Circular Biobased Europe Joint Undertaking: driving innovations towards sustainable agriculture and growth in rural areas.

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Abstract: The Circular Bio-based Europe Joint Undertaking (CBE JU) is a public-private partnership that supports research and innovation fostering the transition towards a competitive, sustainable, and low-carbon economy in Europe. CBE JU and its projects represent a significant business opportunity for the primary sector, and in particular for farmers. The deployment of circular bio-based innovations can help diversify farmer´s activities and generate new sources of income. Since 2022, about 130 million euros have been made available by CBE JU to develop bio-based solutions with the potential to support sustainable agricultural practices and boost rural economies, and currently 84 entities from the primary sector are participating in the projects. The manuscript aims at critically analysing the major findings associated with primary producers involvement in CBE JU programme and elaborate on the specific actions undertaken to ensure that the primary sector can benefit from being concretely participating to innovative bio-based value chains.

Keywords: bioeconomy, primary sector, biorefineries, bio-based industries, public-private partnership

1. INTRODUCTION

The unprecedented trend of global warming, climate change, degradation of the natural ecosystems and increased pollution calls for immediate actions. In response, the European Union (EU) has put in place the European Green Deal, a growth strategy that aims to create a fair, prosperous society with a competitive and resource-efficient economy aiming to achieve net-zero greenhouse gas emissions by 2050 (European Commission, 2019).

To reach these ambitious goals, a transition from a fossil- to a bio-based economy is needed. New innovative, sustainable and circular bio-based products, that reach high technical levels of performance and fully meet market requirements, should be developed so that they can successfully replace their current fossil-based counterparts. In addition, the sustainable and local sourcing of biomass, including all types of bio-based side streams, and the reuse, recycling and upcycling of resources will play a key role in ensuring that bio-based systems are sustainable and efficient in the use of natural resources.

Building on the success of its predecessor, the Bio-Based Industries Joint Undertaking (BBI JU), Circular Bio-based Europe Joint Undertaking (CBE JU) is a pivotal instrument to implement this vision at European level as it facilitates a transition away from fossil fuel dependency, aligning with the goals of the EU Green Deal within the multifaceted policy scenario that govern the bioeconomy and the bio-based sector (European Commission, 2021; Johnson et al., 2021; Mengal et al., 2018; Ruiz Sierra et al., 2021).

Policy development in the bio-based sector and in the bioeconomy area at large have received increasing attention in recent years. In April 2023, the EU Council endorsed conclusions highlighting the bioeconomy's potential to support the environmental and climate objectives of the European Green Deal (General Secretariat of the Council, Special Committee on

Agriculture, 2023). The bioeconomy is seen as a key factor in enhancing EU competitiveness, reducing fossil fuel dependency, and improving food security. The Council stressed the role of bioeconomy in fostering socially and economically viable rural areas, engaging primary producers in climate action, and promoting job creation and equal opportunities across the EU. Additionally, it emphasised the need for sustainable solutions in rural regions and the importance of providing diversified incomes for stakeholders in the bioeconomy, including landowners and small businesses, through new value-added chains and business models.

More recently, in 2024, the final report of the Strategic Dialogue on the Future of Agriculture acknowledged the necessity of collaboration between public and private sectors, as strong public-private partnerships in which rural actors actively participate can help turn niche into norm to support the development and implementation of bioeconomy initiatives (Members of the Strategic Dialogue on the Future of EU Agriculture, 2024).

In addition, in 2024, the European Commission (EC) has proposed a series of targeted actions to boost biotechnology and biomanufacturing in the EU, offering innovative solutions to societal challenges (European Commission, 2024). Biotechnologies which fall into the remit of CBE JU's field of action hold great promise for modernising not only the bio-based industrial sector but also agriculture, forestry, food and feed industries at European level.

Altogether, these important political inputs will constitute the basis for the new Bioeconomy Strategy, that is due for adoption by the end of 2025 and aims to advance innovation and maintain the EU's leadership in the bioeconomy. The new Bioeconomy Strategy will propose actions to unlock the potential of bioeconomy innovations, so that they can reach the market, and will represent a major step forward in the evolving EU economic and political context. In fact, an increasing number of Member States have issued their own national bioeconomy strategies (European Commission, 2018). Particular attention will be given to the role of the

primary sector and the significance of biomass sustainability and availability for strengthening and supporting the bio-based sector across Europe.

In this overall scenario, the objective of this article is to present the activities that CBE JU has performed to ensure that primary sectors benefit from the economic, social, and environmental opportunities offered by circular and bio-based innovations, including the creation and establishment of a dedicated CBE JU working group on primary producers. Data derived from the first three years of programme implementation demonstrates how the effort that has been taken contributed to enhance the role of primary producers in circular bio-based systems and value chains. Last, the article is presenting cases of projects where the involvement of the primary sector is exemplary and showcase the potential impact of the primary sector in the deployment of bioeconomy, with a specific attention to the first-of-a-kind biorefineries that represent a peculiarity of CBE JU funding strategy.

2. CBE JU: A PUBLIC-PRIVATE PARTNERSHIP TO SUPPORT THE GREEN DEAL OBJECTIVES

The CBE JU is a EUR 2 billion Public-Private Partnership between the EU, represented by the EC, and the Bio-based Industries Consortium (BIC), a not-for-profit organisation representing the private sector across the bio-based industries. It is established for the 2021-2031 period under Horizon Europe, the EU's research and innovation framework programme (European Commission, 2021).

Key objectives of CBE JU are to i) accelerate the innovation process and development of bio-based innovative solutions, ii) support the market deployment of mature bio-based innovative solutions and iii) ensure a high level of environmental performance of the bio-based industrial systems. In particular, CBE JU seeks to bridge the gap between the development of new bio-based innovations and their market deployment by promoting research and innovation

103 collaborative projects which integrate stakeholders throughout bio-based value chains,
104 including the primary sector, as vital biomass suppliers. CBE JU aims at de-risking
105 investments, encouraging collaboration, establishing new value chains, and tackling strategic
106 challenges to build a sustainable and prosperous bioeconomy. It ultimately contributes to
107 boosting European competitiveness on the global scale while at the same time reducing
108 dependency and increasing strategic autonomy.

109 CBE JU also aims to enhance the role of the primary sectors in the European bioeconomy with
110 their involvement in new value chains. This is reflected across all the frameworks and activities
111 that CBE JU is performing, from the Council Regulation establishing the Joint Undertakings to
112 the CBE JU Strategic Research and Innovation Agenda (SRIA) and the CBE JU annual work
113 programmes, which are setting the basis for the annual publication of calls for proposals
114 (European Commission, 2021; Bio-Based Industries Consortium, 2022).

115 CBE JU is a central pillar in establishing Europe's bio-based sector as a global leader, and the
116 overall CBE JU project portfolio is composed of 220 projects, including 138 projects funded
117 by the predecessor BBI JU and 82 projects funded by CBE JU up to now. Over 1714 participants
118 from 46 countries have been engaged in CBE JU funded projects, among which 40% are
119 SMEs.

120 Aligned with Horizon Europe, the CBE JU is funding projects through open calls for proposals.
121 In particular, early-stage development (TRLs 3–5) is funded by research and innovation actions
122 (RIAs). Innovation actions (IAs) are represented by two different type of actions: demonstration
123 projects (IA-DEMO) that aims at scale up the technology and validate business cases (TRL 6–
124 7), and flagship projects (IA-FLAG) that are operating at a pre-commercial scale (TRL 8), and
125 aim to support innovations that have already been demonstrated but not yet applied or deployed
126 at industrial and commercial scale in the EU (first-of-a-kind innovation). Last, CBE JU is
127 funding coordination and support actions (CSAs), that address non-technological challenges,

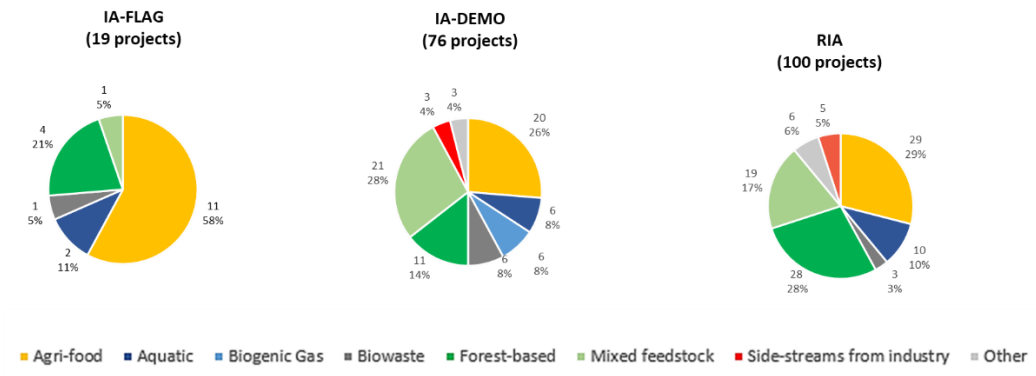
such societal awareness, capacity building, education and skills, among others. Table 1 shows the portfolio of projects funded by CBE JU (and its predecessor BBI JU) divided per type of action and with their associated budget.

Type of Action	Number of funded projects	Total budget	Share of project	Share of total budget	Technology Readiness Level (TRL)
Innovation Action – Flagship	19	333 m€	10%	26%	3-5
Innovation Action – Demonstration	76	516 m€	34%	41%	6-7
Research and Innovation Action	100	383 m€	45%	30%	8
Coordination and Support Action	25	37 m€	11%	3%	---
Total	220	1269 m€			

Table 1. Number of projects funded for Type of Action and relative share in the overall CBE JU portfolio

The main application areas covered by the CBE JU projects are bio-based chemicals, biopolymers and bioplastics, food and feed ingredients, packaging, construction materials, crop protection and fertilisation solutions and textile as shown in Figure 1.

Figure 1. Number of CBE JU projects by main area of application and type of action. CSA projects are not included being horizontal actions to support CBE JU programme.



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140 The main types of feedstocks used in CBE JU projects are agriculture-based feedstock,
141 including residues and by-products from the agri-food industry, followed by forest-based
142 feedstock, including lignocellulosic side streams and wood residues, and finally aquatic
143 feedstock, including aquatic organisms and biomass from fisheries and the aquaculture sector
144 and their residues. Other relevant feedstock for CBE JU projects includes side streams from
145 industry, including black liquor from the pulp and paper industry and dairy process side streams,
146 as well as biowaste, including Organic Fraction of Municipal Solid Waste (OFMSW), and
147 biogenic gases. (see Figure 2).

148 Figure 2. Number of CBU JU projects in relation to their main feedstock divided per type of
149 action.

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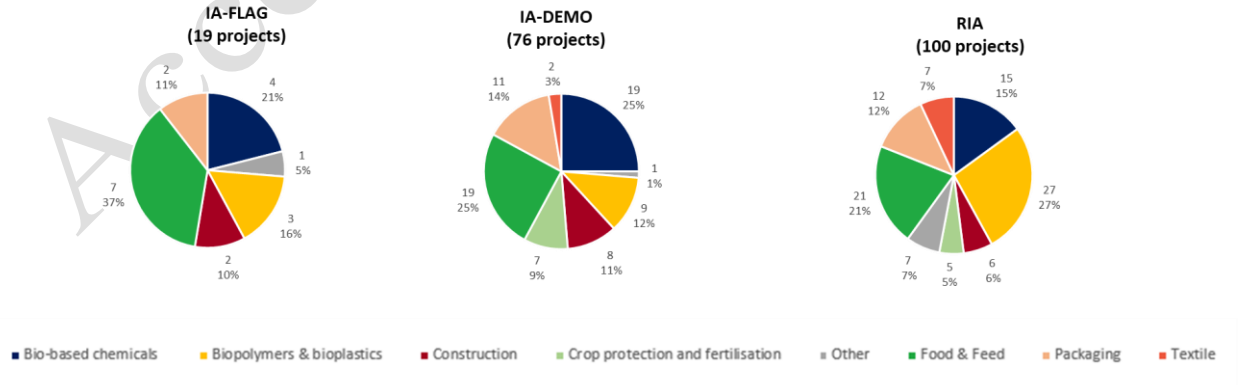

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It is therefore noteworthy to underline the importance of primary and secondary biomasses linked to the agricultural, forestry and marine ecosystems in the overall CBE JU portfolio, representing about 90% of the feedstocks addressed by the CBE JU projects.

3. CHALLENGES OF THE PRIMARY SECTOR INTEGRATION IN THE BIOBASED INDUSTRY AND OPPORTUNITIES OFFERED BY CBE JU TO FARMERS

Enhancing business opportunities for primary producers in cooperation with the rest of the stakeholders involved in the development of new innovative bio-based value chains and promoting bioeconomy in rural areas are at the core of CBE JU's priorities.

Farmers are recognised in the context of CBE JU as crucial actors of the value chains as they are providing biorefineries with different types of biomasses (including residues, side streams and by-products) which are converted into high-value bio-based products and materials. The economic activities along the biorefinery processes have the potential to bring new sources of income for primary producers including farmers and therefore boosting local economies in rural areas where they are located. In addition, farmers are also end-users of the innovations delivered by the CBE JU-funded projects which are developing bio-based crop protection and fertilisation solutions with a high environmental performance. These innovations include bio-based fertilisers, bio-based pesticides, biostimulants, or biodegradable and bio-based plastics used in agricultural practices. These bio-based products represent a real alternative to conventional products being more sustainable (i.e., having a reduced carbon footprint, minimizing the impact on natural land, protecting soil quality and productivity, minimise the emission of chemicals) and supporting ecosystem restoration, greener agricultural practices (including organic farming), decarbonisation and reduction of EU dependency on imports of raw materials used to produce fertilisers.

In order to better understand the main challenges and opportunities for primary producers in the bioeconomy sector, a "Study on the participation of the agricultural sector in the BBI JU: Business Models, Challenges and Recommendations to enhance the impact on Rural Development" (Innovarum, 2019) has been conducted to be used as foundation for the draft of the CBE JU SRIA.

The primary sector plays a fundamental role in the deployment of circular bio-based innovations, significantly influencing the sustainability and success of the broader bio-based economy. As key suppliers of biomass, primary producers provide the essential raw materials needed for bio-based processes. At the same time, they act as both producers and end-users of bio-based products and innovations, making their engagement vital for creating fully integrated, circular value chains. Despite their potential to drive sustainability and innovation, several barriers hinder their full participation and the extent to which they can benefit from these opportunities. One of the core challenges is a lack of awareness regarding the opportunities presented by circular bio-based innovations. Many primary producers remain uninformed about how these innovations can enhance their operations, improve efficiency, and offer new revenue streams. Even when information is available, there is often hesitation to embrace change, stemming from concerns about altering well-established business models. The transition toward bio-based solutions may require significant adjustments to traditional agricultural or forestry practices, leading to uncertainty about economic viability, technical feasibility, and market demand. Several communication-related issues further limit primary producers' ability to engage in bio-based innovation (e.g., language used is too complex, inappropriate interlocutors at the primary producer level, insufficient exchanges between primary producers and industry). From a value chain perspective, primary producers are often only marginally integrated into the bio-based value chains and they are facing technological risks and uncertainties as building a

new supply chain takes many seasons and years, with high risk for the primary sector and with limited short-term results.

By addressing these challenges, primary producers can be empowered to take an active role in circular bio-based innovation, ensuring that they do not just remain suppliers of raw materials but also benefit from the transformative opportunities that this growing sector offers.

Consequently, the CBE JU SRIA underlined that there is still room for further outreach and mobilisation of primary biomass suppliers from the agriculture sector which had already been identified as a special group that needs to play a bigger and more specific role in the bioeconomy and bio-based value chains (Bio-Based Industries Consortium 2022; Innovarum, 2019; Bio-Based Industries Joint Undertaking, 2019).

Among the priorities established in the SRIA for the primary sector, it is proposed i) to engage and integrate primary producers in sustainable circular bio-based systems and value chains; ii) to improve the primary sector's involvement in the value chains with the aim of ensuring high quality and quantity of feedstock, while they are rewarded with a proper share of the profit; iii) to revive and revitalise rural, coastal, and peripheral regions through the development of appropriate technological solutions, and inclusive involvement and empowerment of local bioeconomy actors (including the primary sector).

In the SRIA, it is also foreseen that CBE JU actions will implement a value chain approach**,** and this will ensure that all the relevant actors in the bio-based system, including the supply chain, i.e. primary producers, are appropriately involved in the selected project proposals and are represented to the largest possible extent in the project consortia.

The CBE JU has launched in 2024 dedicated communication campaigns in EU countries that are included in the list of widening countries under Horizon Europe and that were underrepresented through the BBI JU programme implementation, as well as targeted specific stakeholder groups, such as primary producers. Communication material is adapted to the local

language to reach a higher impact. The communication addresses local communities with a message on creating new kinds of jobs and alternative income sources in rural and coastal areas. As a last and relevant operational instrument to foster the primary sector engagement in the biobased industry, CBE JU has created a working group on primary producers (WG PP) that has been officially launched in June 2025. It is an action group and the scope is to propose specific actions to address the challenges faced by the agricultural, forestry and aquaculture & fisheries primary sector and to harness opportunities offered by circular bio-based innovations. The objectives are i) to empower primary producers to play an active and rewarding role in circular bio-based value chains; and ii) ensure they benefit from the economic, social, and environmental opportunities these systems offer (supported by long-term, sustainable, and feasible business models). The WG PP is a group of 64 stakeholders (by June 2024) and consists of organizations representing the agricultural, forestry, fisheries, and aquaculture primary sectors across Europe. The WG PP remains open to incorporate additional primary producers who wish to join the initiative in the future, ensuring broader representation across both sectors and regions. Among the concrete outcomes expected from the WG PP is the development and implementation of an Action Plan over the three years period 2025 –2028, with the possibility of extending the work in a later phase, depending on the results achieved and future decisions. The action plan will then be drafted by the members of the working group, being tailor-made, to cover the specific needs and priorities of the primary sector. While the specific actions and the roadmap to achieve them will be defined by the WG PP over the next year, it is already anticipated, based on the SWOT analysis presented in Figure 3 and feedback gathered during the consultative workshop held in February 2024 (Circular Bio-Based Europe Joint Undertaking, 2024), that the actions will focus on different key areas of activity. The first area of activity focuses on raising awareness and improving understanding of the opportunities that circular bio-based innovations offer to primary producers. This includes reaching out to as many

producers as possible, using the appropriate tools and language to ensure accessibility and impact. To continue, other areas of activities focus on strengthening cooperation of the primary sector with the industry and other stakeholders; deploying feasible business models; and enhancing knowledge exchange on innovation. Furthemore, activity focused on creating synergies and collaboration as well as capitalising on existing efforts and building on the work of established networks such as the EU CAP Network EIP AGRI Operational Group and various EU-funded projects are also sought. Finally, the last area of activity will concentrate on widening participation by mobilising primary producers from regions with unexploited potential and actively engaging them in bio-based value chains (Circular Bio-Based Europe Joint Undertaking, 2025).

Figure 3. SWOT analysis summarising the main findings of the CBE JU analysis on the problem and opportunities on the participation of primary producers in the biobased innovation development

Strengths:	Weaknesses:
• Primary producers are at the forefront of the bio-based value chains. • Direct processing and conversion of biomass at source (primary producers as operators of biorefineries, instead of 'just' biomass suppliers). • Incremental demand for biomass and increasing demand for circular bio-based products from industry and consumers. • Long tradition to cooperate in market-oriented value chains. • Possibility to use different forms of cooperation to strengthen the organisation of the primary sector, e.g., farmers' cooperatives (among themselves, and with industry and regional stakeholders), ensuring the direct and indirect participation of their members in the opportunities offered by the circular bioeconomy. • National support (e.g., farmers' support from national advisory services plus their enhanced role under CAP). • Existence of hubs, training centers, and capacity-building initiatives in rural areas.	• Primary producers do not always/fully benefit from the opportunities offered by cooperation with the bioeconomy/circular bio-based sector. • Mistrust & reluctance about new crops and potential opportunities offered by such crops, including their residues and new farming systems. • Insufficient engagement/cooperation of primary producers in the bio-based value chains (missing integration) and difficulty in maintaining motivation over the years. • Insufficient innovation capacity. • A volatile market for biomass as input to the bio-based sector. • Lack of skills, administrative burden, and language barriers encountered by primary producers to engage in new value chain development through participation in R&I projects. • Individual primary producers' involvement in bio-based value chains, in general, is more difficult than if they are represented by the cooperative or other types of organisations serving their interests. • Replicability of business models in different regions highly affected by local factors
Opportunities:	**Threats:**
• New business opportunities for primary producers based on the efficient use of biomass and valorisation side streams from primary production & crop residues to produce high added-value materials. • Novel business models with environmental benefits, e.g., via circulation of nutrients and new sustainable, diversified production systems. • Revitalisation of the economic sustainability of unused or abandoned rural areas granting benefits to primary producers that provide ecosystem services. • Innovations as a lever for rural regeneration and generational renewal. • Benefits of participating in new innovative value chains: reduce the risk and accelerate the work, networking at the EU level, working closely together with other partners in so-called innovation ecosystems.	• Difficulties in cooperation and an unlevel playing field between large companies/cooperatives and SMEs/individual primary producers (e.g., feasibility of long-term contracts between the primary sector with industry). • Lack of credibility of long-term economic viability of novel bio-based business models and associated technical barriers, e.g., building a new supply chain takes many seasons and years with high risk and very limited short-term results. • Too complex or not clearly communicated environmental requirements, including the competing demands for the use of land: biomass use for food and feed production, carbon storage, biodiversity (set-aside), etc. • Climate change impact and/or other unexpected threats to primary production. • Societal issues, including rural depopulation and aging (the average age of EU farmers is +60 years, and the new generation may not be interested). • Policy, legal & regulatory barriers: e.g., validity of 'new' crops not included in the actual CAP implemented at a national level, difficulty to use abandoned lands, barriers linked to logistics & transport of waste across regions, bio-based sector not considered among the national CAP plans and Operational Groups, fragmented legislative framework, etc.

4. HIGHLIGHTS ON FARMER PARTICIPATION IN CBE JU FUNDED PROJECTS

The CBE JU annual work programmes are designed to support the primary sector's to appropriate involvement and representation to the largest possible extent in the project consortia in the selected project proposals. Several proposed topics are highly relevant and attractive for the agricultural primary sector (indicative list provided in table 2). Also, the expected outcomes envisaged for the projects as described in the topic text envisage positive impacts for farmers and rural areas, such as: engaging with primary producers to ensure that the solutions are meeting their requirements and needs; generating new incomes for farmers; delivering skilled job opportunities in rural areas; supporting the revitalisation of rural areas; fostering cooperation between farmers and bio-based industries; supporting capacity building, training and education for farmers, etc.

In addition, CBE JU-funded projects — particularly those at higher TRL (6-8, all Innovation Actions, including flagships) — are requested to implement the Multi-Actor Approach as part of their methodology to ensure an effective engagement with primary producers by involving them in the project activities, including the design and use of the bio-based solutions. This guarantees that the farmers' requirements and needs are well-considered from the beginning of the development of any innovation and in the building up of a new value chain. Synergies with measures and initiatives undertaken in the frame of the Common Agricultural Policy (CAP), as for example EIP Agri and the EIP Agri Operational Groups, and with the CAP networks are also reflected in several topics, where specific requirements are included in the topic texts and to be implemented in the project.

Table 2. List of CBE JU topics published in calls for proposals relevant for farmers.

CBE JU Call	**Type of action and title of the topic**
2022	IA-02-Cooperative business models for the sustainable mobilisation and valorisation of agricultural residues, byproducts, and waste in rural areas
	RIA-05-Sustainable fibres biorefineries feedstock

2023	IA-01 Small-scale biorefining in rural areas
	IA-02 Production of safe, sustainable, and efficient bio-based fertilisers to improve soil health and quality
	RIA-01 Phyto-management; curing soil with industrial crops, utilising contaminated and saline land for industrial crop production
2024	IAFlag-01 Bio-based value chains for valorisation of sustainable oil crops
	IAFlag-03 Bio-based value chains for valorisation of sustainable natural fibre feedstock
	IA-01 Bio-based materials and products for biodegradable in-soil applications
	RIA-03 Sustainable, bio-based alternatives for crop protection
	CSA-01 New forms of cooperation in agriculture and the forest-based sector
	CSA-03 Supporting the CBE JU Deployment Group on Primary Producers

To monitor the progress of the CBE JU programme implementation with regard to the strategic participation and integration of feedstock producers and suppliers towards large-scale valorisation of sustainable biomass, a dedicated Key Performance Indicator has been set - KPI 1.1. number of primary producers, involved as project beneficiaries and/or engaged in value chains at project level.

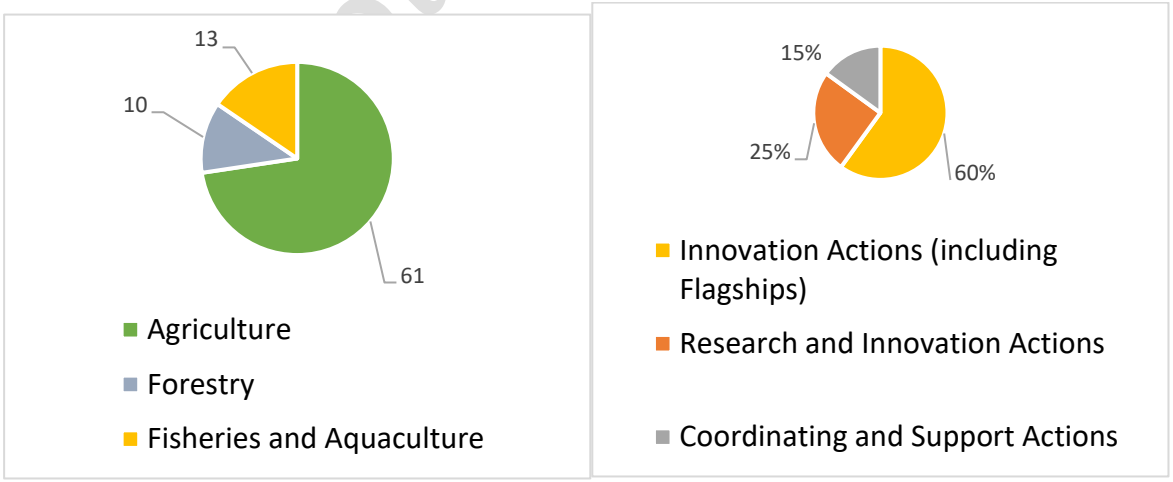
This strategic support framework of CBE JU reaps the benefits. Analysing the data gathered during the first three years of operation, it is worth highlighting that since 2022, 84 organisations from the agricultural, forestry, and aquatic primary sectors have received a total of about 8.5 million euro in CBE JU funding. 61 out of 84 primary producers are farmers (agricultural primary producers; Figure 4, left panel). This means that farmers represent 73% of the primary sector actors involved in CBE JU projects. This is in line with the fact that agri-based feedstocks represent the major share of feedstock addressed by CBE JU projects (Figure 2).

Primary producers are involved in CBE JU projects, both as beneficiaries of projects (direct participation) or in other ways (indirect participation). Indirect participation can take different forms such as contracts as biomass providers, contracts to perform validation services of end-products, involvement in advisory bodies, etc. In this regard, an interesting aspect to explore is the comparison between the figures of direct and indirect participation in CBE JU-funded projects as about 40% of farmers are direct participants while 60% are indirect participants.

This indicates that farmers are interested in participating in CBE JU-funded projects, but not always as direct beneficiaries, and many prefer other forms of involvement that allow them to be engaged in these projects without bearing the administrative burden that come with formal project participation. This approach enables farmers to network and benefit from technical innovations while keeping their focus on their core activities.

Another aspect analysed in this publication is the involvement of primary producers in the different types of projects that CBE JU is funding (figure 4, right panel). The figures show that the involvement is particularly relevant in innovation actions, including flagships, where the full value chain is covered, and their role is vital to supply biorefineries with locally sourced biomass and/or to test the bio-based solutions as final end-users. In fact, since 2022, 60% of primary producers are involved in innovation actions and flagships, while 25% are in RIAs and 15% in CSAs.

Figure 4. Participation of primary producers in the CBE JU projects (2022, 2023 and 2024 calls). On the left, distribution of participation among primary sectors as a percentage of total primary producer participation. On the right, distribution of participation per type of funded action as a percentage of total primary producer participation.



5. EXAMPLES OF CBE JU FUNDED PROJECTS SIGNIFICANTLY INVOLVING PRIMARY PRODUCERS

Among the different projects selected for receiving CBE JU funding that deliver bio-based innovations that represent new opportunities for farmers, a selection of exemplary cases where the involvement of farmers is particularly relevant is presented.

The BRILIAN project has been conceived to support the adoption of sustainable and cooperative business models in rural areas, for the valorisation of agricultural by-products seeking to increase and diversify primary producers' income (BRILIAN project, 2023). The ROBOCOOP-EU project develops circular regional business models for the use of waste streams from three agricultural sectors: grape, olive and stone fruit cultivation (ROBOCOOP-EU project, 2023). The project will offer new commercial opportunities in rural areas of Extremadura, Spain; Apulia, Italy; and West Macedonia, Greece. Another interesting example is MANUREFINERY project that will develop innovative ways to convert livestock manure into bio-based animal feed and fertilisers (MANUREFINERY project, 2024). The project will help reduce the environmental impact of livestock farming and create alternative income sources for farmers on four sites in Romania, Slovenia and Spain. These are only a few examples of Innovation Actions among many others that are carried out with the support of CBE JU.

Particularly interesting is the case of the flagships funded by CBE JU. In fact, CBE JU flagship projects have the aim of covering the full value chain from biomass supply to the delivery of end products and considering their location close to the source of biomass. This is particularly relevant in term of creation of economic impact at territorial level. In this context, the role of farmers in the value chains as biomass suppliers but also end-users, together with the expected cooperation that will be forged between primary producers and biorefinery operators, has a high potential to support them by diversifying their business opportunities and sources of income.

Table 3 summarises the current status of the 19 CBE JU Flagships project with a focus on where the biorefinery plant is located and which is the main associated feedstock.

Table 3. Summary of the CBE JU Flagship and distribution for geographical area, main feedstock and main area of application.

Name of the project	Country of location	Main feedstock	Area of application
CERISEA	France	Agri-food	Bio-based chemicals
PEFERENCE	The Netherlands	Agri-food	Biopolymers and bioplastics
FIRST2RUN	Italy	Agri-food	Bio-based chemicals
PLENITUDE	The Netherlands	Agri-food	Food and feed
LIGNOFLAG	Romania	Agri-food	Other
TERRIFIC	Italy	Agri-food	Biopolymers and bioplastics
SUSTAINEXT	Spain	Agri-food	Food and feed
RUNFASTER4EU	Italy	Agri-food	Bio-based chemicals
AFTERBIOCHEM	France	Agri-food	Bio-based chemicals
FARMYNG	France	Agri-food	Food and feed
CIRCLE	The Netherlands	Agri-food	Bio-based chemicals
SYLPLANT	France	Agri-food and Forest-based	Food and feed
SCALE	France	Aquatic	Food and feed
PROTEUS	Norway	Aquatic	Food and feed
CIRCULAR BIOCARBON	Spain and Italy	Biowaste	Biopolymers and bioplastics
SWEETWOODS	Estonia	Forest-based	Construction
EXILVA	Norway	Forest-based	Biopolymers and bioplastics
VIOBOND	Latvia	Forest-based	Construction
WOODCELL	Estonia	Forest-based	Biopolymers and bioplastics

An example of a flagship project that aims at achieving zero-waste and circular-by-design industrial process in a rural region in Europe is SUSTAINEXT (SUSTAINEXT project, 2023). The project is turning an existing production plant into a digitalised circular biorefinery to produce healthy plant extracts and functional ingredients from medicinal and aromatic crops – rosemary, camomile and lemon verbena – on disused tobacco fields in Extremadura, Spain. It also deploys solar panels to enhance soil use and provide clean energy as well as agricultural side streams – olives, cardoons and pomegranates – to showcase how underexploited biological raw materials can be upcycled. The project will generate value and new jobs for the region,

showing the positive impact of pursuing the European Green Deal objectives. The project's model is easily adaptable and replicable and can run on renewable energy.

Another relevant example is the AFTERBIOCHEM flagship project (AFTERBIOCHEM project, 2020). The EU is the world's largest producer of sugar beet, with about 140 000 sugar beet growers and around 27,000 direct jobs in sugar beet processing. AFTERBIOCHEM is building the first biorefinery for transforming the sugar industry's side streams – mainly pulp and non-food waste – into bio-based molecules of industrial interest, for the flavourings, fragrances, hygiene products, pharmaceuticals, antimicrobials and polymers sectors in Carling Saint-Avold, France. This will increase the economic and environmental sustainability of the sugar beet industry. In addition, the process will be flexible enough to adapt to alternative feedstocks in the future.

6. CONCLUSION

Analysing the current achievements of the CBE JU projects, some key messages can be drawn on the main elements that are contributing to make a compelling proposal a successful project. In particular, while aligning with the CBE JU objectives and directly contributing to the EU Green Deal, circular economy and bioeconomy goals, successful projects are demonstrating innovative breakthroughs and, at the same time it has been shown how the involvement of actors across the entire bio-based value chain, from biomass producers to end-users, is a very relevant prerequisite to provide the conditions that make a brilliant ideas a potential market success. SMEs play a crucial role in the CBE JU programme, accounting for nearly one-third of participants and receiving a corresponding one-third of the total funding. Their leadership is also evident, with one in four projects coordinated by an SME, reinforcing their vital contribution to driving innovation and project execution within the bio-based sector. Accelerating the innovation process for bio-based solutions and fostering technology transfer

are part of core objectives of successfully funded CBE JU projects. Therefore, it is notewhorty that universities and research centres, representing one-quarter of all CBE JU participants, are key providers of innovative bio-based solutions for the projects. Building consortia founded on a strong multi-actor approach with a robust impact potential in term of societal, economic and environmental benefits is also pivotal to drive the market deployment of the biobased sector in Europe in a fair and sustainable way. To this regard, successful projects are mastering effective approaches to strengthen the link between circularity, bioeconomy and availability of sustainable biomass in the real life. This is very important to ensure that the farmers play a strategic role in the biobased transformation and are clearly positioned in the biobased value chains. This strong integration between the primary production and the biobased industry is expected to be further enhanced in the longer term, leading to systemic benefit from these collaborations.

We are in a transition period: the scope of the bioeconomy, including the opportunities for the primary sector, will be further developed in the revision of the European Bioeconomy Strategy expected by the end of 2025.

As proposed by CBE JU, there is a clear trend of supporting research and innovation aimed at enhancing competitiveness while at the same time ensuring high environmental protection, food security and the decarbonisation of the economy. The circular bio-based innovations developed in CBE JU projects are instrumental in achieving this goal. They will be crucial to make the most of the available sustainable biomass, including wastes, side streams, non-food crops, and cultivations in marginal lands to develop circular bio-based solutions in replacement of fossil-based products. These innovative solutions have the potential to protect ecosystems, reduce the utilisation of external inputs, ensure food security, support nature restoration, while diversifying the business models and income streams of the primary sectors. The expected rewarding

cooperation between farmers and the rest of the biorefinery operators will also be important to ensure a proper and fair share of the profit among all the actors involved in the value chain.

The potential of CBE JU to support farmers is high and the partnership's legal framework is extremely supportive, with measures incentivising their involvement in project activities but also beyond that, empowering farmers and enhancing their role in the circular bio-based value chains, as is proved with the launch of the WG PP. Several projects from BBI JU have already finished and demonstrated impacts for the primary sector and rural development. Under CBE JU, some of the projects resulting from the first three cycle of funding are already delivering concrete results and impacts. The project outcomes over the next years will be crucial to further understand the challenges and the opportunities for the involvement of farmers in the European circular bio-based value innovations and the impacts of the promotional CBE JU activities on that.

Altogether, the achievements of CBE JU and the findings related to the integration of primary sector and biobased industry will represent a solid and significant basis, substantiated by concrete outcomes and exploitable results, for the future of the bioeconomy research and innovation support in Europe in the next future.

REFERENCES

AFTERBIOCHEM project from H2020-BBI-JTI-2019 Call (2020). Available at: https://www.cbe.europa.eu/projects/afterbiochem .

Bio-Based Industries Consortium (2022). Strategic Research and Innovation Agenda of CBE JU. Brussels.

Bio-Based Industries Joint Undertaking (2019). Proposal of actions to increase/improve the participation of the agricultural sector in BBI JU and ultimately in the bio-based sector. Available at: https://innovarum.es/wp-content/uploads/2020/07/2019.BBIJU-Study.pdf

BRILIAN project from HORIZON-JU-CBE-2022 Call (2023). Available at: https://www.cbe.europa.eu/projects/brilian

Circular Bio-based Europe Joint Undertaking (2024). Report of the workshop engagement with primary producers in circular bio-based value chains. Available at: https://www.cbe.europa.eu/system/files/2024-04/Report-primary-producers-workshop-2024-02-28.pdf

Circular Bio-Based Europe Joint Undertaking (2025). Available at: https://www.cbe.europa.eu/system/files/2025-01/CBE-JU-WG-PP-concept-note.pdf

European Commission (2018). A sustainable bioeconomy for Europe – Strengthening the connection between economy, society and the environment – Updated bioeconomy strategy. COM (2018)673. Brussels.

European Commission (2019). The European Green Deal. COM (219)640 final. Brussels.

European Commission (2021). Council Regulation (EU) 2021/2085 establishing the Joint Undertakings under Horizon Europe. Official Journal of the European Union 427/17. Brussels.

European Commission (2024). Communication Building the future with nature: Boosting Biotechnology and Biomanufacturing in the EU. COM (2024) 137 final. Brussels.

General Secretariat of the Council, Special Committee on Agriculture/Council (2023). Council Conclusions on the opportunities of the bioeconomy in the light of current challenges with special emphasis on rural areas. Brussels.

INNOVARUM (2019). Study on the participation of the agricultural sector in the BBI JU: Business Models, Challenges and Recommendations to enhance the impact on rural development. Available at: https://innovarum.es/wp-content/uploads/2020/07/2019.BBIJU-Study.pdf

Johnson, C., Ruiz Sierra, A., Dettmer, J., Sidiropoulou, K., Zicmane, E., Canalis, A., Llorente, P., Paiano, P., Mengal, P., and Puzzolo, V. (2021). The Bio-Based Industries Joint Undertaking

as a catalyst for a green transition in Europe under the European Green Deal. EFB Bioeconomy Journal, 1:100014.

MANUREFINERY project from HORIZON-JU-CBE-2023 Call (2024). Available at: https://www.cbe.europa.eu/projects/manurefinery

Members of the Strategic Dialogue on the Future of EU Agriculture (2024). Strategic Dialogue on the Future of EU Agriculture. A shared prospect for farming and food in Europe. Brussels.

Mengal, P., Wubbolts, M., Zika, E., Ruiz, A., Brigitta, D., Pieniadz, A., and Black, S. (2018). Bio-based Industries Joint Undertaking: The catalyst for sustainable bio-based economic growth in Europe. New Biotechnology, 40(A):31–9.

ROBOCOOP-EU project from HORIZON-JU-CBE-2022 Call (2023). Available at: https://www.cbe.europa.eu/projects/robocoop-eu

Ruiz Sierra, A., Zika, E., Lange, L., Ruiz de Azúa, P., Canalis, A,, Mallorquín Esteban, P., Paiano, P., and Mengal, P. (2021). The bio-based industries joint undertaking: A high impact initiative that is transforming the bio-based industries in Europe. New Biotechnology, 60:105–12.

SUSTAINEXT project from HORIZON-JU-CBE-2022 Call (2023). Available at: https://www.cbe.europa.eu/projects/sustainext