BIOECONOMY EDUCATION THEMATIC STUDIES #2

BIOECONOMY EDUCATION IN THE BIOEAST COUNTRIES

THEMATIC STUDY OF THE BIOEAST THEMATIC WORKING GROUP ON BIOECONOMY EDUCATION

Bioeconomy education in the BIOEAST countries

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1. Introduction

The European Commission has set a long-term goal to develop a resource-efficient, competitive and low carbon economy by 2050. This new concept is called 'bioeconomy', and it has been recognized as a key element for smart and green growth in Europe. The term 'bioeconomy' stands for all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. Bioeconomy includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services. It tends to help deliver global food security, improve nutrition and health, create smart bio-based products and biofuels, and help agriculture, forestry, aquaculture and other ecosystems to adapt to climate change. The transition from a dependence on fossil fuels to a situation where agriculture not only will continue to provide food security but also biomass as a renewable raw material for the industry will be the basis of the coming integrated Bioeconomy.

The bioeconomy builds on cross-fertilizations and mutual understanding between various economic sectors, disciplines and governmental, administrative, industrial and societal stakeholders. It requires a wide spectrum of scientific disciplines and technical expertise, as it involves multi-disciplines and is cross-sectoral. The existing role of bio-based sectors is expected to strengthen in the next years, while non-conventional biobased sectors (such as healthcare, automotive, constructions, etc.) are driving the transformation with leverage effects towards the whole bioeconomy. To strengthen the role of existing bio-based sectors and drive the transformation of non-conventual bio-based sectors, a new generation of workers and experts, adapted to the current needs and ready for future needs, is needed. A dedicated bioeconomy education means to satisfy these emerging needs and to prepare this new skilled generation of the working force. Many higher education institutions across Europe have recognised these challenges and opportunities, and work improving their curriculum, to be able to provide the knowledge and expertise for future bioeconomy specialists.

1.1. Objectives

The main objective of this thematic study is to present the current status of bioeconomy education in the BIOEAST region. The BIOEAST region consists of eleven countries: Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia. This study is divided into four sections. The first section provides the initial mapping of the current and future needs of agricultural practice, industry and policy makers in the BIOEAST region. This section represents both the needs in the terms of expertise, as well as research needs related to different aspects of bioeconomy. In addition, it presents the goals of the strategic documents regarding the Bioeconomy. The second section presents the mapping of the capacity of educational organisations, namely: high schools, Faculties/Universities and educational organisations. The third sections present a gap analysis conducted in accordance with the needs of the agricultural practice, industry and policy makers, analysed in the first section, and the capacity of educational organisations analysed in the second section. The thematic study concludes with an action plan for the BIOEAST region on how to improve common actions in bioeconomy. It includes directions on how to improve common actions in bioeconomy in the BIOEAST region, pathway how to cooperate with the European Bioeconomy

University and actions how to implement tailored training in bioeconomy to support the implementation of it in the BIOEAST region.

1.2. Study methodology and concept

The study methodology used for the development of this thematic study can be divided into three groups:

1) **Desk research and analysis-** in the scope of the BIOEAST project, numerous deliverables were developed, that includes material very relevant for bioeconomy in the BIOEAST region. This study is built on those materials, but goes into more details regarding educational capacity and needs regarding the bioeconomy education, in each of the BIOEAST countries. In addition to the deliverables developed in the scope of the BIOEAST project, the documents related to the bioeconomy educations developed in other EU projects (such as those under the BBI Lift initiative) were consulted. To define the goals of the strategic EU documents, numerous bioeconomy related strategic documents, such as the EU Green deal, the Circular Economy Action Plan, the Bioeconomy strategy, etc. were consulted. In addition to this, the most relevant scientific peer-reviewed articles and books were consulted.
2) **Questionnaire collection and input analysis**- the core of this thematic study is the analysis of the input received by the representatives of agriculture practice, industry, policy makers and educational organisations located in the BIOEAST region. To collect this input, two surveys were developed in the EU Survey portal: 1) **Survey on needs of agricultural practice, industrial sector and policy makers**; 2) **Survey on the existing capacity of educational institution**s. The first survey targeted representatives of agricultural practice, industrial sector and policy sector (mostly ministries), while the second survey targeted representatives of high schools, Faculties/Universities and educational organisations. In the first survey, responders were asked **to define the importance of different biobased competence** listed in the survey and to rank the importance of different bio-economy needs. In the second survey, representatives of educational organisations were asked t**o define to what extent does the curriculum** of the educational institution they are representing **includes in the topics whose objective is to provide the competencies** listed in the survey and to what extent does the curriculum of their organisation includes the topics needed to address needs of the bioeconomy regarding different categories (circular bioeconomy, climate and environmental protection, social/economic challenges and impacts).
3) **Consultations with TWG members and coordinators-** this study was developed in strong collaboration with the BIOEAST Bioeconomy Education thematic working group, which was involved in the revision of the surveys developed for this thematic study, as well as the revision of the thematic study.

2. Initial mapping of needs of agricultural practice, industry and policy makers

Skills are also essential for a successful transition to a sustainable and inclusive high-employment bioeconomy. This section presents a common overview of the bioeconomy related needs in the BIOEAST region. It is based on the online surveys developed for this thematic study, filled by representatives of agricultural practice, industry and policymakers in each of the countries of the BIOEAST region.

In the scope of this survey, the target group was asked to indicate how important do the needs listed in the table above, for their sector. The selected options and weighting factors used for analysis are the following:

Not important	Moderately important	Important	Very important
0	33	66	100

2.1. Needs of agricultural practice

The table below presents the analysed and weighted input obtained from the representatives of agricultural practice.

Expertise	BG	HR	CZ	HU	LV	LT	RO	SK	SL	AVG
Exp. in project management	66	100	100	100	83	100	100	33	83	85
Exp. in Life Cycle Assessment (LCA)	59	100	66	66	50	100	100	66	75	76
Engagement capacity to involve different types of stakeholders	80	83	33	100	66	100	100	66	83	79
Exp in bio-based-market knowledge	86	66	66	66	50	100	66	33	75	68
Exp. in techno-economic assessment of bio-based processes	73	66	100	66	50	100	66	33	83	71
Exp. in development of new bio-based business models	73	100	33	66	66	100	66	66	92	74
Exp. in circular bio-economy approaches	59	100	66	100	92	100	66	33	92	79
Exp. in enhancement of profitability of currently used business models	92	83	33	100	92	100	100	100	75	86
Exp. in biomass potential assessment	80	83	66	100	66	100	66	100	92	84
Exp. in the assessment of geographical distribution of biomass/bioenergy potential (Exp. in GIS tools)	66	66	33	-	75	100	66	66	66	67
Exp. in methods for efficient and cost-effective biomass' production	73	83	100	100	83	100	66	100	75	87

Expertise	BG	HR	CZ	HU	LV	LT	RO	SK	SL	AVG
Exp. in raising social awareness for new bio-based products	73	66	66	100	41	100	66	33	66	68
Exp in social innovations	66	66	66	66	22	100	66	66	50	63
Exp in social economy	66	49.5	66	33	41	100	66	66	50	60
Exp. in attracting funding possibilities	86	66.5	66	66	66	100	66	100	83	78
Exp. in new product design from bio-waste	66	66	66	33	33	66	100	66	83	64
T. Exp in high productive technologies for traditional food sector	60	83	66	66	83	66	66	100	92	76
T. Exp in advanced pre-treatments at harvest-storage stage	83	66	33	100	92	66	-	100	83	78
T. Exp in precision farming	92	66	66	100	100	100	-	100	83	88
T. Exp in feedstock-specific & market-driven cascade valorisation	83	83	33	-	89	66	66	66	83	71
T. Exp in work with precision equipment for biomass harvest/collection	73	66	33	100	92	100	66	66	75	75
T. Exp in work with advanced ICT applications to logistic/storage	66	49.5	33	66	77	100	66	66	83	67
T. Exp on advanced technologies to mildly extract or separate functional components	0	-	33	100	66	66	66	66	58	57
T. Exp on design and operation of market flexible and feedstock adaptable multiproduct integrated bio-refineries	66	33	33	66	58	66	66	66	75	59
T. Exp on new processes to improve bio-product yield (biogas yield, chemical yield, etc) from bio-waste	60	83	33	66	67	66	100	33	66	64
T. Exp in secondary conversion processes of bio-based materials	-	-	33	66	66	66	100	66	66	66
T. Exp in materials based on oils and fats from plants and animals (bio-based lubricants, surfactants, solvents)	73	66	33	-	50	33	100	66	66	61
T. Exp in bio-based alternatives for existing polymers and innovative polymers from new bio-based monomers	58	66	33	100	66	33	66	33	58	57

In accordance with the analysed and weighted input obtained from the representatives of agricultural practice, a ranking of the competencies was performed for the BIOEAST region. The results are presented in Figure 1.

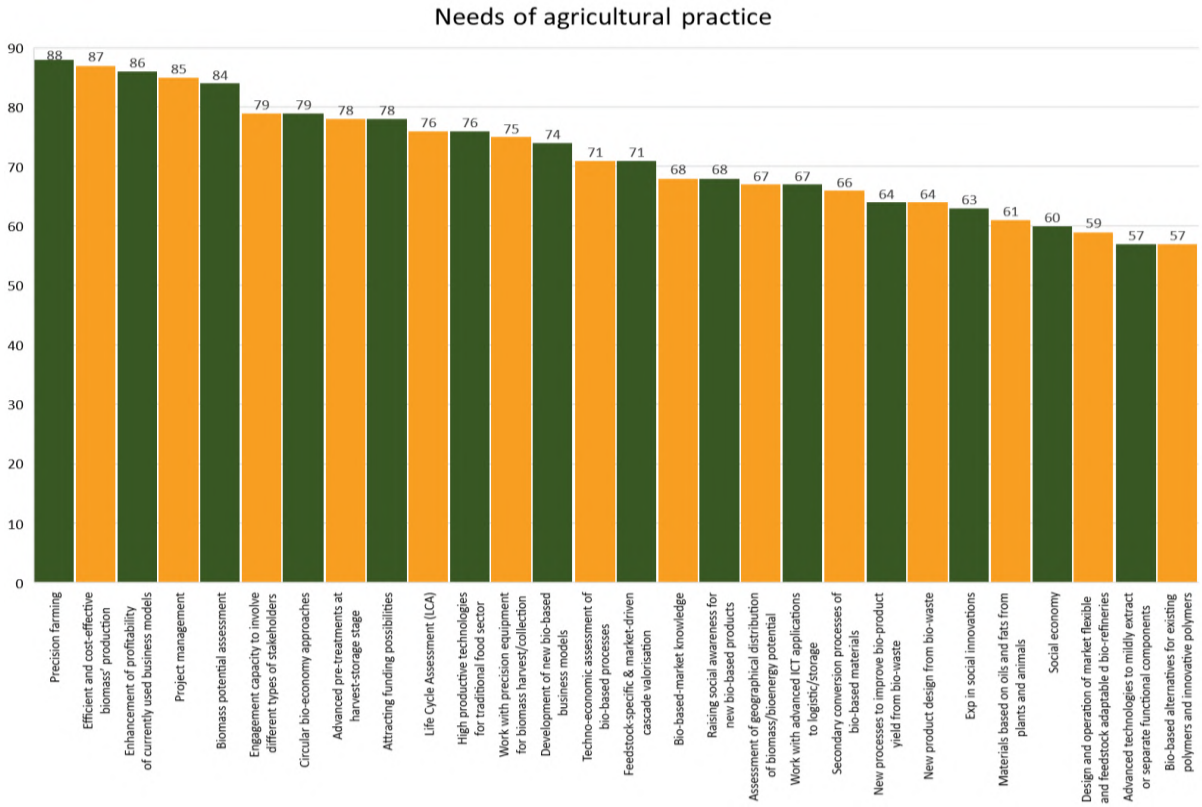


Figure 1: **Ranked competencies of agricultural practice**

As can be seen from, representatives of agricultural practice highlighted technical expertise in precision farming, expertise in methods for efficient and cost-effective biomass' production and expertise in the enhancement of profitability of currently used business models as the most important competencies.

In addition to the skills and competencies listed above, the representatives of agriculture practice were asked to write at least one additional skill/competence, which they consider currently important, important in the next year and important by 2030 for their sector. They provided the following skills/competence:

Currently important

- technical expert analyst on know-how system should work;
- expertise in innovative circular economy learning and knowledge transfer systems;
- knowledge on the agricultural policy;
- good practice examples;
- teamwork;
- multisectoral approach application;
- knowledge of simple biology and circulation of substances in nature;
- a holistic approach of the system;
- leadership skills.

Important in the next few years

- technical expertise in strategies;
- selecting and using methods and procedures appropriate for the situation;
- building a digital tool for calculating agricultural waste and its re-use;

- be actively involved in progress with policy making on the topic;
- practice, training;
- communication skills;
- knowledge on policies and strategies for bioeconomy deployment;
- work with big data and structuring it, hands-on skills, multidisciplinary approach;
- communication, networking skills.

Important by 2030

- knowledge of policies, procedures and strategies to promote on local, state and national level;
- increasing and improving the capacity of the labour market workforce for the needs and demands of the bioeconomy;
- reducing GHG emissions;
- digitalisation (not only precision farming); Knowledge of ecological boundaries;
- regeneration agriculture;
- knowledge exchange and transfer;
- communication and networking;
- adaptability.

2.2. Needs of industry

The table below presents the analysed and weighted input obtained from the representatives of bio-based industry.

Expertise	The bioeconomy	Bio-based electricity	Bio-based chemicals, pharmaceuticals, plastics and rubber	Food, beverage and tobacco	Liquid biofuels	Manufacture of biobased goods	AVERAGE
Exp. in project management	100	100	66	100	100	100	94
Exp. in Life Cycle Assessment (LCA)	100	100	100	66	100	100	94
Engagement capacity to involve different types of stakeholders	100	33	33	100	100	100	78
Exp in bio-based-market knowledge	66	33	100	100	100	100	83
Exp. in techno-economic assessment of bio-based processes	66	100	100	100	100	100	94
Exp. in development of new bio-based business models	66	100	100	100	66	33	78
Exp. in circular bio-economy approaches	66	100	100	66	66	66	77
Exp. in enhancement of profitability of currently used business models	100	100	100	66	100	33	83
Exp. in biomass potential assessment	66	100	100	66	100	100	89
Exp. in the assessment of geographical distribution of biomass/bioenergy potential (Exp. in GIS tools)	66	100	100	66	33	N/A	73
Exp. in methods for efficient and cost-effective biomass' production	66	66	100	33	100	33	66

Expertise	The bioeconomy	Bio-based electricity	Bio-based chemicals, pharmaceuticals, plastics and rubber	Food, beverage and tobacco	Liquid biofuels	Manufacture of biobased goods	AVERAGE
Exp. in raising social awareness for new bio-based products	66	33	100	66	100	66	72
Exp in social innovations	66	33	66	100	66	N/A	66
Exp in social economy	66	33	66	100	66	N/A	66
Exp. in attracting funding possibilities	66	100	100	-	100	66	86
Exp. in new product design from bio-waste	100	66	100	100	0	100	78
T. Exp in high productive technologies for traditional food sector	66	N/A	33	100	33	N/A	58
T. Exp in feedstock-specific & market-driven cascade valorisation	66	100	33	100	33	N/A	66
T. Exp in work with advanced ICT applications to logistic/storage	66	66	100	N/A	33	N/A	66
T. Exp on advanced technologies to mildly extract or separate functional components	66	N/A	100	-	66	66	75
T. Exp on design and operation of market flexible and feedstock adaptable multi-product integrated bio-refineries	66	100	100	-	100	66	86
T. Exp on new processes to improve bio-product yield (biogas yield, chemical yield, etc) from bio-waste	100	100	66	100	33	33	72
T. Exp in secondary conversion processes of bio-based materials	100	66	66	66	-	33	66
T. Exp in materials based on oils and fats from plants and animals (bio-based lubricants, surfactants, solvents)	100	N/A	100	66	N/A	-	89
T. Exp in bio-based alternatives for existing polymers and innovative polymers from new bio-based monomers	66	N/A	33	66	0	100	53
T. Exp in extraction techniques to obtain High added-value biomolecules from marine, agrifood or forest biomass for pharmaceutical, nutraceutical and cosmetic sectors	66	N/A	100	66	-	66	75
T. Exp in new (chemical) building blocks from renewable resources.	66	N/A	33	N/A	-	66	55
T. Exp in new functional bio-based materials and products: plastics, composites, based on lignin, starch, (nano-) cellulose or carbon fibres	66	N/A	33	-	0	100	50

In accordance with the analysed and weighted input obtained from the representatives of the industry, a ranking of the needed competencies was performed for the BIOEAST region. The results are presented in Figure 2.

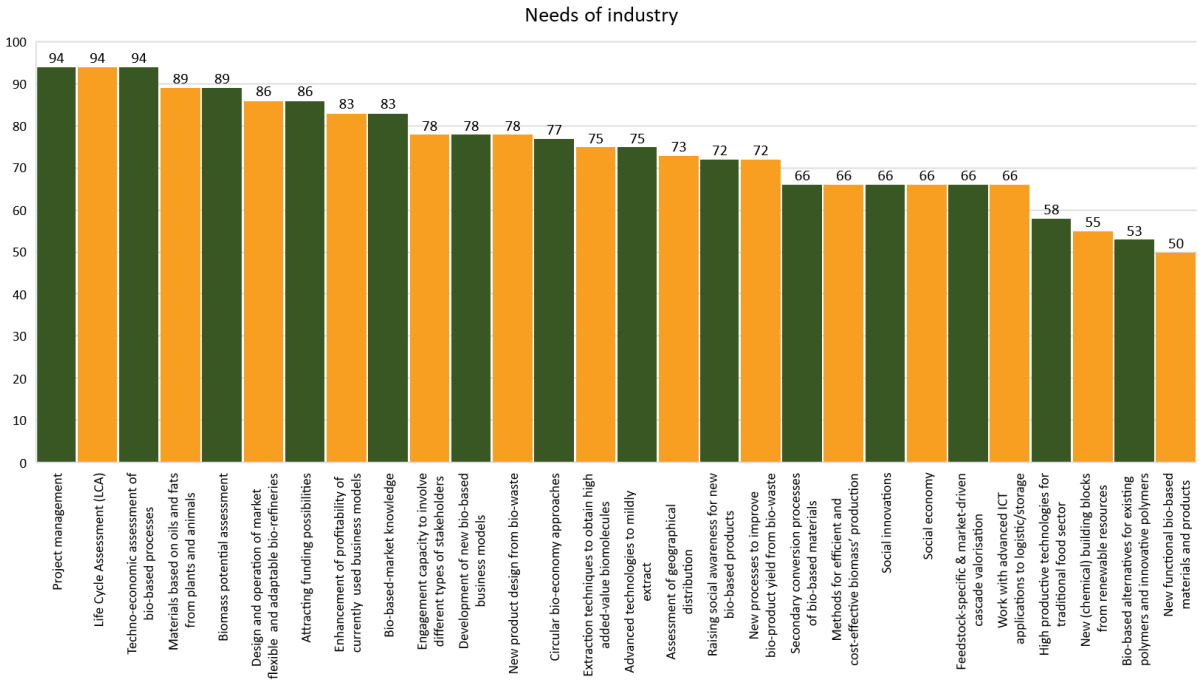


Figure 2: **Ranked competencies of industry**

As can be seen from Figure 2, representatives of the industry highlighted expertise in project management, expertise in Life Cycle Assessment (LCA) and expertise in the techno-economic assessment of bio-based processes as the most important competencies.

In addition to the skills and competencies listed above, the representatives of the industry were asked to write at least one additional skill/competence, which they consider currently important, important in the next year and important by 2030 for their sector. They provided the following skills/competence:

Currently important

- expertise in applying to EU funds;
- desire to learn;
- nanotechnologies
- sustainable development goals in entrepreneurship;
- understanding the basic concepts of the circular economy;
- stakeholder management and lobbing.

Important in the next few years

- expertise in making biomass and biogas plants economically feasible after a feed-in period;
- ability to keep up with innovations;
- biomedicine and nanotechnologies;
- digitalization;
- integration of different economy sectors into regional/global bio-based economy;
- funding expertise.

Important by 2030

- expertise in the involvement of biomass power plants in the electricity balancing market;
- ability to create new, innovative products;
- biomedicine, nanotechnologies;
- technical expertise in the biotransformation of bio-based materials.

2.3. Needs of policy makers

The table below presents the analysed and weighted input obtained from the policy makers of the BIOEAST macro-region.

Expertise	BG	HR	HU	LV	SK	SL	AVG
Exp. in project management	89	78	100	66	66	66	78
Exp. in Life Cycle Assessment (LCA)	100	77	66	66	66	100	79
Engagement capacity to involve different types of stakeholders	89	89	100	100	100	100	96
Exp in bio-based-market knowledge	100	77	66	66	66	66	74
Exp. in techno-economic assessment of bio-based processes	89	44	66	66	66	66	66
Exp. in development of new bio-based business models	100	78	66	66	66	100	79
Exp. in circular bio-economy approaches	89	100	100	66	66	100	87
Exp. in enhancement of profitability of currently used business models	89	66	100	66	66	33	70
Exp. in biomass potential assessment	89	100	100	66	66	100	87
Exp. in the assessment of geographical distribution of biomass/bioenergy potential (Exp. in GIS tools)	89	89	-	66	66	66	75
Exp. in methods for efficient and cost-effective biomass' production	100	100	100	66	66	100	89
Exp. in raising social awareness for new bio-based products	89	89	100	66	66	-	82
Exp in social innovations	50	83	66	66	66	-	66
Exp in social economy	55	77	33	66	66	-	59
Exp. in attracting funding possibilities	83	77	66	100	55	66	75
Exp. in new product design from bio-waste	100	77	33	66	-	100	75
T. Exp in high productive technologies for traditional food sector	89	89	66	66	66	100	79
Exp. in nano and biotechnologies to be applied in medicine	66	50	-	66	-	-	61
T. Exp in advanced pre-treatments at harvest-storage stage	50	66	100	66	66	100	75
T. Exp in precision farming	66	66	100	66	66	100	77

Expertise	BG	HR	HU	LV	SK	SL	AVG
T. Exp in feedstock-specific & market-driven cascade valorisation	50	66	-	66	77	100	72
T. Exp in work with precision equipment for biomass harvest/collection	77	77	100	66	66	100	81
T. Exp in work with advanced ICT applications to logistic/storage	83	77	66	66	66	100	76
T. Exp on advanced technologies to mildly extract or separate functional components	66	66	100	66	66	100	77
T. Exp on design and operation of market flexible and feedstock adaptable multiproduct integrated bio-refineries	66	55	66	66	66	100	70
T. Exp on new processes to improve bio-product yield (biogas yield, chemical yield, etc) from bio-waste	77	77	66	66	77	100	77
T. Exp in secondary conversion processes of bio-based materials	66	77	66	66	66	66	68
T. Exp in materials based on oils and fats from plants and animals (bio-based lubricants, surfactants, solvents)	66	77	-	66	77	66	70
T. Exp in bio-based alternatives for existing polymers and innovative polymers from new bio-based monomers	66	50	100	66	55	100	73
T. Exp in extraction techniques to obtain High added-value biomolecules from marine, agrifood or forest biomass for pharmaceutical, nutraceutical and cosmetic sectors	89	89	66	66	66	66	74
T.Exp in new (chemical) building blocks from renewable resources	83	66	-	66	66	100	76
T. Exp in new functional bio-based materials and products: plastics, composites, based on lignin, starch, (nano-) cellulose or carbon fibres	66	89	66	66	66	100	76

In accordance with the analysed and weighted input obtained from the policy makers, a ranking of the competencies was performed for the BIOEAST region. The results are presented in Figure 3.

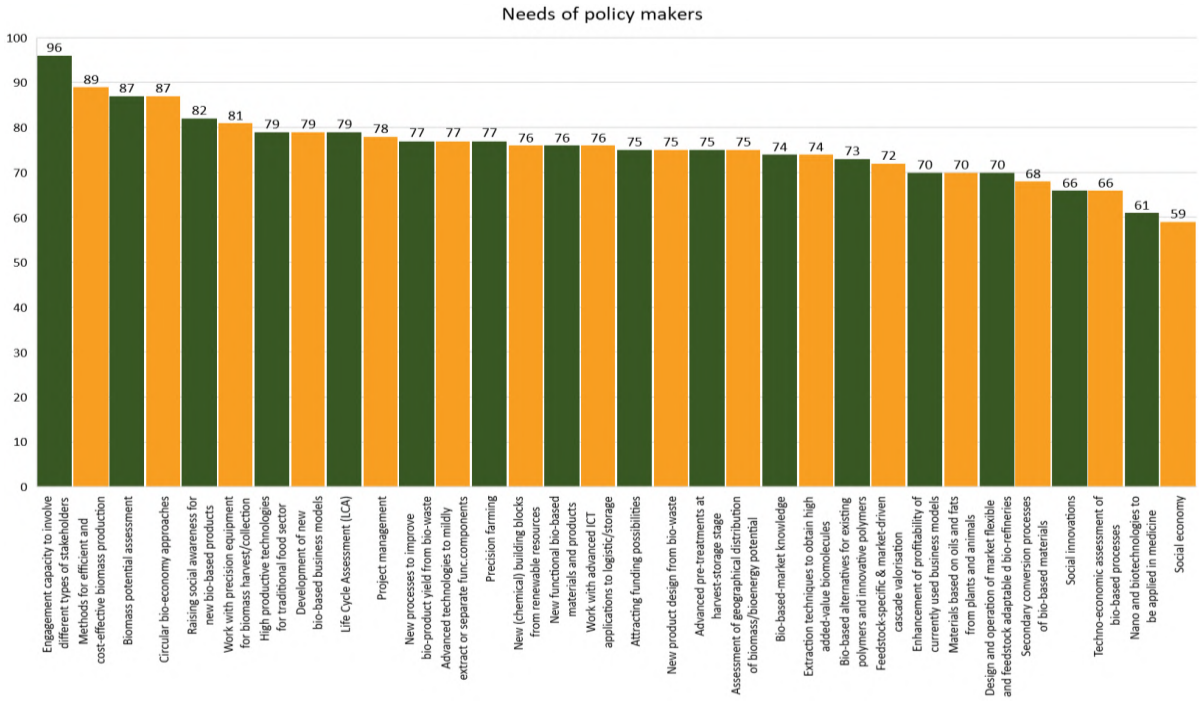


Figure 3: **Ranked competencies of policy makers**

As can be seen from Figure 3, representatives of policy makers highlighted engagement capacity to involve different types of stakeholders, expertise in methods for efficient and cost-effective biomass' production and expertise in biomass potential assessment as the most important competencies.

In addition to the skills and competencies listed above, the policy makers were asked to write at least one additional skill/competence, which they consider currently important, important in the next year and important by 2030 for their sector. They provided the following skills/competence:

Currently important

- expertise in innovative circular economy learning and knowledge transfer systems;
- environmental impacts (boundaries) to bioeconomy, green taxation schemes, valorisation/ certification;
- proposal/project writing, finding and working with partners on projects, understanding of innovation ecosystems, dissemination;
- expertise in the assessment of environmental impacts and sustainability; exp. in multi actors' cooperation and systems approach;
- flexibility and adoption of new technologies and innovations and skills to be applied in production and life;
- networking and collaboration expertise;
- strategic partnerships;
- in methods for efficient and cost-effective biomass production - consultants in the field of construction of biorefineries on the farms of primary biomass producers;
- expertise with working with new system TRACES for control bodies;
- teaching skills.

Important in the next few years

- building a digital tool for calculating agricultural waste and its reuse;
- certification of bioeconomy related products, environmental impacts of bioeconomy, legal framework, innovative financial schemes - green taxation, monitoring and evaluation (common set of EU indicators to monitor the true transition to bioeconomy);
- open science;
- the options mentioned above will be still actual;
- flexibility and adoption of new technologies and innovations and skills to be applied in production and life;
- interdisciplinary and intersectoral cooperation;
- circular business models;
- competence in developing technologies for obtaining biobased, recyclable and degradable products;
- expertise to find what is market needs for bioproducts;
- teaching skills.

Important by 2030

- increasing and improving the capacity of the labour market workforce for the needs and demands of the bioeconomy;
- artificial intelligence systems, BigData technologies;
- fast learning of new digital tools, artificial intelligence;
- expertise in scaling up solutions to achieve carbon neutrality goals;
- flexibility and adoption of new technologies and innovations and skills to be applied in production and life;
- the importance of interdisciplinary skills will improve;
- innovations;
- expertise in the development of high-performance technologies in the food sector;
- expertise to use the energy for crowing the crops with a minimum of energy;
- teaching skills.

2.4. Needs of money-raising institutions

The role of bioeconomy sectors has strengthened in the last decades and it is expected to continue the growth in the upcoming years. Therefore, investments in bioeconomy sectors are attracting the attention of money-raising institutions and this stakeholder group is having an important role in the bioeconomy sector.

3. Initial mapping of existing capacity of education institutions

In the scope of this survey, the target group was asked to what extent does the curriculum of their organisation includes the topics whose objective is to provide the competence listed in the table below.

The possible options and weighting factors used for analysis are:

Not at all	Only a little	To some extent	Rather much	To a great extent
0	25	50	75	100

3.1. Existing capacity of universities

The table below presents the analysed and weighted input obtained from the representatives of universities.

Expertise	BG	HR	CZ	EE	HU	LV	LT	RO	SK	SL	AVG
Exp. in project management	88	75	100	75	100	85	75	63	63	50	77
Exp. in Life Cycle Assessment (LCA)	38	58	75	50	50	69	75	38	58	38	55
Engagement capacity to involve different types of stakeholders	63	42	50	75	25	80	75	63	58	46	58
Exp in bio-based-market knowledge	63	30	50	75	0	90	75	50	63	42	54
Exp. in techno-economic assessment of bio-based processes	63	56	75	75	50	85	75	50	67	60	66
Exp. in development of new bio-based business models	38	25	25	75	0	80	75	38	67	44	47
Exp. in circular bio-economy approaches	50	54	50	100	50	80	75	50	58	42	61
Exp. in enhancement of profitability of currently used business models	75	30	25	50	75	65	75	63	58	35	55
Exp. in biomass potential assessment	75	67	25	100	25	85	75	38	75	60	63
Exp. in the assessment of geographical distribution of biomass/bioenergy potential (Exp. in GIS tools)	75	58	0	100	N/A	65	50	0	38	46	48
Exp. in methods for efficient and cost-effective biomass' production	75	38	50	75	25	75	50	25	63	46	52
Exp. in raising social awareness for new bio-based products	50	38	50	75	-	80	75	38	44	50	56
Exp in social innovations	38	33	50	75	0	85	75	38	31	33	46
Exp in social economy	50	25	50	75	25	85	50	50	50	33	49
Exp. in attracting funding possibilities	63	46	100	50	-	80	50	25	63	45	58
Exp. in new product design from bio-waste	50	60	75	75	25	65	25	13	44	45	48

Expertise	BG	HR	CZ	EE	HU	LV	LT	RO	SK	SL	AVG
T. Exp in high productive technologies for traditional food sector	88	55	50	75	50	85	50	50	67	50	62
Exp. in nano and biotechnologies to be applied in medicine	100	35	25	50	75	25	-	0	50	50	46
T. Exp in advanced pre-treatments at harvest-storage stage	100	50	25	75	50	60	50	25	50	42	53
T. Exp in precision farming	88	20	0	50	N/A	75	50	13	38	42	42
T. Exp in feedstock-specific & market-driven cascade valorisation	50	6	0	75	50	55	25	13	0	40	31
T. Exp in work with precision equipment for biomass harvest/collection	63	8	25	50	-	60	50	0	25	40	36
T. Exp in work with advanced ICT applications to logistic/storage	50	19	0	50	25	60	25	13	63	30	34
T. Exp on advanced technologies to mildly extract or separate functional components	100	45	0	50	75	50	0	0	50	50	42
T. Exp on design and operation of market flexible and feedstock adaptable multiproduct integrated bio-refineries	25	44	25	50	25	40	0	50	13	38	31
T. Exp on new processes to improve bio-product yield (biogas yield, chemical yield, etc) from bio-waste	38	50	0	50	25	60	25	38	25	50	36
T. Exp in secondary conversion processes of bio-based materials	38	44	50	50	25	60	25	38	50	50	43
T. Exp in materials based on oils and fats from plants and animals (bio-based lubricants, surfactants, solvents)	75	31	25	25	25	56	0	0	33	40	31
T. Exp in bio-based alternatives for existing polymers and innovative polymers from new bio-based monomers	25	44	75	25	25	38	-	0	38	45	35
T. Exp in extraction techniques to obtain High added-value biomolecules from marine, agrifood or forest biomass for pharmaceutical, nutraceutical and cosmetic sectors	50	45	50	50	50	44	-	50	50	55	49
T. Exp in new (chemical) building blocks from renewable resources.	0	35	25	25	-	50	0	25	58	38	28
T. Exp in new functional bio-based materials and products: plastics, composites, based on lignin, starch, (nano-) cellulose or carbon fibres	0	50	75	25	25	35	-	38	50	55	39

In accordance with the analysed and weighted input obtained from the representatives of universities, the capacity of the universities to provide the bio-economy related competence was ranked for the BIOEAST region. The results are presented in Figure 4.

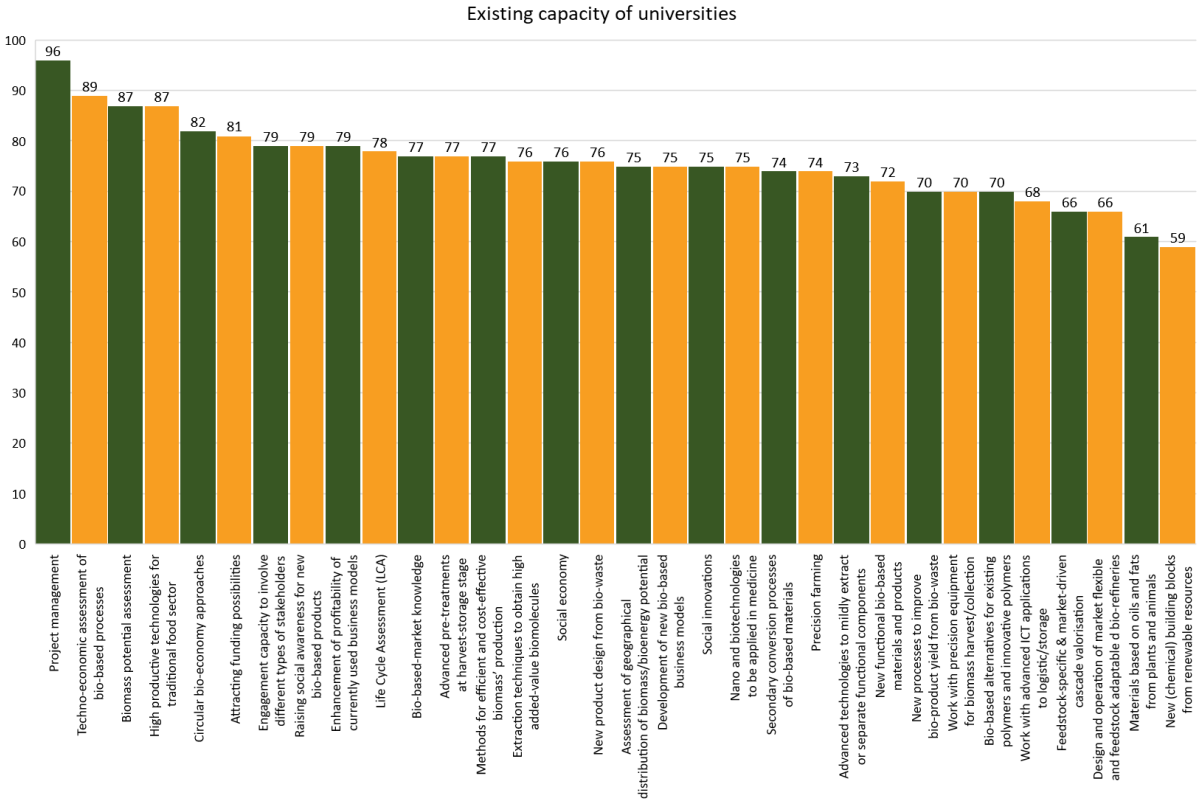


Figure 4: **Ranked capacity of universities**

As can be seen from Figure 4, universities have the greatest capacity to provide competence in project management, expertise in techno-economic assessment of bio-based processes and expertise in biomass potential assessment.

3.2. Existing capacity of high schools

The representatives of high schools were also asked to fill out the survey and indicate the capacity of the high school they are representing. However, as many of the respondents did not consider that the high school they are representing includes topic related to bioeconomy, the number of respondents were low and therefore the table below presents the average weighted results.

Expertise	AVG
Exp. in project management	33
Exp. in Life Cycle Assessment (LCA)	38
Engagement capacity to involve different types of stakeholders	25
Exp in bio-based-market knowledge	50
Exp. in techno-economic assessment of bio-based processes	38
Exp. in development of new bio-based business models	38
Exp. in circular bio-economy approaches	75
Exp. in enhancement of profitability of currently used business models	25
Exp. in biomass potential assessment	13
Exp. in the assessment of geographical distribution of biomass/bioenergy potential (Exp. in GIS tools)	0

Expertise	AVG
Exp. in methods for efficient and cost-effective biomass' production	0
Exp. in raising social awareness for new bio-based products	8
Exp in social innovations	25
Exp in social economy	25
Exp. in attracting funding possibilities	13
Exp. in new product design from bio-waste	0
T. Exp in high productive technologies for traditional food sector	13
Exp. in nano and biotechnologies to be applied in medicine	8
T. Exp in advanced pre-treatments at harvest-storage stage	13
T. Exp in precision farming	0
T. Exp in feedstock-specific & market-driven cascade valorisation	13
T. Exp in work with precision equipment for biomass harvest/collection	0
T. Exp in work with advanced ICT applications to logistic/storage	13
T. Exp on advanced technologies to mildly extract or separate functional components	13
T. Exp on design and operation of market flexible and feedstock adaptable multiproduct integrated bio-refineries	13
T. Exp on new processes to improve bio-product yield (biogas yield, chemical yield, etc) from bio-waste	0
T. Exp in secondary conversion processes of bio-based materials	0
T. Exp in materials based on oils and fats from plants and animals (bio-based lubricants, surfactants, solvents)	0
T. Exp in bio-based alternatives for existing polymers and innovative polymers from new bio-based monomers	0
T. Exp in extraction techniques to obtain High added-value biomolecules from marine, agrifood or forest biomass for pharmaceutical, nutraceutical and cosmetic sectors	0
T. Exp in new (chemical) building blocks from renewable resources.	0
T. Exp in new functional bio-based materials and products: plastics, composites, based on lignin, starch, (nano-) cellulose or carbon fibres	0

3.3. Existing capacity of educational agencies

The number of responses collected in the scope of this survey collection was not sufficient to lead to relevant conclusions. Therefore, desk research was performed. In the scope of the UrBIOfuture project (urbiofuture.eu), an exploration to identify map educational programmes related to the biobased industry for each country of the European Union was carried out and a platform that includes this information was developed This platform includes the educational programmes at VET (Vocational education and training), Undergraduate and PhD level. The platform included the list of VET programmes in the Czech Republic, Latvia, Lithuania, Poland, but did not include any VET programmes available in Bulgaria, Croatia, Estonia, Hungary, Romania, Slovakia, Slovenia. The mapped VET programmes are presented in the table below.

Country	Name of educational programme	Name of the institution
Czech Republic	Ecology and environment	Střední odborná škola a Střední odborné učiliště
	Ecology and environmental protection, Food analysis	Vos, SPS a Sos Podskalska
	Ecology and environment	Albrechtova střední škola
	Ecology and environment	Church Elementary School Plzeň
Latvia	Environment technician	Mechanics and Technology College of Olaine
	Food quality inspector	
	Biotechnologist assistant	
Lithuania	Nanotechnology and Environmental Protection	Kaunas University of Technology
	Methods in Molecular Genetics	Baltic Summer University
	Investigation of Biodiversity	
Poland	Microbiology	BIOMAXIMA
	Environment Protection	Lublin counselling and training centre

The following conclusions can be made regarding the capacity of educational organisations in the BIOEAST region:

- There is a lack of data on educational agencies in the BIOEAST region, that provides vocational education and training related to bioeconomy education. This is mostly due to a small number of educational agencies in BIOEAST countries, as the BIOEAST region is underperforming in life-long learning practice, in comparison to other EU countries (more detailed description is provided in Section Action plan)
- The educational programmes on the VET level are, in most cases, not specifically focused on bioeconomy education. As can be seen from the table above, most of those programs are either covering more general topics where bioeconomy presents one part of the topic (such as ecology and environment, environment protection).

3.4. Skillset needed to achieve the goals of the strategic documents regarding the Bioeconomy

The European and global strategic documents have recognised the significant role of the bioeconomy in renewable, green, sustainable and circular development. Skillset which should be improved, to achieve goals related to bioeconomy in Green deal, the Bioeconomy Strategy, the Sustainable Development Goals, the Circular Economy Action Plan, and BIOEAST Foresight exercise are:

- digitalization of the agri-food system;
- valorisation of the resource potential that can be obtained from biowaste and wastewater streams;
- improvement of economic productivity that goes hand to hand with environmental and social aspects;
- implementation of holistic land use management practice in terms of resource efficiency, agroecology practices and the potential use of biotechnology and innovation;
- fostering of vibrant rural areas;
- delivering affordable, nutritionally adequate, safe and healthy (and even culturally acceptable) food;

- reducing food waste and food losses and minimizing the impacts on the environment and society
- development of holistic and sustainable food and nutrition system; a nutrition-positive agri-food system and engaged citizens;
- implementation of the sustainability principles throughout the whole value chain (pre-production, production, supply chain, consumption);
- biodiversity protection;
- design and application of innovative ways to protect harvests from pests and diseases;
- eco-design development and improvement of durability, reusability, upgradability and reparability;
- solid verification and certification;
- increase monitoring of degraded land areas or land at risk of climate change impacts such as desertification, to underpin action for restoration of land based systems.
- sourcing, labelling and use of bio-based plastics, based on assessing where the use of bio-based feedstock results in genuine environmental benefits, going beyond a reduction in using fossil resources;
- production of biodegradable or compostable plastics;
- market development for secondary bio-based materials;
- implementation of circular bioeconomy approaches;
- implementation of just transition mechanisms;
- providing a competitive advantage in clean technologies through large-scale deployment and demonstration of new technologies across sectors;
- building new innovative value chains;
- sustainable re- and afforestation;
- strengthen and scale-up the bio-based sectors, unlock investments and market;
- develop tools for the integration of pollinators and pollination service into the design of sustainable biomass supply value chains;
- increasing the understanding of microbial biodiversity with a view to develop microbiome-based solutions;
- replace fossil-based textiles and plastics, boost the use of nanofibril applications in bio-based adhesives, laminates, 3D printing and flexible electronics, as well as use foldable corrugated cardboard for the large scale packaging business for Internet products;
- increase harvest rates and wood mobilisation without exceeding the total annual increments;
- mobilise private investment in the biobased industry.

4. Gap analysis

This section compares the existing capacity of educational institutions with the needs of agricultural practice, industry and policy makers.

4.1. Gap analysis of the existing capacity of educational institutions and needs of agricultural practice, industry and policy makers

The define a gap between the existing capacity of educational institutions and needs of agricultural practice, industry and policy makers, a comparison of the weighted results was conducted, as presented in the equation:

$$\frac{\textit{Existing capacity of educational institutions (weighted factors)}}{\textit{Needs of agricultural practice/ industry/ policy makers (weighted factors)}}$$

In this gap analysis, the educational capacity of Faculties/Universities was used for a comparison with the needs of agricultural practice, industry and policy makers. To indicate the gap between the capacity and the needs, the following legend was used.

0%-20%	20%-40%	40%-60%	60%-80%	>80%

As can be seen from the equation, the gap between the capacity of educational institutions and needs of agricultural practice, industry and policy makers is higher where the number (percentage) is lower. The results are presented in the table below:

Expertise	Agricultural practice	Industry	Policy- makers
Exp. in project management	91%	82%	99%
Exp. in Life Cycle Assessment (LCA)	73%	58%	69%
Engagement capacity to involve different types of stakeholders	73%	75%	60%
Exp in bio-based-market knowledge	80%	65%	73%
Exp. in the techno-economic assessment of bio-based processes	93%	70%	100%
Exp. in development of new bio-based business models	64%	61%	59%
Exp. in circular bio-economy approaches	78%	79%	70%
Exp. in the enhancement of profitability of currently used business models	64%	66%	79%
Exp. in biomass potential assessment	75%	71%	73%
Exp. in the assessment of the geographical distribution of biomass/bioenergy potential (Exp. in GIS tools)	71%	66%	64%
Exp. in methods for efficient and cost-effective biomass' production	60%	78%	59%
Exp. in raising social awareness for new bio-based products	82%	78%	68%
Exp in social innovations	73%	69%	69%
Exp in social economy	82%	74%	82%
Exp. in attracting funding possibilities	75%	67%	78%

Expertise	Agricultural practice	Industry	Policy- makers
Exp. in new product design from bio-waste	75%	62%	64%
T. Exp in high productive technologies for traditional food sector	82%	107%	78%
Exp. in nano and biotechnologies to be applied in medicine	119%	55%	76%
T. Exp in advanced pre-treatments at harvest-storage stage	68%	/	71%
T. Exp in precision farming	48%	/	54%
T. Exp in feedstock-specific & market-driven cascade valorisation	44%	47%	43%
T. Exp in work with precision equipment for biomass harvest/collection	48%	42%	44%
T. Exp in work with advanced ICT applications to logistic/storage	50%	51%	45%
T. Exp on advanced technologies to mildly extract or separate functional components	74%	56%	54%
T. Exp on design and operation of market flexible and feedstock adaptable multiproduct integrated bio-refineries	53%	36%	44%
T. Exp on new processes to improve bio-product yield (biogas yield, chemical yield, etc) from bio-waste	56%	50%	47%
T. Exp in secondary conversion processes of bio-based materials	65%	65%	63%
T. Exp in materials based on oils and fats from plants and animals (bio-based lubricants, surfactants, solvents)	51%	35%	44%
T. Exp in bio-based alternatives for existing polymers and innovative polymers from new bio-based monomers	61%	66%	48%
T. Exp in extraction techniques to obtain High added-value biomolecules from marine, agrifood or forest biomass for pharmaceutical, nutraceutical and cosmetic sectors	/	66%	67%
T. Exp in new (chemical) building blocks from renewable resources	/	51%	37%
T. Exp in new functional bio-based materials and products: plastics, composites, based on lignin, starch, (nano-) cellulose or carbon fibres	/	78%	52%

4.2. Gap analysis of research needs

Representatives of agricultural practice, industry and policy makers were asked to rank the following needs of the bioeconomy regarding the following thematic groups: 1) innovative by-products, methods or technologies, 2) circular economy, 3) climate and environmental protection, 4) social/economic challenges and impacts. For each thematic group, a list of the needs was listed and the respondees ranked from more important towards less important needs. On the other hand, the representatives of educational organisations were asked to define the extent to which the curriculums of BIOEAST Faculties/Universities include the topics needed to address those needs (the same ones ranked by the first target group). The tables below present the ranking, going from more important research needs toward the less important research needs and the capacity of educational organisations.

Ranking of needs and corresponding capacity related to the research needs regarding innovative by-products, methods or technologies is presented in the following table:

	Ranking	Research needs regarding innovative by-products, methods or technologies	Capacity
More important ↑	1.	New research on the transformation of biomass and agricultural raw materials into products such as chemicals, biopolymers, materials and commodities	46
	2.	Improvement of food processing technologies to reduce losses	51
	3.	Development of new technologies for obtaining bio-based, recyclable and degradable products	50
	4.	Introduction of new technologies in more efficient use of plant and animal raw materials and fish	49
	5.	Introduction of new technologies in treatment, recycling and recovery of bio-waste* Innovations and new technologies in the forestry and wood-processing industries *	49 57
	6.	Innovation in the fields of clean technologies with a focus on bio-waste free technologies	49
	7.	Application of new technologies based on natural resources in the field of water purification and reuse	48
	8.	Innovations in the production of biologically based drugs	31
	9.	Development of sustainable, cost- and resource-efficient RAS (reliability, availability and serviceability) technologies (such as optimization of tank design and improved water treatment technologies)	41
	10.	Development of breeding technologies for new species with great aquaculture potential	39
↓Less important	11.	Innovations in "blue" technologies and application of new methods and technologies in the sustainable use of river and marine resources	39
	12.	Introduction of ecodesign, a priority in the key-value chains – plastics	32
	13.	Innovation in the fields of bio-mechatronics technologies	35
	14.	Introduction of ecodesign, a priority in the key-value chains – textile	22

Ranking of needs and corresponding capacity related to the research needs regarding circular bioeconomy is presented in the following table:

	Ranking	Research needs regarding circular economy	Capacity
More important ↑	1.	Development of standards for the use of bio-based products produced from recycled biomass	44
	2.	Efficient waste management and recovery of biological ingredients from side-streams in the production of industrial bio-based products	47
	3.	Analysis of the effect of the reuse of treated water from the processing industry for irrigation of different crops	34
	4.	Update of the methodology for determining the composition of bio-waste and providing reliable information about their volume and processing	43
	5.	Carrying out of an in-depth study of food waste along the entire chain of formation and introduction of measures for their reduction	43
	6.	Study of the impact of climate change on the water regime and implementation of adaptation measures	44
	7.	Construction of installations for recycling and utilization of biomass of forestry origin	46
↓Less important	8.	Deep processing of cellulose	42

Ranking of needs and corresponding capacity related to the research needs regarding climate and environmental protection is presented in the following table:

	Ranking	Research needs regarding climate and environmental protection	Capacity
↑ More important ↓ Less important	1.	Research on reduction of environmental pollution from food processing	49
	2.	Study of the impact of climate change on the water regime and implementation of adaptation measures	42
	3.	Protection and management of water resources against pollution with non-degradable pollutants	41
	4.	Research on the impact of Wastewater treatment plants (WWTP) sludge on crops and human health	39
	5.	Development of national criteria for the use of digestate produced as a by-product of anaerobic digestion	44
	6.	Development of national criteria for the use of compost produced from sludge from waste water treatment plant	41
	7.	Study of good practices for the establishment and management of intensive forest crops for biomass production and for the determination of norms for felling residues	53
	8.	Water purification in the pulp and paper industry	30

Ranking of needs and corresponding capacity related to the research needs of the bioeconomy regarding social / economic challenges and impacts is presented in the following table:

	Ranking	Research needs regarding social / economic challenges and impacts	Capacity
More important ↑ Less important ↓	1.	Improvement of energy and resource efficiency	49
	2.	Development of safe, sustainable and healthy foods and nutritional supplements	56
	3.	New industries for healthy life and biotechnology (including food) (bio-technologies with direct application for a healthy lifestyle	45
	4.	Preservation of food quality and safety in the context of post-COVID-19 crisis and recovery	50
	5.	New technologies in creative and recreation industries (alternative rural, ecotourism and sports to stimulate non-seasonal, non-mass and permanent niche tourism)	37

4.3. SWOT analysis

In accordance with the results of the gap analysis, a summary and conclusions in relation to SWOT elements are conducted and presented below:

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 biowaste, 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.

5. Action plan for the BIOEAST region on how to improve common action in bioeconomy- education

5.1. How to improve common action in bioeconomy education

Education in the circular bioeconomy must be transdisciplinary, including complex systems thinking. To achieve the goals set in the strategic document and to shift to circular bioeconomy a multidisciplinary education system, multi-level education of specialists in the bioeconomy and circular economy, and a systemic programme to raise the environmental awareness of society should be created in BIOEAST countries. 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 of circularity, acting local and global at the same time and raising interest for bio-based careers;
- **At universities**: a systematic curriculum is needed, combining life science, engineering, economics and marketing, and enabling the dynamics for the development of transversal skills, capable to support 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.

One of the great challenges, that should be overcome to achieve this is to increases the percentage of workers and unemployed people that participate in lifelong learning, which is in the BIOEAST region far lower, in comparison to other EU countries. To achieve sustainable change, lifelong learning should become a common practice.

In most of the BIOEAST countries, is necessary to create a new curriculum dedicated to the bioeconomy and circular economy and/or implement the changes and/or changes in existing curriculums. The level of complexity should be developed along with the curricula.

It is not sufficient to provide solutions for the current population; the challenges must be addressed sustainably to provide a secure future for succeeding generations 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;

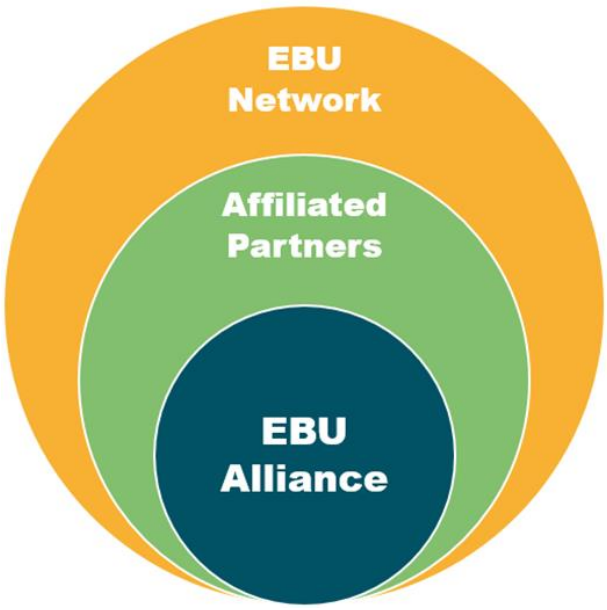
- Investment in relevant research areas, both within each of the sectors and by encouraging multidisciplinary programmes;
- Making entrepreneurship within the Bioeconomy a desirable career option;
- Providing a skilled workforce by making the various sectors of the bioeconomy attractive career options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

5.2. Pathway how to cooperate with the European Bioeconomy University

Europe's six leading universities in the field of bioeconomy are intensifying their cooperation and joining forces in research, teaching, education, and innovation. They have set the Consortium for the "European Bioeconomy University" (EBU), which consist of: University of Bologna (UniBo, Italy), University of Eastern Finland (UEF, Finland), University of Hohenheim (Germany), AgroParisTech, Paris Institute of Technology for Life, Food and Environmental Sciences (France), University of Natural Resources and Life Sciences, Vienna (BOKU, Austria), Wageningen University and Research (WUR, Netherlands).

The aim of EBU is to strengthen the capacity and competitiveness of bioeconomy research, education and innovation through cooperation with other universities as well as non-university research institutions and relevant stakeholders in the field of bioeconomy. The EBU collaboration structure comprises three different circles of cooperation, as depicted in Figure below.

Figure 5: **EBU collaboration structure**



Circle 1 EBU Alliance: The European Bioeconomy Alliances comprises the six founding members AgroParisTech, BOKU, UEF, UHOH, UniBo and WUR.

Circle 2 Affiliated Partners: A collaboration with affiliated partners aims at an intensive, middle- to long-term cooperation with other universities that demonstrate scientific excellence and academic leadership in research, teaching and transfer in the bioeconomy.

Circle 3 EBU Network: The EBU Network is targeted at all kinds of cooperation with stakeholders in policy, research, education, industry and society and other networks and organizations, incl. (national) research organizations.

As indicated in this thematic study, most educational organisations need to change or adjust their curriculum, to have sufficient capacity to address the needs of the bioeconomy. The change of curriculum is a time-consuming task and requires a high level of knowledge on education in bioeconomy, but also experience on know-how. Through a collaboration with EBU, either as affiliated partners or as a Network member, Universities of the BIOEAST region can benefit from the support EBU could provide them.

One additional possibility for BIOEAST educational and research organisations to cooperate with EBU, share the knowledge and mutually learn is through joint participation in Erasmus+ projects. Erasmus+ program is the programme for education, training, youth and sport. It provides an opportunity for organisations for research organisations all over the EU.

The COVID-19 Pandemic brought numerous challenges in the educational system but also forced great progress in digitalisation of the education. Therefore, it is nowadays more common than ever to participate in online education, which overcomes the challenge of the distance between the professors and students but also allows to build a bridge across disciplines, bringing students and researchers together in their efforts to create a knowledge-based bioeconomy in Europe.

5.3. Actions how to implement tailored training events in bioeconomy to support the implementation of it in the BIOEAST macro-region.

The ongoing transformation of labour markets and the cross-country division of labour has increased demand for work flexibility and decreased job stability. Training and education are needed to meet new skills requirements. Furthermore, informal learning activities play a role in the acquisition of entrepreneurial skills and soft skills. The completion of educational programs that respond to the training needs identified in this study require maximum collaboration between the educational organisations, agriculture practice, industry and policy makers, and business sectors, in order to achieve the best results for bio-economy development. In addition to this, joint social objectives must be defined in order to seek to achieve a higher awareness level of citizens. To support the implementation of tailored training events in bioeconomy in the BIOEAST region, the following factors must be considered:

- **The training model definition:** Training models are part of instructional design. This refers to the is the creation of learning experiences and materials in a manner that results in the acquisition and application of knowledge and skills. It follows a system of assessing needs, designing a process, developing materials and evaluating their effectiveness. The main objective of a training model is to define specific processes that should achieve a professionally competent trainee, having the expected qualification in terms of knowledge, skills, qualities, experience and individual activity style. It is important to adopt effective and robust training models. Trainees from various regions, sectors, education and social background may significantly differ. Lack of adaptation to these specific attitudes is, therefore, a potential inhibitor.
- **The regional labour market analysis:** A regional labour market is a place where supply and the demand for jobs meet, with the workers providing labour (supply) and employers providing jobs (demand). A factor that connects those two entities is the salary. The salary as the balancing point depends on the surplus or deficit of supply (workers/specialists). Nowadays, trainees often opt to become specialists in deficit areas, which allows them to ask for a higher salary. Training events should adapt to market necessities.
- **Future forecast:** Education should not only satisfy the current market necessities but should look for a step future, taking into account development tendencies of one or another brunch, scientific knowledge in general, scientific and technological discoveries and prospects of their usage in future, goals and directions of national and EU strategic documents. From the results obtained in the BIOEAST macro-region it is clear that in many BIOEAST countries, educational organisations have a lack of capacity in satisfying future needs of

the bioeconomy, where non-conventual biomass sectors are driving the transformation with leverage effects towards the whole bioeconomy.

- **Educational organisation capabilities:** Educational organisations implementing the programme, should possess materials and technical base, corresponding to the acting technical norms adapted to the bioeconomy frames and provide training realization based on a specific curriculum. For educational organisations, the following aspects are essential: human resources and their qualification; materials and technical potential; educational conditions; educational laboratory equipment. For bioeconomy training, it proved to be very useful for the coaching and supervision of trainees in the laboratory of pilot plants. However, this requires considerable resources and specific arrangements for occupational safety and confidential issues. Although enterprises seek workers with high expertise and practical skills in specific bioeconomy areas, many of them are not willing to allow training events on their pilot cases, due to safety and confidential issues.
- **Regional factors:** as mentioned in the first bullet (the training model definition), lack of adaptation to specific attituded can be a potential inhibition in training. Bioeconomy education has a strong regional influence and is often unique on a case-by-case basis. However, it is important to have a common implementation plan in all countries of the BIOEAST region and have a synchronous development, independent from the existing regional differences. The differences between the countries of the BIOEAST region provide opportunities for mutual knowledge and experience exchange, and mutual learning.
- **Awareness raising and promotion of vocational training events and lifelong learning:** The BIOEAST region is lagging behind the practice of lifelong learning. Countries of BIOEAST regions are at the bottom of the scale of adults participating in lifelong learning in the EU, significantly above the EU percentage (11.1%). To overcome this challenge, behavioural and societal changes are needed. Environmental agencies, businesses, agriculture and forestry chambers can contribute to awareness-raising by boosting their role as communicators.

6. Conclusion

The BIOEAST macro-region is rich in biomass resources availability and national plans for using those resources for the benefit of rural development, economic growth and societal prosperity. This natural potential and policy support is an optimal basis for fully sustainable use of the natural resources, based on bioeconomy principles with added economic value. To ensure a knowledge-based transformation towards a biobased economy, new transdisciplinary curricula should be developed and existing ones should be adjusted to existing needs of the agricultural practice, industry and policy makers, as well as the foreseen needs for the upcoming decades. This transformation will not provide new jobs, but would also encourage new employment opportunities within the field of the circular bioeconomy.

In the scope of this thematic study, the existing capacity of educational organisations was mapped, as well as the needs of the agricultural practice, industry and policy makers, but also the goals of the strategic documents. In accordance with this input, a gap analysis was conducted and the existing capacity was compared with the needs of the target groups. From the gap analysis, it is clear that Faculties/Universities address most of the needs of the agricultural practice, industry and policy makers. However, the capacity to address those bioeconomy needs is not provided in one unique course but is often partly addressed in many different courses.

The high schools in the BIOEAST macro-region are still not sufficiently addressing the needs of the bioeconomy and the topics related to bioeconomy are only addressed in the scope of the “general” subjects, such as biology.

Regarding the educational agencies, the greatest barrier is that there is a low number of educational agencies in the BIOEAST regions, as the countries of the BIOEAST regions are underperforming in life-long learning practice.

The results obtained from the gap analysis of the input gathered through online surveys, but also the data obtained from the desk research were used for the development of the Action plan for the BIOEAST macro-region on how to improve common action in bioeconomy- education. This action plan includes the recommendation on how to improve common action in bioeconomy education for three levels of education- education in primary and high schools, at universities and vocational training, but also defines the key areas for providing a secure future for succeeding generations. In addition to this, the action plan indicates the pathway how to cooperate with the European Bioeconomy University and outline actions on how to implement tailored training events in bioeconomy to support the implementation of it in the BIOEAST macro-region.

7. Literature

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