

Perspectives on Sustainable Bioeconomy in the Baltic Sea Region

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Abstract—‘Bioeconomy’ is a complex concept that cuts across many sectors and covers several policy areas. To achieve an overall understanding and support a successful bioeconomy, a cross-sectorial approach is necessary. In practice, due to the concept’s wide scope and varying international approaches, fully understanding bioeconomy is challenging on policy level. This paper provides a background of the topic through an analysis of bioeconomy strategies in the Baltic Sea region. Expert interviews and a small survey were conducted to discover the current and intended focuses of these countries’ bioeconomy sectors. The research shows that supporting sustainability is one of the keys in developing the future bioeconomy. The results highlighted that the bioeconomy has to be sustainable and based on circular economy principles. Currently, traditional bioeconomy sectors like food, wood, fish & waters as well as fuel & energy, which are in the core of national bioeconomy strategies, are best known and are considered more relevant than other bioeconomy industries. However, there is increasing potential for novel sectors, such as textiles and pharmaceuticals. The present research indicates that the opportunities presented by these bioeconomy sectors should be recognised and promoted. Education, research and innovation can play key roles in developing transformative and sustainable improvements in primary production and renewable resources. Furthermore, cooperation between businesses and educators is important.

Keywords—Bioeconomy, circular economy, policy, strategy.

I. INTRODUCTION

A ‘bioeconomy’ is an economy that relies on renewable biological resources (e.g., plants and animals) and their conversion into food, feed, products, materials and energy [1]. A bioeconomy utilises new resources of renewable biomass and includes a wide range of sectors: traditional ones, for example include agriculture, forestry, fisheries, pulp and paper production. However, novel bioeconomy sectors such as some aspects of the chemical, biotechnology and energy industries, contribute increasingly to overall bioeconomic production [2]. The bioeconomy relies on biotechnologies for providing perspectives on how to apply science and use resources in the most effective way [3].

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More recent definitions of bioeconomy have included sustainability. It has been increasingly recognised that circular economy principles should be integrated into bioeconomy [4]. In a circular economy, resource efficiency is maximised and waste production is minimised; in other words, natural resources have to be utilised in a responsible and efficient way in order to achieve a more sustainable economy [5]. This both benefits the environment and also reduces production costs [6].

The European Union (EU) recently updated its definition of bioeconomy and now states that a successful bioeconomy must ‘have sustainability and circularity at its heart’ [7]. Other international and intergovernmental organisations are also actively working to develop and refine bioeconomy principles. For example, the Nordic Council of Ministers defines bioeconomy as a strategic framework based on circular thinking and biological resources that are produced and used in a sustainable way [8]. The most recent definition comes from the Organisation for Economic Cooperation and Development, which at the end of 2018 defined a ‘circular bioeconomy’ as an economy where organic wastes are used as feedstock for bio-based production while creating added value for products [9].

II. BACKGROUND

There has been a global trend towards developing bioeconomy, and about 50 countries worldwide have recently adopted bioeconomy-related policy strategies [10]. This increase has been especially evident in Europe since the EU’s 2012 publication of the European Bioeconomy Strategy [2]. At the same time, the EU also introduced research and innovation strategies for smart specialisation in its regions (RIS3) [11]. Within this context, several regions saw opportunities to integrate a bioeconomy into their regional development plans. Moreover, these initiatives will play even more decisive roles in the upcoming EU programming period, in which decision making is to be delegated to local and regional authorities.

Since bioeconomy is a complex concept that cuts across many economic sectors and covers several policy areas, a holistic, interdisciplinary approach is important for achieving successful development. However, there are challenges in policy coordination. For example, legislation and public procurement processes typically do not support the multifaceted context of a bioeconomy. In addition, there are often missing links between local/regional initiatives and national regulations. There are good local examples of sustainable bioeconomies, but a systemic approach and

consideration of trade-offs are often missing.

The Baltic Sea Region (BSR) has a lot of potential in bioeconomy. The region has a well-developed infrastructure, a high level of technological and environmental knowledge and, above all, a large concentration of biomass in agriculture, forestry and fishery. All of the BSR countries have established 'green growth' based on biological resources as a high priority [12]-[17]. Widespread bioeconomy coordination between the countries of the BSR provides a unique opportunity to establish a sustainable regional bioeconomy. Transnational cooperation opportunities, facilitated by the EU Strategy for the BSR—the first EU 'macro-regional strategy' [18]—have

already contributed to the social, environmental and economic development of the region, and joint processes and coordinated project implementations have been initiated. For example, the Policy Area Bioeconomy coordinates national bioeconomy policies, promotes the usage of bio-based business solutions, fosters the development of biological resources and new technologies and reaches out to new stakeholders. Recently, strong efforts have also been made to increase the attractiveness of bioeconomy industries to youth and to increase youth involvement. [18] Table I summarises the main bioeconomy policies and sectors of bioeconomy in BSR countries [12]-[17].

TABLE I
NATIONAL BIOECONOMY POLICIES IN THE BSR [19]

Country	Relevant policy documents	Main bioeconomy strengths or sectors of focus
Denmark	Policy initiatives dedicated to bioeconomy/green economy - 'Growth Plan for Water, Bio and Environmental Solutions' (2013) - 'Growth Plan for Food' (2013)	- Agriculture - Fishery - Testing of high-value products
Estonia	Dedicated national bioeconomy strategy under development	- Forestry, wood - Agriculture
Finland	Dedicated national bioeconomy strategy: - 'The Finnish Bioeconomy Strategy' (2014)	- Forestry, wood - Agriculture - Chemical and energy industries - Bioenergy
Germany	Dedicated national bioeconomy strategies: - 'National Policy Strategy on Bioeconomy' (2013) - 'National Research Strategy BioEconomy 2030' (2010)	- Agriculture - Forestry, wood - Fishery - Biotechnology
Iceland	Dedicated national bioeconomy strategy under development	- Fishery - Macro- and micro-algae
Latvia	Dedicated national bioeconomy strategy: - 'Latvian Bioeconomy Strategy 2030' (2017)	- Agriculture - Forestry
Lithuania	Dedicated national bioeconomy strategy under development. Current focus on high-tech: - 'National Industrial Biotechnology Development Programme' (2007-2010)	- Industrial enzyme production - Agriculture, food production - Biotechnology
Norway	Dedicated national bioeconomy strategy: - "Familiar resources – undreamt possibilities" (2016)	- Forestry - Marine by-products, fishery - Seaweed/macro-algae - Agriculture
Poland	Policy initiative dedicated to bioeconomy: - 'Strategic R&D programme Environment, Agriculture and Forestry' (2013)	- Agriculture - Forestry, wood
Russian Federation	A bioeconomy-related strategy, with a focus on technology: - 'Bioindustry and Bioresources - BioTech2030' (2011)	- Agriculture - Chemical industry - Forestry, wood - Biotechnology
Sweden	Policy initiative dedicated to bioeconomy, with a focus on research and innovation: - 'Swedish Research and Innovation Strategy for a Bio-based Economy' (2012)	- Forestry, wood - Agriculture - Biofuels for transportation

Among the BSR countries, Finland, Germany, Latvia and Norway have developed dedicated bioeconomy strategies with cross-sectoral approaches, while Estonia, Lithuania and Iceland are in the process of setting up bioeconomy strategies. Denmark and Sweden have one or several single-sector strategic documents or partnerships that support their respective national bioeconomies.

Most of the national bioeconomy documents listed in Table I focus on the production and use of biological resources. Generally, agriculture and forestry are seen as the most significant bioeconomy industries, although countries like Norway and Iceland that have strong marine sectors also prioritise their fishery and algae industries. A few countries emphasise additional specific strengths; for example, industrial enzyme production is a particular focus in Lithuania,

while Germany's strategy highlights a high-tech approach with a focus on bioscience. However, when analyzing the strategies it is also important to keep in mind that there exist regional differences in priorities within each country.

This paper is based on a pre-study on designing a Baltic Leadership Programme (BLP) on Youth and Bioeconomy assigned by the Swedish Institute [19], [20]. The paper presents the results of the pre-study regarding expert's views on the bioeconomy and its development.

III. METHODS

Internet-based desk research, a small-scale survey of experts and interviews were conducted during summer 2018 [19]. Survey participants consisted of bioeconomy experts in

all of the BSR countries except Russia. The list of targeted participants was created by the Swedish Institute. The survey was conducted in June 2018 and the language used was English. Altogether, 19 bioeconomy experts replied to the survey. Since there were only 19 survey responses, the results are presented through descriptive analysis and not clustered.

Survey responses were received from participants in all countries except for Norway and Germany, but most respondents were from Sweden, Latvia, Poland and Finland. The gender distribution was relatively equal (11 women and 8 men). Their level of education was relatively high, as expected: all respondents held either a Master's degree ($n = 12$) or a PhD ($n = 7$). Most respondents were working in the research sector ($n = 6$) or in public administration ($n = 6$).

Additionally, phone interviews with 7 experts were conducted in June and July 2018. The interviews lasted 20–40 minutes and provided more depth to the responses provided on the survey.

IV. RESULTS

A. Definition of 'Bioeconomy'

There was significant uncertainty among the experts regarding the actual definition of bioeconomy. Respondents were asked to state their definition of the concept of bioeconomy, but only two respondents provided comprehensive definitions and just one of these mentioned sustainability. A few experts replied to this question with general terms like 'everything' or 'all aspects of biotechnology', and some did not respond to this question at all. Among the responses that were provided, bioeconomy was mainly defined as 'an economy using biological resources'. Fewer than half of all respondents ($n = 8$) touched on the concept of sustainability, and only one response mentioned 'circular economy', such as in the sample responses here:

'Creating value from renewable biological sources using biotechnology.' Iceland, researcher in a private company, Master's degree, survey. [19]

'Bioeconomy is an important component of a circular economy, where products become sustainable, recyclable and where renewable materials are replaced over time by renewable ones.' Sweden, public administration, Master's degree, survey. [19]

Thus, while it might be assumed that sustainability and circularity are seen as obvious components of a bioeconomy, these results clearly indicate that sustainability needs to be emphasised more in bioeconomy-related communications.

B. Current Focus of Bioeconomy

Survey respondents were also asked to specify which bioeconomic sectors, among a given list, they saw as being most relevant; the possible answers were 'strong importance', 'some importance', 'little importance' or 'no importance'. As shown in Fig. 1, most of the listed sectors were viewed as having 'strong' or 'some' importance. In fact, 60% of respondents rated all of the given bioeconomic sectors except for 'textiles and clothing' as having strong importance.

Among the traditional sectors, the 'food and animal feed' and 'fish and waters' sectors were rated as very important by 15 and 17 out of 19 respondents. 'Biowaste and wastewater sludge' was also frequently listed as a highly important sector.

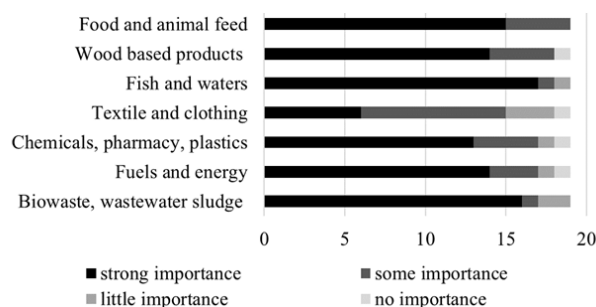


Fig. 1 Which sectors in bioeconomy do you find relevant ($n = 19$)? [19]

Survey respondents also had the option to further explain their views. Several respondents emphasised a holistic approach and underscored that, while some sectors are more important at the present moment, new areas hold more potential for the future.

'In my opinion there is no such thing as no importance regarding any of the sectors. In some countries, fishery sector is more profound, while in others the bioeconomy lies on the strong history of using wood. The importance comes down to the country, its local resources and local industry, and choosing the right path (or several) for them.' Estonia, researcher in a private company, master's degree, survey. [19]

'Food and feed from agriculture and forestry are big parts of the regional bioeconomy. Biofuels and waste management are important to climate change mitigation. In my opinion, the rest of the sectors are important as well, as they have a great potential to produce high value from biomass.' Sweden, public administration, Master's degree, survey. [19]

In the telephone interviews, a holistic and sustainable approach to bioeconomy was highlighted by almost all of the interviewees. Applying circular economy principles to bioeconomy was seen as a great opportunity.

'The bioeconomy is a holistic concept; it's about bringing value to natural resources. The opportunities lie in cascading natural resources in a lot of different ways. Bioenergy is familiar, but there are huge possibilities in creating higher value products, like medicine products. There will be a huge demand for high value products in the future.' Denmark, manager of a private research company, Master's degree, interview. [19]

'The combination of bioeconomy and circular economy is a big opportunity. To build up a regenerative bioeconomy is both an opportunity and challenge. To build up resilience in bioeconomy by combining bioeconomy and circular economy. Circular economy itself is the most important because we should circulate everything, in combining bioeconomy and circular

economy the biggest thing is to renew: how to renew material by bioeconomy.’ Finland, researcher in a public institute, PhD, interview. [19]

C. Bioeconomy Communications

The survey asked respondents to indicate which bioeconomy topics they perceived to be emphasised in current communications directed at youth and which sectors they felt should be emphasised more. As shown in Fig. 2 respondents indicated that the bioeconomy potential of ‘textile and clothing’ as well as ‘chemicals, pharmacy and plastics’ is not well communicated at present and should be emphasised more heavily in future communications. Regarding the ‘other ecosystem services’ category, respondents mentioned biodiversity and that communications related to all kinds of biologically-related products should be increased. Over half of respondents stated that the importance of all the listed sectors should be better communicated in future, emphasising a need for better communication in general.

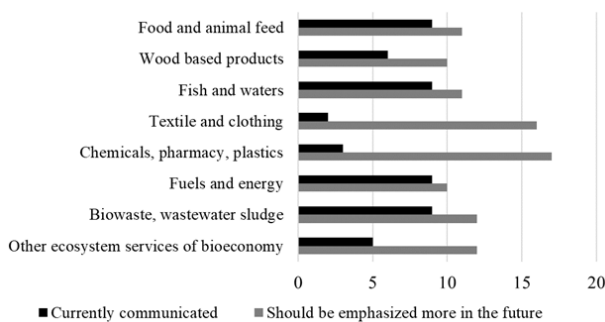


Fig. 2 How are the main topics in bioeconomy communicated to youth at the moment and where should emphasis be in the future ($n = 19$)? [19]

The responses made clear that communications about the bioeconomy should happen via several channels but education plays a central role at all levels. All respondents agreed that improvements are needed to their country’s education system’s promotion of the bioeconomy. Furthermore, the complexity of the bioeconomy was perceived as creating communication challenges; the concept is not familiar enough, which makes it difficult to understand. Moreover, survey respondents stated that bioeconomy job opportunities could be presented to youth in far better ways than they are at present:

‘I think they [youth] know some parts of it [bioeconomy] but not in full scale, which is why it should be taught in every level.’ Finland, researcher/lecturer at a public institution, PhD, survey. [19]

‘It is difficult to answer [if the job opportunities related to bioeconomy have been presented well enough], but in my country I think there is some gap in thinking.’ Poland, researcher/lecturer at a public institution, Master’s degree, survey. [19]

Respondents also felt that education should extend beyond school lectures. For example, study visits or class trips to companies and company visits to schools were seen as the

most relevant ways to increase knowledge about the bioeconomy among youth. Equally important for developing expertise among the younger generation were internship programmes for bioeconomy students, as highlighted in this interview quote:

‘Teaching the teachers is the key. To approach all teachers. Sustainable ways interest youth, but there should be concrete projects, to create their interest. Bioeconomy is so general, it should be explained through examples and projects where youth can participate. Estonia, manager of a private research company, PhD, interview. [19]

D. Promoting the Bioeconomy

Several methods of promoting the bioeconomy are employed within and among countries; however, respondents perceived some methods to be more important than others. As shown in Fig. 3, ‘supportive regulations and legislation’ ($n = 14$) and ‘research and innovation activities’ ($n = 14$) were most widely perceived to have ‘strong importance’, and ‘stakeholder cooperation’ was also cited as being of strong importance by over half of the experts ($n = 12$). In contrast, ‘certification and labels’ were rated as being of strong importance by only 4 respondents.

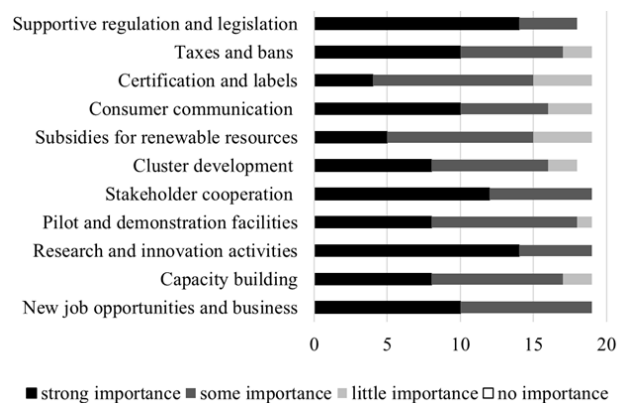


Fig. 3 Which priorities in promoting bioeconomy listed here do you find relevant ($n = 19$)? [19]

In an interview, one expert highlighted that, in general, the focus of the bioeconomy sector should be heading towards a holistic understanding of bioeconomy as a business overall and that it is especially important to broaden the understanding of bioeconomy among experts in other fields:

‘The focus should not be among them who are already interested in bioeconomy, but on engineering and financing. It is the key that they would understand.’ Estonia, manager of a private research company, PhD, interview. [19]

V. DISCUSSION AND CONCLUSIONS

Bioeconomy is a complex concept that intersects several industries and policy areas. Researchers and policymakers understand the concept in different ways, and this complexity

creates challenges at the policy level, as strategies must involve a variety of government ministries and experts. Thus, a cross-cutting approach that includes successful cooperation between all stakeholders is essential for holistic development. As stated by one interviewee,

‘The bioeconomy business is not a straightforward thing, it is more complex. To build a sustainable business approach, it has to be built on cluster basis, symbiosis between companies creating strong trust, to utilize the side flows of each other. In bioeconomy one single actor cannot create the success alone.’ Finland, researcher at a public institution, PhD, interview. [19]

Promoting sustainability was perceived as being key to developing a bioeconomy. A successful bioeconomy should be both sustainable and based on circular economy principles. Traditional bioeconomy sectors, such as agriculture, forestry and fisheries, are at the core of national bioeconomy strategies, and they are more familiar to most people and are naturally considered important. However, while the potential for new sectors, such as textiles, pharmaceuticals and plastics, is recognised, these sectors should be more clearly presented as parts of the bioeconomy. The strategic importance of these sectors is growing and will soon become even clearer. It is also evident that high-tech industries have not yet fully discovered the potential opportunities provided by the bioeconomy. One explanation is that these industries still follow traditional approaches and that available bioeconomy funding mechanisms have not reached out to the high-tech sector. As a whole, blue and green growth companies and innovative technology companies have also not yet fully adopted bioeconomy principles, even though huge EU funds are available (e.g., the Blue Investment Platform). The reasons for this are multifaceted, but one likely explanation is the traditional outlook and classical business model typically used in those sectors. However, food technology and clean technology innovations have rapidly increased thanks to comprehensive regional development plans, including the use of e.g. cluster and incubator approaches, and these approaches could likely also help other sectors.

To comprehensively develop the bioeconomy and release its potential, different sectors need new dynamics and stronger attractions. At present, it appears that government bodies do not necessarily know what and how to communicate regarding the bioeconomy. It is crucial to open up the bioeconomy and to make it more inclusive for a broader range of participants, especially youth. This requires regular communication and participatory approaches from policy coordinators. First steps towards such an approach were taken by the BLP on Youth and Bioeconomy; however, continued efforts remain necessary. For example, greater discussion is needed regarding different understandings of bioeconomy. The BLP fostered communication and reduced knowledge gaps in capacity-building sessions, and it created small groups focused on sustainability, circular economy and societal challenges that provided excellent insights into a holistic approach to bioeconomy from participants with different starting points.

New business models can only be adapted if there is

stronger awareness of the different bioeconomy sectors. There is a clear need for communication involving diverse stakeholders. Involving more youth could be a first step that would introduce new dynamics and new actors. Observations from the BLP suggested that women with a specialisation in sustainability and biotechnology were particularly interested in active involvement in the bioeconomy. Overall, however, bioeconomy sectors hold great opportunities to attract highly skilled, engaged and well-educated people.

Education, research and innovation play central roles in countries and regions are developing transformative developments in primary production and renewable resources. Promoting bioeconomy principles and its associated industries across different levels of education is key to raising awareness about sustainability and the circular economy principles that are inherent to the bioeconomy. Cross-cutting business and education connections are crucial for developing a successful bioeconomy. Concrete actions, e.g. study visits, across all levels of education is necessary to address the challenge of introducing youth to the opportunities presented by the bioeconomy. At the same time, the need for new bioeconomy developments will continue to increase demands for innovative solutions and will attract investment and talent to the multifaceted sectors of the bioeconomy.

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