training programs to improve capacity building with a focus on digital, technical, and management skills, all resulting in overcoming resistance to change and risk aversion among the farmers and general population in rural areas, and involvement in environmentally friendly food production.

- Public education campaigns to raise community engagement and awareness: promotion of food, cuisine, region, as well as promotion of diverse career opportunities in agri-food sector, this also involves establishment of community gardens and urban agriculture activities to facilitate community involvement in food growing activities; promote direct sale of the local products through different innovative short food supply chains, i.e., pick your own food, box scheme delivery, online sale.

Regardless of the proposed scenario and because of the vivid nature and complexity of the agri-food sector, there are no universal solution to spurt twin (digital-green) transition in Western Balkan economies. To unlock full potential of the sector, but also complementary sectors, there are urgent need for policy shifts towards the legal and financial incentives, programs to support technical, social, and institutional innovation, integration and utilization of data knowledge and capabilities. Research and innovation ecosystems have to be starting point in this transformation pathway. This can be achieved through the establishment of research networks that connect universities, research institutes, extension services, and private actors to co-develop context-specific solutions (e.g., climate-resilient varieties, precision farming tools, sustainable input alternatives). Support participatory and demand-driven research models where farmers and communities are active contributors—not just recipients—of innovation, followed by strong public-private partnerships to accelerate research and technology transfer while ensuring that results remain accessible to small and medium-scale producers. High dependence on consultancy (particularly external) can be solved with modernization of agricultural extension systems to act as innovation brokers, integrating digital tools (e.g., online platforms, AI-driven advisory apps) with on-site demonstrations and farmer field schools, pilot farms, demonstration sites, living labs and innovation hubs, farmer-to-farmer mentoring programs. Education and capacity building have to integrate agri-food system thinking, sustainability, and digital literacy into all levels of education—from vocational training to

university curricula, while there should be more joint education–industry programs (apprenticeships, internships, hackathons) to align workforce skills with emerging technological and sustainability needs. Finally, financial and legal incentives should be focused on social innovation in food systems, such as cooperative governance, participatory certification, and community-based business models, to complement technological advances.

7. REFERENCES

1. Akyazi, T., Goti, A., Oyarbide, A., Alberdi, E., & Bayon, F. (2020). A guide for the food industry to meet the future skills requirements emerging with Industry 4.0. Foods, 9(4), 492. https://doi.org/10.3390/foods9040492
2. Antonelli, M., Basile, L., Gagliardi, F., Riccaboni, A., & Isernia, P. (2019). 2019 AGRIFOODMED DELPHI: Trends, challenges and policy options for water management, farming systems and agri-food value chains in 2020-2030 (PRIMA Annual Work Plan 2018). University of Siena. https://www.primaitaly.it/wp-content/uploads/2019/06/AGRIFOODMED-Delphi-Final-Report.pdf
3. Bai, C., Dallasega, P., Orzes, G., & Sarkis, J. (2020). Industry 4.0 technologies assessment: A sustainability perspective. International Journal of Production Economics, 229, Article 107776. https://doi.org/10.1016/j.ijpe.2020.107776
4. Bell, W. (2003). Foundations of futures studies: Human science for a new era (Vol. 1). Transaction Publishers.
5. Braun, A. T., Colangelo, E., & Steckel, T. (2018). Farming in the era of Industrie 4.0. Procedia CIRP, 72, 979–984. https://doi.org/10.1016/j.procir.2018.03.048
6. European Commission Joint Research Centre. (2025). Environmental and climate action in the Western Balkans. European Commission. https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/western-balkans-advances-environmental-and-climate-action-more-efforts-needed-2025-02-13_en
7. European Commission. (2021). Strategic foresight in the Western Balkans: Recovery on the horizon. European Commission. https://research-and-innovation.ec.europa.eu/knowledge-publications-tools-and-data/publications/all-publications/strategic-foresight-western-balkans_en
8. European Commission. (2023). The digitalisation of the European agricultural sector. Retrieved from https://digital-strategy.ec.europa.eu/en/policies/digitalisation-agriculture
9. European Training Foundation. (2022). Identifying technological changes and skills needs in the Western Balkan agri-food sector: Cross-country report. https://westernbalkans-infohub.eu/links/etf-network-skilling-up-the-western-balkan-agri-food-sector-digitalising-greening/
10. European Training Foundation. (2025). Western Balkans agri-food sector foresight report: Skilling up the Western Balkans agri-food sector. European Training Foundation. https://www.etf.europa.eu/sites/default/files/2025-06/ETF_agri-food%20foresight_Final%20Report.pdf
11. FAO. (2022a). The future of food and agriculture – Drivers and triggers for transformation (The Future of Food and Agriculture, No. 3). Rome. https://doi.org/10.4060/cc0959en
12. Ferreira Gregorio, V., Pié, L., & Terceño, A. (2018). A systematic literature review of bio, green and circular economy trends in publications in the field of economics and business management. Sustainability, 10(11), 4232. https://doi.org/10.3390/su10114232
13. Food and Agriculture Organization of the United Nations & CIRAD. (2025). Foresight for the transformation of agrifood systems through agroecology: Guidance document for decision makers and practitioners. FAO & CIRAD. http://openknowledge.fao.org/items/a43c6f99-9823-4168-885a-a0ef10b6bebc
14. Food and Agriculture Organization of the United Nations. (2022b). Thinking about the future of food safety: A foresight report. FAO. https://doi.org/10.4060/cb8667en
15. Giuntoli, J., Oliver, T., Kallis, G., Ramcilovic-Suominen, S., & Monbiot, G. (2023). Exploring new visions for a sustainable bioeconomy.

16. Global Panel on Agriculture and Food Systems for Nutrition. (2020). Future food systems: For people, our planet, and prosperity (Foresight 2.0 report). https://www.glopan.org/wp-content/uploads/2020/09/Foresight-2.0_Future-Food-Systems_For-people-our-planet-and-prosperity.pdf

17. Gupta, B., Zurek, M., Woodhill, J., Ingram, J. (January, 2025). Food Systems of the Future: A synthesis of food system drivers and recent scenario studies. Foresight4Food. Oxford, United Kingdom. https://foresight4food.net/wp-content/uploads/2025/03/FS4F-Driver-report_v3.pdf

18. Imbert, E., Ladu, L., Morone, P., & Quitzow, R. (2017). Comparing policy strategies for a transition to a bioeconomy in Europe: The case of Italy and Germany. Energy Research & Social Science, 33, 70-81. https://doi.org/10.1016/j.erss.2017.08.006

19. Kotevska A., Martinovska Stojcheska, A., Erjavec, E. (2024). European Integration and Agriculture in the Western Balkans. Challenges and opportunities for sector development. Standing working group for regional rural development, Skopje, North Macedonia. **https://seerural.org/wp-content/uploads/2025/01/European-Integration-of-Western-Balkan-Agriculture.pdf**

20. Kuosa, T. (2012). The futurist and the strategist: Scenarios for the future. Foresight, 14(1), 11–25. https://doi.org/10.1108/14636681211190452

21. Leng, J., et al. (2020). Blockchain-empowered sustainable manufacturing and product lifecycle management in Industry 4.0: A survey. Renewable and Sustainable Energy Reviews, 132, Article 110112. https://doi.org/10.1016/j.rser.2020.110112

22. Lezoche, M., Hernandez, J. E., Díaz, M. D. M. E. A., Panetto, H., & Kacprzyk, J. (2020). Agri-food 4.0: A survey of the supply chains and technologies for the future agriculture. Computers in Industry, 117, Article 103187. https://doi.org/10.1016/j.compind.2020.103187

23. Lioutas, E. D., & Charatsari, C. (2020). Smart farming and short food supply chains: Are they compatible? Land Use Policy, 94, Article 104541. https://doi.org/10.1016/j.landusepol.2020.104541

24. Mariotti, I., & Sasso, M. (2024). *Revitalizing rural areas through innovation and entrepreneurship: Public and private initiatives to train, attract and retain human capital* (JRC138968). European Commission, Joint Research Centre. https://publications.jrc.ec.europa.eu/repository/handle/JRC138968

25. Martinovska Stojcheska, A., Kotevska, A., Charalambos, K., Pavlovska Gjorgjieska, D. (2022) *Agricultural policy developments in the EU pre-accession countries*, European Commission, doi: 10.2762/638991

26. Martinovska Stojcheska, A., Znaor, D., Zhllima, E., Bajramović, S., Sopi, L., Martinović, A., Kotevska, A., and Bogdanov, N.(2021). Policy recommendations for facilitation of the approximation process of the Western Balkan countries to the EU CAP segment related to green economy and entrepreneurship. Skopje: Rural Development Network of North Macedonia.

27. Mazhar, W., & Zilahy, G. (2025). Pathways to green food purchases: exploring the nexus of attitudes, habits and lifestyles using SEM and NCA. British Food Journal, 127(13), 208-229.

28. Moller, B., Voglhuber-Slavinsky, A., & Dönitz, E. (2020). Three scenarios for Europe's food sector in 2035. Fraunhofer Institute for Systems and Innovation Research ISI. https://www.isi.fraunhofer.de/content/dam/isi/dokumente/ccv/2020/Fox_Scenario_Brochure.pdf

29. Mujčinović, A., Bojnec, Š., Nikolić, A., Bušljeta Tonković, A., Gašparović, S., Lazereg, M., Stojanović, A., Bojadjieva, D. (2024). Pathways for Young Farmers' Entrepreneurship in Sustainable Rural Development, in Eds. Simões, F. & Erdogan, E. (2024). NEETs in European Rural Areas: An Interdisciplinary, Transnational Reader. https://doi.org/10.1007/978-3-031-45679-4_5

30. Nikolić, A., Mujčinović, A., & Bošković, D. (2022). Get ready for Industry 4.0 – tool to support food value chain transformation. In M. Brka, et al. (Eds.), 10th Central European Congress on Food (pp. 453–476). Springer International. https://doi.org/10.1007/978-3-031-04797-8_39

31. Nikolić, A., Mujčinović, A., Milošević, I., Stojanović, A., & Ellena, A. M. (2025). Are we ready for climate-friendly food choices?–The cross-country study of Bosnia and Herzegovina, Serbia and Italy. *Food and Humanity*, *4*, 100515. https://doi.org/10.1016/j.foohum.2025.100515

32. OECD. (2025). Strategic foresight toolkit for resilient public policy. Organisation for Economic Co-operation and Development. https://www.oecd.org/content/dam/oecd/en/publications/reports/2025/01/foresight-toolkit-for-resilient-public-policy_9ad1cd60/bcdd9304-en.pdf

33. Paddeu, D., & Lyons, G. (2024). Foresight through developing shared mental models: The case of Triple Access Planning. Futures, 155, 103295. https://doi.org/10.1016/j.futures.2023.103295

34. Pahalvi, H. N., Rafiya, L., Rashid, S., Nisar, B., & Kamili, A. N. (2021). Chemical fertilizers and their impact on soil health. In Microbiota and biofertilizers, Vol 2: Ecofriendly tools for reclamation of degraded soil environs (pp. 1-20). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-61010-4_1

35. Radovanovic, N., & Stevanovic Carapina, H. (2024). *Green transition and smart specialisation in the Western Balkans* (JRC136482). European Commission, Joint Research Centre. https://publications.jrc.ec.europa.eu/repository/handle/JRC136482
36. Radovanovic, N., Sanz, M. and Burzic, I., (2023) Perspectives on growth of the agri-food sector in the Western Balkans, Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/885420, JRC135420.
37. Regional Cooperation Council. (2025). Action Plan for the Implementation of the Sofia Declaration on the Green Agenda for the Western Balkans 2021-2030. https://www.rcc.int/download/docs/Action%20Plan%20ENG%20ver%20I%20(1).pdf

38. Sestino, A., Prete, M. I., Piper, L., & Guido, G. (2020). Internet of Things and big data as enablers for business digitalization strategies. Technovation, 98, Article 102173. https://doi.org/10.1016/j.technovation.2020.102173

39. Stričević, R., Prodanović, S., Đurović, N., Petrović Obradović, O., & Đurović, D. (2019). Report on observed climate change impacts on agriculture in Serbia and future projections of climate impacts based on different scenarios regarding future emissions. UNDP. https://www.klimatskepromene.rs/en/publications/

40. Tian, H., Wang, T., Liu, Y., Qiao, X., & Li, Y. (2020). Computer vision technology in agricultural automation—a review. Information Processing in Agriculture, 7(1), 1–19. https://doi.org/10.1016/j.inpa.2019.10.003

41. Tijan, E., Aksentijević, S., Ivanić, K., & Jardas, M. (2019). Blockchain technology implementation in logistics. Sustainability, 11(4), 1185. https://doi.org/10.3390/su11041185

42. Vivien, F. D., Nieddu, M., Befort, N., Debref, R., & Giampietro, M. (2019). The hijacking of the bioeconomy. Ecological economics, 159, 189-197. https://doi.org/10.1016/j.ecolecon.2019.01.027

43. World Bank. (2025). Greening agriculture in the Western Balkans. World Bank Group.
44. World Economic Forum. (2018). Driving the sustainability of production systems with Fourth Industrial Revolution innovation. Cologny/Geneva, Switzerland: World Economic Forum. https://www3.weforum.org/docs/WEF_White_Paper_Accelerating_Sustainable_Production_report_2018.pdf

45. Županić, F. Ž., Radić, D., & Podbregar, I. (2021). Climate change and agriculture management: Western Balkan region analysis. Energy, Sustainability and Society, 11(51). https://energsustainsoc.biomedcentral.com/articles/10.1186/s13705-021-00327-z

ANNEX

ANNEX 1. STRUCTURE OF THE FIRST ONLINE QUESTIONNAIRE – SCREENING PHASE 1

Foresight Study: Challenges and Digital Opportunities in the Agri-Food Sector. Thank you for agreeing to participate in our survey — your contribution is highly appreciated. This survey is part of a Foresight study aimed at identifying key challenges in the agri-food sector and exploring the potential of digital technologies to address them. We are particularly interested in your views on how the sector may develop over the next decade. Please note that this study seeks to gather expert insights and informed opinions, rather than evidence-based or data-supported responses. Your reflections, grounded in your professional experience and knowledge, are what matter most. Should you feel that you are not in a position to respond to certain questions, you may simply leave them unanswered. We understand that not all participants will have detailed knowledge on every aspect covered. Thank you once again for your time and valuable input. Participation: Participation in this study is voluntary; you are free to withdraw at any time. Your answers are completely anonymous. Data reliability: Your answers are completely anonymous. Contact person(s): If you have some questions regarding the topic, you can contact us via e-mail: ikurtovic@credi.ba

Where are you living?

1. Albania
2. Bosnia and Herzegovina
3. Kosovo
4. Montenegro
5. North Macedonia
6. Serbia
7. Other

In what sector you are working?

1. Academia
2. Public/civil organization
3. Private organization – companies/farms
4. Governmental organization
5. International Organization
6. Other

What are the ten most pressing key challenges, barriers or obstacles in the agri-food sector in next ten years?

What are the ten most pressing key challenges in the agri-food sector associated with workforce shortages in next ten years?

What are the ten most pressing key challenges in the agri-food sector associated with skills shortages in next ten years?

How digital technologies can help with agri-food sector development in next ten years?

What are current key national strategies or policies that influence agri-food sector (five to ten strategies/ policies)?

How do you see agri-food sector development in next 10 years? Can you think about some elements that are going to improve and please elaborate, and some elements that are going to get worse over the next ten years, and also elaborate on that?

Please leave us your email address so we can contact you for the next round of research.

ANNEX 2. STRUCTURE OF THE SECOND ONLINE QUESTIONNAIRE – SCREENING PHASE 2

Foresight Study: Challenges and Digital Opportunities in the Agri-Food Sector. Thank you once again for being part of our Foresight study – your continued contribution is truly appreciated. You are now invited to take part in the second round of the survey. This round is based on the results from the first one and is designed to collect your reflections on areas where consensus has not yet been reached. It will not take more than 5 minutes to complete. The aim of this study is to identify the most pressing challenges in the agri-food sector in the Western Balkans and to explore the potential of digital technologies in addressing them. We are especially interested in your professional judgement about how these challenges may evolve in the coming years. Please remember: The study seeks expert insights and opinions, not data-based evidence. If you are unsure how to answer a particular question, feel free to skip it. Participation is voluntary and responses are anonymous. If you have any questions or concerns, feel free to contact us at ikurtovic@credi.ba.

Where are you living?

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4. Governmental organization
5. International Organization
6. Other

Please rate the importance of following emerging trends in the agri-food sector. Likert scale 1-5 (1 – very unimportant, 2 – unimportant, 3 – neutral, 4 – important, 5 – very important)

	1	2	3	4	5

AI, precision farming, IoT, and robotics are transforming the productivity and efficiency of the agri-food sector.	❑	❑	❑	❑	❑
Digital traceability and blockchain for transparency and supply chain optimization.	❑	❑	❑	❑	❑
Regenerative agriculture and sustainable practices.	❑	❑	❑	❑	❑
Valorization of byproducts and circular economy approaches.	❑	❑	❑	❑	❑
Demand for nutritious, transparent, local, and sustainable food.	❑	❑	❑	❑	❑
Increased funding for industrial-scale agri-tech and sustainable infrastructure.	❑	❑	❑	❑	❑
Focus on empowering smallholders, rural women, and inclusive value chains.	❑	❑	❑	❑	❑
Need for modernized, practical, and accessible training programs.	❑	❑	❑	❑	❑

How do you rate the importance of following opportunities to improve the situation in the agri-food sector? Likert scale 1-5 (1 – very unimportant, 2 – unimportant, 3 – neutral, 4 – important, 5 – very important)

	1	2	3	4	5
Precision agriculture and resource management (i.e., use of sensors, drones, satellite imagery, and IoT devices to monitor soil condition, moisture, temperature, and plant health).	❑	❑	❑	❑	❑
Data analysis (i.e., application of Big Data and artificial intelligence to analyze weather conditions, market trends, and yield forecasting).	❑	❑	❑	❑	❑
Automation (i.e., introduction of automated machines and robots for fieldwork and processing, addressing labor shortages and increasing productivity).	❑	❑	❑	❑	❑
Supply Chain Tracking (i.e., use of blockchain technology and IoT to track products from farm to consumer, enhancing food safety and consumer trust).	❑	❑	❑	❑	❑
E-commerce (i.e., online platforms connecting producers directly with buyers and traders, shortening supply chains and expanding market reach).	❑	❑	❑	❑	❑

Digital education and knowledge exchange (i.e., digital platforms for remote education, workshops, and networking among farmers, especially small producers and rural communities.	❑	❑	❑	❑	❑
Smart logistics (i.e., IoT systems to optimize storage conditions, reduce losses, and preserve product quality).	❑	❑	❑	❑	❑
Digital financial services (i.e., digital financial services such as mobile banking and microcredits enabling investments in technology and resources).	❑	❑	❑	❑	❑
Monitoring and certification (i.e., digital tools for monitoring environmental parameters and compliance with sustainability standards)	❑	❑	❑	❑	❑
Bridging the digital divide (i.e., development of internet infrastructure and raising digital competencies of workers through training and educational programs).	❑	❑	❑	❑	❑

What skills do you find most important to develop for the future of the agri-food sector? Likert scale 1-5 (1 – very unimportant, 2 – unimportant, 3 – neutral, 4 – important, 5 – very important)

	1	2	3	4	5
Digital literacy and advanced data skills to operate and maintain new technologies.	❑	❑	❑	❑	❑
Data management, cybersecurity, and digital systems integration.	❑	❑	❑	❑	❑
Sustainable agronomy, soil health, and environmental science.	❑	❑	❑	❑	❑
Circular economy principles and sustainable resource management.	❑	❑	❑	❑	❑
Food science, biotechnology, and functional food development.	❑	❑	❑	❑	❑
Marketing, business management, and consumer engagement skills.	❑	❑	❑	❑	❑
Entrepreneurial, project management, and operational skills to scale innovations.	❑	❑	❑	❑	❑
Soft skills such as problem-solving, teamwork, communication, and adaptability.	❑	❑	❑	❑	❑
Flexible education curricula, matching between education and industry needs, and upskilling	❑	❑	❑	❑	❑

Please leave us your email address so we can contact you for the next round of research.

ANNEX 3. SUMMARY OF STAKEHOLDERS' FEEDBACK

As part of the SMARTLabor Conference, following the presentation of the report *"Sustainable digital and green agri-food transformation/ Twin (Green Digital) Transformation in WB Agri-Food Sector"*, an interactive workshop was organized with participants coming from different sectors – education, farming, institutions, civil society, and international partners.

Participants were divided into groups, each working on predefined scenarios for the development of the agri-food sector. The goal of the workshop was to discuss opportunities, challenges, and to jointly define recommendations and directions for future action.

The group work and discussions resulted in the following conclusions for each scenario:

Scenario 1 - Asymmetric market power and anticipation

Work on this scenario was carried out in two groups – one working online and the other on site. Both groups discussed the role of digitalization, data transparency, and ethical practices in creating a more resilient and competitive agricultural sector.

- to support publishing data from private companies to become public
- to support GDPR
- to support digital skills for smart agriculture
- to support the development of ethical practice in data polling
- taxation of larger monopolistic companies, in addition to creating financial insurance for small farmers
- to support unions for farmers + digital literacy
- support to most efficient farms 1-2ha – as they give up on traditional practices
- small farmers' financial literacy – how to take loans, pay off debt, keep books – recordkeeping practices, track financial records, how to evolve from substantial farms to actual business models
- establish blockchain traceability in the whole agricultural process
- cooperatives, institutes, collective focus on local products
- public sistematization of these systems with practical, understandable (for farmers) information, so that farmers can easily analyse, use, and implement.

Scenario 2 - Technology-enriched food system

The group working on this scenario emphasized the importance of experimentation and innovation through pilot farms, as well as the role of education and awareness-raising in preparing future generations for sustainable agriculture.

Establishment of pilot farms:

- pilot farms for testing of climate change resilient crops
- pilot farms for carbon farming for easy green transition (green energy from composting)
- pilot farms for the introduction of new practices in agriculture, including digital IT tools
- local heroes
- training to participate in Horizon 2020 or similar international projects

Public education campaigns:

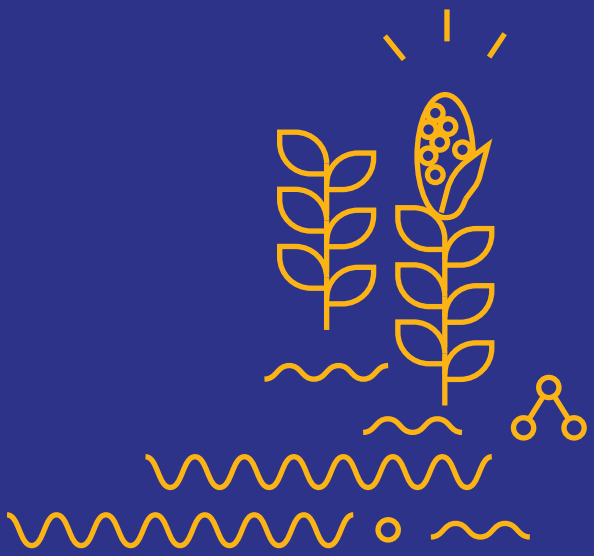
- training center for pupils from VET agriculture and students from agricultural faculties for the development of specific skills, which will make them ready for the labour market
- training center (adult education) for people who do not have basic knowledge in agriculture, but work in agriculture
- campaign in primary and secondary school „Agriculture is fun because life is fun“

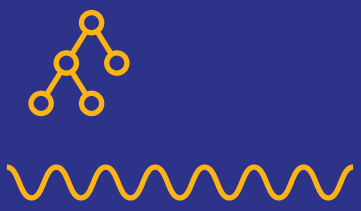
Scenario 3 - Integrated participatory approach

Discussions in this group focused on strengthening collective action through cooperatives, identifying both opportunities for joint work and structural obstacles that currently limit their effectiveness.

Support cooperatives development, and activities such as:

- Support to buy inputs together, get technical information – education/training, use mechanization together, organize marketing activities together, and achieve higher standardization, quality, and short value chains
- To overcome problems with a lack of young people to be involved in cooperatives, no or little support from the government, lack of trust, selfishness, support from the government goes to individual farms rather than cooperatives, lack of facilities, and lack of democratic capacities.





Norway
SMART Balkans
Civil Society for Shared Society in the Western Balkans
CPCD
Centar za promociju civilnog društva
Institute for Democracy and Mediation
CRPM
Center for Research and Policy Making
...policy impact since 2004
CENTAR
PUBLIC POLICY RESEARCH
re:people
CREDI
Centar za razvojne evaluacije i društvena istraživanja
IMPETUS
CIDGG