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biofertilizers and circular bioeconomy solutions
for a sustainable agriculture*

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Handbook on Innovative Best Practices in Sustainable Agriculture and Circular Bio-Economy

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Summary

Deliverable 2.1, “Handbook on Innovative Best Practices in Sustainable Agriculture and Circular Bio-Economy” for the project I3-4-BIOFERTILIZERS consolidates key findings from a comprehensive analysis of interregional cooperation in sustainable agriculture and the bio-fertilizer industry, involving 73 experts across eight EU countries—Portugal, Spain, France, Belgium, Italy, Greece, Sweden, and Hungary. This initiative maps current strengths and weaknesses across the interregional ecosystem, including existing platforms, twinning models, and interregional action plans, while identifying best practices and benchmarking successful strategies across diverse regions. By exploring future trends and opportunities, the handbook provides actionable insights for developing new value chains in the circular bioeconomy and specialization in biofertilizers, supporting the emergence of Regional Innovation Valleys.

The handbook is built on insights drawn from a detailed questionnaire, informed by a detailed SWOT analysis of the interregional ecosystem to outline strategic recommendations and practical solutions. These strategies foster collaboration, advance innovation, and enable regional specialization in circular bio-solutions. Key sections highlight actionable pathways to address ecosystem challenges, enhance regional strengths, and drive interregional cooperation to build a resilient and sustainable agrifood system.

This deliverable provides a roadmap for stakeholders to capitalize on emerging opportunities and address critical challenges in the agrifood sector, aligned with EU policy priorities, i.e., the European Green Deal, the Circular Economy Action Plan, and the Farm to Fork Strategy. In summary, the handbook of Deliverable 2.1 serves as a practical guide for stakeholders, offering innovative strategies and best practices to support the transition towards a sustainable, circular bioeconomy and a more integrated interregional agrifood ecosystem.

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Introduction

By 2050, the European Union sets the ambitious goal of transforming the EU into a green, resource-efficient, and climate-neutral economy, according to the ambitious European Green Deal. As part of this, greener practices are being progressively used in agriculture. Difficulties remain, though, especially in lowering the industry's carbon impact while enhancing soil quality and protecting the environment. Given the substantial environmental effects of both manufacturing and consumption, fertilizers are important in this equation.

With a yearly value of €20–25 billion, synthetic fertilizers dominate the EU fertilizer sector, accounting for 80% of sales. Fossil fuel-derived nitrogen-based fertilizers contribute to greenhouse gas emissions and environmental deterioration, including soil and water pollution. These concerns are made worse by the overuse of chemical fertilizers, which results in denitrification, acidity, and leaching.

Sustainable solutions are provided by environmentally friendly substitutes such as biostimulants and biofertilizers. By reducing reliance on synthetic fertilizers, these products increase crop growth, improve soil fertility, and lessen the environmental effects of farming. In July 2022, the new Fertilizing Products Regulation (EU 2019/1009) entered into force to encourage these solutions. By permitting fertilizers derived from organic waste streams to be sold in the EU, this legislation fosters the growth of bio-based products that support sustainable agriculture and the circular economy.

The agri-food industry requires innovation across European areas to meet these difficulties and promote competitiveness. Using economies of scale and interregional collaboration, biofertilizers—including biostimulants—represent a viable growth field. By fostering more cooperation between regions, companies, and research institutions, initiatives such as the S3P Agri-Food platform hope to develop creative value chains that promote the use of sustainable biofertilizers and aid in the EU's green transition objectives.

1.1 Objectives of the Handbook

Handbook on Innovative Best Practices in Sustainable Agriculture thoroughly examines the interregional collaboration and circular bio-solutions for the agri-food industry. In addition to highlighting best practices and comparing regional triumphs, it charts the interregional ecosystem's current advantages and disadvantages, including platforms, twinning models, and action plans. Apart from analysing new trends and opportunities, this handbook assists in creating cooperative approaches along value chains for the circular bioeconomy and novel biofertilizers. Additionally, it emphasizes chances for specialization to help create Regional Innovation Valleys, which will promote agricultural innovation and sustainability.

1.2 Significance of Mapping Ecosystems and Analysing Trends in Sustainable Agriculture

Investigating interregional ecosystems within sustainable agriculture and circular bio-solutions is essential for grasping the current dynamics of collaboration, innovation, and value generation in the agri-food industry. This detailed mapping exercise reveals existing strengths, such as platforms, action plans, and effective twinning models, while also highlighting weaknesses and gaps that impede advancement. This initiative illuminates pathways to encourage innovation and boost collaboration across different regions by evaluating best practices and exploring improvement opportunities.

Beyond assessing the present situation, examining emerging trends equips stakeholders with the ability to foresee upcoming challenges and opportunities. These insights are vital for the development of new bio-fertilizer and circular bio-economy value chains that align with sustainability and specialization objectives. By facilitating the expansion of Regional Innovation Valleys, this initiative reinforces interregional networks and empowers the agri-food sector to adopt innovative solutions, thereby ensuring lasting resilience, environmental responsibility, and economic competitiveness.

1.3 Methodology

The comprehensive analysis of biofertilizers and circular bio-solutions was conducted using a systematic methodology that integrated data collection, evaluation, and strategic planning. Central to this approach, a carefully designed questionnaire, a crucial component of the I3-4-BIOFERTILIZERS project, was distributed to experts, stakeholders, and practitioners in sustainable agriculture, interregional cooperation, and bio-fertilizer value chains. This survey aimed to capture a detailed understanding of current practices, ecosystem dynamics, and potential areas for innovation within the biofertilizer and circular bio-economy sectors.

The responses collected provided the basis for a SWOT analysis, a strategic framework used to identify strengths, weaknesses, opportunities, and threats within the biofertilizer ecosystem. By applying this analytical method, the project not only gained insights into the current landscape but also pinpointed key strategies to build resilience and drive innovation. These findings will inform the creation of robust interregional collaborations, facilitate the development of sustainable bio-fertilizer value chains, and support the establishment of Regional Innovation Valleys, advancing the sustainability and competitiveness of the agri-food sector.

Part 1. Categorization and strategic alignment of respondents and their organizations

The initial phase of our questionnaire analysis aimed to capture a concise yet comprehensive profile of each respondent's organization within the biofertilizer and sustainable agriculture sectors. This step is critical for several reasons: it allows for accurate categorization of respondent types, assessment of their areas of expertise, and understanding of their alignment with the project's focus on advancing biofertilizers and circular bio-solutions. Key data points gathered include the organization's name, type, primary country of operation, regions covered, and specific focus areas in sustainable agriculture and biofertilizers. These insights provide a structured foundation for meaningful analysis by enabling a clear understanding of the scope, reach, and specialization of each respondent.

This structured approach ensures that subsequent discussions and report findings are tailored to the diverse contexts and operational realities within the biofertilizer industry. It also facilitates the identification of best practices and innovative strategies that align with the mission of the project to promote interregional cooperation and sustainable advancements in the agri-food sector.

Understanding the depth of expertise among respondents is essential for highlighting their contributions and leveraging their insights to foster innovation and resilience in biofertilizer and circular bioeconomy value chains.

Question 1.1. - Organization type

The data reveals a varied range of respondent organizations, with notable representation from Research Institutes (6) and Public Administration entities (5). Universities are also prominently featured (2), alongside Small and Medium-sized Enterprises (SMEs) (4), reflecting the diverse nature of the sector. Additional contributions come from Public Limited Companies (PLC) (1), Cluster Organizations (1), Consulting Companies (1), Large Companies (1), and Non-Profit Organizations (4) (Figure 1). This mix of organizational types highlights the breadth of expertise and the various roles these entities play in the sustainable agriculture and biofertilizer landscape.

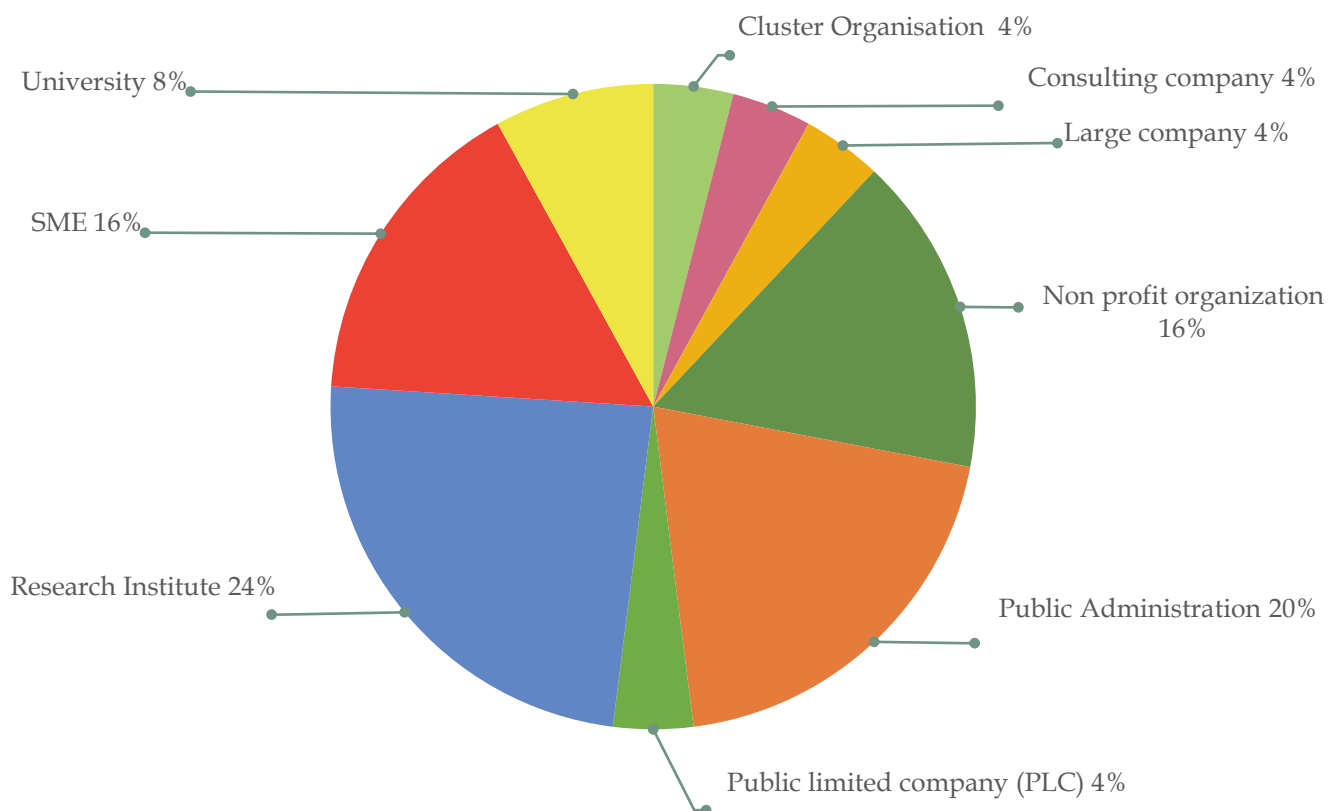


Figure 1. Type of the organization

Question 1.2 - Organization's primary location

The distribution of respondents' primary locations reflects the focused scope of our survey within Europe, with notable contributions from Portugal (7), Spain (5), and France (5), emphasizing their key roles in the sustainable agriculture and biofertilizer sectors. The survey also highlights significant engagement from Greece (3), Italy (3), and Belgium (1), which further aligns with the geographic focus of the biofertilizer industry. Additionally, the inclusion of respondents from Hungary (1) introduces valuable regional insights, expanding the dataset to reflect diverse perspectives on sustainable farming and biofertilizer practices within Europe (Figure 2).

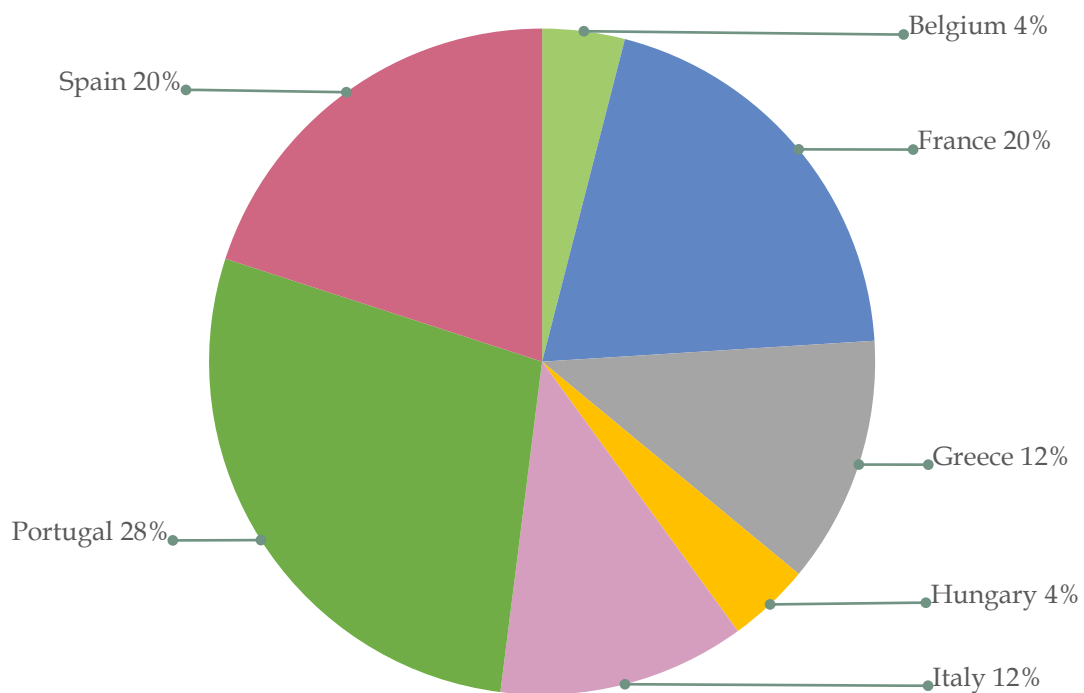


Figure 2. Organization's primary location

Question 1.3. - Regions covered by your organization

The distribution of the broader regions covered by the organizations responding to the questionnaire reflects a diverse and comprehensive engagement across Europe, underlining the geographical distribution of efforts within the agri-food sector and sustainable agriculture sector. The responses showcase a strong representation of Portugal, Greece, France, Italy, Belgium, Spain, Sweden, Hungary, and Germany. Specifically,

- Portugal stands out with significant contributions from the Autonomous Region of the Azores (n=5), which appears repeatedly, reflecting its key role in the sector. Additionally, Alentejo (n=1) and the district of Coimbra (n=1) also feature in the responses.
- Greece is represented by multiple regions including Attiki (n=1) and Region of Central Macedonia (n=2), underscoring the diverse regional involvement in sustainable agricultural practices.
- Spain is similarly represented by Catalonia, with multiple mentions (n=5), indicating its active role in the sector.
- France contributes across various regions including Centre Region-Val de Loire (n=4), Isle of France (n=2), and Brittany (n=2), Loire Region (n=2), Lower Normandy (n=1), and Auvergne-Rhone-Alpes (n=1).
- Italy is represented by regions such as Emilia-Romagna (n=3), which also appears multiple times, as well as Abruzzo and The Marches (n=1).
- Belgium is represented by Brussels-Capital Region (n=2) and Province Oost-Vlaanderen (n=1), reflecting its involvement in sustainable agricultural initiatives.
- Spain also makes a notable contribution to Stockholm (n=1).
- Other regions from Hungary, such as Southern Transdanubia (n=1) help broaden the geographical scope of the data, bringing insights from Eastern and Northern Europe.

The selection pattern among regions covered by organizations reveals a broad and diverse engagement:

- A single organization covers one region, suggesting a targeted approach focused on specific areas of sustainable agriculture or biofertilizers.
- 2 regions are covered by multiple organizations, indicating a growing cross-regional collaboration within specific countries, particularly within Spain and France.
- 3 regions are mentioned by several organizations, highlighting a multi-regional approach to advancing sustainable agricultural practices, especially in countries like Portugal, Italy, and Greece.
- 4 or more regions are covered by a variety of organizations, underscoring a comprehensive effort to tackle sustainability challenges across multiple European regions. Notably, Autonomous Regions of Azores (PT) and Loire Region/Centre Region-Val de Loire (FR) are frequently cited from different organizations, reflecting their key roles in fostering cooperation and sustainable biofertilizer initiatives.

The wide geographical representation across these regions highlights the international scope of collaboration and innovation within sustainable agriculture and biofertilizer practices. The diverse involvement of these regions suggests a robust network of expertise, with each contributing with unique perspectives to the development of sustainable farming practices and the circular bioeconomy.

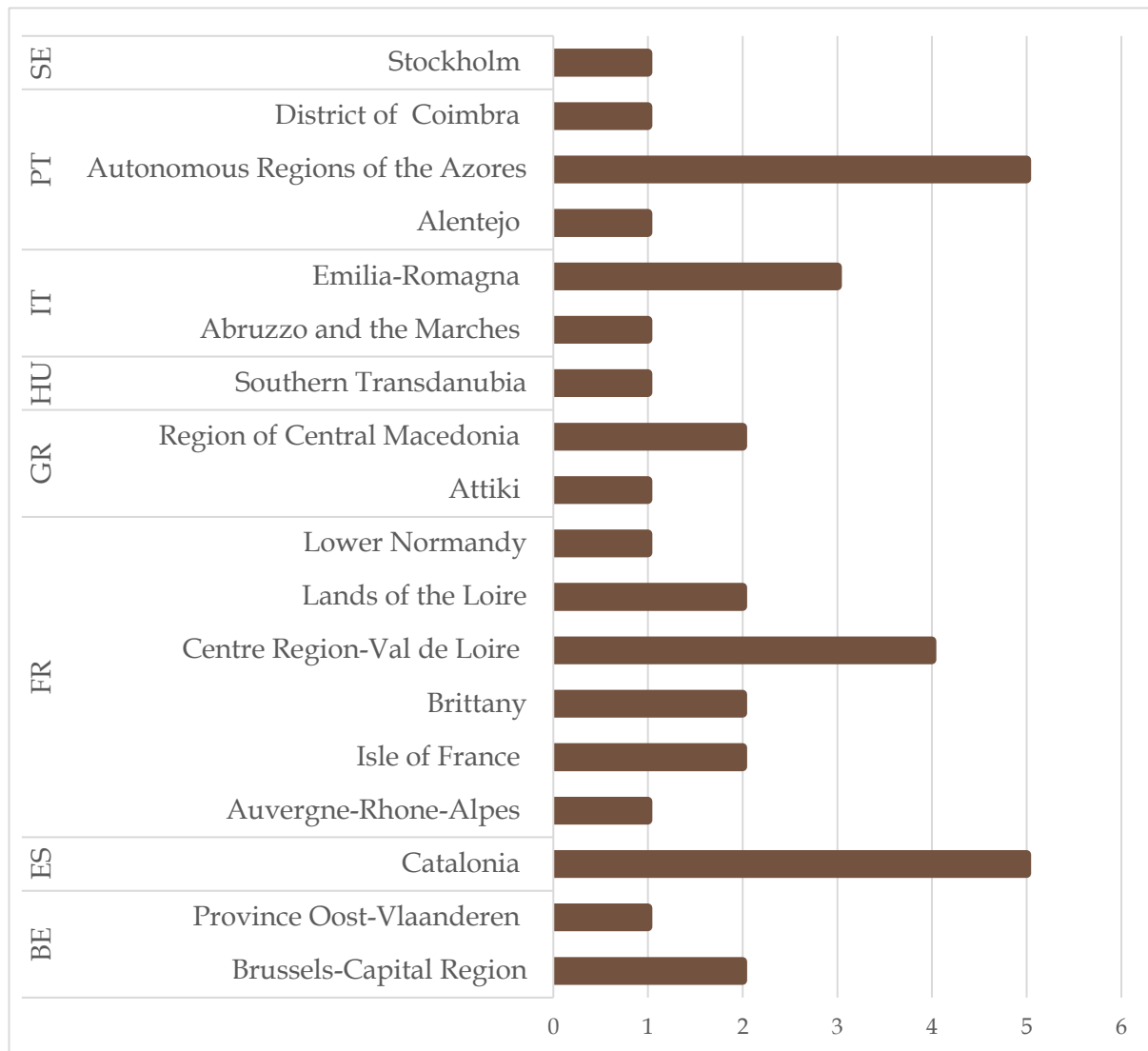


Figure 3. Regions covered by each organization

Question 1.4. Focus Area on Sustainable Agriculture/Biofertilizers (select all that apply)

The focus areas in sustainable agriculture and biofertilizers, as identified across various countries, reflect a diverse and integrated approach to promoting sustainability and innovation. Research and innovation stand out as a key priority, with many countries investing in advancements to address modern agricultural challenges, enhance productivity, and ensure environmental sustainability. Biofertilizer production is another prominent area of focus, emphasizing the shift towards eco-friendly farming practices that reduce dependence on chemical fertilizers and improve soil health.

The circular bioeconomy also features heavily, highlighting the importance of sustainable resource management, waste reduction, and the valorisation of agricultural by-products. This approach aims to create closed-loop systems that maximize efficiency while minimizing environmental impact. Similarly, sustainable farming practices are prioritized, demonstrating a widespread commitment to environmentally responsible and resource-efficient agriculture that balances productivity with ecological preservation.

Policy formulation is a critical area of focus, with several countries working to develop regulatory frameworks and strategies that support the adoption of sustainable practices and biofertilizers. Specialized initiatives include efforts to integrate the "farm-to-fork" value chain, addressing every stage from production to consumption, including ICT systems, advanced equipment, logistics, and waste valorisation. Composting facilities and the treatment of organic waste, such as the organic fraction of municipal solid waste, are also being advanced to further sustainability goals.

Additional focus areas include the integration of biochar into standard farming practices, which enhances soil fertility and supports carbon sequestration, and innovations in transformation and packaging plants to improve the efficiency and sustainability of food processing. Technological integration is emphasized through the use of ICT systems and advanced machinery, modernizing agriculture and improving efficiency across the sector. Furthermore, efforts to manage food by-products and waste, along with improvements in logistics, demonstrate a strong commitment to circular practices and reducing the environmental footprint of farming systems. Collectively, these focus areas represent a comprehensive strategy to drive sustainable agriculture and biofertilizer development globally (Figure 4).

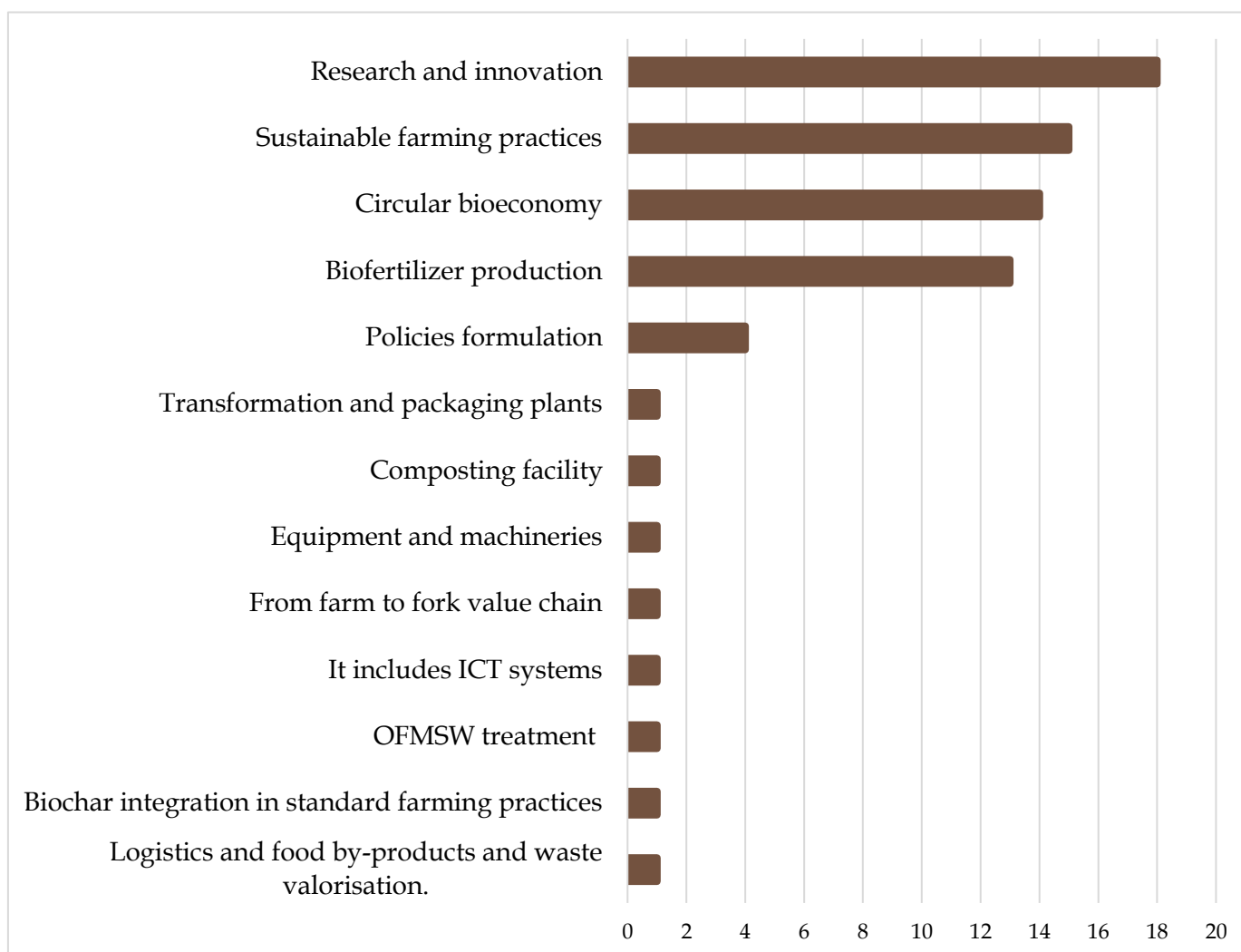


Figure 4. Focus area in sustainable agriculture/biofertilizers among all countries involved in the research

Several countries are moving forward on sustainable agriculture practices and biofertilizers use, each emphasizing specific focus areas:

Biofertilizer production is a significant focus in Greece, Spain, Portugal, France, Italy, and Hungary. These nations are actively working to develop and expand the use of biofertilizers to improve soil health and reduce reliance on chemical fertilizers. The circular bioeconomy, which promotes sustainable resource use and waste valorization, is a key area of interest for Greece, Spain, Portugal, France, and Italy. These countries aim to integrate circular practices across agricultural systems to reduce waste and enhance environmental sustainability. Sustainable farming practices, which emphasize environmentally friendly and resource-efficient agriculture, are prioritized by Greece, Spain, Portugal, France, Hungary, and Italy. These efforts focus on creating resilient farming systems that contribute to food security and environmental conservation. Research and innovation, crucial for driving advancements in agricultural technologies and sustainable practices, are central to the strategies of Portugal, Greece, Spain, France, Hungary, and Belgium. These nations are investing in scientific research and technological developments to address the challenges facing modern

agriculture. Regarding other focus areas Greece, Spain, Portugal, and Italy are working on policy frameworks to support sustainable agricultural practices and biofertilizer use. Italy is particularly focused on integrating biochar into standard farming practices, composting facilities, and treating organic fraction municipal solid waste (OFMSW), while Italy also addresses the entire value chain from production to consumption, including ICT systems, equipment, transformation plants, logistics, and food waste valorisation (Figure 5).

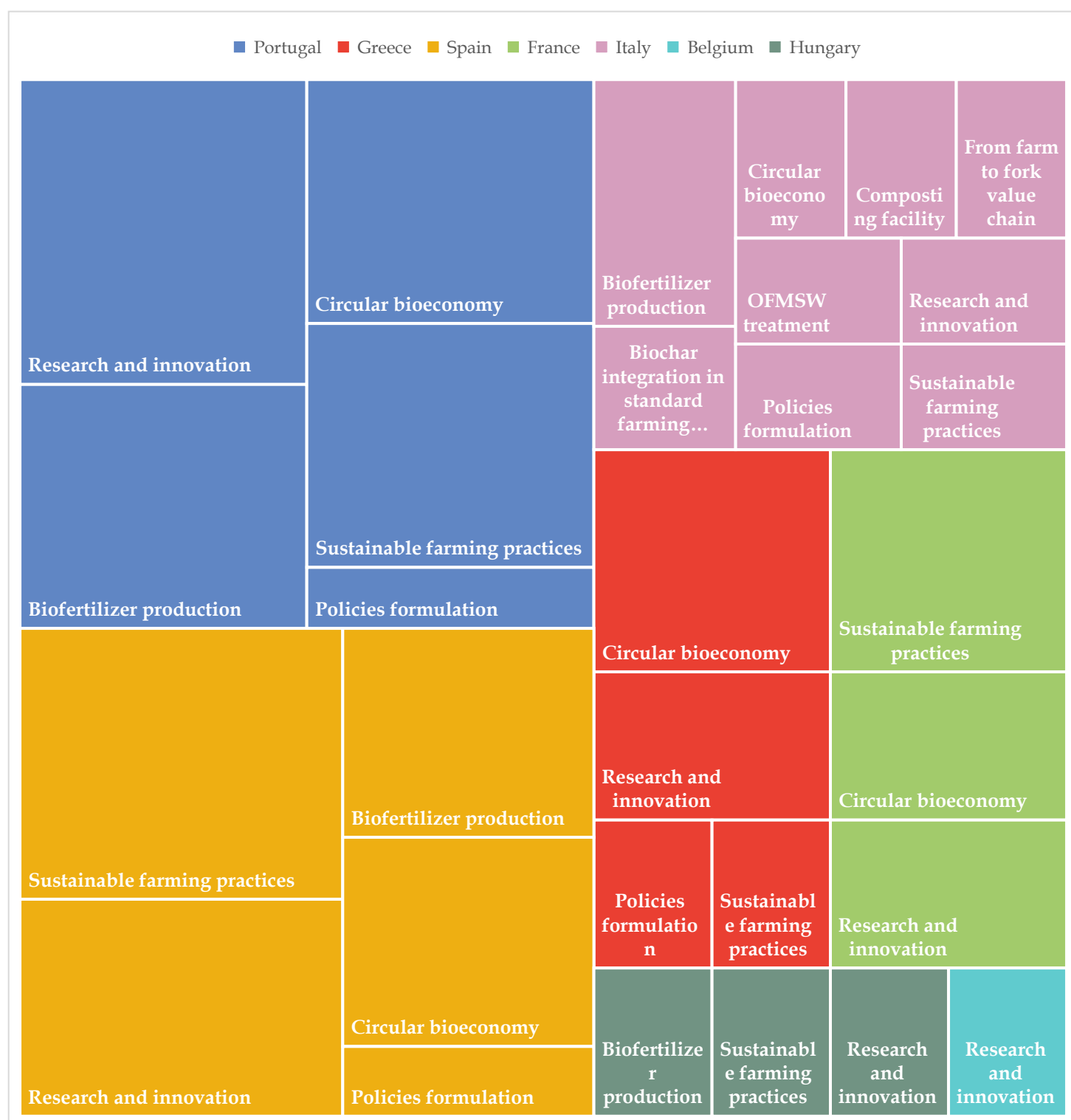


Figure 5. Focus area in sustainable agriculture/biofertilizers for each country involved in the research

Part 2. Key platforms and networks for interregional cooperation in sustainable agriculture and biofertilizers: Opportunities and challenges

The second phase of our questionnaire analysis focused on identifying and evaluating the key platforms and networks within the biofertilizer and sustainable agriculture sectors that foster interregional cooperation. This phase is vital for understanding how different regions and stakeholders work together to promote sustainability, biofertilizer adoption, and circular bio-solutions within the agri-food sector. By asking respondents to list key platforms, clusters, hubs, and institutions within their region, we sought to map out the existing collaboration landscape and assess the effectiveness of these platforms in driving innovation, research, and knowledge exchange.

In addition to identifying these platforms, the questionnaire also explored whether these networks are enabling effective collaboration. Responses provided insights into the strengths and challenges of these platforms, helping to pinpoint areas for improvement. This information is crucial for evaluating the impact of regional networks on advancing sustainable agricultural practices, especially in the context of biofertilizers, and identifying potential barriers to effective interregional cooperation.

The analysis also highlighted the limitations that may hinder collaboration within these networks. For example, issues such as insufficient funding, lack of coordination among stakeholders, regulatory barriers, and limited access to resources were identified as potential challenges that could prevent these platforms from realizing their full potential. By recognizing these limitations, we can develop targeted strategies to address these gaps and enhance the overall effectiveness of interregional cooperation in sustainable agriculture.

Question 2.1. What are the key platforms/networks (digital or physical) in your region for interregional cooperation in sustainable agriculture and biofertilizers? (e.g., clusters, hubs, institutions)

The various platforms, networks, and initiatives listed below (Table 1) represent a global effort to foster innovation, sustainability, and collaboration in the agricultural sector, focusing particularly on sustainable farming practices, biofertilizers, and the bioeconomy. These networks span across Europe, with a heavy concentration in Portugal, Greece, Spain, France, Belgium, Italy, and Hungary, providing key support for agricultural development through research, technology, and collaboration.

In Portugal, institutions like the Agri-Environment and Climate Network and the Alentejo Regional Development Commission emphasize promoting sustainable agricultural practices and enhancing climate resilience in farming systems. Similarly, Feedinov and IACA focus on innovation in feed production and sustainable practices in agriculture, offering resources and collaborative research in biofertilizers. FRCT and TERINOV are also key players in regional innovation, supporting agricultural research and technological advancements in agriculture, particularly in the Azores.

In Greece, the ELGO-DIMITRA research organization leads agricultural research and development, while networks like Smart Agro Hub encourage the use of agro-technology and sustainable practices in farming. HUMOFERT SA is notable for producing fertilizers and other specialty agricultural products aimed at improving crop growth and productivity.

Spain's contributions to sustainable agriculture include entities like BETA Technological Center, IRTA and Xarxa d'Innovació Agroalimentària (XIA), which focus on research and innovation in biofertilizers, circular economy solutions, and agro-food collaborations. Spain's Clúster Bioenergia Catalunya and BioHubCat further promote sustainable practices in bioenergy and the circular bioeconomy, connecting businesses and research centres to foster innovation.

In France, organizations like Vegepolys Valley (agronomic clusters) and INRAE (academic research) drive forward research and innovation in sustainable agricultural solutions, biofertilizers, and biostimulants, or national networks like La Ferme Digitale which gathers agronomic start-ups, fostering digital transformation in agriculture. There are also several regional agronomical networks (like GRAB) between farmers, and Regional Agricultural Chambers which are key actors in promoting sustainable practices.

Italy is well-represented by networks such as CREA Emilia-Romagna, which promotes sustainable farming practices and biofertilizer technologies in the region. The Clust-ER and CAI Consorzi Agrari Italiani networks further bolster Italy's agricultural industry through innovation, collaboration, and sustainable practices.

In Belgium, entities like Bio-based Industries Consortium (BIC) and Wagralim provide innovation platforms for sustainable agricultural development, focusing on bio-based industries and agri-food collaborations. The Flanders' FOOD network connects the agri-food industry with new technologies, ensuring sustainability in food production systems.

Hungary's agricultural development is driven by networks like the Agri-food Cluster, which fosters collaboration and sustainable farming solutions, and the Agri Research Institute of the Hungarian Academy of Sciences, which leads in agronomic research for sustainability.

These platforms and networks demonstrate a concerted effort to advance sustainable agricultural practices across Europe, addressing climate change, resource efficiency, and circular economy principles. They are pivotal in fostering innovation in biofertilizers, agro-technology, and sustainable food production systems, ensuring the resilience of the agricultural sector while promoting eco-friendly solutions for future generations.

Table 1. Key platforms and networks for interregional cooperation in sustainable agriculture and biofertilizers among countries and their role description

Country	Platform/Network	Description
Portugal	Agri-Environment and Climate Network (Rede de Agricultura e Ambiente)	Promotes sustainable agricultural practices and enhances resilience in farming systems in Alentejo.
	Alentejo Regional Development Commission (CCDR Alentejo)	Coordinates initiatives related to agriculture, environmental sustainability, and rural development.
	AgroAlentejo Innovation Hub	Digital platform promoting innovation in agriculture, biofertilizers, and sustainable farming practices.
	Feedinov; IACA; FEFAC	Collaborative laboratories and associations for feed production, bioeconomy, and sustainable agriculture.
	FRCT (Fundo Regional para a Ciência e Tecnologia)	Promotes research and innovation in the Azores, focusing on sustainable agriculture and regional development.
	TERINOV - Science and Technology Park	Innovation hub in the Azores supporting business ecosystems in agriculture and technology.
	Regional Directorate for Agriculture, Veterinary and Food (DRAVA)	Develops public policies for sustainable agriculture and livestock in the Azores.
	Azores University (CBA and IITA)	Focuses on biotechnology, agriculture, and environmental research with a special emphasis on sustainability.
	ELGO-DIMITRA	Research organization promoting agricultural research and sustainable practices in Greece.
Greece	Smart Agro Hub	Competence center for smart farming focusing on agro-technology, circular economy, and innovation.
	HUMOFERT SA	Greek company producing fertilizers and specialty products that enhance plant growth.
	AGcluster	Platform supporting agricultural innovation and cooperation within Greece, promoting sustainability.

Spain	BETA Tech. Center	Technology center focused on the sustainability of rural areas.
	IRTA (Institut de Recerca i Tecnologia Agroalimentàries)	Catalan research institute focusing on sustainable agriculture and biofertilizer projects.
	Xarxa d'Innovació Agroalimentària (XIA)	Innovation network connecting companies, research centers, and entities in Catalonia for agricultural sustainability.
	CCTF (Centre de Ciència i Tecnologia Forestal de Catalunya)	Focuses on sustainable forest and agricultural systems, including biofertilizers and agroforestry.
	Clúster Bioenergia Catalunya	Promotes collaboration in the agricultural and energy sectors, including bioenergy and biofertilizers.
	BioHubCat	One-stop shop for developing Catalonia's circular bioeconomy, connecting businesses and research centers.
	Catalan Nutrient Platform	Platform bringing together stakeholders involved in nutrient management and fertilizer production in Catalonia.
	Catalan Bioenergy Cluster	Non-profit association promoting the sustainable use of bioenergy and digestate valorization as biofertilizer.
	FEMAC clúster de la maquinària i els mitjans de producció agrícola	Cluster of agricultural machinery and production means, fostering sustainable practices in agriculture.
	Biovegen - plataforma tecnològica de biotecnologia vegetal	Technological platform for plant biotechnology, focusing on sustainable agricultural solutions.
Belgium	SETAC Society of Environmental Toxicology and Chemistry	A society focused on environmental toxicology and its application to agricultural sustainability.
	Bio-based Industries Consortium (BIC)	European non-profit organization promoting the development of bio-based industries and biofertilizers.
	Wagralim	Growth accelerator for Wallonia's agri-food industry, promoting innovation and sustainable practices.
Italy	Flanders' FOOD	Innovation platform for the Flemish agri-food industry, promoting sustainability and new technologies.
	CREA Emilia-Romagna	Research institution advancing sustainable farming and biofertilizer technologies in Emilia-Romagna.

France	Regione Emilia-Romagna's Department of Agriculture and Food Supply	Coordinates sustainable agricultural programs, including biofertilizers and organic farming.
	Bioindustria Emilia-Romagna	Hub for businesses and research centers focused on bio-industrial practices and biofertilizers.
	Clust-ER	Network fostering collaboration in the agri-food industry to promote innovation and sustainable practices.
	CAI Consorzi Agrari Italiani	Largest network for the distribution of national agricultural products, focusing on sustainability.
	Vegepolys Valley	Competitiveness cluster supporting innovation in agriculture, with expertise in biofertilizers and biostimulants.
	INRAE	National research center focusing on agronomic and sustainable agricultural research.
	La Ferme Digitale	Association supporting agronomic start-ups to bring innovation to agriculture.
	AFAIA	National syndicate for biofertilizers in France, focusing on eco-friendly agricultural solutions.
	FRAB/GRAB	Network supporting organic farming with advisors, research, and training in Brittany.
	Initiative Bio Bretagne (IBB)	Cluster of companies supporting organic farming and promoting sustainable practices in Brittany.
	Techniloire	Provides technical support for wine-growing sector, focusing on sustainable practices.
	Agricultural Chambers	Provides support and advice for farmers, cooperatives, and agricultural stakeholders in France.
	ACR+ Network	Association of cities and regions promoting sustainable resource management through recycling and reuse.
	Agri-food Cluster	Collaborative network in Hungary promoting sustainable agriculture and food production practices.
Hungary	Agri Research Institute of Hungarian Academy of Sciences	Agricultural research institute focused on sustainable farming and biofertilizer development.
	Agro University	Agricultural university in Hungary promoting research and education in sustainable agricultural practices.

Question 2.2. Do these platforms/networks enable effective collaboration?

The data reveals that several platforms and networks are recognized as enabling effective collaboration. In Portugal, networks such as Feedinov (Laboratório Colaborativo), IACA (Associação Portuguesa dos Industriais de Alimentos Compostos para Animais), and the European Feed Manufacturer's Association (FEFAC) play pivotal roles in fostering cooperation. Other notable contributors include FRCT - Regional Fund for Science and Technology, TERINOV - Science and Technology Park, the Regional Directorate for Agriculture, Veterinary and Food (DRAVA), the Biotechnology Centre of Azores (CBA), and the Institute of Agricultural and Environmental Research and Technologies (IITAA). These platforms highlight Portugal's dedication to advancing sustainable agricultural practices (Figure 6).

In Greece, effective collaboration is facilitated by ELGO-DIMITRA, Smart Agro Hub, and HUMOFERT SA, demonstrating the country's innovation in agriculture and biofertilizers. Similarly, in Spain, institutions such as BETA Tech. Center, IRTA (Institut de Recerca i Tecnologia Agroalimentàries), Xarxa d'Innovació Agroalimentària (XIA), the Centre de Ciència i Tecnologia Forestal de Catalunya (CCTF), and the Clúster Bioenergia Catalunya are recognized for their collaborative efforts in sustainable agriculture and research. Spain also benefits from other impactful networks like BioHubCat, the Catalan Nutrient Platform, and the Catalan Bioenergy Cluster.

France showcases its innovation through platforms and clusters such as Vegopolys Valley, La Ferme Digitale, ABBA, LEGGO, and Techniloire, which all contribute to strengthening agricultural cooperation and sustainability. Belgium is represented by impactful initiatives like the Bio-based Industries Consortium (BIC), Wagralim, and Flanders' FOOD, emphasizing their contributions to agricultural innovation. Italy's CREA Emilia-Romagna, Regione Emilia-Romagna's Department of Agriculture and Food Supply, and Bioindustria Emilia-Romagna also stand out as effective collaborative networks. Finally, Erasmus+ is a notable international program contributing to collaboration in Portugal and beyond.

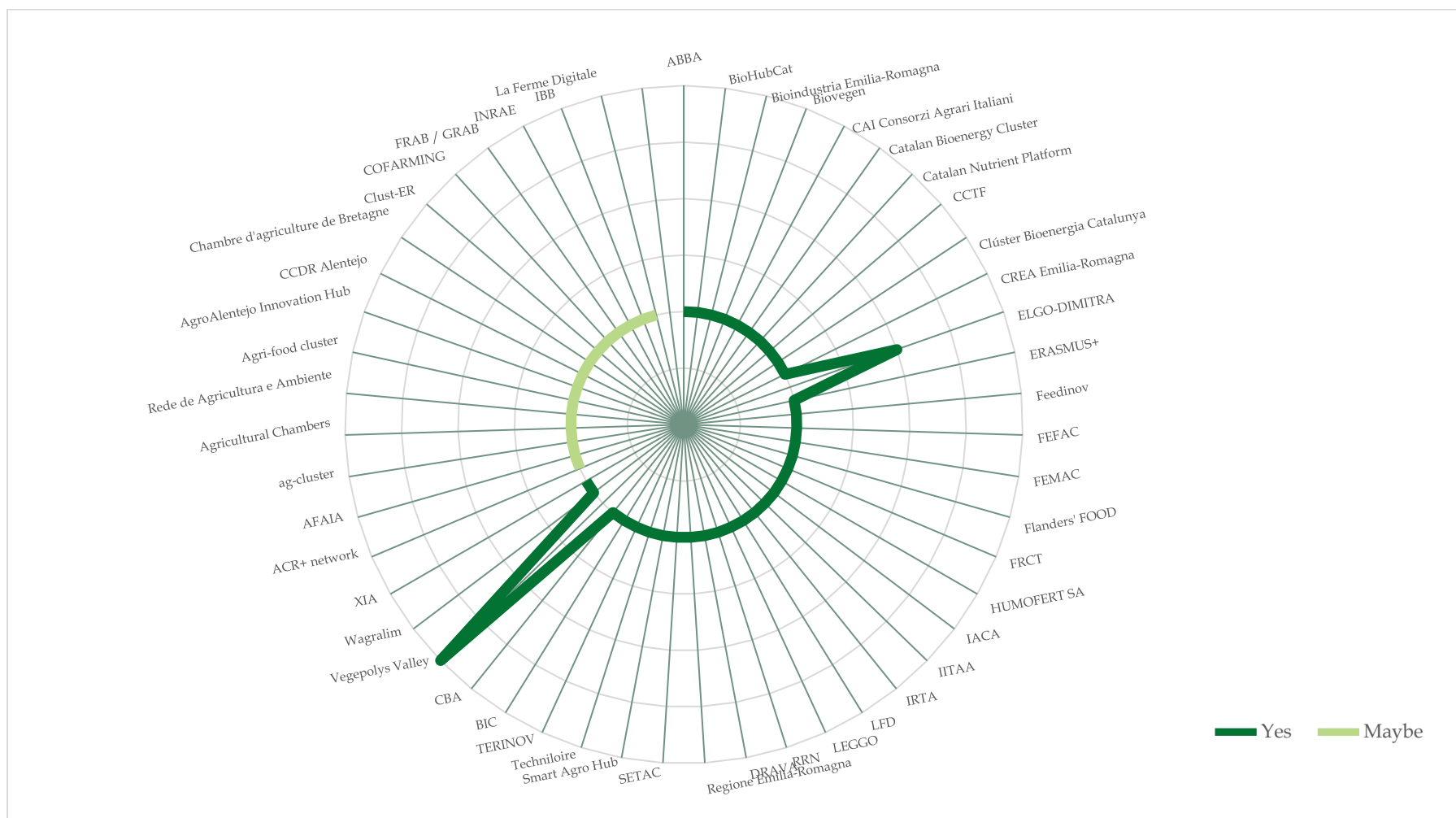


Figure 6. Provision of effective collaboration of platforms/networks among all countries

Question 2.3. If No/Maybe what are the main limitations?

Despite the successes in collaboration, platforms and networks categorized as "Maybe" face significant limitations that impede their ability to foster effective collaboration. Key challenges include communication barriers, budget constraints, and the expense of subscribing to certain platforms (Table 2). A lack of critical mass and overlapping functions among platforms leads to inefficiencies and confusion. Divergent interests among stakeholders and the proliferation of platforms, clusters, and associations dilute knowledge and action, complicating collaboration. For instance, national platforms often lack effective regional connections, except for Vegopolys Valley, which focuses on specific regions.

Additional challenges include difficulties in accessing some networks, the need to strengthen links between existing structures, and the differing priorities of stakeholders involved. These limitations underscore the need for enhanced coordination, greater integration of resources, and targeted efforts to align the goals and interests of diverse participants. Addressing these obstacles could significantly improve the effectiveness of platforms and networks, paving the way for more robust interregional cooperation in sustainable agriculture and biofertilizers.

Table 2. Main limitations in the provision of effective collaboration of platforms/networks among all countries

Category	Platform/Network	Country	Limitation
Communication Barriers	Agri-Environment and Climate Network	Portugal	Communication barriers hinder effective collaboration.
	Alentejo Regional Development Commission	Portugal	
	AgroAlentejo Innovation Hub	Portugal	
Critical Mass and Overlap	Clust-ER	Italy	Critical mass and overlapping functionalities.
Divergent Interests	INRAE	France	Multiplication of platforms, clusters, and associations leading to confusion and knowledge/action dilution.
	COFARMING	France	
	AFAIA	France	
	La Ferme Digitale	France	
	VEGEPOLYS VALLEY (Some regions)	France	
Accessibility Challenges	AG-cluster	Greece	Not easy to reach.
Need for Better Links	FRAB/GRAB	France	Need to improve links and coordination between existing structures and networks.
	Initiative Bio Bretagne	France	
	Chambre d'agriculture de Bretagne	France	
	Agricultural Chambers	France	
	ACR+ network	France	
Stakeholder Misalignment	Agri-food cluster, Agri Research Institute	Hungary	Different interests of the stakeholders.

Part 3. Twinning models and interregional cooperation initiatives in sustainable agriculture and biofertilizers: Effectiveness, successes, and challenges

This part of the questionnaire aimed to assess the level of participation of regions in twinning models or interregional cooperation initiatives focused on sustainable agriculture and biofertilizers. By asking respondents to list specific initiatives, the questionnaire sought to identify which programs are currently active in promoting cross-sectoral networking and collaboration. Additionally, it aimed to evaluate the effectiveness of these initiatives in facilitating knowledge exchange and fostering innovation, particularly in the areas of sustainable agriculture practices and biofertilizer development. Furthermore, the questionnaire sought to gather insights into the successes and challenges encountered within these models. It aimed to capture examples of successful collaborations, such as impactful innovations or strengthened regional partnerships, while also highlighting any difficulties, such as barriers to collaboration or limitations in implementing these initiatives effectively. The overall goal was to understand how interregional cooperation can be improved, identify best practices, and share lessons learned that can benefit other regions involved in similar initiatives.

Question 3.1. Does your region participate in any twinning models or interregional cooperation initiatives focused on sustainable agriculture or biofertilizers? (e.g., cross sectoral networking, projects such as nextfood project.eu)

Regarding the availability of twinning models in each country, a significant majority of responses affirm participation, with 17 indicating "Yes", demonstrating engagement in cross-sectoral networking and projects like NextFood. Meanwhile, 7 responses suggest "Maybe", demonstrating some level of uncertainty or partial involvement in such initiatives. Lastly, 2 responses indicate "No", showing limited or no engagement in these types of collaborations (Figure 7).

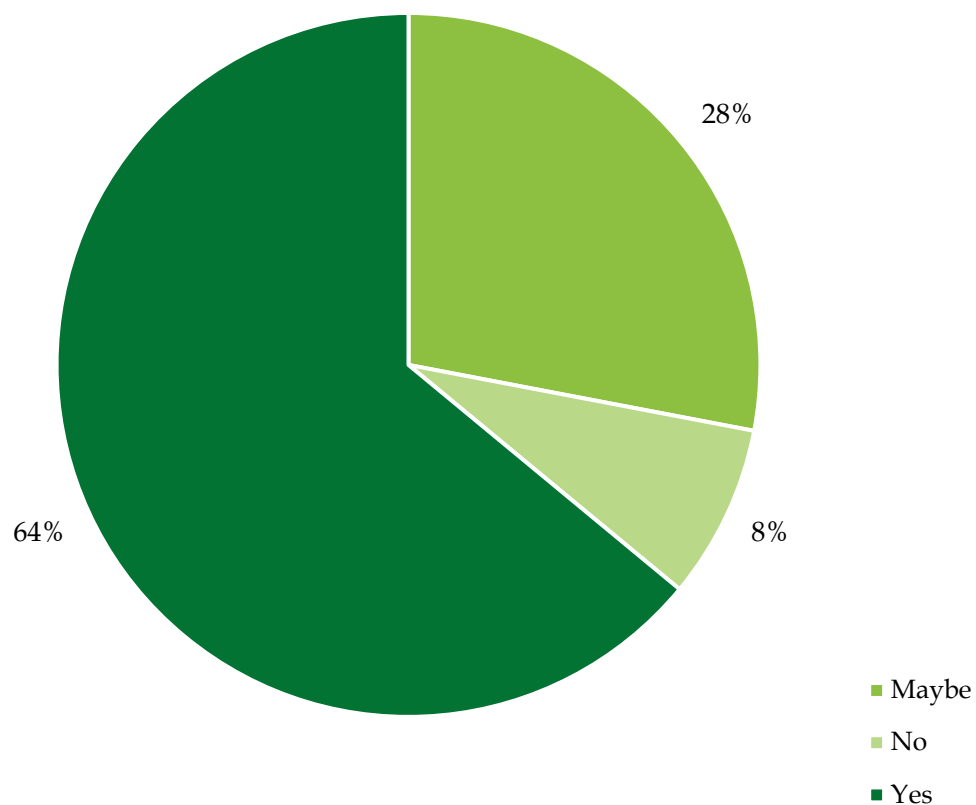


Figure 7. Participation percentage of each region in twinning models or interregional cooperation initiatives focused on sustainable agriculture or biofertilizers

Question 3.2. If yes, please list the initiatives (up to 3)

The responses to the question regarding participation in twinning models or interregional cooperation initiatives focused on sustainable agriculture or biofertilizers indicate that various regions are involved in a wide range of initiatives aimed at fostering collaboration, knowledge exchange, and innovation in the sector. For example, regions such as Alentejo are engaged in programs like INTERREG Europe and SUSFOOD, which focus on enhancing sustainable food systems and agricultural practices across Europe, particularly in the Mediterranean (Table 3). The initiative allows regions to collaborate on biofertilizer development and sustainable agriculture solutions.

In addition, several regions, such as Emilia-Romagna, participate in initiatives like the INTERREG Europe program, the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI), and various twinning agreements. These initiatives help to create a framework for sharing best practices, implementing innovative solutions, and advancing sustainable agricultural practices. Similarly, the region of Central Macedonia in Greece is part of the Agronutritional Cooperation, an initiative that brings together numerous institutions to support the development and promotion of agrifood products in the region.

Other regions also participate in EU-supported programs, such as the EU CAP Network, SMART4ENV, and AGRI-BIOCIRCULAR-HUB, which connect multiple stakeholders to promote the adoption of biofertilizers and other sustainable practices. Some regions, including Catalonia Madeira and Azores, have projects like the Interreg MAC and Interreg Europe Programmes and Azores also has RIS3 Azores (Smart Specialization Strategies), which aim to strengthen political, economic, and institutional ties between regions to improve sustainability in agriculture and the agroindustry.

Table 3. Participation in twinning models and interregional cooperation initiatives focused on sustainable agriculture and biofertilizers by country

Country	Initiative
Portugal	INTERREG Europe, Sustainable Food in the Mediterranean (SUSFOOD), Interreg MAC Programme, RIS3 Azores (Smart Specialization Strategies), CHEER4EU
Greece	Agronutritional Cooperation of the Region of Central Macedonia, Interreg Europe
Italy	INTERREG Europe Program, European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI), Twinning Agreements with Neighboring Regions of Emilia-Romagna
Spain	AGRIREGENCAT, FERTILAB, FANGS, EU CAP Network, SMART4ENV, AGRI-BIOCIRCULAR-HUB
Belgium	AgriFood4Future Erasmus+
France	INTERREG North West Europe, Plant InterCluster, Valocepts project, BIOREGIO, RUSTICA project, BIOTRANSFORM
Hungary	AGRO4SDG, HIGHFIVE

Question 3.3. How effective are these twinning models in knowledge exchange and innovation?

To assess the impact and success of twinning models and interregional cooperation initiatives in promoting the exchange of knowledge and fostering innovation, particularly in the areas of sustainable agriculture and biofertilizers, this question of the questionnaire seeks to understand how well these collaborative programs facilitate the sharing of best practices, the adoption of new technologies, and the development of innovative solutions across regions or countries. It also aims to evaluate how these initiatives contribute to the advancement of sustainable agricultural practices, environmental sustainability, and the effectiveness of biofertilizer use, helping to improve local policies, practices, and technologies.

Table 4. Evaluation of each initiative. Color intensity demonstrates efficiency (white: neutral, light green: effective, dark green: very effective)

Region (Country)	Initiative
Alentejo (PT)	INTERREG Europe Sustainable Food in the Mediterranean (SUSFOOD)
Autonomous Region of the Azores (PT)	INTERREG MAC Programme RIS3 Azores (Smart Specialization Strategies)
District of Coimbra (PT)	INTERREG Europe (CHEER4EU) Agronutritional Cooperation of the Region of Central Macedonia (NEXTFOOD)
Region of Central Macedonia (GR)	INTERREG Europe INTERREG Europe Program European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) Twinning Agreements with Neighboring Regions of Emilia-Romagna AGRIREGENCAT FERTILAB FANGS EU CAP Network SMART4ENV AGRI-BIOCIRCULAR-HUB
Emilia-Romagna (IT)	AgriFood4Future Erasmus+
Catalonia (ES)	Plant InterCluster INTERREG North West Europe
Brussels-Capital Region (BE)	Plant InterCluster Valoiceps project
Brittany (FR)	INTERREG North West Europe
Auvergne-Rhone-Alpes (FR)	Plant InterCluster Valoiceps project INTERREG North West Europe
Centre Region - Val de Loire (FR)	Plant InterCluster Plant InterCluster BIOREGIO RUSTICA BIOTRANSFORM
Loire Region (FR)	INTERREG North West Europe AGRO4SDG HIGHFIVE
Southern Transdanubia (HU)	

Question 3.4. Elaborate on any successes or challenges on these models

In the context of sustainable agriculture and biofertilizers, various twinning models and interregional cooperation initiatives have achieved significant successes but also faced notable challenges. These models, aimed at fostering innovation and knowledge exchange, have had diverse impacts across different regions.

The successes include:

1. Coordination and Cooperation

INTERREG Europe promotes international cooperation and facilitates good practices in sustainable development. Similarly, the Interreg MAC Programme supports regional RD&I and promotes innovation in sustainable development, encouraging international cooperation and fostering innovation for SMEs. The CHEER4EU initiative facilitates the replication of successful circular hubs in regions like Portugal, where they have not yet been implemented. In the same vein, the Agronutritional Cooperation of the Region of Central Macedonia developed education and training programs for sustainable agrifood and forestry systems through NextFOOD, producing 12 case studies for future knowledge sharing. SMART4ENV developed a smart irrigation system demo to improve water efficiency in agriculture. Meanwhile, AgriFood4Future Erasmus+ supports the transformation of the agri-food sector, providing diverse skill development programs and offering educational opportunities for stakeholders. AGRO4SDG promotes effective mutual learning, knowledge sharing, joint development, and investment, with a flexible cooperation approach.

2. Collaboration and Engagement

Plant InterCluster organizes discussions and interactions between regions and sectors, fostering collaboration. The Valocepts Project functions as a territorial scale project that enables task distribution based on available resources and promotes mutual learning.

The challenges include:

1. Coordination and Financial Constraints

The Valocepts Project faces difficulty coordinating financial contributions from partners. Similarly, AgriFood4Future Erasmus+ struggles with large-scale implementation, balancing stakeholder needs, and adapting to changing technologies.

2. Limited Regional Connections

Plant InterCluster faces a challenge with a lack of strong connection between regions, requiring stronger initiatives for more effective collaboration.

Twinning models and interregional cooperation initiatives offer substantial potential for fostering innovation and sustainable practices in agriculture, particularly with regard to biofertilizers. However, their success is often contingent on overcoming barriers such as funding limitations, regulatory hurdles, and effective knowledge dissemination. Continued efforts to strengthen collaboration, enhance funding mechanisms, and streamline

communication across sectors will be key to maximizing the potential of these initiatives in driving agricultural sustainability (Table 5).

Table 5. Overview of the successes and challenges of each initiative

Initiative	Region (Country)	Successes	Challenges
INTERREG Europe	Alentejo (PT)	Promotes international cooperation, follows innovation policies, and facilitates knowledge exchange and biofertilizer innovations and good practices in sustainable development.	
	Region of Central Macedonia (GR)		
Interreg MAC Programme	Emilia-Romagna (IT)	International cooperation, innovation in sustainable development, supports regional RD&I, and promotes SME innovation.	
	Autonomous Region of the Azores (PT)		
CHEER4EU	District of Coimbra (PT)	Replicates successful circular hubs in regions like Portugal where they have not yet been implemented.	
Agronutritional Cooperation of the Region of Central Macedonia (NEXTFOOD)	Region of Central Macedonia (GR)	NextFOOD develops education and training programs for sustainable agrifood and forestry systems; and produces 12 case studies for future knowledge sharing.	
SMART4ENV	Catalonia (ES)	Developed a smart irrigation system demo to improve water efficiency in agriculture.	
AgriFood4Future Erasmus+	Brussels-Capital Region (BE)	Supports agri-food sector transformation, provides diverse skill development, and offers educational programs.	Challenges in large-scale implementation, balancing stakeholder needs, adapting to changing technologies.

Plant InterCluster	Brittany (FR) Auvergne-Rhone-Alpes (FR) Centre Region - Val de Loire (FR) Loire Region (FR)	Organizes discussions and interactions between regions and sectors, fostering collaboration.	Lack of strong connection between regions, need for stronger initiatives.
	Centre Region - Val de Loire (FR)	Territorial scale project enabling task distribution based on resources, promoting mutual learning.	Difficulty coordinating financial contributions from partners.
Valocepts Project			
AGRO4SDG	Southern Transdanubia (HU)	Effective mutual learning, knowledge sharing, joint development, and investment. Flexible cooperation.	

Part 4. Regional and interregional action plans for sustainable agriculture, biofertilizers, and the circular bioeconomy: Strengths and weaknesses

The questions of this part of the questionnaire aim to assess the presence, characteristics, and effectiveness of regional and interregional action plans related to sustainable agriculture, biofertilizers, and the circular bioeconomy.

The objectives of the questions aim to:

- **Identify Existing Action Plans:** To determine whether regional or interregional action plans are in place that focus on sustainability, biofertilizer use, or circular bio-economy practices.
- **Understand Plan Characteristics:** To gather details about these action plans, including their scope, objectives, and focus areas, providing insights into how regions are addressing sustainability challenges.
- **Analyse Strengths:** To identify the key strengths of the action plans, such as innovative approaches, stakeholder engagement, funding structures, or practical implementation strategies.
- **Evaluate Weaknesses:** To uncover potential gaps or weaknesses, such as limited scope, insufficient funding, regulatory hurdles, or lack of stakeholder coordination, which may hinder the effectiveness of these plans.
- **Explore Interregional Collaboration:** To determine whether there are interregional initiatives that foster cooperation between regions, such as those developed through programs like Interreg.
- **Examine Interregional Plan Effectiveness:** To evaluate the strengths and weaknesses of interregional action plans, understanding their role in promoting sustainable practices and facilitating knowledge exchange across borders.

By addressing these dimensions, the questions aim to provide a comprehensive overview of the current state of regional and interregional efforts in promoting sustainable agriculture and the circular bioeconomy, while also identifying areas for improvement and opportunities for collaboration.

Question 4.1. Are there any regional action plans in place in your region related to sustainable agriculture, biofertilizers, or the circular bioeconomy? (e.g., action plan for bioeconomy in the region of central Macedonia)

The survey results highlight a strong prevalence of regional action plans related to sustainable agriculture, biofertilizers, or the circular bioeconomy (Figure 8). Of the 25 responses collected:

- 18 respondents (72%) confirmed the existence of such plans in their regions, indicating significant regional activity and focus on sustainability and circular bioeconomy initiatives.
- 6 respondents (24%) were uncertain, answering "Maybe," which suggests either a lack of information or ongoing development of such plans.
- Only 1 respondent (4%) stated that no such plans exist in their region, reflecting a minimal level of inactivity in this domain.

Overall, the results suggest a strong alignment toward sustainable agricultural practices and bioeconomy goals, while also indicating room for improved communication and awareness regarding these regional initiatives.

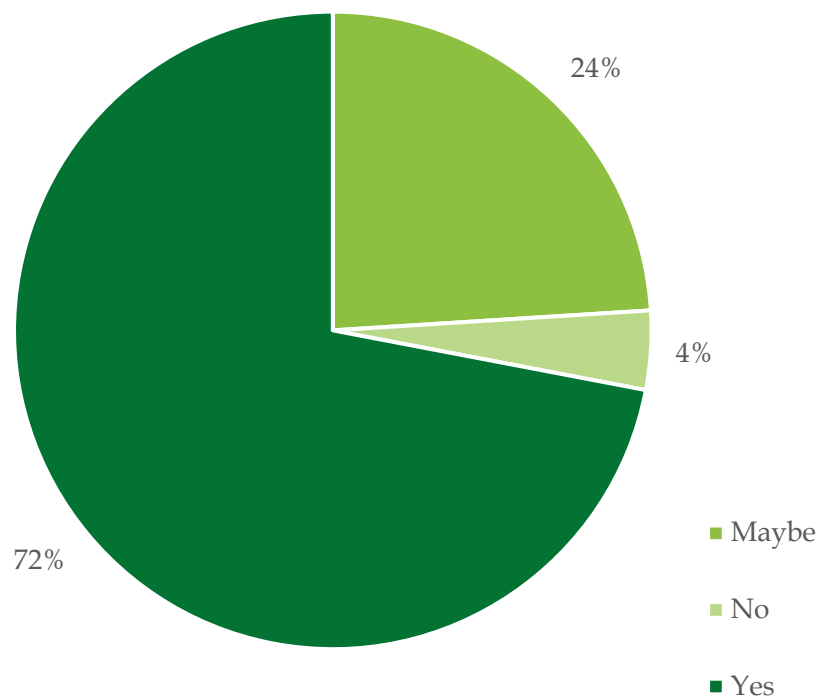


Figure 8. Availability of regional action plans among all countries related to sustainable agriculture, biofertilizers, or the circular bioeconomy

Question 4.2. If yes, provide a brief description of these regional action plans

The data outline various action plans and strategies among the participating countries (Figure 9), focused on sustainable development, circular economy, bioeconomy, climate adaptation, and innovation, summarized in Table 6. These plans follow the key themes of:

1. Regional Development and Innovation:

- Alentejo Regional Programme 2021–2027: Focuses on making the region smarter, greener, and more inclusive through investments in research, digitalization, transport electrification, social cohesion, and urban-rural integration.
- Regional Innovation Plan for Brussels (2021–2027): Enhances economic resilience and societal transitions with a focus on climate, health, and innovation under the Smart Specialisation Strategy (RIS3).

2. Bioeconomy and Circular Economy Strategies:

- Strategies for promoting circular bioeconomy in regions like Central Macedonia (e.g., BIOREGIO and CESME projects) and Catalonia (Estratègia de la Bioeconomia de Catalunya 2030).
- Initiatives include developing biogas and digestate management strategies, promoting renewable energy, and fostering sustainable waste management.
- The Azores Circular Economy Agenda focuses on agroforestry, sustainable agriculture, and decarbonization in RIS3-Azores.
- Circular Economy Plan in the Loire Region (France) to optimize the use of agricultural by-products, valorize organic matter, and implement actions that enhance collaboration, train farmers, promote innovative projects, and support the entire value chain.

3. Environmental and Climate Action Plans:

- Regional Programme for Climate Change in the Azores (PRAC): Combines adaptation to climate impacts with mitigation measures.
- Plano Nacional Energia e Clima 2030 (PNEC 2030): Advocates for reducing synthetic fertilizers and increasing soil organic carbon to promote sustainability.

4. Agriculture and Rural Development:

- Rural Development Plans (2014–2020): Investments in innovation, competitiveness, and sustainable management.
- Strategies like 2030 Ambition for Agriculture in Centre Val de Loire aim to scale agroecology and align with greenhouse gas reduction goals.

5. Social and Economic Transitions:

- The 2030 Agenda for Sustainable Development integrates environmental, social, and economic sustainability.
- Plans like SRTES 2023–2027 in Brittany focus on ecological and economic transitions, including agricultural systems and social inclusion.

6. Specific Sectoral Initiatives:

- Promotion of bio-based industries, biorefineries, and renewable energy through the Circular Bio-Based Europe Joint Undertaking (CBE JU).
- Strategies for urban regeneration, decarbonization, and sustainable infrastructure.

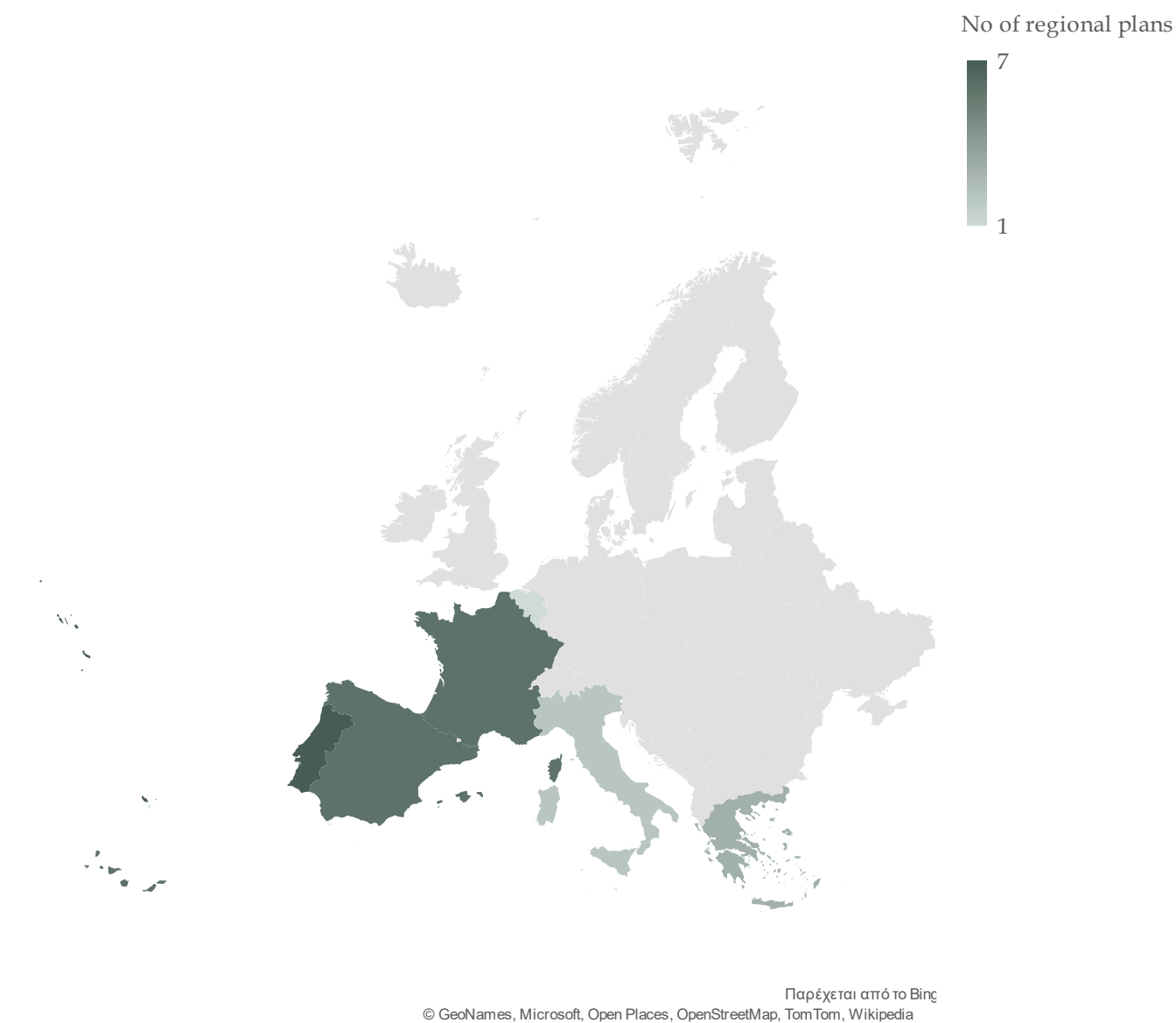


Figure 9. Number of regional action plans per participating country

Table 6. Regional action plans and strategies among the participating countries

Country	Region	Regional Action Plan	Description
Portugal	Alentejo	Alentejo Regional Programme 2021–2027	Focuses on making the region greener, more connected, and inclusive through investments in research, digitalization, sustainable transport, urban regeneration, social cohesion, lifelong learning, and Just Transition Fund for diversification and green transition.
Portugal	Autonomous Regions of the Azores	RIS3-Azores (Smart Specialization Strategies)	Prioritizes agriculture, agro-industry, circular economy, and decarbonization to foster environmental sustainability in agriculture, forestry, and agro-industry.
Portugal	Autonomous Regions of the Azores	PRAC - Azores Regional Programme for Climate Change	Combines adaptation (climate impact reduction) and mitigation (GHG reduction) with sustainable land-use planning and coastal zone adaptation strategies.
Portugal	District of Coimbra	Plano de Ação para a Economia Circular (PAEC 2023–2027)	Aims to reduce synthetic fertilizers, replace them with organic compost, and increase soil organic carbon for sustainability.
Greece	Region of Central Macedonia	Circular Bioeconomy Action Plan (Central Macedonia) (CBAP)	Integrates CBAP actions into ROP (2014–2020), funds SMEs in waste management and energy reuse, and emphasizes circular bioeconomy in the 2021–2027 ROP.
Greece	Region of Central Macedonia	National Strategy of Circular Economy (2018)	A national framework adopted to promote the circular economy; specific action plans developed under Interreg projects like BIOREGIO and CESME in Central Macedonia.
Spain	Catalonia	Estratègia de Bioeconomia de Catalunya 2021, 2030	Promotes efficient use of natural resources through innovation and technology for integrated management and territorial development.
Spain	Catalonia	PDRCAT 2014–2022 (Catalonia)	Rural development plan that promotes sustainability and competitiveness.
Spain	Catalonia	Catalan Biogas and Digestate Strategy	Promotes the valorization of livestock and organic waste to produce biogas and biofertilizers. Identifies barriers and outlines objectives across environmental, energy, and economic fields.
Spain	Catalonia	Hoja de Ruta del Biogás en España (Biogas Roadmap)	Aims to enhance biogas production, focusing on sustainability, waste management, and GHG reduction.

Italy	Emilia-Romagna	Rural Development Plan 2014–2020	Invests in innovation, agro-industrial competitiveness, and sustainable environment and climate management.
Italy	Emilia-Romagna	Regional Strategy 2030 Agenda for Sustainable Development	Adopts all 17 UN SDGs with an emphasis on sustainability, social inclusion, and local community engagement for implementing the global action plan.
France	Centre Region - Val de Loire, Loire Region, Brittany, Auvergne-Rhone-Alpes	Plan d'Action Nitrates	Action plan to prevent water pollution by nitrates.
France	Centre Region - Val de Loire, Loire Region, Brittany, Auvergne-Rhone-Alpes	GIEE / Groupes 30,000	Farmers' collectives promoting agroecology through information sharing and good practices.
France	Brittany	SRTES 2023–2027	Strategy for climate and ecological transformations, strengthening sovereignty, and promoting social cohesion with an agricultural roadmap.
France	Centre Region - Val de Loire	2030 Ambition for Agricultural Strategy	Develops agroecology in Centre Val de Loire to align with national GHG reduction goals and organizes sector-specific support contracts.
France	Loire Region	Circular Economy Plan	Includes studies, actions, and financial calls for circular economy initiatives.
Belgium	Brussels-Capital Region	Regional Innovation Plan for Brussels (2021–2027)	Strategic framework under RIS3 to drive innovation in climate, health, and social inclusion while improving urban life.

Question 4.3. What are the strengths of these regional action plans?

The regional action plans highlighted above demonstrate several key strengths across different regions and sectors (Table 7), such as:

- **Strategic Focus and Alignment with Policies:** Many action plans align with broader EU policies and global sustainability goals, such as the UN's 2030 Agenda for Sustainable Development. They emphasize coherence with frameworks like Smart Specialisation Strategies (RIS3) and the Circular Economy Action Plan, ensuring consistency and alignment with high-level objectives.
- **Integration and Collaboration:** The plans often promote collaboration between public and private stakeholders, including governments, SMEs, farmers, cooperatives, and research institutions. This approach fosters a sense of shared responsibility and helps build robust innovation ecosystems.
- **Emphasis on Sustainability:** A recurring theme is the promotion of sustainability, including goals such as decarbonization, waste reduction, sustainable water and waste management, and biodiversity preservation. Plans like Catalonia's Bioeconomy Strategy 2030 focus on efficient resource use, climate resilience, and environmental protection.
- **Support for Innovation and R&D:** Investment in research, development, and innovation is a key focus. Several action plans, such as the Brussels-Capital Region's strategy, encourage technological advancements and innovative solutions to address societal challenges like climate change, health, and mobility.
- **Capacity Building and Skill Development:** Support for education, lifelong learning, and employment is prevalent. Plans aim to equip the workforce with skills aligned with the demands of the green transition, enhancing local competitiveness.
- **Sector-Specific Initiatives:** Action plans often include tailored measures for specific industries, such as agriculture, biogas production, and agroforestry. For instance, Catalonia's strategies for biogas and digestates prioritize environmental, energy, and economic sustainability within these sectors.
- **Financial Support Mechanisms:** Several plans provide financial incentives or funding opportunities for innovation and sustainable practices. For example,

Central Macedonia's Circular Bioeconomy Action Plan includes innovation vouchers for SMEs to implement waste management solutions.

- **Regional Adaptation:** Strategies are often customized to regional characteristics, such as the Azores' focus on addressing challenges related to its geographic dispersion and small-scale SMEs.
- **Stakeholder Engagement:** The involvement of local communities and stakeholders in the development and implementation of these plans ensures that initiatives are grounded in regional realities and garner broader support.
- **Monitoring and Measurable Goals:** Many plans feature structured approaches with defined objectives, SMART goals, and mechanisms to track progress and outcomes, ensuring accountability and effectiveness.

These strengths collectively underscore the commitment of regions to addressing environmental, economic, and social challenges through innovative, inclusive, and sustainable strategies.

Question 4.4. What are the weaknesses of these regional action plans?

Despite the strengths of the regional action plans, several challenges and limitations hinder their effectiveness (Table 7):

- **Implementation Challenges:** Many action plans face significant barriers in implementation. For instance, in the Azores and Catalonia, the geographic dispersion of islands or insufficient preparedness of local communities creates logistical and structural challenges. Similarly, bureaucratic hurdles and complex governance structures, as seen in Brussels-Capital Region, slow down the deployment of initiatives. In regions like Centre Region-Val de Loire, actions are not frequently renewed, which can reduce their long-term impact.
- **Resource Constraints:** A lack of adequate infrastructure, financial support, and human resources limits the scalability and impact of many plans. This is evident in the Azores, where small SMEs and limited innovation ecosystems struggle to participate in planned actions. Catalonia also faces challenges with inadequate financial backing and resource allocation. In the Circular Economy Plan of France, there is difficulty in interconnecting circular economy strategies with agricultural measures, further complicating resource allocation.
- **Stakeholder Engagement Issues:** While stakeholder collaboration is highlighted in many strategies, insufficient mobilization of key actors, particularly in the agricultural and SME sectors, remains a challenge. For example, Catalonia's plans face difficulty engaging small farmers and SMEs, limiting widespread adoption of sustainable practices, while in Centre Region-Val de Loire, insufficient actor mobilization is a challenge.
- **Lack of Practical Implementation and Follow-Up:** Some regions, such as the Azores and Catalonia, lack a strong focus on follow-up actions or fail to translate strategic plans into tangible, impactful measures. The absence of mechanisms to monitor or validate project results is a recurring issue. For the Central Macedonia Circular Bioeconomy Action Plan (CBAP), practical implementation and monitoring are challenging, resulting in the limitation of the effectiveness of the plan's prioritization actions.
- **Regulatory and Policy Limitations:** Weak legal frameworks and poorly defined regulations hinder progress. For instance, Catalonia's strategies suffer from gaps in regulatory clarity, particularly for biogas and digestate projects. Similarly, changes in consumer mindset and business practices required for a circular economy face resistance due to inadequate regulatory support. The

Plan d' action Nitrates, and GIEE initiatives of France focus on recurring themes, which lead to a lack of significant regional impact.

- **Overemphasis on National Strategies:** In several cases, regional initiatives appear as declinations of national programs rather than independent, region-specific plans. This reduces the adaptability and effectiveness of these plans at the regional level, as seen with the GIEE initiatives or Nitrate action plans in France.
- **Insufficient Ambition or Scope:** Some plans lack clear, ambitious goals or fail to address diverse regional needs comprehensively. For example, while Catalonia's biogas strategy emphasizes livestock and organic waste, it does not detail actions across a broader range of raw materials and regulatory affairs.
- **Economic and Financial Constraints:** Regions such as Brussels-Capital face financial difficulties due to mounting public debt and insufficient funding mechanisms to support their ambitious plans. Municipalities often struggle to align resources for coordinated efforts, which exacerbates implementation delays.
- **Knowledge Dissemination and Adoption:** Even when projects yield results, dissemination remains an issue. In regions like Central Macedonia and France, innovative solutions from funded projects often fail to reach larger scales, preventing their adoption by a wider audience.
- **Social Inequities and Urban Challenges:** In Brussels-Capital, socioeconomic disparities and demographic pressures pose persistent challenges. The lack of affordable housing and mobility issues undermines the broader goals of inclusivity and sustainability.

Table 7. Strengths and weaknesses of regional action plans among all countries

Regional Action Plan	Strengths	Weaknesses
Alentejo Regional Programme 2021-2027	- Decentralizing energy production - Preparing for climate change - Promoting sustainable water and waste management - Preserving biodiversity and natural heritage - Promoting sustainable urban mobility	
Central Macedonia Action Plans (BIOREGIO, CESME)	- Best practices identified - Stakeholders mapping - Green business models	
Catalonia Regional Plans (e.g., Bioeconomy Strategy 2030, Biogas Strategy)	- Strong biomass industrial sector - Public concern for circular bioeconomy - Administration adapts regulations to favor bioeconomy - Emphasis on circular economy, innovation, and environmental sustainability - Local community engagement	- Lack of preparation of society for circular bioeconomy - Challenges in training small farmers - Bureaucratic hurdles - Complex documentation and validation processes - Resource constraints and insufficient financial support
Azores Regional Plans (e.g., RIS3-Azores, PRAC)	- Comprehensive integration of sustainability goals - Long-term vision and SMART goals - Multi-stakeholder collaboration - Adaptation and mitigation strategies for climate change	- Small research and innovation ecosystem - Limited involvement of SMEs - Geographic dispersion challenges - Bureaucratic hurdles and underutilization of funds
Brussels-Capital Region Innovation Plan (2021-2027)	- Strategic focus aligned with RIS3 - Comprehensive societal challenges addressed - Structured innovation domains - Economic resilience and ecological transitions - Regional strengths leveraged	- Complex governance structure - Housing shortage - Mobility and traffic congestion issues - Coordination challenges with municipalities - Social inequalities ("Brussels paradox")

Central Macedonia Circular Bioeconomy Action Plan (CBAP)	- Collaboration with stakeholders	- Financial constraints and debt issues - Insufficient investment coordination - Pressure from growing population
	- Establishment of innovation vouchers for SMEs - Prioritization of CBAP actions in Regional Operational Programs (ROP)	- Hard to implement and monitor
Centre-Val de Loire Agricultural Strategy (2030)	- Co-constructed with agricultural sectors - 4-year contracts provide visibility - Connects actors with supported actions	- Insufficient actor mobilization - Actions not frequently renewed
Circular Economy Plan (France)	- Regional animation of stakeholders - Financial calls for initiative support	- Lack of diverse financial sources - Difficulty interconnecting circular economy strategies with agricultural measures
Plano de Ação para a Economia Circular (PAEC 2023-2027) and PNEC 2030 (Portugal)	- Alignment with EU policies - Promotes innovation and research - Stakeholder involvement	- Lack of adequate infrastructure - Complexity in regulation and monitoring - Challenges in consumer and business practices
SRTES 2023-2027	- Annual action plans with conclusions - Regional innovation ecosystem support	- Animation and coordination still to be organized
Estratégia para o Desenvolvimento da Agricultura Biológica (Portugal)	At least there's a plan/strategy	- No practical implementation - Lack of follow-up
Catalonia Biogas and Digestate Strategy	- Governance model to ensure proper deployment - Financial support for specific actions - Public-private collaboration	- Insufficient financial support - Weak legal framework - Ambitious objectives not met

Question 4.5. Are there any interregional action plans in place in your region related to sustainable agriculture, biofertilizers, or the circular bioeconomy? (e.g., action plan created during the implementation of an Interreg funded project)

The survey results highlight a mixed level of engagement with interregional action plans related to sustainable agriculture, biofertilizers, or the circular bioeconomy (Figure 10). Of the 25 responses collected:

- 8 respondents (32%) confirmed the existence of interregional action plans in their regions, showcasing active collaboration and focus on sustainable practices through initiatives like Interreg-funded projects.
- 15 respondents (60%) were uncertain, answering "Maybe," which points to a lack of accessible information or clarity about the implementation of such plans. This highlights the need for improved awareness and communication around these initiatives.
- 2 respondents (8%) explicitly stated that no such plans exist in their regions, indicating limited interregional collaboration in these areas.

Overall, the responses suggest a mix of activity levels, with a subset of regions showing clear progress in interregional cooperation, while many others require greater transparency or development of such plans to strengthen sustainable agricultural practices and the circular bioeconomy.

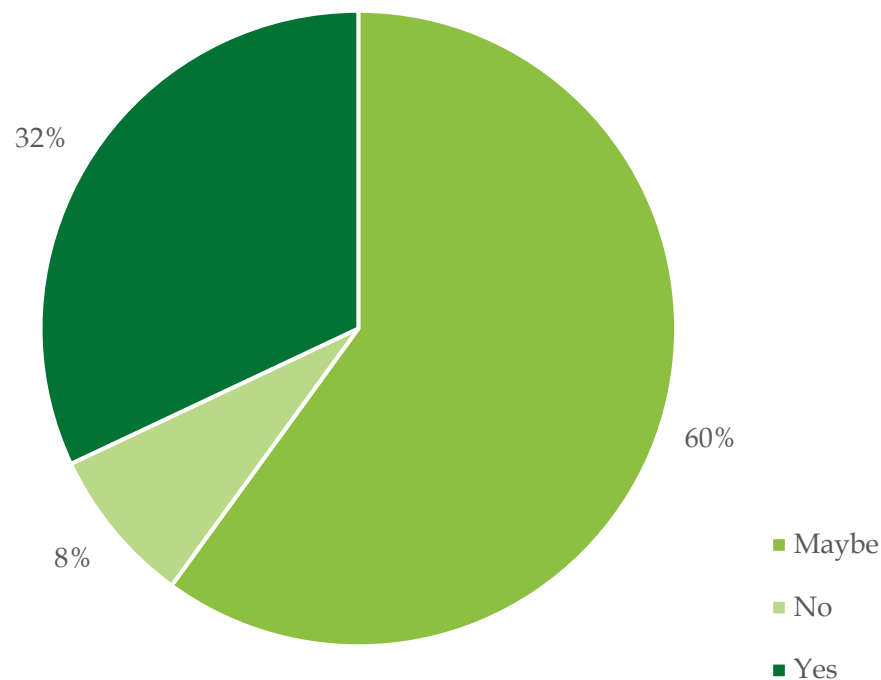


Figure 10. Availability of interregional action plans among all countries related to sustainable agriculture, biofertilizers, or the circular bioeconomy

Question 4.6. If yes, provide a brief description of these interregional action plans

The data highlight various interregional action plans and strategies across different countries, emphasizing sustainable development, the circular economy, bioeconomy, and innovation. These action plans may be grouped under the key themes:

1. Sustainable Agriculture and Bioeconomy Initiatives:
 - SinCE-AFC Project (Italy): An Interreg Europe-funded initiative engaging SMEs in the agri-food chain to adopt circular economy practices, enhancing sustainability.
 - CIRCOTRONIC Project (Italy): This project aims to implement the EU's Circular Economy Action Plan (CEAP) 2020, fostering circular practices in agriculture through transnational collaboration.
 - GECO2 Project (Italy): A collaboration under Interreg Italy-Croatia, focusing on circular economy practices in agriculture through regional partnerships.
 - REAL-MAC (Spain): Promotes the reuse of agri-food effluents for microalgae production, contributing to circular agriculture in the region.
2. Climate Adaptation and Circular Economy Strategies:
 - BIOEAST (Hungary): A joint initiative of Central and Eastern European countries, focusing on accelerating a biomass-based circular bioeconomy from environmental, economic, and social perspectives.
 - Agroecology Partnership (France): Encourages agroecological practices between European regions/countries with the strong participation of the Loire region with living labs and research infrastructures, integrating stakeholders from various sectors such as agriculture, science, and policy.
3. Agricultural and Rural Development Plans:
 - Val de Loire 2030 Plans (France): Focuses on sustainable viticulture with action plans for both Pays de la Loire and Centre Val de Loire regions, aiming to enhance value throughout the entire wine-growing sector.
4. Sectoral and Industry-Specific Initiatives:
 - Circular Agronomics Project (Spain): Promotes sustainable agricultural practices by integrating circular economy principles, supporting a broader vision of sustainability in agriculture.

These action plans underline a strong commitment to the promotion of sustainable agriculture, circular economy practices, and the development of bioeconomy initiatives across various regions, facilitating cross-border collaboration and innovation.

Question 4.7. What are the strengths of these interregional action plans?

The strengths of the interregional action plans reveal promising opportunities in promoting sustainable agriculture, bioeconomy, and circular economy initiatives across European regions (Table 8). These include:

- **Collaboration and Knowledge Sharing:** A prominent strength of many interregional action plans is their focus on fostering cross-border collaboration. Projects such as the SinCE-AFC and GECO2 initiatives demonstrate the value of knowledge transfer and innovation through regional partnerships, aligning with broader EU strategies and sharing best practices. The EIT Food Program is another notable example, which brings together a wide range of stakeholders, from businesses to research organizations, to drive innovation in food systems.
- **Focus on Innovation and Sustainability:** Many plans prioritize innovation and sustainability. For example, the CIRCOTRONIC project, focused on the circular economy, and the Catalan biogas strategy 2024-2030 highlight efforts to integrate renewable energy, sustainable waste management, and bioeconomy practices. The AGROECOLOGY PARTNERSHIP also aims to create a sustainable agroecological economy through multi-sector collaboration.
- **Clear Goals and Governance Models:** Several plans, like the Catalan Bioeconomy Strategy 2030 and BIOEAST, provide structured frameworks with clear, well-defined goals and governance models. These frameworks ensure effective deployment and long-term planning for sustainable practices. The Interreg Brussels-Capital Region Program exemplifies the opportunity to leverage large budgets for innovation in sectors like circular economy and climate action.
- **Financial Support and Resources:** Many interregional action plans offer significant financial resources to support projects and initiatives. The EIT Food program and the Interreg Brussels-Capital Region Program are prime examples, offering funding opportunities that enable the scaling of initiatives and provide financial support for stakeholder collaboration.

Question 4.8. What are the weaknesses of these interregional action plans?

While interregional action plans provide a robust framework for advancing sustainability, bioeconomy, and circular economy goals, they face challenges (Table 8). These include:

- **Implementation and Coordination Challenges:** Despite the ambitious goals, many interregional action plans face challenges in terms of implementation. For example, projects like CIRCOTRONIC and SinCE-AFC highlight the complexity of coordinating actions across different regions, especially when diverse stakeholders are involved. Ensuring that plans are effectively put into practice often requires overcoming bureaucratic hurdles and aligning the interests of multiple actors.
- **Financial Constraints:** While many action-plans benefit from substantial financial backing, some face difficulties in securing adequate resources for full-scale implementation. The Catalan Bioeconomy Strategy 2030, for instance, struggles with insufficient financial support for its ambitious objectives. Similarly, the Plan of Action for the Wine-Growing Sector 2030 and BIOEAST face challenges related to coordinating financial support from various sources and stakeholders.
- **Lack of Infrastructure and Governance Structures:** Some plans, such as the Catalab biogas strategy 2024-2030, lack sufficient infrastructure to support their goals. Others, like the REAL-MAC project, face challenges due to weak governance structures that hinder long-term sustainability. These issues can affect the ability to scale initiatives effectively and ensure continued success after initial funding periods.
- **Political and Regulatory Challenges:** Political gridlock and regulatory complexities are recurring weaknesses. The Interreg Brussels-Capital Region Program faces difficulties due to the complex governance structure, while the EIT Food Program grapples with issues such as delayed or diluted food policy decisions. Furthermore, plans like the Catalan Bioeconomy Strategy 2030 face public concern and resistance to circular bioeconomy practices, particularly due to the complexity of training small farmers and adapting societal attitudes to new systems.
- **Diverse Stakeholder Interests:** In some regions, conflicting interests based on economic orientations can slow down the progress of initiatives. The BIOEAST collaboration, which spans several Central and Eastern European countries, faces challenges due to varying economic priorities and interests among the participating nations, which may hinder the development of cohesive, unified strategies.

Table 8. Strengths and weaknesses of interregional action plans among all countries

Interregional Action Plan	Strengths	Weaknesses
Catalan biogas strategy 2024-2030 (Spain)	- Integrated waste management model - Use of organic materials to obtain value-added products in the fertilizer market	- Lack of infrastructure
PERTE Agroalimentario, Proyectos de Innovación y Desarrollo (Spain)	- Promotes interregional cooperation between companies	- Complex project presentation process
SinCE-AFC Project (Italy)	- Cross-border collaboration - Knowledge transfer and innovation promotion - Alignment with EU strategies	- Complexity of coordination - Implementation challenges
GECO2 Project (Italy)	- Collaboration across regions (Italy and Croatia) - Focus on environmental sustainability	- Complexity in implementation and coordination
CIRCOTRONIC Project (Italy)	- Development of a Transnational Action Plan to implement EU Circular Economy Action Plan	- Coordination challenges across regions
REAL-MAC Project (Spain)	- Living lab and transformative innovation	- Lack of long-lasting governance structures
Catalan Bioeconomy Strategy 2030 (Spain)	- Strong governance model - Stakeholder engagement through roundtables	- Insufficient financial support for implementation
Interreg Brussels-Capital Region Program (Belgium)	- Cross-border collaboration - Significant funding opportunities - Alignment with EU priorities	- Political gridlock - Complexity in coordination with diverse stakeholders
EIT Food Program (Belgium)	- Cross-border collaboration - Focus on innovation and entrepreneurship - Diverse stakeholder involvement	- Consumer trust issues - Public-private partnership challenges - Behavioral change difficulties
Agroecology Partnership (France)	- Stakeholder involvement from agriculture, policy, and science sectors - Focus on long-term sustainable agroecological goals	- Lack of experience in project implementation - Weak governance and coordination early on
Plan of Action for Wine-Growing Sector 2030 (France)	- Clear focus on creating value for the entire wine sector - Effective territorial connections between regions	- Coordination difficulties between various financiers - Governance challenges
BIOEAST (Hungary, Poland, Slovakia, Czech Republic)	- Broad regional coverage (11 countries) - Clear goals and knowledge-sharing across regions	- Different interests based on economic orientations of participants

Part 5. Strengths, weaknesses, and best practices in the regional ecosystem for sustainable agriculture and biofertilizers

This part of the questionnaire is designed to gather insights into the strengths, weaknesses, and best practices related to sustainable agriculture and biofertilizers within a specific region. It aims to better understand the local ecosystem's capacity for promoting sustainable agricultural practices and the development of biofertilizers by exploring various factors such as innovation, policy support, and research, as well as identifying challenges and successful examples of interregional collaboration.

1. **Strengths of the Region's Ecosystem:** The first section invites respondents to highlight the key factors that contribute to the success and effectiveness of sustainable agriculture and biofertilizer development in their region. This includes identifying innovative companies, supportive policy frameworks, strong research institutions, or any other regional strengths that create a conducive environment for growth in this sector. Respondents are asked to pinpoint up to three specific strengths that they believe are most critical to their region's ecosystem in this context.
2. **Weaknesses or Challenges:** The second section focuses on understanding the barriers or obstacles that hinder the progress of sustainable agriculture and biofertilizer development in the region. This may involve challenges such as insufficient funding, regulatory constraints, lack of collaboration, or other systemic issues that limit the region's ability to scale up or innovate in these areas. By identifying these weaknesses, the questionnaire aims to uncover areas where targeted improvements or interventions are needed.
3. **Best Practices in Interregional Cooperation or Biofertilizer Innovation:** Finally, the questionnaire seeks to gather examples of successful interregional cooperation or biofertilizer innovations that have emerged within the region. This helps to identify best practices that can serve as models for other regions or projects. Respondents are encouraged to share up to two specific examples that highlight the region's ability to collaborate effectively with other regions or showcase notable innovations in the biofertilizer sector.

Question 5.1. What do you see as the strengths of your region's ecosystem in sustainable agriculture and biofertilizers (e.g., innovative companies, supportive policy frameworks, strong research base)?

The strengths related to the ecosystem in sustainable agriculture and biofertilizers varied among regions. Some regions excel in research, policy, or agricultural ecosystems, while others focus on specific innovations or economic frameworks. The diversity in strengths allows for complementary collaboration between regions in interregional initiatives. More specifically:

1. Abruzzo e Marche (IT):
 - Strength lies specifically in innovative companies, with less emphasis on research or policy.
2. Alentejo (PT):
 - Combines multiple strengths: strong research base, policy frameworks, and innovative companies. This region stands out for the balance between academic and industrial innovation.
3. Attiki (GR):
 - Highlights innovative SMEs and farmers cooperatives, unique in focusing more on agricultural entrepreneurship than broader industrial innovation.
4. Auvergne-Rhône-Alpes (FR) and Bretagne (FR):
 - Excel at agricultural ecosystem strengths, with numerous field actors, cooperatives, and interconnected stakeholders. These regions are distinct for their biostimulant/biofertilizer ecosystems.
5. Catalunya (ES):
 - Notable for its biomass bioavailability, strong focus on the circular economy, and cluster-based systems for public-private collaboration.
6. Dél-Dunántúl (HU):
 - Emphasizes local commitment, quadruple helix collaborations, and supportive innovation policies.
7. Emilia-Romagna (IT):
 - Strong in policy frameworks, cooperatives, and R&D. Unique in its comprehensive Rural Development Programme and leading role in quality food production.
8. Île de France (FR) and Centre-Val de Loire (FR):

- Combine competitiveness clusters and strong industry-linked innovation funds.

9. Autonomous Regions of Azores (PT):

- This region is unique for its living lab potential, competitive tax system, and focus on livestock farming and dairy industries.

10. Région de Bruxelles-Capitale (BE):

- Distinct urban focus with an emphasis on sustainable food systems, urban agriculture, and cross-border cooperation.

11. Region of Central Macedonia (GR):

- Notable for its circular-economy principles and financial mechanisms for waste management.

12. Bretagne (FR):

- This region's focus lies in combining field-based agricultural practices with cutting-edge innovation in biofertilizers and leveraging its robust network of cooperatives, experts, and EU projects.

Some regions are specialized in specific areas while others are more balanced across multiple domains. Emilia-Romagna (IT), Brussels-Capital Region (BE) excel in policy and funding support. Catalonia (ES), Region of Central Macedonia (GR) are focused on circular economy, and Brittany (FR) and the Loire region (FR) are focused on the agricultural sector strengthening. Regions like Alentejo (PT), Catalonia (ES), and Auvergne-Rhône-Alpes (FR) combine research, innovation, and stakeholder networks effectively, while regions like Abruzzo and the Marches (IT) and Attiki (GR) are narrower in scope, focusing primarily on innovative companies or SMEs.

Question 5.2. What are the main weaknesses or challenges in your region's ecosystem (e.g., lack of funding, regulatory barriers, limited collaboration)?

While the regions share many overlapping weaknesses, such as funding limitations, regulatory hurdles, and collaboration gaps, some regions are more affected by specific local dynamics. These differences highlight the need for tailored strategies that address both common and region-specific barriers. More specifically:

1. Abruzzo and the Marches (IT):
 - Limited schedule and timing imposed by the EU – a unique operational constraint not heavily emphasized elsewhere.
2. Alentejo (PT):
 - Weakness in stakeholder collaboration, combining limited access to funding with less networked innovation efforts.
3. Attiki (GR):
 - Specific focus on limited cooperation between cooperatives and national forums, unique to the region's agricultural cooperative system.
4. Auvergne-Rhône-Alpes (FR) and Brittany (FR):
 - Shared challenges like lack of dynamics in biofertilizer innovation and weak funding applications, but Bretagne also struggles with long commercialization times for innovative products.
5. Catalonia (ES):
 - A combination of biomass variety issues, consumer acceptance challenges, and incoherent policies, making it stand out for its policy-practice disconnect.
6. Autonomous Regions of Azores (PT):
 - Distinct weaknesses tied to its archipelagic condition, including climatic vulnerability, limited resources, and a small business fabric.
7. Brussels-Capital Region (BE):
 - Unique urban challenges, including limited agricultural land and dependence on surrounding regions.

8. Emilia-Romagna (IT):

- High implementation costs for sustainable agriculture measures and a lack of skilled workforce are specific barriers.

9. Region of Central Macedonia (GR):

- Limited funding opportunities for small producers and weak collaboration between research institutions and producers stand out.

Common challenges among regions include lack of funding access and regulatory barriers which are systemic issues across Europe. Weak stakeholder collaboration and limited investment are widespread, but their scale and context differ by region. However, certain regions face challenges based on their geographic or economic context. Urban regions like Brussels (FR) struggle with land availability and farming decline. Peripheral regions like the Autonomous Regions of Azores (PT) face logistical and climatic constraints, while regions with advanced policy frameworks like Catalonia (ES) struggle with coherence and effective implementation.

Question 5.3. Can you identify any best practices in interregional cooperation or biofertilizer innovation in your region?

While approximately half of the respondents could point to notable practices in the area of interregional cooperation or biofertilizer innovation, the other half either did not recognize such practices or were uncertain about their existence (Figure 11).

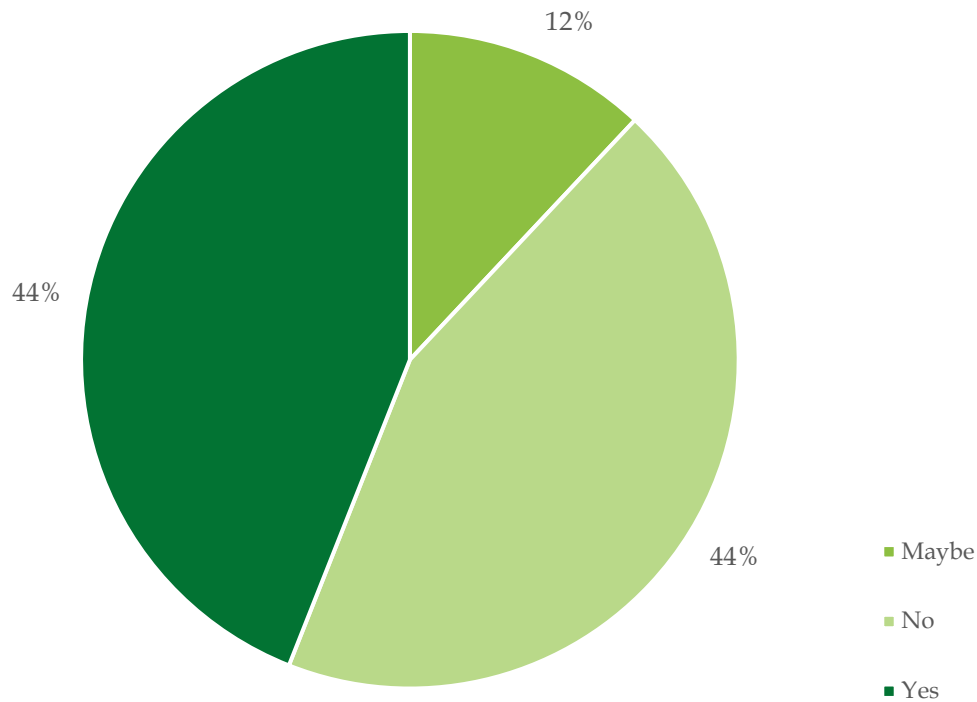


Figure 11. Identification of best practices in interregional cooperation or biofertilizer innovation

Question 5.4. If yes, please mention up to 2 best practices

According to the 44% of the responders positively responding to Question 5.3, there are notable best practices in the field of biofertilizer innovation and interregional cooperation, demonstrating how various regions and organizations are advancing sustainable agriculture, biofertilizer production, and the circular economy, as listed below:

1. Biofertilizer Production by Agraçor: Biofertilizer production aimed at promoting sustainable agricultural practices.
2. Alcarràs Bioproductors Biogas Plant: A biogas plant that produces biogas and biofertilizer from organic waste. This initiative brings together 150 livestock farming families in a unique project: valorizing livestock waste into a high quality product, closing the nutrient cycle and promoting soil health and organic farming.
3. NewCo Biorg Biomethane Production Plant: A biomethane production plant in Spilamberto, built by NewCo Biorg (a partnership between Herambiente and Inalca), which also produces biofertilizer. The biofertilizer is derived from recycled biodegradable waste and food industry by-products, offering characteristics comparable or superior to industrial fertilizers.
4. BettER-Bio Project: A project funded by the Emilia-Romagna Region focusing on organic wheat production using biostimulants. The project integrates microbial (mycorrhizae, trichoderma, rhizospheric bacteria) and non-microbial (protein hydrolysates) biostimulants and incorporates Decision Support Systems (DSS) to optimize interventions and reduce chemical inputs.
5. AGRIREGENCAT: A project focused on regenerating soil fertility using sustainable practices.
6. FERTILAB: A project focused on obtaining high-value agricultural products from biogas by-products.
7. Benchmarking Visits to Denmark and Ireland: Visits to countries such as Denmark and Ireland to understand the biogas sector and digestate treatment practices in those regions.
8. Living Lab Approach: A collaborative model engaging various stakeholders in co-creation activities to foster innovation in sustainable food systems.

9. Cross-Border Cooperation: Efforts to coordinate with neighboring regions like Wallonia and Flanders on sustainable food initiatives.
10. Regional Actors' Involvement in National or EU Projects: Involvement of regional actors (such as chambers, clusters, etc.) in national or EU projects.
11. Amino Acids Fertilizer from Non-GMO Plants: A project focused on extracting amino acids from non-GMO plants to create biofertilizer.
12. Collaborative Projects Between Companies and Laboratories: Cooperation between companies and academic laboratories to advance biofertilizer development.
13. Project RUSTICA: A collaborative project involving biofertilizer producers, users, technical experts, and academics to develop innovative biofertilizers.
14. Greenman-UniPannon Collaboration: A joint research and innovation project on biofertilizers, involving university students and young researchers.

Part 6. Emerging Trends, Opportunities, and Specialization in Sustainable Agriculture and Biofertilizers

The last part of the questionnaire focuses on gathering insights about the future of sustainable agriculture and biofertilizers. It aims to identify emerging trends that are shaping or are expected to shape these sectors, encouraging respondents to highlight key developments or innovations in the field. Additionally, it explores opportunities for increased interregional cooperation, asking for suggestions on areas where regions can collaborate to advance sustainable agriculture and biofertilizer initiatives. This may include joint projects, knowledge exchange, or resource-sharing to foster innovation and sustainability across different regions. This part of the questionnaire also seeks to understand the potential for specialization within Regional Innovation Valleys. It inquires how respondents perceive their region developing expertise in sustainable agriculture and biofertilizers, potentially leading to the creation of innovation hubs that focus on research, development, and technological advancements in these areas.

Question 6.1. What emerging trends do you see in sustainable agriculture and biofertilizers?

The emerging trends in sustainable agriculture and biofertilizers, as identified by the respondents, show a clear focus on environmentally friendly practices and technological innovation. The most frequently selected trend was the increased demand for bio-based solutions, which was chosen by 15.7% of the respondents (Figure 12). Soil health and biodiversity followed closely, selected by 14.5%, emphasizing the growing interest in regenerative and ecological farming practices. Integration of digital tools in agriculture received 13.3%, reflecting the rise of technology in improving agricultural efficiency and sustainability. Similarly, circular bioeconomy initiatives were highlighted by 10.8%, underlining the importance of waste reduction and resource reuse in farming.

Other notable trends included advances in precision agriculture technologies (10.8%) and climate change mitigation (8.4%), showing the increasing need for climate-resilient agricultural practices. Regulatory support for sustainable practices, such as the EU Green Deal, was selected by 7.2% of respondents, indicating the importance of policy frameworks in promoting sustainable agriculture. Development of next-generation biofertilizers (4.8%) and rise in organic farming practices (3.6%) were chosen by fewer respondents, suggesting that while these areas are important, they may not be as prioritized compared to other trends.

An additional trend, raising the transversality between agricultural policies and the environment, was mentioned separately by some respondents, even though it was not part of the predefined choices. This suggests an interest in greater alignment between agricultural policies and environmental considerations to drive more integrated solutions in the sector.

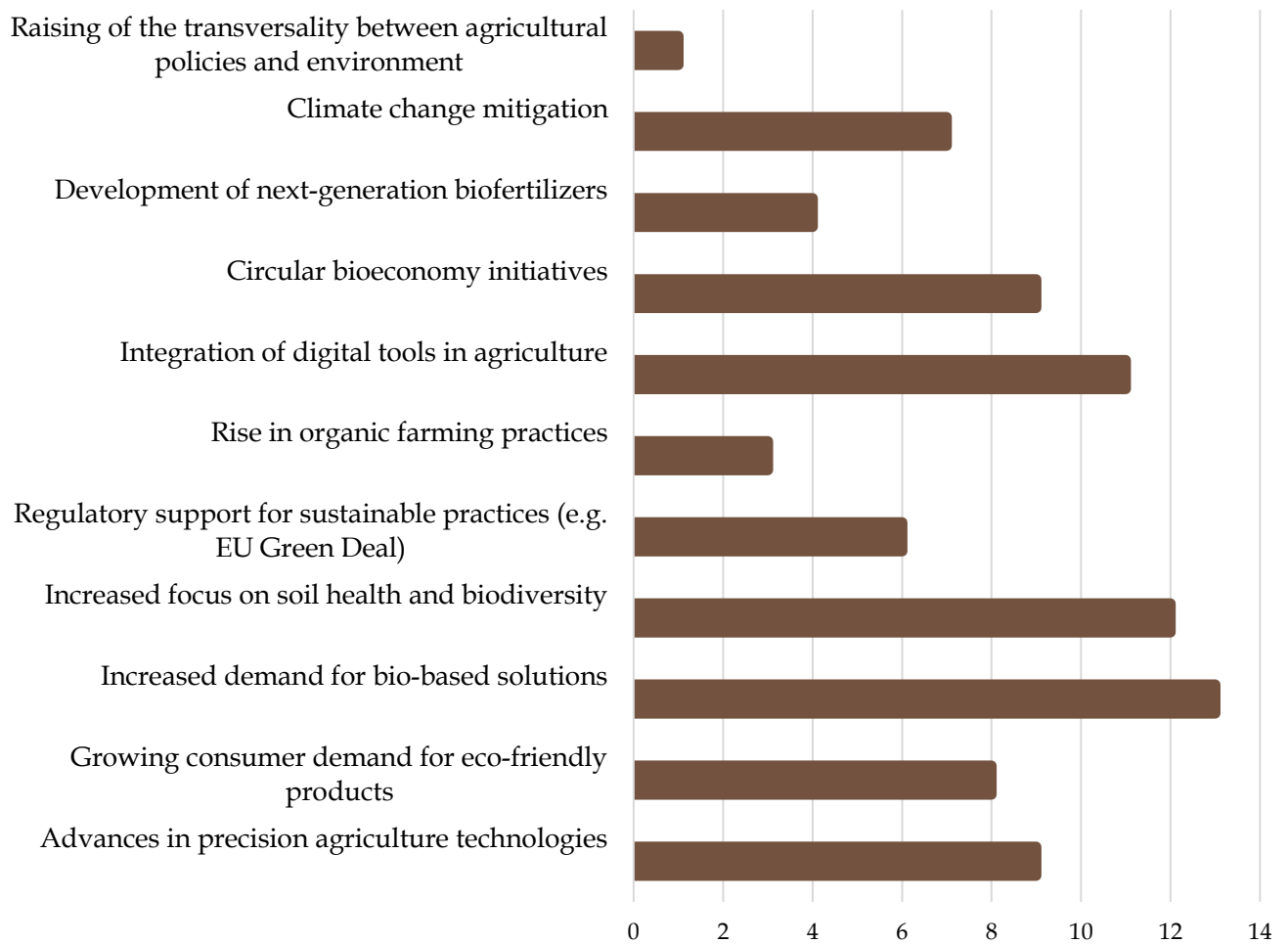


Figure 12. Emerging trends in sustainable agriculture and biofertilizers

Question 6.2. What are the opportunities for increased interregional cooperation in sustainable agriculture and biofertilizers?

The opportunities for increased interregional cooperation in sustainable agriculture and biofertilizers, as identified by the respondents, highlight several areas where collaboration could foster growth and innovation. The most frequently selected opportunity was joint research and development projects, chosen by 20.3% of the respondents (Figure 13). This reflects the strong interest in collaborative research efforts to advance sustainable practices and biofertilizer innovation across regions.

Following closely, building strategic partnerships with industry stakeholders was selected by 15.9% of respondents, emphasizing the importance of forging strong relationships with industry players to drive progress. Funding opportunities for collaborative projects was another popular choice, selected by 14.5%, highlighting the need for financial support to enable interregional cooperation.

Other notable opportunities included sharing best practices and innovation models and strengthening regional innovation ecosystems, both selected by 10.1% of respondents, suggesting a focus on knowledge exchange and enhancing regional capabilities. Development of cross-regional biofertilizers value chains was chosen by 8.7%, pointing to the potential for creating interconnected supply chains across regions.

Opportunities for creating common policies and standards for biofertilizers and establishing educational and training programs were each selected by 7.2%, indicating an interest in establishing clearer frameworks and improving knowledge and skills. Finally, networking through existing platforms and clusters was chosen by 5.8% of respondents, underlining the value of leveraging existing networks for collaboration and growth.

In addition to the questionnaire responses, a few isolated suggestions were noted:

- Support for farmers using biofertilizers: This includes training, communication, field support, and financial assistance to help farmers manage the risks of adopting biofertilizers.
- Integration of environmental criteria in public policies: There's a call to strengthen environmental considerations within agricultural policies to promote sustainability.
- Deregulation for innovation: Respondents emphasized the need for EU, national, and local governments to reduce regulatory barriers to foster innovation in sustainable agriculture and biofertilizers.

These points highlight the importance of policy adjustments and support mechanisms for advancing sustainable agriculture practices.

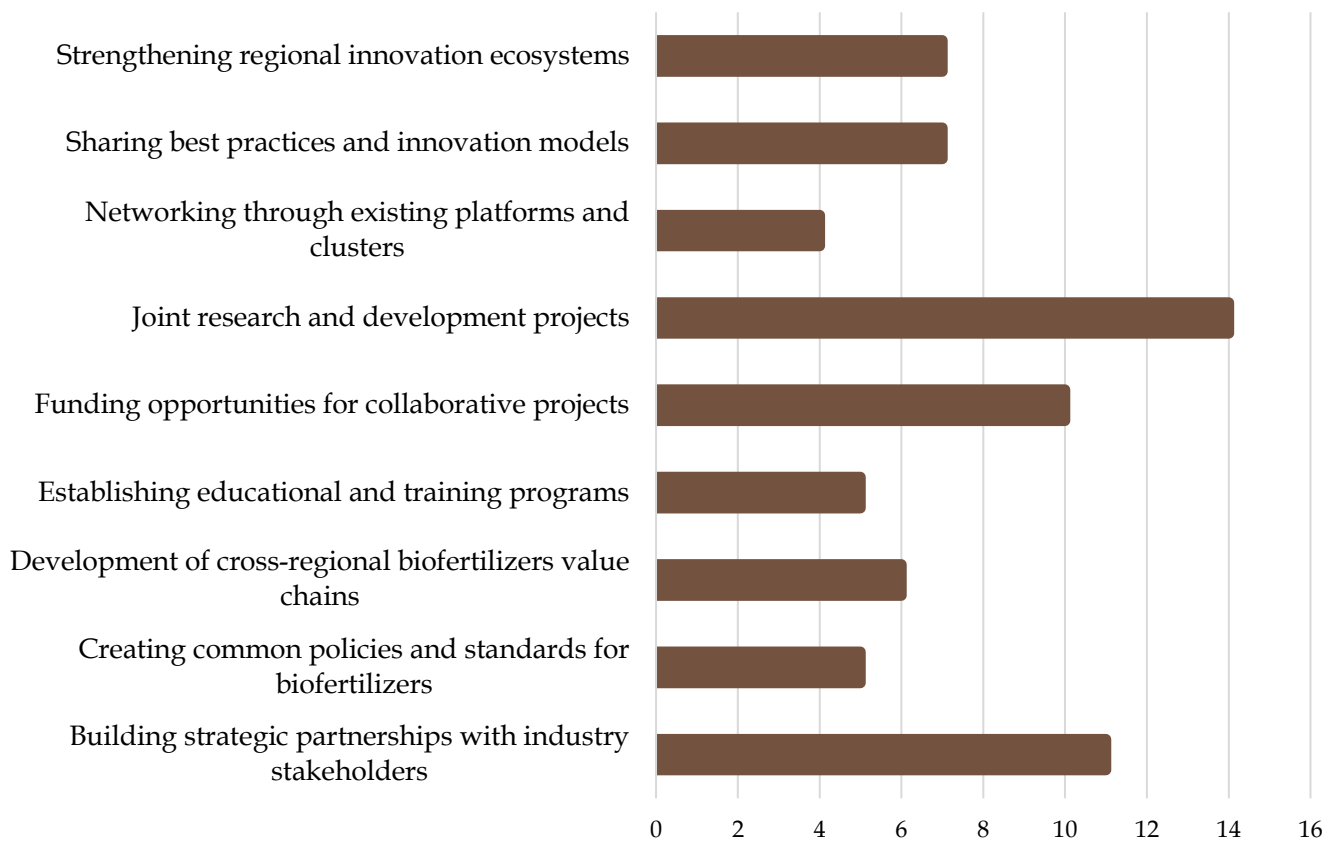


Figure 13. Opportunities for increased interregional cooperation in sustainable agriculture and biofertilizers

Question 6.3. How do you foresee specialization opportunities for Regional Innovation Valleys in your region?

The responses regarding the specialization opportunities for Regional Innovation Valleys in the region highlight several key areas of focus. The most prominent opportunity identified was the development of circular bioeconomy hubs, with 13 selections, emphasizing the importance of advancing circular systems within agriculture (Figure 14). This was closely followed by the specialization in sustainable biofertilizer production, selected by 11 respondents, indicating a strong interest in environmentally friendly biofertilizer solutions.

Other notable opportunities included the integration of digital agriculture solutions, with 10 selections, which reflects a growing focus on leveraging technology to improve agricultural practices, and specialization in new biofertilizer technologies, which was selected by 9 respondents. Additionally, 8 selections were made for specialization in organic farming solutions, indicating a desire for further development in organic farming methods.

Other responses suggested the establishment of research and innovation centers in biofertilizers (7 selections) and a focus on precision agriculture and data-driven farming (6 selections). Additionally, 5 selections were made for the development of eco-friendly packaging and supply chains, highlighting sustainability concerns beyond just farming practices.

There were also a few additional responses not directly tied to the main options but offering valuable insights. These included a call for experimentation development and the integration of all concerned actors to discuss and organize biofertilizer and circular economy actions, particularly including local communities. Moreover, there was a strong emphasis on the need for deregulation of innovation by EU, national, and local governments to foster growth in these areas.

Overall, the responses suggest a clear trend towards advancing sustainable practices, fostering innovation, and improving collaboration across various stakeholders in the agricultural sector.

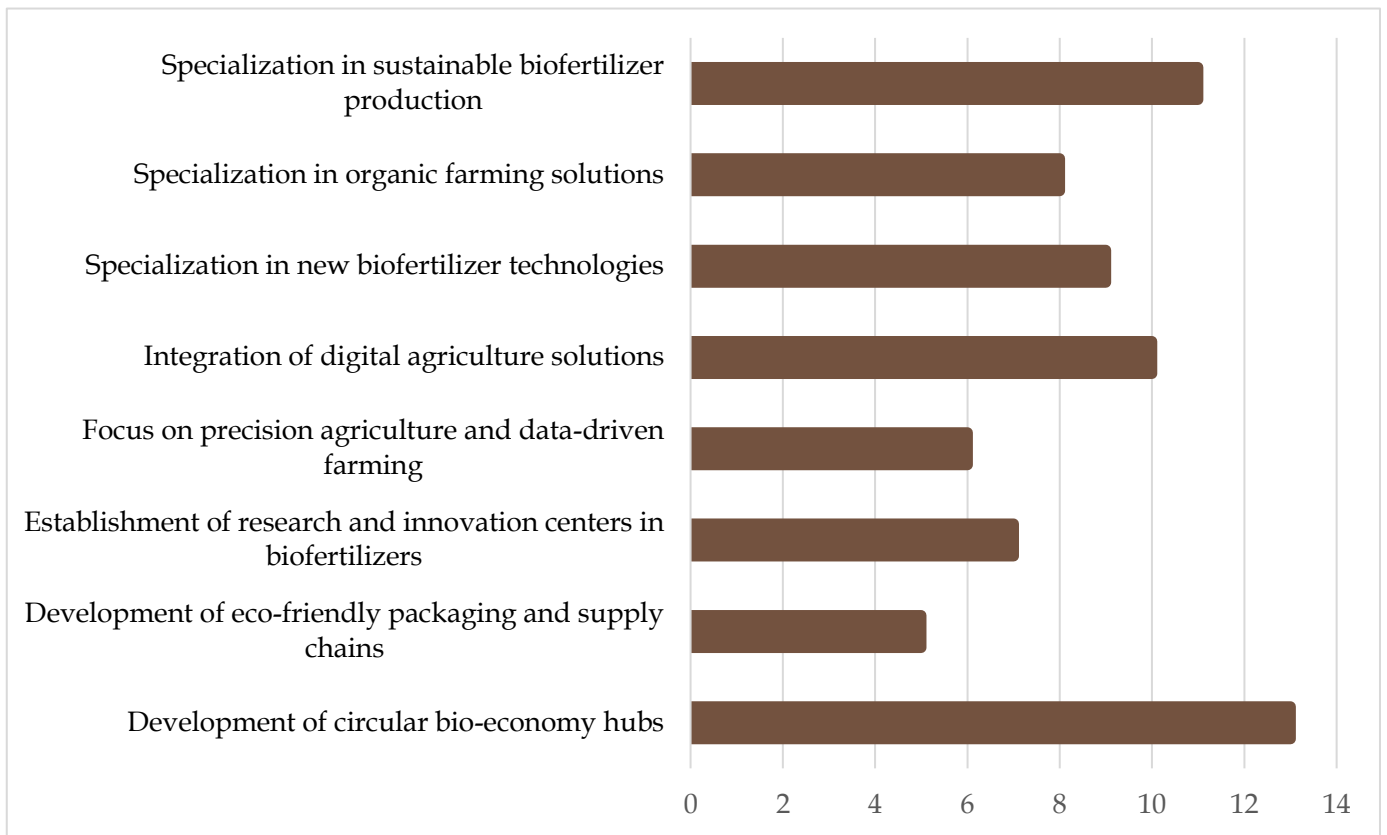


Figure 14. Specialization opportunities for Regional Innovation Valleys

Part 7. SWOT analysis (Strengths, Weaknesses, Opportunities, Threats)

Building on the findings of the questionnaire, Part 7 delves into a detailed SWOT analysis to connect the previously identified skills gaps with strategic approaches tailored to address them (Table 9, 10). This handbook consolidates insights from interregional cooperation in sustainable agriculture and the biofertilizer industry. By mapping the strengths, weaknesses, opportunities, and threats of the interregional ecosystem, this section seeks to translate the analysis into actionable strategies.

The focus of Part 7 aligns with the handbook's objective to support innovation, collaboration, and regional specialization in circular bioeconomy solutions. The strategic recommendations derived here contribute to fostering resilient value chains in biofertilizers while addressing ecosystem challenges, enhancing regional strengths, and supporting EU policy priorities such as the European Green Deal and the Farm to Fork Strategy.

Table 9. Emerging Strengths, Weaknesses, Opportunities, and Threats per Field/ Area

Field/Area	Strengths	Weaknesses	Opportunities	Threats
Circular Bioeconomy Transition	Strong alignment with EU policies (EU Green Deal, Circular Economy Action Plans)	Lack of effective coordination between sectors (agriculture, innovation, and policy)	Expansion of circular hubs across regions, enabling cross-regional collaboration	Regulatory complexity and slow policy implementation
	Policy initiatives supporting circular economy in multiple regions (e.g., Loire Region)	Insufficient infrastructure for bio-based solutions	Increased focus on reducing synthetic fertilizers and promoting organic compost	Slow adaptation of industries to new circular economy models
	EU support for sustainable agriculture and bioeconomy transition (e.g., INTERREG Europe, BIOREGIO)	Fragmentation of circular economy strategies across different regions	Potential for regional innovation ecosystems to be strengthened through EU projects (e.g., CHEER4EU)	Possible resistance from traditional industries (e.g., conventional farming, synthetic fertilizer sectors)
Biofertilizer Production and Use	Growing market demand for bio-based solutions and biofertilizers	High initial investment costs for biofertilizer production	Development of new bio-based fertilizers to replace synthetic fertilizers	Limited awareness and knowledge on biofertilizers, hindering adoption by farmers and industries
	Increasing investment in biofertilizer technologies and innovations (e.g., RUSTICA project)	Technology transfer barriers between research and industry	Strong alignment with sustainable farming trends and organic farming practices	Dependence on complex regulatory approvals and certifications

Policy and Strategic Alignment	Collaborations between researchers, industries, and farmers in various regions	Lack of well-established biofertilizer value chains	Rising consumer demand for eco-friendly products and sustainable agricultural solutions	Initial reluctance to adopt new technologies due to uncertainty or risks
	Regional policies and action plans aligned with EU Green Deal and circular economy goals	Limited integration of biofertilizer and agricultural policies	Enhanced cross-sectoral policy alignment between agriculture, environment, and bioeconomy	Regulatory complexity and challenges in policy enforcement
	National Action Plans in various countries (e.g., PAEC in Portugal, 2030 Agricultural Plan)	Difficulties in policy implementation and monitoring at the regional level	Opportunities for multi-stakeholder involvement in policy design and bioeconomy strategy development	Lack of effective communication and collaboration between regional and EU-level policymakers
Funding and Financial Barriers	Financial calls in some regions supporting circular economy projects	Lack of access to funding for emerging circular economy and biofertilizer projects	Potential for cross-sectoral funding to support bioeconomy innovation	Insufficient financial resources for early-stage innovation and emerging projects
	Some funding models and calls from EU programs (e.g., INTERREG, Horizon Europe)	Financial fragmentation, with lack of coordination on financial support between public/private sectors	Targeted financial mechanisms for bioeconomy projects, e.g., private-public partnerships	High initial investment costs and financial barriers for small and medium-sized enterprises (SMEs)

Collaboration and Knowledge Sharing		Limited knowledge of available financial resources	Funding opportunities for joint research and collaborative projects in the circular bioeconomy	Limited private-sector investment in biofertilizer innovation due to perceived risk
	Strong networks of knowledge-sharing (e.g., BIOEAST, BIOREGIO, AGRO4SDG)	Siloed knowledge within sectors (e.g., agriculture, research, and industry)	Cross-regional collaborations between stakeholders (e.g., farmers, research institutions, businesses)	Technological transfer barriers and lack of interdisciplinary collaboration
	Existing innovation ecosystems in certain regions (e.g., Hungary, Brittany)	Weak interconnection between agricultural and innovation sectors	Joint development projects for biofertilizer and circular bioeconomy solutions	Difficulty in integrating local actors and farmers into knowledge-sharing initiatives
	Quasi-public-private partnerships supporting innovation and sustainability	Limited public awareness of circular economy opportunities and biofertilizer benefits	Educational programs and research collaborations to increase stakeholder engagement	Resistance to change among stakeholders with vested interests in traditional practices
Regulatory and Implementation	Alignment with EU's Green Deal and Circular Economy Action Plans	Regulatory complexity and lack of enforcement	Opportunities for streamlining policy integration and promoting cross-sector collaboration	Slow adoption of policies at the regional level, impacting quick implementation
	Some regions have strong policy frameworks promoting biofertilizer use	Weak monitoring systems for regulatory adherence	Simplified regulations for the development and market introduction of biofertilizer solutions	Resistance from agricultural sectors to adopt regulatory changes or new policies

Technological Development and Innovation	Advancements in bio-based technologies and precision agriculture	Limited access to cutting-edge research for biofertilizer innovations	Investments in bio-based solutions as part of the circular bioeconomy transition	Barriers to technology transfer and implementation, especially for SMEs
	Collaborative R&D projects (e.g., Greenman-UniPannon)	Limited infrastructure for the development of innovative technologies	Growing interest in digital agriculture solutions and eco-friendly technologies	High costs of new technology adoption by traditional farming sectors
	Integration of digital tools to enhance biofertilizer production and farming practices	Slow pace of technological uptake by farmers and industry due to lack of awareness or perceived complexity	Innovation hubs focusing on biofertilizer development and circular farming solutions	Market resistance to new, untested technologies in traditional farming practices

Table 10. SWOT analysis on the overall Strengths, Weaknesses, Opportunities, and Threats

Strengths	Weaknesses
- Alignment with EU policies in circular bioeconomy and biofertilizer use (EU Green Deal, Circular Economy Action Plans) - Policy initiatives supporting circular economy, bioeconomy, and sustainable agriculture - Growing market demand for bio-based solutions and biofertilizers - Increasing investment and innovation in biofertilizer technologies - Collaborative R&D projects and knowledge-sharing networks	- Lack of coordination between sectors (e.g., agriculture, innovation, research, industry, policy) - Insufficient infrastructure for bio-based solutions and innovative technologies - High initial investment costs for biofertilizer production and lack of well-established biofertilizer value chains - Technology transfer barriers between research and industry - Fragmentation of circular economy strategies across regions - Limited funding access and financial resources for emerging projects
Opportunities	Threats
- Expansion of circular hubs and cross-regional collaboration and enhanced cross-sectoral policy alignment between agriculture, environment, and bioeconomy - Development of bio-based fertilizers to completely replace synthetic ones in alignment with sustainable farming trends and organic farming practices - Educational programs and research collaborations to increase stakeholder engagement - Multi-stakeholder involvement, public-private partnerships, joint research, and regional collaborations to support bioeconomy innovation and policy integration - Simplification of regulations and policy integration - Rising consumer demand for eco-friendly and sustainable products	- Regulatory complexity and slow/complex policy implementation - Limited awareness and difficulty integrating stakeholders into knowledge-sharing, and slow policy adoption with low private-sector investment - Reluctance to adopt new technologies due to uncertainty, high costs, market resistance, and opposition from traditional agricultural sectors

With the strong alignment to EU policies like the Green Deal and Circular Economy Action Plans, alongside growing market demand and rising investment in bio-based solutions, there is significant momentum for progress. Opportunities such as the development of bio-based fertilizers to replace synthetic ones and enhanced cross-regional collaboration further strengthen this potential. Targeted efforts can bridge sectoral coordination gaps, improve infrastructure, and address funding limitations while mitigating threats like resistance to change, regulatory complexity, and slow adoption of new technologies. Leveraging these strengths and opportunities can drive sustainable advancements in the circular bioeconomy and biofertilizer sectors. Specifically, efforts for improvement should aim to:

1. Strengthen Coordination and Policy Alignment

Establish cross-sectoral task forces and platforms to improve coordination between agriculture, research, innovation, industry, and policymakers, and enhance regional and EU-level integration of circular economy strategies to address fragmentation and align actions across regions.

2. Invest in Infrastructure and Value Chains

Prioritize funding and public-private partnerships to build infrastructure for bio-based solutions, including biofertilizer production, and develop comprehensive biofertilizer value chains to bridge gaps from production to market adoption, ensuring scalability.

3. Simplify and Accelerate Policy Implementation

Advocate for streamlined regulatory frameworks to reduce complexity and improve policy adoption speed and enhance communication between policymakers and stakeholders to ensure policies are practical and actionable.

4. Foster Innovation and Technology Transfer

Support collaborative R&D initiatives and innovation hubs to bridge technology transfer gaps between research and industry and seek to provide financial incentives for SMEs and startups to adopt and scale biofertilizer technologies.

5. Increase Stakeholder Awareness and Engagement

Develop educational campaigns targeting farmers, industry players, and local actors to increase knowledge of biofertilizer benefits and circular bioeconomy opportunities and expand training programs and workshops to encourage stakeholder participation in innovation and sustainable practices.

6. Address Resistance to Change

Build trust through pilot programs that demonstrate the efficacy and economic benefits of bio-based fertilizers and circular practices, and offer subsidies, tax incentives, or risk-sharing mechanisms to reduce financial barriers for farmers and industries adopting new technologies.

7. Leverage Market Demand and Opportunities

Capitalize on rising consumer demand for eco-friendly products by promoting biofertilizers and circular bioeconomy solutions as essential for sustainable farming and align biofertilizer development with organic farming trends to ensure market penetration and acceptance.

The transition to a circular bioeconomy and the adoption of biofertilizers are promising but require a strategic approach. By addressing weaknesses such as lack of coordination, infrastructure gaps, and funding shortages, and by mitigating threats like regulatory complexity and stakeholder resistance, the opportunities for innovation, market growth, and policy alignment can be fully realized. Collaborative action and targeted investment will be key to achieving sustainable progress in these areas.