STRATEGIC RESEARCH & INNOVATION AGENDA

BIOECONOMY EDUCATION

THEMATIC WORKING GROUP OF THE BIOEAST INITIATIVE

This document is confidential and represent a text for the internal discussion among TWG BE Edu members

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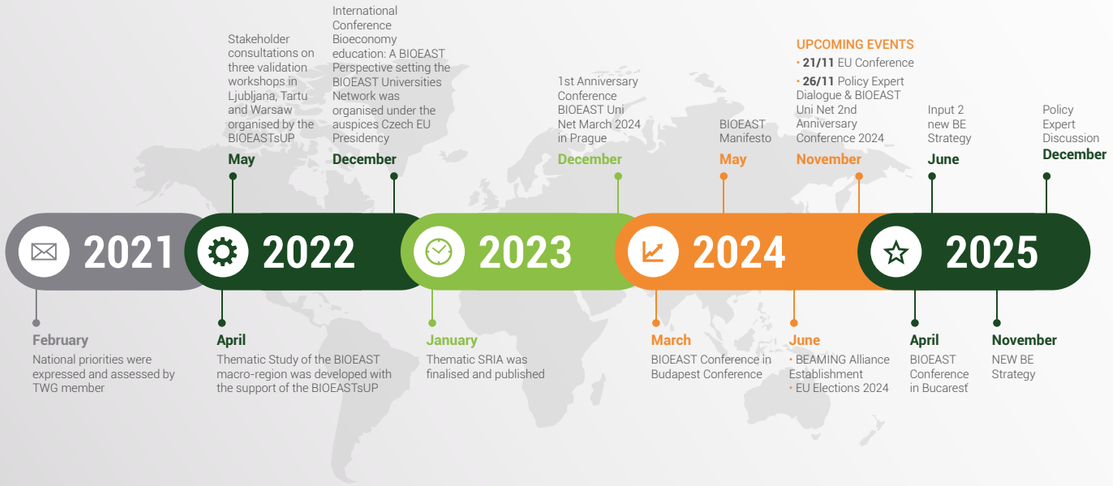
MANAGERIAL EXECUTION

Bioeconomy offers a realistic opportunity to reconcile economic growth in a sustainable way and within an environmentally responsible frame. This development requires an interdisciplinary approach to research and innovation for the implementation of innovative solutions achieved by a new generation of skilled experts. In this perspective, tailored bioeconomy education and training are important to enhance the transition to sustainable development. Bioeconomy Education has been a key issue on the European Strategy for Bioeconomy from the very beginning. In both Strategy documents (2012 and 2018) the issue appears as a main priority for Europe. The Bioeconomy Stakeholders Manifesto issued in 2019, places Education as a top priority for sustainable development and growth and finally the European Commission tends to institutionalize the issue.



The BIOEAST Foresight Report highlighted the structural problems in the BIOEAST macro region, the lack of human resources in higher education and research is one of the main bottlenecks to accomplishing the goals of the European Green Deal. The BIOEAST Initiative fully acknowledges the importance of the coordinated approach and tackles the issue of bioeconomy education in the BIOEAST macro region. The Thematic Working Group Bioeconomy Education and Skills was established in 2020 to meet the specific macro-regional education needs of the BIOEAST macro-region. It is coordinated by the BIOEAST HUB CR, z.u. The **BIOEAST University Network** BIOEAST UniNet was established in December 2022 as a structural part of the BIOEAST Thematic Working Group on Bioeconomy Education and Skills in Prague at the international conference **"Bioeconomy Education: A BIOEAST Perspective"** organised under the auspices of the EU Czech Presidency, December 8, 2022. In January 2024 a new ERA Widening project BEAMING was launched that enhanced the BEAMING Alliance. The **BEAMING Alliance** plays a pivotal role in advancing bioeconomy research across the **BIOEAST macro-region** and **WIDENING countries** by fostering collaboration, capacity-building, and innovation. It serves as a strategic platform to bridge the gap between research institutions in the BIOEAST macro-region and Western Balkans and their counterparts in more research-intensive areas, addressing regional disparities in research capabilities. **BEAMING Alliance** is helping to build research capacity by facilitating training programs, providing resources for early-career researchers, and advocating for increased investment in bioeconomy-related fields.

From the very beginning, members [1] of the TWG BE EDU have been discussing priorities concerning the bioeconomy education in the BIOEAST macro-region and immersed developing the Thematic Strategic and Research and Innovation Agenda for the Bioeconomy Education of the BIOEAST macro-region (hereinafter referred as "Thematic SRIA BE EDU"). This document identifies strategic thematic areas to tackle challenges and enhance the full potential of bioeconomy education and represents an updated **Thematic Strategic Research and Innovation Agenda** of the BIOEAST Thematic Working Group on Bioeconomy Education. The preparation was supported by the **Boost4BIOEAST** project. The current version is now offered to stakeholders for consultation, inviting input to ensure it effectively addresses regional needs and priorities. Input from stakeholders outside the BIOEAST macro-region is also welcomed, as it may provide valuable inspiration and insights. The EU is currently navigating numerous challenges that require rapid responses across multiple policy areas. To address these, the Thematic SRIA has been launched as a dynamic, living document open to continuous updates. It is designed with adaptability in mind, allowing it to reflect ongoing changes, emerging issues, and trends. This flexible approach ensures that the SRIA remains relevant and aligned with evolving priorities in bioeconomy and related sectors.

[1] There are currently representatives of the following governmental bodies and research institutions involved in the agenda: Ministry of Agriculture Poland, Ministry of Agriculture Hungary, Ministry of Agriculture Czech Republic, Ministry of Education and Science Bulgaria, Ministry of Education and Science Croatia, Estonian University of Life Science, The Agricultural University – Plovdiv, Agronomic Faculty Zahřeb, Vytautas Magnus University Lithuania, Polnohospodářská Univerzita Nitra, University Ljubljan

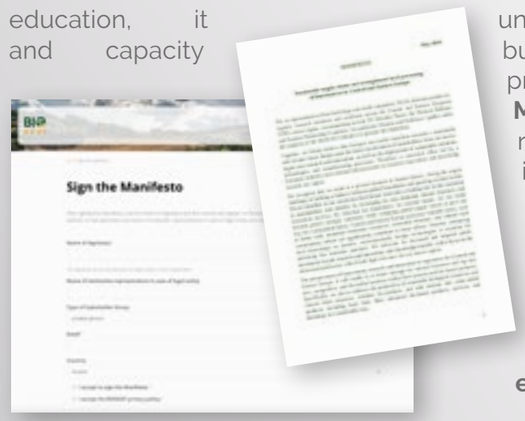
INTRODUCTION

In an evolving bioeconomy, it is widely acknowledged that future growth and economic strength will hinge on a multidisciplinary and cross-sectoral approach. This emerging framework demands coordinated collaboration among diverse scientific fields, technical expertise, and is accompanied by critical political and economic decision-making processes. These factors are reshaping business dynamics and market demands as the bioeconomy becomes central to EU priorities, addressing global challenges like climate change, water erosion, and biodiversity loss.

Additional to the above, the development of multiple geopolitical issues further complicates the overall landscape

In her keynote speech, President von der Leyen emphasised several key implications for bioeconomy education, which reflect broader trends in environmental sustainability and innovation. **Education must prioritise innovation and prepare future generations to tackle environmental challenges such as climate change and biodiversity loss through new technologies and nature-based solutions.** Education should also include an emphasis on **financial tools and incentive systems that reward sustainable practices,** aligning economic outcomes with environmental stewardship. She articulated that educational programs must incorporate **principles that link economic growth with environmental sustainability, preparing students for a future where businesses balance profit with ecological preservation** showing both global and local perspectives on bioeconomic policies and practices. This vision is particularly urgent for the BIOEAST macro-region.

In spring 2024, the Stakeholder BIOEAST **Manifesto** *Sustainable supply chains and strengthened local processing* was published focused on the role of Central and Eastern Europe in driving a sustainable and circular bioeconomy. The document emphasises the importance of involving the **Western Balkans** to ensure a cohesive regional approach, leveraging shared knowledge and resources. While the document does not explicitly focus on bioeconomy education, it underscores the importance of **knowledge transfer** and capacity building to foster the adoption of sustainable practices across the region. Although the **Youth Manifesto 2024** does not explicitly call for a specific requirement to change the educational system, it suggests an **overarching need for education systems to adapt in response to emerging global challenges.** Given the focus on climate change, sustainability, and future job markets, the document **implies that educational reforms are needed to better prepare young people for a world shaped by bioeconomy, innovation, and environmental responsibility.**



METHODOLOGY

The **Strategic Research and Innovation Agenda (SRIA)** for the **Thematic Working Group on Bioeconomy Education (TWG BE Edu)** will be developed to foster the long-term growth of bioeconomy education across the **BIOEAST macro-region**. The SRIA will follow a structured approach, focusing on three main strands of activities: **Mapping, Assessment, and Building**, with a strong emphasis on **stakeholder engagement** and **co-creation**.

The **Mapping** phase will lay the foundation by identifying the key elements that shape bioeconomy education. This will build on the first version of the **Thematic SRIA** from January 2023 and the insights from the **Thematic Study** supported by the BIOEASTsUP Project. These resources will be fully utilised to pinpoint **core educational concepts**, define **research and innovation orientations**, and identify priority areas and gaps in bioeconomy education.

The **Assessment** phase will involve a **comprehensive evaluation** aimed at aligning bioeconomy education with both public and institutional needs. Experts and policymakers will co-develop a **holistic framework** that integrates both **theoretical knowledge** and **practical applications**. This framework will outline the **skills, competencies, and values essential** for students in bioeconomy-related fields, while also evaluating current educational strategies, tools, and best practices for teaching bioeconomy.

In the final phase, **Building**, the insights from the Mapping and Assessment stages will be translated into **actionable strategies**. This will involve developing **concrete scenarios** and **action plans** to shape the future of bioeconomy education. Central to this phase is the **engagement of the related stakeholders**—educators, students, policymakers, and industrial representatives—who will be actively involved in consultations to assess educational needs, share best practices, and ensure the integration of bioeconomy into existing educational systems. By focusing on collaboration and input from a wide range of stakeholders, the SRIA will help create an inclusive, future-oriented bioeconomy education framework that meets the evolving demands of both the sector and society.

The current update of the Thematic SRIA BE Edu (November 2025) integrates the outcomes of the 2024 stakeholder survey and expert consultations of the BIOEAST Thematic Working Group on Bioeconomy Education, ensuring that the new research and training priorities reflect both regional needs and the evolving direction of the European Bioeconomy Strategy. This revision incorporates several new thematic elements responding to the feedback gathered during the "Call for Evidence – Towards a Circular, Regenerative and Competitive Bioeconomy."

A new **Research Topic (RT 10): Digital Transformation in Bioeconomy Education** has been introduced to address the integration of Artificial Intelligence, data analytics, precision farming technologies, and digital twins into curricula and learning platforms. The **Key Topics** section has been expanded to reinforce the importance of **cross-disciplinary integration**, promoting T-shaped competences and systems thinking across bioeconomy domains. The scope of **RT**

4 (Vocational Training) has been extended to include **Living Labs** and experiential learning environments that connect academia, industry, and policy actors. Likewise, **RT 9 (Sustainable Entrepreneurship and Financing)** now encompasses a short-term, highly intensive program for bioeconomy managers, strengthening leadership and business capacity in the sector. Finally, **RT 7 (Tutorials for Green Public Procurement)** has been broadened to incorporate **ESG implementation for small and micro bioeconomy enterprises**, responding to the growing demand for sustainability compliance and responsible governance practices.

Together, these updates ensure that the Thematic SRIA BE Edu remains closely aligned with the objectives of the updated EU Bioeconomy Strategy and the broader BIOEAST Initiative. They highlight education as a **strategic enabler** of a just, innovative, and regionally inclusive bioeconomy transition, reinforcing the BIOEAST macro-region's role in advancing digitalisation, cross-sectoral collaboration, and sustainability-oriented skills development across Europe.

BACKGROUND OF STRATEGIC PRIORITIES

This chapter is demonstrating the footing for strategic research priorities summarising the key documents, surveys and events.

Bioeconomy Education Factor For the Transition

Bioeconomy transitions will also require changes in behaviour and attitudes on the part of individuals and society. These changes can foster resistance in the form of psychological, non-science/evidence based opposition to new technologies and practices. Therefore, the establishment of specialized education and training concepts has become a necessity and many higher education institutions all over the world are already working toward this effort. Lifelong learning will be pivotal, developing a skilled workforce equipped to tackle the complex and interdisciplinary challenges of bioeconomy.

The New European Economic strength and growth are building based on a new concept including the valorisation of natural resources and human manpower in a sustainable way. Those are the concepts of Bioeconomy, Biobased Economy and Circular Economy, which will become substantial elements for future development. In the forthcoming years more and more processes will be designed on these principles. The current dynamics in business and market requirements are changing. Therefore, it is demanded a new generation of skilled working force, educated according to these needs. This education presupposes multi-disciplinarity in a wide spectrum of topics, so the competent teams can gradually be complemented by skilled individuals. The educational perspective must be aligned with European priorities for growth, offering a good potential for improvement at all levels (technological, economic, social and regulatory). Considering National and Regional priorities, the educational programs should be flexible enough and adjustable on a case-by--case basis according to specific demands and conditions.

Key topics for bioeconomy oriented education

The importance of integrating bioeconomy principles into education, especially in **finance and business,** to foster innovation, strategic planning, and sustainability in bio-based industries is articulated in literature. Education in bioeconomy finance and business can focus on understanding governance frameworks and enabling policies that are needed for effective governance mechanisms that support the transformation towards a bio-based economy (Dietz et al., 2018). Universities play a vital role in disseminating knowledge, fostering innovation, and should enhance entrepreneurial skills in bioeconomy-related business and finance (Socaciu, 2014), when finance and business programs should include sustainability, stakeholder engagement, and policy frameworks (Takala et al., 2019) and bioeconomy finance should include strategic planning, business development, and investment in bio-based technologies (Adamowicz et al., 2017)

Lifelong learning is a key element of bioeconomy education, particularly for developing a skilled workforce capable of addressing the complex, interdisciplinary challenges that bioeconomy presents. The "Charter for the European Community of Practice for Bioeconomy Education" highlights the need for a comprehensive education ecosystem that includes lifelong learning, vocational education, and academic programs. The Charter promotes the development of bioeconomy education that caters not only to students but also to professionals seeking to upgrade their skills in response to the evolving demands of bioeconomy. This ensures that both current and future professionals are well-prepared for the challenges of sustainability and circularity. The BIOBEC report on "Plans for Lifelong Learning Programs" emphasizes the importance of developing lifelong learning programs tailored to the bioeconomy sector, targeting existing workers in the industry. The report outlines strategies for implementing continuous education programs that address the ongoing skills gaps in bio-based industries. This integration of lifelong learning supports the industry's sustainability goals and helps workers adapt to technological advancements and new business models.

The development of a skilled workforce for the bioeconomy is closely tied to the implementation of lifelong learning programs, ensuring that professionals across sectors remain competitive and adaptable to new technologies. Various papers highlight the importance of integrating interdisciplinary knowledge into education frameworks, combining fields like biology, economics, and environmental sciences to address the complexity of bioeconomy challenges. Lifelong learning in the bioeconomy also involves continuous reskilling to align with innovations in bio-based production, sustainability, and circular economy principles. Additionally, lifelong learning programs tailored to the bioeconomy must involve both theoretical knowledge and practical skills, targeting existing professionals through workshops, vocational training, and digital platforms. This ensures a responsive educational system that

caters to evolving market needs and industry requirements.

Sustainable entrepreneurship education (SEE) is integral to bioeconomy, emphasizing the need for innovation, interdisciplinary collaboration, and lifelong learning. It fosters critical thinking and challenge-based learning to equip students with the entrepreneurial skills necessary for creating sustainable business solutions, particularly in bio-based industries. SEE helps students integrate economic, social, and environmental values into ventures, aligning with the bioeconomy's goals of sustainability and circularity. Moreover, SEE supports the development of human capital for the bioeconomy by promoting innovation in green supply chains and bio-based technologies, ensuring entrepreneurs are prepared to tackle sustainability challenges and contribute to sectors such as agriculture, bioproducts, and energy. This educational approach not only meets the bioeconomy's need for innovative market-based solutions but also encourages sustainable value chains that drive circular economy models.

To address the **complexity of the bioeconomy, education** must promote cross-disciplinary learning environments connecting life sciences, engineering, economics, and social sciences. Universities should co-create T-shaped curricula that blend deep expertise with integrative systems thinking. Collaborative, cross-faculty modules and joint degrees should be encouraged to strengthen transversal competences in innovation management, policy, ethics, and circular systems design.

The inclusion of **Micro-credentials** into the Bioeconomy Education system is also a must. These are elements certifying the learning outcomes of short-term learning experiences, for example a short course or training. They offer a flexible, targeted way to help people develop the knowledge, skills and competences they need for their personal and professional development. THe EC gives a great emphasis in this approach in all educational domains including bioeconomy.

CHALLENGES IN THE BIOEAST MACRO-REGION

The identified gaps in bioeconomy education in the European Union (EU), particularly in Central and Eastern Europe (CEE), highlight the **need for more interdisciplinary, flexible, and lifelong learning approaches to support the transition to a sustainable bioeconomy.** One of the key gaps is the lack of interdisciplinarity in education programs. Many current higher education courses in the bioeconomy are still designed around narrow, discipline-specific training (I-shaped profiles), which is inadequate for the complex, interconnected nature of bioeconomy. Professionals need T-shaped profiles, combining deep expertise in one discipline with the ability to integrate knowledge across multiple fields. For instance, effective bioeconomy professionals should be able to bridge life sciences and social sciences to address both the scientific and policy dimensions of sustainability (Paris et al., 2023; Bioeconomy Education Topics, 2024).

Lifelong learning also emerges as a crucial area for improvement.
As job descriptions in bioeconomy sectors evolve due to technological advances, the need for continuous education becomes more pronounced. However, there is currently a lack of accessible vocational education and training (VET) programs that incorporate bioeconomy principles, particularly for small and medium-sized enterprises (SMEs). **This gap is even more evident in Central and Eastern Europe, where the provision of lifelong learning opportunities remains limited, hindering the region's ability to develop a skilled workforce for the bioeconomy** (Paris et al., 2023; Thomchick et al., 2024).

Furthermore, existing bioeconomy education programs, particularly at the higher education level, **remain heavily theoretical.** These programs often **lack a focus on practical, experiential learning approaches, such as work placements and partnerships with industry.** Practical skills in sectors like forestry, agriculture, and bioproduct development are essential for bioeconomy professionals, but many academic programs fail to provide students with the real-world experience needed to succeed in these areas (Paris et al., 2023; Bioeconomy Education Topics, 2024).

There is also a significant gap in business and finance education related to the bioeconomy. The European Investment Bank highlights the difficulty bio-based industries face in accessing private capital, especially when scaling up from pilot projects to industrial-scale operations. **To address this, educational initiatives must be developed to equip professionals with the financial knowledge required to navigate the complexities of bioeconomy projects, including understanding regulatory frameworks and managing investment risks** (Bioeconomy Education Topics, 2024).

Additionally, regional disparities in access to bioeconomy education are evident, particularly in BIOEAST (CEE) countries. These regions often have fewer specialized bioeconomy programs, and the integration of sustainability into business education is underdeveloped compared to other parts of the EU. Addressing these disparities is essential for ensuring that all EU regions can contribute to and benefit from the growth of bioeconomy (Thomchick et al., 2024).

These findings unfortunately mirror results provided in the "Thematic Study of the BIOEAST Thematic Working Group on Bioeconomy Education." The study highlights the critical lack of interdisciplinary education, as many programs in BIOEAST countries remain narrowly focused on traditional agricultural or environmental sciences, failing to integrate broader disciplines. Similarly, the study identifies **lifelong learning** as a significant gap, emphasizing the absence of lifelong learning and vocational training programs, both of which are essential for keeping skills up to date in the rapidly evolving bioeconomy sectors. The thematic study also underscores the need for a stronger connection between academic programs and industry demands, particularly noting the underdevelopment of vocational training across the BIOEAST region. Furthermore, **business and finance education** represent another critical shortfall. The study calls for a greater emphasis on financial literacy, entrepreneurship, and market dynamics, particularly within bio-based industries. For more information about the Thematic study please refer to Annex 2. This is consistent with the broader literature, which similarly notes that bioeconomy programs often neglect the financial and market considerations necessary for successfully scaling up innovations.

To the above, it is necessary to underline the clear distinction between Education at all levels and vocational Training. This is still a clear weakness in the BIOEAST countries basically due to the lack of interest expressed from the BioBased Industry. It is therefore crucially important to enhance the Industry's interest and engagement in all educational perspectives.

STRATEGIC THEMATIC AREAS

There is a clear need for systematic mapping of the bioeconomy education landscape in the BIOEAST macro-region, including identifying and evaluating existing programs, structures, and synergies within educational initiatives. This mapping should align regional educational priorities with those of other areas, especially Western Europe, emphasizing key topics such as sustainable entrepreneurship and targeted programs for investors and managing authorities. Strengthening partnerships among universities, industry, and the public sector and focusing education around problem-based learning will equip the next generation with the cross-sectoral skills needed to manage sustainable supply chains for soil, water, climate, and biomass.

The BIOEAST UniNet can play a vital role in this effort by addressing educational needs, forecasting labor market demands, and supporting institutions in implementing bioeconomy programs. This includes lifelong learning, coaching, and peer review learning, as well as supervision for practical applications. Additionally, there is a need to develop pilot facilities and case studies to support student education and also adult retraining, reskilling, and upskilling, tailored to the region's strengths. Moreover, introducing vocational training suited to the region's natural resources will simplify the adaptation of new technologies, create new value chains, attract private investment, and foster an environment conducive to startups. To accelerate progress, additional projects should facilitate the exchange of best practice and success stories, bridging gaps between Western and Eastern Europe.

Additional to the above, operational priorities such as common courses, mobility of students and teachers, organization of dedicated events and summer schools, must be high in the agenda.

Finally, special courses and events for the responsible Educators should be considered so their capacity is accurate, competitive and the top state of the art

Main Research Topics

The following key research topics were identified.

RT 1: Mapping the Bioeconomy Education Landscape in the BIOEAST Macro-Region

This activity will systematically map existing bioeconomy education programs and structures, identifying synergies and gaps, particularly in interdisciplinary learning and lifelong education. It will assess current programs against regional needs and socio-economic dynamics, with a focus on **developing guidelines for policymakers** to better align education with bioeconomy priorities. Special attention will be given to regional disparities and tailoring educational initiatives to fit local contexts.

RT 2: Identifying Regional Priorities for Bioeconomy Education

A regional approach is essential for bioeconomy applicability. This activity will identify and specify educational programs that meet local needs, taking into account regional clusters, innovation systems, and labour market demands. By analysing demographics, environmental factors, and socio-economic characteristics, this RT will inform the **development of problem--based learning approaches that build cross-sectoral skills necessary for sustainable supply chains, enabling students and professionals to manage resources for soil, water, climate, and biomass.**

RT 3: Coordination of Actions and Facilitating the BIOEAST UniNet

This RT focuses on fostering partnerships across universities, industry, and the public sector to strengthen bioeconomy education. By facilitating collaboration with key networks (ICA, CoP, EBU, EC, BIC), and participating in international events, the BIOEAST UniNet will support joint projects (e.g., Erasmus+, Horizon Europe) and organise activities such as summer schools and conferences. This coordinated approach will allow the sharing of resources, knowledge, and best practices, enhancing bioeconomy education across the region.

RT 4: Emphasis on Vocational Training for Bioeconomy

This RT will focus on developing tailored vocational training for a wide spectrum of target groups, addressing the need for lifelong learning and hands-on training. Vocational programs will be designed to utilise the region's natural strengths, facilitating the adoption of new technologies, creation of new value chains, and attracting private investment. By incorporating case studies in freshwater management, soil resilience, water purification, and biogas refinement, these programs will provide practical, region-specific insights. This RT will also include **"Bioeconomy Living Labs and Training Farms"** for experiential learning, link universities, SMEs, and municipalities to co-develop real-life experiments and integrate **challenge-based learning**.

RT 5: Innovative Governance in Bioeconomy Education

This RT will explore how bioeconomy education frameworks can be integrated into broader governance structures, ensuring alignment with national and EU sustainability goals. This activity aims to support the establishment of bioeconomy education policies that facilitate sustainable transitions and enhance public sector engagement with bio-based innovations.

RT 6: Awareness-Raising & Knowledge Exchange

This topic targets the general public, value chain actors, and higher education institutions to promote awareness and facilitate knowledge exchange about the benefits of bioeconomy. By developing targeted awareness-raising campaigns and knowledge-sharing platforms, this RT will support the dissemination of best practices across sectors like agriculture, forestry, and bio-manufacturing. This will be crucial for bridging the gap between industry needs and educational outputs, supporting regional innovation and sustainable development.

RT 7: Development of Tutorials for Green Public Procurement and ESG

This RT will focus on creating **educational materials** to support green public procurement and foster a demand for bio-based products. Training modules will cover **sustainable purchasing decision factors**, including the environmental and social benefits of bio-based products, providing critical resources for both public and private sector procurement. This RT will also develop comprehensive tutorials and online modules for integrating environmental, social, and governance (ESG) principles into the operations of small and micro bioeconomy enterprises and provide relevant training.

RT 8: Development of Place-Based and Context-Specific Circular Bio-Based Business Models

This RT will focus on developing **circular bio-based business models** that reflect regional strengths and market conditions, supporting sustainable entrepreneurship and sustainable financing. By showcasing the social and environmental benefits of bio-based products, this activity aims to inspire new ventures and attract investment in the bioeconomy, helping establish the BIOEAST macro-region as a model of sustainable innovation.

RT 9: Sustainable Entrepreneurship and Financing

This RT emphasises sustainable financing and entrepreneurship, transitioning from a sectoral to a value-chain approach. It will support bioeconomy business education that focuses on scaling bio-based innovations and building an investment-friendly environment. Pilot facilities and in-depth case studies will be developed to provide training, retraining, and upskilling opportunities for students and professionals alike, ensuring a skilled workforce ready to drive bioeconomy growth across the region. This RT proposes the creation of a **short, high-impact training program—"Bioeconomy Executive School**"—for managers and decision-makers from SMEs, cooperatives, and public administrations. The program will focus on circular business models, ESG implementation, and financing tools for bio-based innovation.

RT 10: Digital Transformation in Bioeconomy Education

This RT focuses on integrating digital technologies into bioeconomy education to enhance learning, innovation, and cross-regional collaboration. It will incorporate tools such as artificial intelligence (AI), data analytics, precision farming technologies, and digital twins into educational curricula to better equip learners with future-oriented skills. In parallel, it will support the development of digital learning platforms and open-access resources to facilitate knowledge exchange across countries and institutions. Special attention will be given to the use of AI-driven learning analytics to personalise training pathways, improving the effectiveness and accessibility of bioeconomy and sustainability education.

CONCLUSION

Based on the analysis of bioeconomy education in the BIOEAST macro-region, several strategic challenges and gaps have been identified, underscoring the need for an updated and comprehensive educational approach to support the bioeconomy transition. One of the key issues is the lack of interdisciplinary education. Many current programs remain narrowly focused on specific disciplines, which limits the ability to address the complex, interconnected nature of bioeconomy. A multidisciplinary approach is essential, blending life sciences, economics, engineering, and social sciences, and focusing on preparing students with T-shaped skills—deep expertise in one area with the ability to integrate knowledge across other fields.

Another critical challenge is the gap in lifelong learning. Continuous education and vocational training are vital for reskilling and upskilling the workforce to meet the evolving demands of bio-based sectors. However, there is currently a shortage of such programs, particularly in vocational training and practical skills development, which are needed to complement the more theory--heavy educational offerings. The bioeconomy transition also requires a societal shift in behavior, driven by greater public awareness and an evidence-based adoption of new technologies. Education must play a central role in fostering this shift, preparing future generations to embrace the bioeconomy by linking economic growth with environmental sustainability.

The regional disparities in bioeconomy education are another challenge. The BIOEAST macro--region lags behind Western Europe in offering specialized bioeconomy programs and integrating sustainability into business and finance education. This disparity limits the region's ability to fully participate in and benefit from the growth of the bioeconomy. Additionally, the mismatch between education and industry needs is a recurring issue. Educational programs often fail to provide the practical, industry-relevant skills required by bio-based sectors. There is a pressing need for programs that align more closely with market demands and provide students with real-world experience. Finally, the lack of integration of business and finance education into bioeconomy programs is a significant barrier to the commercialization and scaling of bio-based innovations. Programs must focus on financial literacy, investment management, and market dynamics to prepare professionals for the complexities of the bioeconomy.

This revised set of RTs aligns with the goals of enhancing bioeconomy education through collaborative, interdisciplinary, and regionally-tailored approaches. By incorporating training, knowledge exchange, vocational education, and governance support, the RTs aim to build a resilient bioeconomy that leverages the unique strengths of the BIOEAST macro--region.

Addressing these challenges requires a multidisciplinary, flexible, and region-specific approach to bioeconomy education that promotes lifelong learning, fosters innovation, and aligns with the needs of both industry and society in the BIOEAST macro-region.

Implementation of the above-mentioned actions will support the public and industrial sector to align sustainability priorities with proper framework for bioeconomy education. The universities

and in general the education system will have capacity to significantly contribute to the understanding of bioeconomy. The BIOEAST Initiative and its TWG will be able to advance upon the above-mentioned challenges, continue acting and articulating the demands and specify needs while connecting policy makers and universities from the BIOEAST macro-region with the counterparts from all over Europe.

Key Takeaway for the EU Bioeconomy Strategy

To ensure the European Bioeconomy **Strategy** effectively supports a just and inclusive transition toward sustainability and innovation, bioeconomy education must be treated as a strategic enabler. Education systems must integrate interdisciplinary, practice-oriented, and regionally adapted approaches.

Specifically, the Commission should:

- Support financial instruments and incentives for education and skills development in bioeconomy, vocational training, and lifelong learning tailored to circular and bio-based industries**—especially in underrepresented regions such as BIOEAST macro-region.**
- **Support BIOEAST UniNet** as a bottom-up, community-anchored initiative to coordinate universities, vocational institutions, industry, and local authorities in co-creating curricula and educational resources aligned with regional innovation ecosystems.
- **Mainstream Bioeconomy Education into EU R&I strategic orientation and funding, especially under Horizon Europe, Erasmus+, and the Widening Participation actions—**prioritizing interdisciplinary, applied learning approaches that integrate life sciences, business, policy, and engineering
- **Boost research, innovation, and capacity-building in regions such as the BIOEAST macro-region**, which are uniquely positioned to pioneer **inclusive, region-specific education models** that reflect local natural resources, socio-economic dynamics, and sustainable value chains.
- *To consider, promote and encourage Universities and Educational Units to adopt alternative educational practices such as challenge-based learning, and to include lateral issues in a holistic approach.*

To accelerate progress, we need **additional projects that facilitate the exchange of best practices and success stories, helping to bridge the gap between Western and Eastern Europe.** Europe's Bioeconomy can only thrive through shared knowledge and cohesive efforts.

ABBREVIATIONS

- BIOEAST Initiative - CENTRAL AND EASTERN EUROPEAN INITIATIVE FOR KNOWLEDGE--BASED AGRICULTURE, AQUACULTURE AND FORESTRY IN THE BIOECONOMY
- Thematic SRIA EDU - Thematic Strategic and Research Agenda for the Bioeconomy Education of the BIOEAST macro-region
- TWG BE EDU - Thematic Working Group Bioeconomy Education

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Annex 1

Conference Bioeconomy Education: The BIOEAST perspective

The conference was structured into three sections: (1) The regional perspectives of the Bioeconomy education, (2) Presentation of the universities' profiles which signed the memorandum of understanding for a network of bioeconomy universities in the BIOEAST macro-region, and (3) Panel discussion focused on challenges and some practical steps to be taken in the near future.

The discussions highlighted the most prominent problems of the countries, namely the missing national level strategic thinking and action plans. Without political and policy priorities on bioeconomy, none of the countries will be able to take advantage of the benefits of a sustainable bioeconomy. Moreover, the education system cannot thrive, the industrial sector will not be able to align with the sustainability priorities. **Six years ago, the European Bioeconomy Universities alliance of bioeconomy universities from Western, Northern and South Europe, was established. The newly established BIOEAST Uni Net is meant to become a new ally.** Of course, this network is still open to other Universities from the CEE region to join.

The universities, and in general the education system can significantly contribute to the understanding of bioeconomy, but without political priority this development raises questions about the labour market development, innovation and research driven economy and societal understanding.

The conference highlighted the need to be better engaged in bioeconomy education development projects. This situation could further enlarge the disparities among EU macro-regions as a lot of activities are happening outside the BIOEAST macro-region. The European Commission supports the newly established BIOEAST Uni Net, and an encouragement to express the needs and demands was clearly conveyed. EBU and ICA-CoP declared support for the newly established BIOEAST Uni Net and offer cooperation. **The BIOEAST TWG Bioeconomy Education can advance upon the above-mentioned discussion, continue on acting and articulating the demands and specify needs, while connecting policy makers and universities from the BIOEAST macro-region with the counterparts from all over Europe.**

Annex 2

Thematic study Conclusion

The Thematic Study on Bioeconomy Education in the BIOEAST macro- region contributed substantially in both (i) perceiving the situation of the Bioeconomy Education in the region and (ii) providing a context on its dynamics and perspectives. At the end, the study provided suggestions structured in the form of an action plan for the improvement of this sector in the region.

More specifically, the study mapped and analyzed the needs and the expectations of several stakeholder groups, mainly from the Agri-Food sector, the Bio-based Industry, the Policy makers and the public administration and the private investors and money raising groups. These needs were expressed according to their importance but also according to their validity in a forecasting perspective. Finally, they were evaluated in a detailed spectrum of various domains and therefore demonstrating a significant profile on a regional and sectorial basis. Moreover, a similar analysis was conducted reflecting the existing capacity of the Educational Institutions in the whole macro-region also including all the different categories of the educational spectrum.

Next to the data collection a GAP analysis was executed considering both the needs versus the capacities. This approach gave a clear view of the potential in the current time and also in a short and mid-term basis. Finally, the study ended with a SWOT analysis evaluating Strengths, Weaknesses, Threats and Opportunities of the whole scheme.

The study concluded with a well justified action plan providing specific steps and paths for an effective strategy. This action plan provided elements for a consideration of various scenarios on a case-by-case basis providing elements on how to improve the whole Bioeconomy Education frame. More specifically, it was underlined that education must be transdisciplinary, including complex systems thinking. Diversification in education and learning requires the development of special programmes at each level of learning, from primary schools up to universities, and

training and knowledge communication to public audiences. Here, three levels of education can be distinguished in Bioeconomy:

- Education in primary and high schools: teaching principles, acting local and global at the same time and raising interest;
- At universities: where a systematic curriculum is needed, combining life science, engineering, economics and marketing, and enabling the dynamics for the development of transversal skills, capable of supporting the students to become Bioeconomy entrepreneurs or management. Most of the universities in the BIOEAST region cover to a great extent the Bioeconomy educational aspects, but through different faculties and/or modules, thus not providing comprehensive Bioeconomy education to the students;
- Vocational training: there is a need to match requirements for skills in various sectors involving regional and local actors. Vocational training should introduce some specific concepts and illustrate some practical examples.

Besides the solutions, the challenges must be addressed sustainably also in a way that makes economic sense. Research and educational organisations should form a synergic network with business and public bodies that works together on sustainable solutions for Bioeconomy education. Some of the key areas for providing a secure future for succeeding generations are:

- Addressing the gap between the capacity of educational organisation and needs of industry, agriculture practice and policy makers;
- Investment in relevant research areas, both within each of the sectors and by encouraging multidisciplinary programmes;
- Making entrepreneurship within the Bioeconomy a desirable career option;
- Providing a skilled workforce by making the various sectors of the bioeconomy attractive career options through secondary, tertiary and vocational education;
- Encouraging innovation to make sure that more of the knowledge developments reach the commercialisation stage.

SWOT analysis rooted the following recommendations:

STRENGTHS	WEAKNESSES
The capacity of educational organisations fully addresses the following needs of the agricultural practice, industry and policy-makers: exp. in project management; exp in bio-based-market knowledge, engagement capacity to involve different types of stakeholders, exp in bio-based-market knowledge; exp. in the techno-economic assessment of bio-based processes; exp. in development of new bio-based business models, exp. in circular bio-economy approaches, exp. in the enhancement of profitability of currently used business models, exp. in biomass potential assessment, exp. in the assessment of the geographical distribution of biomass/bioenergy potential (Exp. in GIS tools), exp. in raising social awareness for new bio-based products, exp in social innovations, exp in the social economy, exp. in attracting funding possibilities, exp. in new product design from bio-waste, exp in high productive technologies for traditional food sector.	The capacity of educational organisations does not sufficiently address the following needs of the agricultural practice, industry and policy-makers: exp in precision farming, Exp in feedstock-specific & market-driven cascade valorisation, exp in precision farming, Exp in feedstock-specific & market-driven cascade valorisation, exp in work with precision equipment for biomass harvest/collection, Exp in work with advanced ICT applications to logistic/storage, exp on advanced technologies to mildly extract or separate functional components, exp on design and operation of market flexible and feedstock adaptable multiproduct integrated bio-refineries, exp on new processes to improve bio-product yield (biogas yield, chemical yield, etc.) from bio-waste, exp in materials based on oils and fats from plants and animals (bio-based lubricants, surfactants, solvents), exp in new (chemical) building blocks from renewable resources.
OPPORTUNITIES	**THREATS**
There are opportunities for educational organisations to better address the following needs of the agricultural practice, industry and policy-makers: exp. in Life Cycle Assessment (LCA), exp. in methods for efficient and cost-effective biomass' production, exp. in nano and biotechnologies to be applied in medicine, exp in advanced pre-treatments at a harvest-storage stage, exp in secondary conversion processes of bio-based materials, exp in bio-based alternatives for existing polymers and innovative polymers from new bio-based monomers, exp in extraction techniques to obtain high added-value biomolecules from marine, agrifood or forest biomass for pharmaceutical, nutraceutical and cosmetic sectors, exp. in new functional bio-based materials and products: plastics, composites, based on lignin, starch, (nano-) cellulose or carbon fibres.	There are many educational needs that are sufficiently addressed with the existing educational capacity. However, educational organisations should look for a step future and improve the capacity needed to address the needs which would arise in the following years and decades. It is to expect, that new types of bioeconomy industries will strengthen in the BIOEAST region, and there is a great threat that the existing educational organisations will not be able to address the needs of those new industries. In addition to this, the BIOEAST region has a low number of educational agencies, which are the key organisations for life-long learning.

This document is confidential and represent a text for the internal discussion among TWG BE Edu members

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