



Natural resources and
bioeconomy
studies 38/2018

Synthesis on bioeconomy monitoring systems in the EU Member States

- indicators for monitoring the progress of bioeconomy

Markus Lier, Martti Aarne, Leena Kärkkäinen, Kari T. Korhonen,
Anja Yli-Viikari and Tuula Packalen

Synthesis on bioeconomy monitoring systems in the EU Member States

- indicators for monitoring the progress of bioeconomy

Markus Lier, Martti Aarne, Leena Kärkkäinen, Kari T. Korhonen,
Anja Yli-Viikari and Tuula Paakkala



Recommended citation: Lier, M., Aarne, M., Kärkkäinen, L., Korhonen, K.T., Yli-Viikari, A. and Packalen, T. (2018). Synthesis on bioeconomy monitoring systems in the EU Member States - indicators for monitoring the progress of bioeconomy. Natural resources and bioeconomy studies 38/2018. 44 p. Natural Resources Institute Finland, Helsinki 2018.

ISBN 978-952-326-608-7 (Print)

ISBN 978-952-326-607-0 (Online)

ISSN 2342-7647 (Print)

ISSN 2342-7639 (Online)

URN <http://urn.fi/URN:ISBN:978-952-326-607-0>

Copyright: Natural Resources Institute Finland (Luke)

Authors: Markus Lier, Martti Aarne, Leena Kärkkäinen, Kari T. Korhonen, Anja Yli-Viikari and Tuula Packalen

Publisher: Natural Resources Institute Finland (Luke), Helsinki 2018

Cover Photo: Luke archive

Year of publication: 2018

Printing house and publishing sales: Juvenes Print, <http://luke.juvenesprint.fi>

Summary

Markus Lier², Martti Aarne¹, Kari T. Korhonen², Leena Kärkkäinen², Anja Yli-Viikari³ and Tuula Paakkala²
Natural Resources Institute Finland (Luke), Helsinki¹, Joensuu², Jokioinen³, 2018

The urgent need to shift our economy towards a more sustainable, resource-efficient economy based on renewable resources that either makes less use of fossil resources or dispenses with them entirely, the so called bioeconomy, has been recognized all over Europe. As a result, many EU Member States (EU MS) have formulated national and regional bioeconomy strategies, related policies or initiatives. An important tool for the successful implementation of a strategy is the monitoring and evaluation of the success of the measures undertaken to reach the strategy's goals.

The EC review report of the EU Bioeconomy strategy concluded the need for better monitoring and assessment frameworks, *“new actions are needed to develop relevant indicators and scientific evidence for policy making, and to implement a more holistic monitoring and assessment framework”* (EC 2017). However, up to now, there is no commonly agreed set of indicators to measure the bioeconomy at EU level.

Because the main drivers for the transition towards a bioeconomy often strongly vary between EU MS on the country-specific economic and ecological settings, legal framework, and social demands, also the national or regional bioeconomy strategies vary in their goals and measures. Consequently, proxies and indicators used to measure the development of a national bioeconomy or the success of a bioeconomy strategy depend on the national goals, and are therefore often not applicable in any other country. Nevertheless, synchronizing the national bioeconomy monitoring-activities is necessary to ensure comparability of the results of the national monitoring systems. As a first step towards a common European bioeconomy monitoring-activity, it is crucial to get an overview over the numerous scattered ongoing monitoring activities at EU MS level. Therefore, there is the need for an overview study presenting information on existing approaches of monitoring bioeconomy strategies in the EU MS.

This report presents an overview of existing bioeconomy strategies, policies or related initiatives and indicators to monitor and assess these at EU MS level, and the importance of existing bioeconomy sectors at national level. Furthermore, it presents the existing or needed most suitable bioeconomy key indicators and related indicators, and their respective data availability, for assessing and monitoring the progress of a bioeconomy at national level. The identified most suitable bioeconomy indicators important and feasible at the national context, can contribute to the further discussions when setting the frame for the development of a common EU bioeconomy monitoring system.

Keywords: bioeconomy, indicators, progress monitoring, statistical classifications

Contents

Summary	3
1. Introduction	5
2. Methods and material	6
2.1. Work plan, milestones and expected outputs of MontBioeco.....	6
2.2. Literature reviews of different bioeconomy indicator initiatives at national, EU and international level ..	7
2.3. Drafting suitable key indicators and related indicators for describing the progress of a bioeconomy.....	8
2.4. Online-survey	8
3. Results	10
3.1. List of suitable key indicators and related indicators for describing the progress of a bioeconomy	10
3.2. Results of the online survey	10
3.2.1. Existing bioeconomy strategies, policies or related initiatives and indicators to monitor and assess these at national level.....	10
3.2.2. Industries and activities included, partly included and not included in the bioeconomy sector at national level.....	11
3.2.3. EU bioeconomy strategy objectives included in country's bioeconomy strategies, policies and/or related initiatives	13
3.2.4. Evaluation of national relevance of the identified indicators under each EU bioeconomy strategy objectives	14
3.2.4.1 National relevance of key indicators and related indicators, and respective data availability under the objective "Creating jobs and maintaining competitiveness"	14
3.2.4.2 National relevance of key indicators and related indicators, and respective data availability under the objective "Reducing dependence on non-renewable resources"	17
3.2.4.3 National relevance of key indicators and related indicators, and respective data availability under the objective "Mitigating and adapting climate change"	19
3.2.4.4 National relevance of key indicators and related indicators, and respective data availability under the objective "Ensuring food security"	20
3.2.4.5 National relevance of key indicators and related indicators, and respective data availability under the objective "Managing natural resources sustainably"	21
4. Discussions.....	23
4.1. Existing bioeconomy strategies, policies or related initiatives, and existing bioeconomy indicator sets ..	23
4.2. Bioeconomy sectors included in a bioeconomy at national level	23
4.3. Identified most suitable bioeconomy key indicators and related indicators at national level	24
4.4. Data comparability	26
5. Conclusions	27
Appendices	28
Annex 1 Glossary	28
Annex 2 Online-survey	32
Annex 3 Identified most suitable key indicators and related indicators	39
References	44

1. Introduction

The urgent need to shift our economy towards a more sustainable, resource-efficient economy based on renewable resources that either makes less use of fossil resources or dispenses with them entirely, the so called bioeconomy, has been recognized all over Europe. A bioeconomy includes the *“production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy... (including) agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical, biotechnological and energy industries”* (EC 2012a). According to the EU Bioeconomy strategy review report (EC 2017) the *“2012 Bioeconomy Strategy...has brought the bioeconomy principles and cross-cutting objectives to the attention of national and regional policy-makers...”* As a result, many European Union Member States (EU MS) have formulated national and regional bioeconomy strategies, related policies or initiatives, or are planning to formulate such strategies, related policies or initiatives.

An important tool for the successful implementation of a strategy is the monitoring and evaluation of the success of the measures undertaken to reach the strategy’s goals. This has also been recognised by EU Bioeconomy strategy *“establish a Bioeconomy Observatory...collaboration with existing information systems that allows regularly assess the progress and impact of the bioeconomy and develop forward-looking and modelling tools”* (EC 2012a). In addition, the European Commission (EC) review report of the EU Bioeconomy strategy concluded the need for better monitoring and assessment frameworks, *“new actions are needed to develop relevant indicators and scientific evidence for policy making, and to implement a more holistic monitoring and assessment framework”* (EC 2017). However, up to now, there is no commonly agreed set of indicators to measure the bioeconomy at EU level.

Because the main drivers for the transition towards a bioeconomy often strongly vary from EU MS to EU MS depending on the country-specific economic and ecological settings, legal framework, and social demands, also the national or regional bioeconomy strategies vary in their goals and measures. Consequently, proxies and indicators used to measure the development of a national bioeconomy or the success of a bioeconomy strategy depend on the national goals, and are therefore sometimes not applicable in any other country. Nevertheless, synchronizing the national bioeconomy monitoring-activities is necessary to ensure comparability of the results of the national monitoring systems. As a first step towards a common framework for European bioeconomy monitoring, it is crucial to get an overview over the ongoing monitoring activities at EU MS level.

The project MontBioeco (Synthesis on bioeconomy monitoring systems in the EU Member States) aims at identifying and comparing the different approaches within the EU MS to monitor the progress in a country’s bioeconomy. An integrated part is the participatory approach of the project, by direct involvement of Ministries and research organizations responsible for developing, assessing and monitoring national bioeconomy strategies, policies and/or related initiatives. This allows MontBioeco to identify the already existing and desired bioeconomy key indicators, as well as their respective data availability at national level. The identified bioeconomy indicators important and feasible at the national context, can contribute to the further discussions when setting the frame for the development of a common EU bioeconomy monitoring system

MontBioeco was co-ordinated by the Natural Resources Institute Finland (Luke), and co-financed by Luke, the Standing Committee on Agricultural Research (SCAR) Bioeconomy Strategic Working group (BSW), the Common Agricultural and Wider Bioeconomy Research Agenda (CASA) and the Ministry of Agriculture and Forestry Finland (MMM). The project duration was 11/2017-6/2018 and the total budget EUR 85 000.

2. Methods and material

2.1. Work plan, milestones and expected outputs of MontBioeco

The research was conducted by experts from the forest and agriculture sector, and supported from experts in bioeconomy statistics in three working packages and WP-related Milestones and outputs (Figure 1).

The results of this report are based on three parts including:

- i) a literature review of different existing bioeconomy indicator initiatives at national, EU and international level; a draft of suitable key indicators and related indicators for describing the progress of a bioeconomy (WP1)
- ii) a quantitative online survey sent to SCAR BSW member (including Ministries and research organisations at national level responsible for developing, assessing and monitoring national bioeconomy strategies, policies and/or related initiatives in thirteen EU MS) mapping existing bioeconomy sectors; existing and/or needed bioeconomy key indicators and indicators for assessing and monitoring bioeconomy strategies, policies and/or related initiatives at national level; and data availability for bioeconomy key indicators and related indicators at national level (WP1)
- iii) an analyses of the quantitative online survey results, including discussions about the already existing and most needed key indicators and related indicators, as well as their respective data availability identified from the survey results (WP2)
- iv) an outline of the most suitable key indicators and related indicators towards a common set of indicators for measuring the progress of bioeconomy at EU level (WP3)

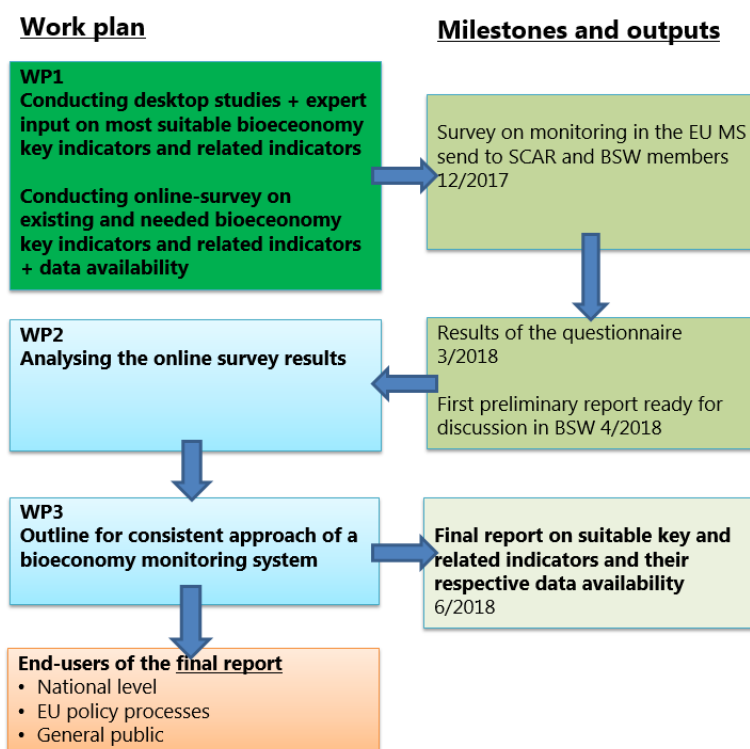


Figure 1. Work plan, milestones and output of MontBioeco.

2.2. Literature reviews of different bioeconomy indicator initiatives at national, EU and international level

In order to obtain an overview of different existing bioeconomy indicator initiatives at national, EU and international level reviews on scientific literature and ongoing international indicator processes were conducted. Focus was set on i) indicators for describing bioeconomy at national level, ii) studies on assessing the sustainability of bioeconomy, iii) studies focusing on existing indicators used by a specific bioeconomy sector. In addition, focus was set on ongoing international indicator processes (FOREST EUROPE, OECD) (Table 1).

Table 1. Reviewed literature of different bioeconomy indicator initiatives at national, EU and international level.

Study focus on	Authors	Indicators related to dimension
indicators for describing bioeconomy at national level	Blumberga et. al 2017 , Talavyria 2017, Muiziniece et al. 2016	economic, social and ecological dimension
certain indicators for describing bioeconomy	Ronzon et al. 2018, Van de Pas, J. 2015	economic dimension of several sectors
assessing the sustainability of bioeconomy	Karvonen et al. 2017 Fritsche and Iriarte 2014 Trydeman et al. 2015, Pfau et al. 2014	indicators for ecological, economic and social dimensions
existing criteria and indicators of one sector to be used in the whole bioeconomy discussion	Wolfslehner et al. 2016	economic, social and ecological dimension of SFM criteria and indicators to be used in the bioeconomy discussion
Other: ongoing pan-European, international indicator processes		
FOREST EUROPE Criteria and Indicators for Sustainable Forest Management (SFM)	FOREST EUROPE	economic, social and ecological dimension of SFM
OECD Green Growth Indicators	OECD Green Growth Studies 2017	economic, social and ecological dimension of several sectors
European Classification of Economic Activities (NACE, Rev. 2)	EUROSTAT	national economies divided into industries and sectors
JRC Bioeconomy Report	JRC 2016	economic dimension of several sectors

2.3. Drafting suitable key indicators and related indicators for describing the progress of a bioeconomy

Outcomes of section 2.2 were used by the research group to draft suitable key indicators (suitable for general progress monitoring) and related indicators (related to each key indicator a list of related indicator for a detailed progress monitoring) for describing the progress of a bioeconomy at national level. Most of the selected key indicators and related indicators are currently used in ongoing pan-European and/or international bioeconomy-focused and/or bioeconomy-related indicator processes. Because the focus of the study are on the EU MS, the research group decided to structure the identified suitable key indicators and related indicators for describing the progress of a bioeconomy around the EU bioeconomy strategy objectives (EC 2012b):

- creating jobs and maintaining competitiveness,
- reducing dependence on non-renewable resources,
- mitigating and adapting climate change,
- ensuring food security, and
- managing natural resources sustainably.

2.4. Online-survey

The aim of the quantitative online-survey was to get a comprehensive overview of existing bioeconomy monitoring systems at EU MS level. The identified 29 suitable key indicators and 161 related indicators, grouped under each EU bioeconomy objective, were used for developing a quantitative online-survey on existing bioeconomy sectors; on already existing or needed bioeconomy key indicators to assess and monitor bioeconomy strategies, policies and/or related initiatives; and the availability of data on bioeconomy key indicators at national level.

The quantitative online-survey (Annex 2) was structured in five parts:

- general information
- existence of bioeconomy strategies, policies and/or related initiatives and indicators to monitor and assess the bioeconomy strategies, policies and/or related initiatives
- industries and activities (defined in accordance to NACE-classification¹) included, partly included and not included in the bioeconomy sector at national level
- EU bioeconomy objectives included in country's bioeconomy strategies, policies and/or related initiatives
- evaluation of national relevance of the identified draft key indicators and related indicators (indicator "included", "not included, but needed" and "not needed" at national level) under each EU bioeconomy strategy objectives (EC 2012b)

¹ European Classification of Economic Activities (NACE, Rev. 2) was applied to present national economies divided into industries and sectors. NACE provides the framework for collecting and presenting a large range of statistical data according to economic activity in the fields of economic statistics (e.g. national accounts, production, employment) and in other statistical domains. Statistics produced on the basis of NACE are comparable at European and, in general, at world level. The use of NACE is mandatory within the European Statistical System. The comparability of NACE-based figures also at global level is due to the fact that NACE is part of the global ISIC classification (International Standard Industrial Classification).

- the national relevance of the identified draft key indicators and related indicators: scale 1 (poor) to 10 (excellent)
- data availability of suitable indicators at national level

In addition, a glossary list (Annex 1) containing definitions of the different indicators was compiled to be used by the country correspondents of the online-survey.

The online-survey was sent in December 2017 to Ministries and research organizations responsible for developing, assessing and monitoring national bioeconomy strategies, policies and/or related initiatives in 21 EU MS and non-EU countries. All country correspondents were members of the Standing Committee on Agricultural Research (SCAR) Bioeconomy Strategic Working Group (BSW). The online-survey received 13 responses from 11 EU MS and two correspondents from non-EU countries by April 2018 (Table 2). The correspondents had the opportunity to revise the provided answers in a second phase, where the aggregated information was presented in excel table format. The excel table format was chosen for a better presentation of the given answers. The draft results from the online-survey were presented to the correspondents in April 2018 via E-mail and in the SCAR BSW meeting in Berlin on 16.4.2018.

Table 2. Main correspondents and other organisations involved in answering the survey by country.

Country	Main respondent and other organisations involved in answering the survey
Denmark	Ministry of Environment, Food and Ministry of Higher Education and Science
Estonia	Ministry of Rural Affairs
Finland	Ministry of Agriculture and Forestry
France	Ministry of Agriculture and Food (main correspondent), Ministry of Ecology, Ministry of Industry, Ministry of Research, Research centres and national agencies (ADEME, Agence Nationale pour la Recherche, France Agrimer, Institut National de l'Information Géographique et Forestier, INRA, IRSTEA), Technical institutes for agriculture and food industries Clusters
Germany	Federal Ministry of Education and Research (main correspondent), Federal Ministry of Economic Affairs and Energy, Federal Ministry of Food and Agriculture, Projektträger Jülich (PtJ), Forschungszentrum Jülich GmbH; Agency for Renewable Resources
Italy	CREA-PB (main respondent), Ministry of Agricultural, Food and Forestry Policies, Research and experimentation Office - DISR IV
Latvia	Ministry of Agriculture
Netherlands	Ministry of Agriculture, Nature and Food Quality
Norway	Research Council of Norway
Slovakia	Bioeconomy Cluster
Spain	Spanish National Institute for Agricultural and Food Research and Technology (INIA)
Turkey	Ministry of Food, Agriculture and Livestock
UK	Knowledge Transfer Network (main correspondent), Department Business Energy and Industrial Strategy, AgriFood and Biosciences Institute, Department Environment, Food and Rural Affairs

3. Results

3.1. List of suitable key indicators and related indicators for describing the progress of a bioeconomy

The research group identified in sections 2.2 and 2.3 suitable key indicators and related indicators for describing the progress of a bioeconomy at national level are around the EU bioeconomy strategy objectives (EC 2012b) (Table 3). The detailed indicator list is presented under section 3.2.4.

Table 3. Number of identified suitable key indicators and related indicators for describing the progress of a bioeconomy at national level for each EU bioeconomy strategy objective (EC 2012b).

EU bioeconomy strategy objective	Number of identified key indicators	Number of identified related indicators
Creating jobs and maintaining competitiveness	5	90
Reducing dependence on non-renewable resources	6	15
Mitigating and adapting climate change	6	8
Ensuring food security	7	22
Managing natural resources sustainably	5	26
SUM	29	161

The identified 29 key indicators and 161 related indicators, grouped under each objective, were used for developing a quantitative online-survey (section 2.4) on existing bioeconomy sectors; existing or needed bioeconomy key indicators to assess and monitor bioeconomy strategies, policies and/or related initiatives; and the availability of data on bioeconomy key indicators at EU level.

3.2. Results of the online survey

3.2.1. Existing bioeconomy strategies, policies or related initiatives and indicators to monitor and assess these at national level

Among the 13 responding countries eight countries have an existing national bioeconomy strategy, policy or related initiative, of which one half have also existing indicators to monitor and assess the national bioeconomy strategy, policy or related initiative. Meanwhile in four countries national bioeconomy strategy, policy or related initiatives are under development (Figure 2). In four countries, a national indicator set is being under development, of which in two countries this process is undertaken in parallel to the development of a national bioeconomy strategy. In addition one country informed that the process of developing national bioeconomy indicators set was initiated using the results of the online-survey.

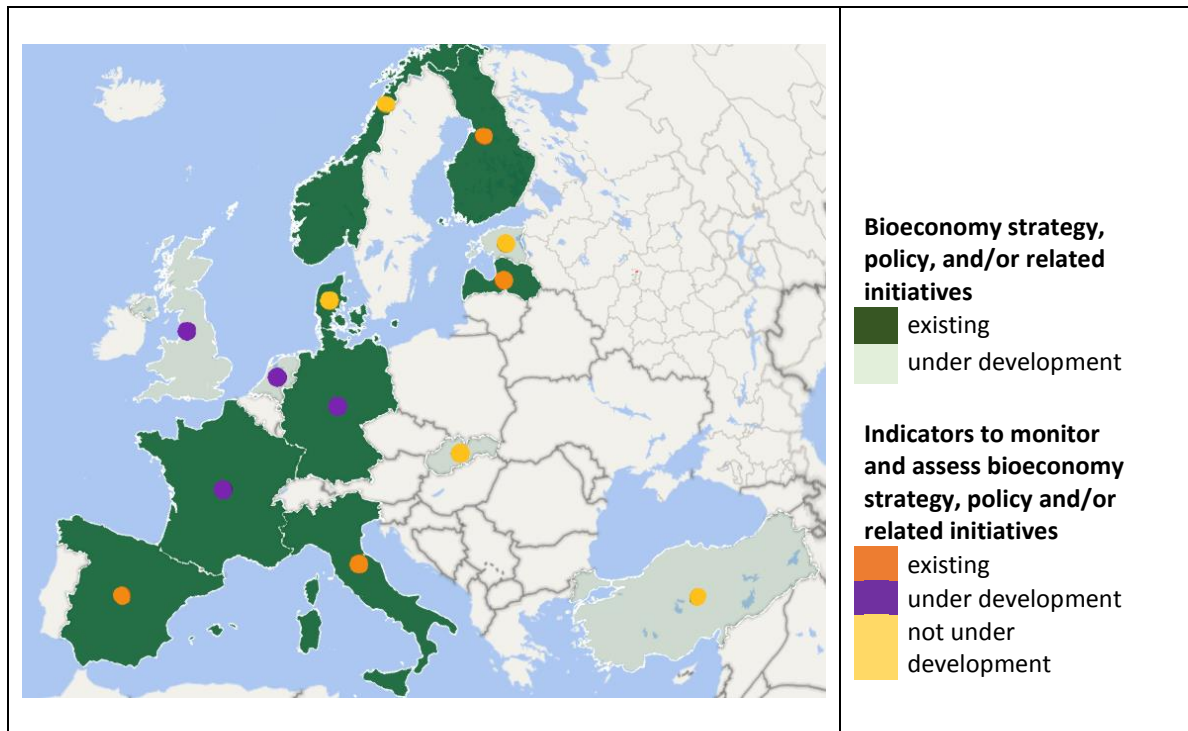


Figure 2 Survey results on existing bioeconomy strategy, policy and/or related initiatives and existing indicators to monitor and assess these at EU MS and non-EU country level.

3.2.2. Industries and activities included, partly included and not included in the bioeconomy sector at national level

As to be expected, survey results show (Figure 2, Figure 3 and Table 4) that sectors that are currently considered as included in the bioeconomy at national level in all responding countries are sectors related to primary production of biomass or food (mostly agriculture and forestry, followed by aquaculture and fisheries). Sectors focusing on secondary processing of raw materials (e.g. food industry, wood products, renewable energy and pulp and paper industry) are considered by the responding countries at least as partly included. The pharmaceutical industry and chemical industry are for half of the responding countries seen as partly included in the national bioeconomy.

The country specific social-economic and ecological settings are well reflected in the responses, e.g. the sector nature tourism is considered as included or partly included mostly in Northern European countries. Other country specific sectors that were not included in the online-survey, but mentioned by some responding countries were sectors like the textile industry, and the biotechnology sector with its related services.

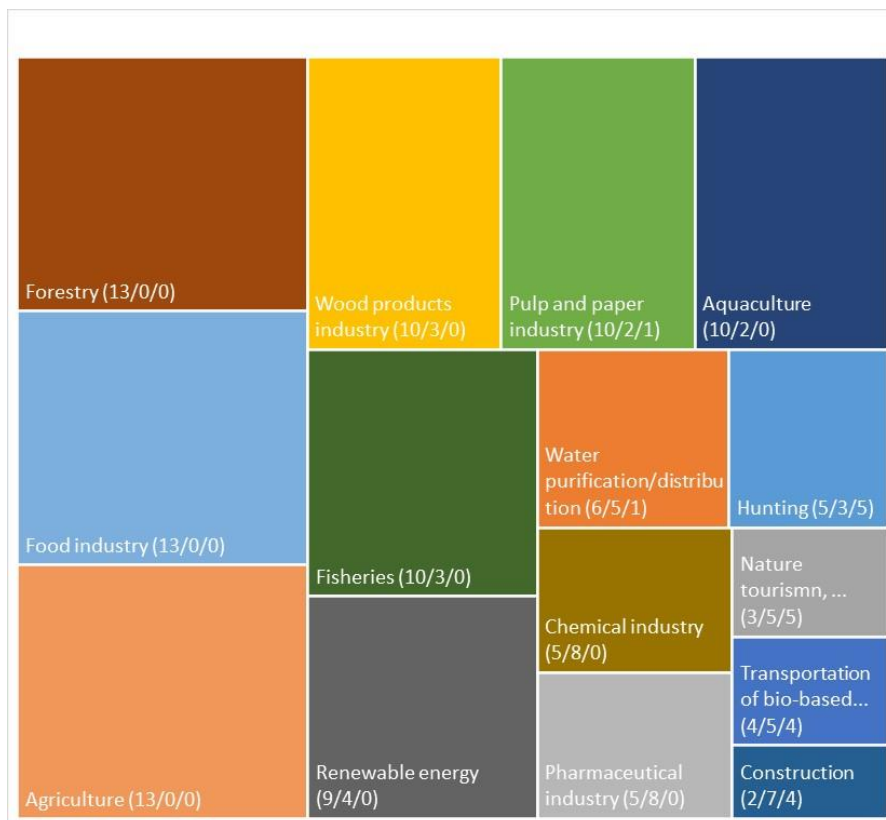


Figure 3 Hierarchical view on survey results on sum of industries and activities (“included”/”partly included”/”not included”) in the bioeconomy sector at national level. The bigger the sector box the higher the sum of countries including an industry and activity at national level. Sectors are defined in the *European Classification of Economic Activities (NACE, Rev. 2)*.

Table 4. Industries and activities according to the *European Classification of Economic Activities (NACE, Rev. 2)* (included= “++”/ partly included = “+” /not included =“-”) in the bioeconomy sector at national level.

NACE category	DENMARK	ESTONIA	FINLAND	FRANCE	GERMANY	ITALY	LATVIA	NETHERLANDS	NORWAY	SLOVAKIA	SPAIN	TURKEY	UK
Agriculture	++	++	++	++	++	++	++	++	++	++	++	++	++
Aquaculture	++	++	++	++	++	++	++	+	++	+	++	++	++
Chemical industry	+	+	++	+	+	++	+	+	+	+	++	++	++
Construction	+	-	++	+	+	-	+	-	+	-	+	++	+
Fisheries	++	++	++	++	++	++	++	+	++	+	++	++	+
Food industry	++	++	++	++	++	++	++	++	++	++	++	++	++
Forestry	++	++	++	++	++	++	++	++	++	++	++	++	++
Hunting	+	++	++	-	+	-	++	-	++	+	-	++	-
Nature tourism, green care and recreation	+	++	++	+	-	-	+	-	+	-	+	++	-
Pharmaceutical industry	+	+	++	+	+	++	+	++	+	+	+	++	++
Pulp and paper industry	++	++	++	++	++	++	-	++	++	+	++	++	+
Renewable energy	+	++	++	+	+	++	++	++	++	++	++	++	+
Transportation of bio-based raw materials and products	+	++	++	++	+	-	-	+	+	-	++	-	+
Water purification and distribution	+	-	++	+	+	+	++	++	++	+	+	++	+
Wood products industry	++	++	++	++	++	++	++	+	++	+	++	+	++

3.2.3. EU bioeconomy strategy objectives included in country's bioeconomy strategies, policies and/or related initiatives

To the question if the five EU bioeconomy strategy objectives (EC 2012) **Creating jobs and maintaining competitiveness**, **Reducing dependence on non-renewable resources**, **Mitigating and adapting climate change**, **Ensuring food security**, and **Managing natural resources sustainably** are included or partly included in a country's bioeconomy strategy, policy and/or related initiative, almost all correspondents answered positively (including non-EU countries Norway and Turkey) (Figure 4). This applies also to countries where a bioeconomy strategy, policy and/or related initiative is currently under development. Additional bioeconomy objectives mentioned by the correspondents being included at national level are: producing new bioeconomy-based knowledge and innovation, promoting locally routed sustainable growth, developing new business from bioeconomy and a strong bioeconomy competence base, supporting the decarbonisation of society, creating right market conditions, and promoting a circular economy that includes the efficient use of resources.

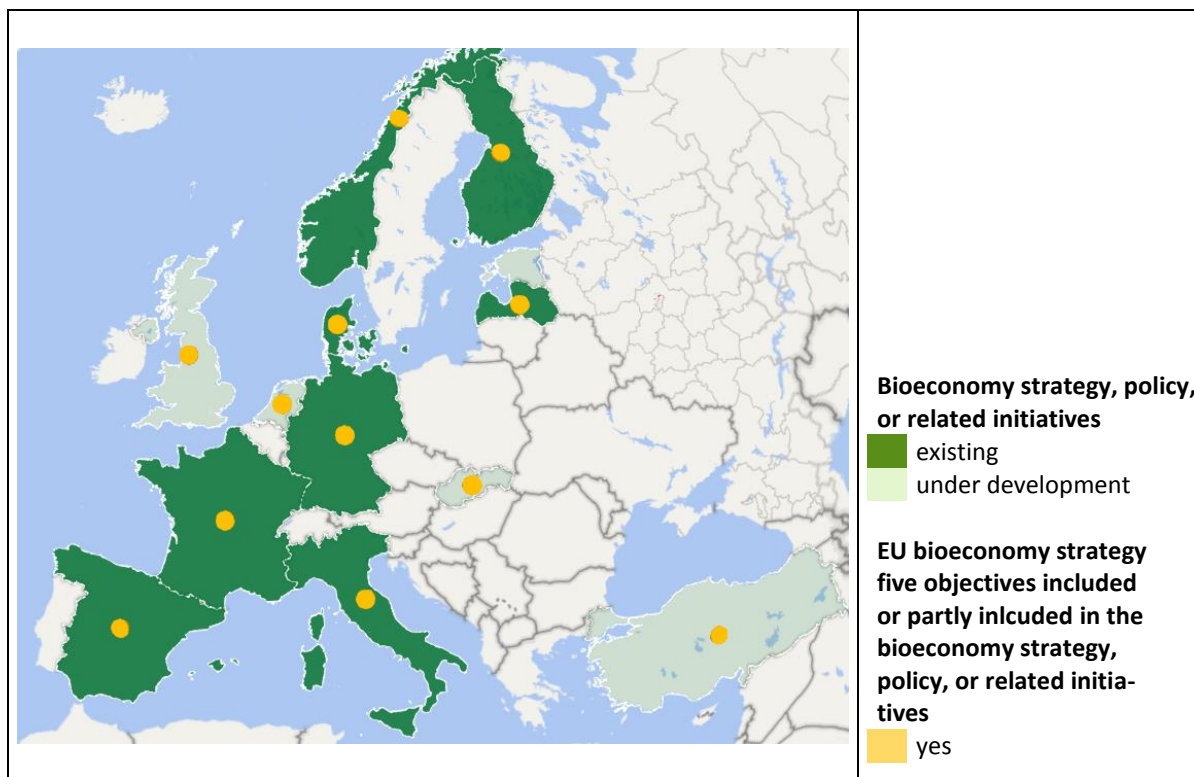


Figure 4 Survey results on existence of bioeconomy strategies, policies and/or related initiatives. EU bioeconomy strategy (2012 version) five objectives included or partly included in the national bioeconomy strategies, policies and/or related initiatives at EU and non-EU country level.

3.2.4. Evaluation of national relevance of the identified indicators under each EU bioeconomy strategy objectives

This section synthesizes the results of the online-survey on the evaluation of suitability and relevance of the identified bioeconomy key indicators and related indicators as identified under the five EU bioeconomy objectives at national level (Section 3.1). Hereby, correspondents were asked to rate if an indicator is already “*included*”, “*not included, but needed*” or “*not needed*”. The national relevance of the drafted key indicators and the related indicators could be rated on a scale from 1 being poor to 10 being excellent. However, due to the weak response rate of the national relevance, the research group decided to exclude the results of the analyses. The correspondents were also asked to evaluate the availability of data for suitable key indicators and related indicators at national level.

3.2.4.1 National relevance of key indicators and related indicators, and respective data availability under the objective “Creating jobs and maintaining competitiveness”

The indicators related to the objective **Creating jobs and maintaining competitiveness** were grouped into five key indicators *1.1 Number of employed persons in rural and urban areas; 1.2 Value added; 1.3 Contribution to the GDP; 1.4 Investment in research and innovation and 1.5 Exports* and respectively into 18 related indicators.

Results of the online-survey suggest (Table 5) that among the correspondents the key indicators focused around the objective **Creating jobs and maintaining competitiveness** are “*included*” at national level or are “*not included, but needed*” in most of the responding countries and have been recognised in the formulation of national bioeconomy strategy, policy and/or related initiatives. The highest rates however were given by countries to key indicator 1.2 and the related indicators under 1.2. The table suggests that the data availability for 1.2. and the related indicators is good. When it comes to the indicators under 1.1, 1.2., 1.3, 1.4 and 1.5, the traditional bioeconomy sectors including agriculture, food industry, aquaculture, forestry, wood products industry and pulp and paper industry seem to be higher rated than new arising industries that are a cross-sectoral resulting in new value-added products and services (e.g. bio-based material for packaging and construction). However, the opinions of the country correspondents were clearly divided on the need of related indicators on 1.n.4 Water purification and distribution, 1.n.5 Transportation of bio-based raw materials/products, 1.n.6 Bioeconomy services, 1.n.6.1 Nature tourism, green care and recreation, 1.n.6.2 Hunting and 1.n.6.3 Fisheries.

The data availability is good for all key indicators and varies for the related indicators between the countries. It can be assumed that that data on relative shares of bioeconomy for indicators on wood constructions, chemical industry and pharmaceutical industry are currently mainly based on expert estimates in many countries.

The country specific social-economic and ecological settings are well reflected in the responses connected to the related indicators, e.g. water purification and distribution; transportation of bio-based raw materials and products; nature tourism, green care and recreation; hunting; and fisheries are considered by a few countries.

Table 5. Results of the online-survey on existing and needed bioeconomy key indicators and related indicators, as well as their respective data availability, under the bioeconomy objective “Creating jobs and maintaining competitiveness”.

Bioeconomy key indicators and related indicators as identified under the bioeconomy objective “Creating jobs and maintaining competitiveness”	Key indicator	Related indicator	Demand			Supply
			SUM countries that answered "included" at national level	SUM countries that answered "not included, but needed" at national level	SUM countries that answered "not needed"	Data availability in countries
1.1 Number of employed persons in rural and urban areas (1000 persons)	x		8	0	0	8
1.1.1 Food sector		x	7	1	1	8
1.1.1.1 Agriculture		x	7	1	1	9
1.1.1.2 Food industry		x	8	1	1	8
1.1.1.3 Aquaculture		x	7	2	1	6
1.1.2 Bioeconomy goods		x	9	1	0	4
1.1.2.1 Forestry		x	8	1	1	8
1.1.2.2 Wood products industry		x	6	3	1	7
1.1.2.3 Pulp and paper industry		x	4	4	2	5
1.1.2.4 Construction		x	5	2	3	7
1.1.2.5 Chemical industry		x	6	3	1	7
1.1.2.6 Pharmaceutical industry		x	5	4	1	8
1.1.3 Renewable energy		x	4	5	0	3
1.1.4 Water purification and distribution		x	3	4	2	4
1.1.5 Transportation of bio-based raw materials/products		x	1	6	3	3
1.1.6 Bioeconomy services		x	3	5	1	1
1.1.6.1 Nature tourism, green care and recreation		x	2	5	2	2
1.1.6.2 Hunting		x	2	4	4	6
1.1.6.3 Fisheries		x	4	3	2	7
1.2. Value added (1000 EUR)	x		10	1	0	10
1.2.1 Food sector		x	9	1	0	10
1.2.1.1 Agriculture		x	9	1	0	9
1.2.1.2 Food industry		x	9	1	0	9
1.2.1.3 Aquaculture		x	5	3	1	6
1.2.2 Bioeconomy goods		x	6	3	0	6
1.2.2.1 Forestry		x	6	3	0	7
1.2.2.2 Wood products industry		x	6	2	1	7
1.2.2.3 Pulp and paper industry		x	4	4	1	4
1.2.2.4 Construction		x	4	3	2	7
1.2.2.5 Chemical industry		x	6	3	0	6
1.2.2.6 Pharmaceutical industry		x	5	4	0	7
1.2.3 Renewable energy		x	6	4	0	5
1.2.4 Water purification and distribution		x	2	4	3	4
1.2.5 Transportation of bio-based raw materials/products		x	2	4	3	3
1.2.6 Bioeconomy services		x	3	5	1	2
1.2.6.1 Nature tourism, green care and recreation		x	1	4	3	1
1.2.6.2 Hunting		x	3	1	4	2
1.2.6.3 Fisheries		x	3	3	1	3

Table 5 (cont.) Results of the online-survey on existing and needed bioeconomy key indicators and related indicators, as well as their respective data availability, under the bioeconomy objective “Creating jobs and maintaining competitiveness”.

Bioeconomy key indicators and related indicators as identified under the bioeconomy objective “Creating jobs and maintaining competitiveness”	Key indicator	Related indicator	Demand			Supply
			SUM countries that answered "included" at national level	SUM countries that answered "not included, but needed" at national level	SUM countries that answered "not needed"	Data availability in countries
1.3. Contribution to the GDP (%)	x		6	3	0	8
1.3.1 Food sector		x	7	2	0	7
1.3.1.1 Agriculture		x	5	3	0	6
1.3.1.2 Food industry		x	6	2	0	5
1.3.1.3 Aquaculture		x	6	2	0	5
1.3.2 Bioeconomy goods		x	6	3	0	4
1.3.2.1 Forestry		x	5	3	0	5
1.3.2.2 Wood products industry		x	4	3	1	4
1.3.2.3 Pulp and paper industry		x	5	3	0	4
1.3.2.4 Construction		x	2	3	2	5
1.3.2.5 Chemical industry		x	6	3	1	5
1.3.2.6 Pharmaceutical industry		x	5	3	0	6
1.3.3 Renewable energy		x	6	3	1	5
1.3.4 Water purification and distribution		x	1	3	4	4
1.3.5 Transportation of bio-based raw materials/products		x	2	4	3	3
1.3.6 Bioeconomy services		x	3	4	2	1
1.3.6.1 Nature tourism, green care and recreation		x	1	3	3	0
1.3.6.2 Hunting		x	2	1	4	0
1.3.6.3 Fisheries		x	4	2	1	2
1.4 Investment in research and innovation (1000 EUR)	x		6	3	0	8
1.4.1 Food sector		x	6	3	0	7
1.4.1.1 Agriculture		x	4	4	0	6
1.4.1.2 Food industry		x	5	3	0	5
1.4.1.3 Aquaculture		x	4	2	1	5
1.4.2 Bioeconomy goods		x	5	3	1	4
1.4.2.1 Forestry		x	3	4	1	5
1.4.2.2 Wood products industry		x	3	4	1	4
1.4.2.3 Pulp and paper industry		x	3	4	1	4
1.4.2.4 Construction		x	2	2	2	5
1.4.2.5 Chemical industry		x	4	3	1	5
1.4.2.6 Pharmaceutical industry		x	4	2	1	6
1.4.3 Renewable energy		x	4	5	0	5
1.4.4 Water purification and distribution		x	1	5	2	5
1.4.5 Transportation of bio-based raw materials/products		x	1	5	2	4
1.4.6 Bioeconomy services		x	3	5	1	4
1.4.6.1 Nature tourism, green care and recreation		x	1	4	2	3
1.4.6.2 Hunting		x	1	2	5	2
1.4.6.3 Fisheries		x	3	3	1	3

Table 5 (cont.) Results of the online-survey on existing and needed bioeconomy key indicators and related indicators, as well as their respective data availability, under the bioeconomy objective “**Creating jobs and maintaining competitiveness**”.

Bioeconomy key indicators and related indicators as identified under the bioeconomy objective “Creating jobs and maintaining competitiveness”	Key indicator	Related indicator	Demand			Supply
			SUM countries that answered “included” at national level	SUM countries that answered “not included, but needed” at national level	SUM countries that answered “not needed”	Data availability in countries
1.5 Export (1000 EUR)	x		8	1	0	9
1.5.1 Food sector		x	9	1	0	10
1.5.1.1 Agriculture		x	8	1	0	8
1.5.1.2 Food industry		x	8	1	0	9
1.5.1.3 Aquaculture		x	8	1	0	8
1.5.2 Bioeconomy goods		x	8	1	1	7
1.5.2.1 Forestry		x	6	2	1	7
1.5.2.2 Wood products industry		x	6	1	2	7
1.5.2.3 Pulp and paper industry		x	5	1	3	4
1.5.2.4 Construction		x	4	3	2	8
1.5.2.5 Chemical industry		x	7	2	0	8
1.5.2.6 Pharmaceutical industry		x	7	2	0	7
1.5.3 Renewable energy		x	6	4	0	6
1.5.4 Water purification and distribution		x	4	1	4	3
1.5.5 Transportation of bio-based raw materials/products		x	2	4	3	3
1.5.6 Bioeconomy services		x	2	4	2	2
1.5.6.1 Nature tourism, green care and recreation		x	0	3	5	2
1.5.6.2 Hunting		x	2	0	6	2
1.5.6.3 Fisheries		x	3	2	3	5

3.2.4.2 National relevance of key indicators and related indicators, and respective data availability under the objective “Reducing dependence on non-renewable resources”

The indicators related to the objective **Reducing dependence on non-renewable resources** were grouped into six key indicators *2.1 Production of renewable energy; 2.2 Production of biofuels and biogas; 2.3 Material and waste recycling and recovery rates; 2.4 Material replacing non-renewable resources (bio-materials); 2.5 Public financial support and private investments for reducing dependence on non-renewable resources, 2.6 Investment in research and innovation* and respectively into 15 related indicators.

The correspondents answered that the key indicators 2.1 and 2.2 Production of biofuels and biogas are already “included” or “not included, but needed” in most of the countries (Table 6). Correspondents suggested to merge 2.1. and 2.2, because both key indicators deal with the issue on production of renewable energy. Further results of the online survey show that among the responding countries the issues of replacing non-renewable resources by renewables in e.g. energy production has been recognised in the formulation of national bioeconomy strategy, policy, or related initiatives. The data availability is good for all key indicators and varies for the related indicators between the countries.

The correspondents were divided on the issues if solar, wind, geothermal energy and hydropower can be considered as renewable energy sources, and being a part of bioeconomy. Although these related indicators have received high rating in “not needed”, the country specific social-economic and ecological settings should be taken into account when deciding on key indicators and related indicators in the future. This applies also to the related indicator on wood based-constructions and bio-based textiles.

As in previous sections, the country specific social-economic and ecological settings are well reflected in the responses connected to the related indicators, and sectors like nature tourism, green care and recreation, hunting, and fisheries are considered as need by only a few countries.

Table 6. Results of the online-survey on existing and needed bioeconomy key indicators and related indicators, as well as their respective data availability, under the bioeconomy objective “Reducing dependence on non-renewable resources”.

Bioeconomy key indicators and related indicators as identified under the bioeconomy objective “Reducing dependence on non-renewable resources”	Key indicator	Related indicator	Demand			Supply
			SUM countries that answered “included” at national level	SUM countries that answered “not included, but needed” at national level	SUM countries that answered “not needed”	Data availability in countries
2.1 Production of renewable energy (share of renewable resources on the total energy production, %)	x		8	1	0	7
2.1.1 Wood fuels		x	9	0	1	7
2.1.2 Solar energy		x	6	1	3	7
2.1.3 Wind energy		x	6	1	3	7
2.1.4 Geothermal energy		x	5	1	4	6
2.1.5 Hydropower		x	5	1	3	7
2.2 Production of biofuels and biogas (toe)	x		8	1	0	8
2.2.1 Forest biomass		x	9	0	0	7
2.2.1.1 Biofuels		x	8	0	0	6
2.2.1.2 Biogas		x	8	0	0	7
2.3 Material and waste recycling and recovery rates (toe)	x		5	4	0	5
2.3.1 Wood products		x	4	4	1	4
2.3.2 Organic waste		x	4	4	0	6
2.4 Material replacing non-renewable resources (bio-materials)	x		4	5	0	3
2.4.1 Wood-based constructions (m3)		x	4	1	3	4
2.4.2 Bio-based textiles (tonnes)		x	1	5	2	1
2.4.3 Biodegradable plastics (toe)		x	2	5	0	2
2.5 Public financial support and private investments for reducing dependence on non-renewable resources (1000 EUR)	x		4	4	0	2
2.5.1 Public investments		x	7	1	0	3
2.5.2 Private investments		x	4	3	0	1
2.6 Investment in research and innovation (1000 EUR)	x		5	1	0	4

3.2.4.3 National relevance of key indicators and related indicators, and respective data availability under the objective “Mitigating and adapting climate change”

The indicators related to the objective **Mitigating and adapting climate change** were grouped into six key indicators, namely *3.1 Carbon sequestration*; *3.1.1 Forest carbon emissions/sinks*; *3.1.2 Agricultural emissions/sinks*; *3.1.3 Water area carbon emissions/sink*; *3.2 Public financial support and private investments for mitigating and adaptation*; *3.3 Investment in research and innovation* and respectively into 11 related indicators.

Results of the online-survey suggest (Table 7) that among the correspondents the key indicators 3.1.1 Forest carbon emissions/sinks and 3.1.2 Agricultural emissions/sinks are already “included” at national level or are “not included, but needed” by most of the countries. The reported relatively low data availability for some of the key indicators might not reflect the current situation, as most of the respondent countries do report annually data under the UNFCCC (United Nations Framework Convention on Climate Change) and Kyoto Protocol on LULUCF (Land Use, Land-Use Change and Forestry).

The country specific social-economic and ecological settings are well reflected in the responses connected to the related indicators, e.g. indicators related to Water area carbon emissions/sinks, have been rated by half of the correspondents as “not needed” at national level. The low relevance of *Water area carbon emissions/sinks* at national level can be explained by the relatively low share of inland surface waters in the majority of the responded countries.

Table 7. Results of the online-survey on existing and needed bioeconomy key indicators and related indicators, as well as their respective data availability, under the bioeconomy objective “Mitigating and adapting climate change”.

Bioeconomy key indicators and related indicators as identified under the bioeconomy objective “Mitigating and adapting climate change”	Key indicator	Related indicator	Demand			Supply
			SUM countries that answered “included” at national level	SUM countries that answered “not included, but needed” at national level	SUM countries that answered “not needed”	Data availability in countries
3.1 Carbon sequestration (CO2 eq. tonnes)	x		6	2	1	4
3.1.1 Forest carbon emissions/sinks	x		4	1	1	4
3.1.1.1 Forest carbon emissions		x	7	1	1	6
3.1.1.2 Forest carbon sinks		x	7	1	0	5
3.1.2 Agricultural emissions/sinks		x	6	2	0	4
3.1.2.1 Greenhouse gas emissions from agriculture	x		7	1	1	5
3.1.2.2 Agricultural soils as sinks		x	7	1	1	5
3.1.3 Water area carbon emissions/sinks	x		1	3	4	1
3.1.3.1 Water area carbon emissions		x	2	4	4	0
3.1.3.2 Water area sinks		x	1	3	3	1
3.2 Public financial support and private investments for mitigating and adaptation (1000 EUR)	x		3	5	1	3
3.2.1 Public investments		x	3	5	1	2
3.2.2 Private investments		x	2	7	1	2
3.3 Investment in research and innovation (1000 EUR)	x		3	1	1	2

3.2.4.4 National relevance of key indicators and related indicators, and respective data availability under the objective “Ensuring food security”

The indicators related to the objective **Ensuring food security** were grouped into seven key indicators, namely 4.1 *Domestic food supply of the food commodities in terms of production, import and stock change*, 4.1.1 *Agricultural products*; 4.1.2. *Fish products*; 4.1.3. *Non-wood forest products*; 4.1.4. *New food products*; 4.2 *Public financial support and private investments for reducing dependence on non-renewable resources*; 4.3 *Investment in research and innovation* and respectively into 26 related indicators.

Results of the online-survey suggest (Table 8) that among the responding countries the key indicators on 4.1.1 and 4.1.2. and the related indicators are already *included* at national level or are *not included but needed* by all countries. When it comes to the indicators related to 4.1.3 *Non-wood forest products* and 4.1.4 *New food products (insects)*, the indicators are considered by some countries as not relevant for food security, but seen as important for the development of value added products in bioeconomy, and also for cosmetics and pharmaceuticals. Low importance on the related indicators for agricultural products like olives and grapes reflect the country specific social-economic and ecological settings.

The data availability is, with the exception of some related indicators good for these key indicators and related indicators.

Table 8. Results of the online-survey on existing and needed bioeconomy key indicators and related indicators, as well as their respective data availability, under the bioeconomy objective “Ensuring food security”.

Bioeconomy key indicators and related indicators as identified under the bioeconomy objective “Ensuring food security”	Key indicator	Related indicator	Demand			Supply
			SUM countries that answered "included" at national level	SUM countries that answered "not included, but needed" at national level	SUM countries that answered "not needed"	Data availability in countries
4.1 Domestic food supply of the food commodities in terms of production, import and stock change	x		9	0	0	9
4.1.1 Agricultural products (1000 EUR)	x		8	1	0	7
4.1.1.1 Crops		x	6	2	1	7
4.1.1.1.1 Potatoes		x	6	2	1	8
4.1.1.1.2 Cereals		x	7	1	1	8
4.1.1.1.3 Sugar beets		x	6	2	1	8
4.1.1.1.4 Vegetables		x	7	0	2	8
4.1.1.1.5 Fruit		x	5	1	2	6
4.1.1.1.6 Grapes		x	3	1	4	4
4.1.1.1.7 Olives		x	1	1	4	2
4.1.1.2 Meat (1000 EUR)		x	8	0	1	7
4.1.1.2.1 Veal and beef		x	6	1	2	7
4.1.1.2.2 Pig meat		x	7	1	1	7
4.1.1.2.3 Sheep and goat meat		x	7	1	1	7
4.1.1.2.4 Poultry		x	6	1	1	6
4.1.1.3 Milk products		x	6	0	1	5
4.1.2. Fish products (1000 EUR)	x		9	0	0	9
4.1.2.1 From aquaculture		x	8	1	0	6

4.1.2.2 From capture		x	6	4	0	5
4.1.3. Non-wood forest products (1000 EUR)	x		3	2	3	2
4.1.3.1 Mushrooms		x	2	1	4	1
4.1.3.2 Fruits, berries and edible nuts		x	2	2	3	1
4.1.4. New food products (1000 EUR)	x		1	4	2	1
4.1.4.1 Insects		x	1	3	3	1
4.1.4.2 Wood-based ingredients		x	0	2	2	0
4.2 Public financial support and private investments for reducing dependence on non-renewable resources (1000 EUR)	x		4	3	0	3
4.2.1 Public investments		x	3	2	1	3
4.2.2 Private investments		x	1	3	0	1
4.3 Investment in research and innovation (1000 EUR)	x		3	2	1	2

3.2.4.5 National relevance of key indicators and related indicators, and respective data availability under the objective “Managing natural resources sustainably”

The indicators related to the objective **Managing natural resources sustainably** were grouped into five key indicators, namely *5.1 Land cover*; *5.2 Resource availability*; *5.3 Sustainable resource*; *5.4 Environmental protection*; *5.5 Public financial support and private investments for ecosystem services* and respectively into 26 related indicators.

Results of the online-survey suggest (Table 9) that among the correspondents the key indicators on *5.1 Land cover*, *5.2 Resource availability*, *5.3 Sustainable resource use* and *5.4 Environmental protection* are already “included” at national level or are “not included, but needed” by most of the responding countries. The data suggest that the issues on managing natural resources sustainably has been recognised in the formulation of national bioeconomy strategy, policy, or related initiatives.

The respective data availability of the key indicators and the related indicators is rather good. When comparing the responses given for the data availability under the key indicators and related indicators under 5.3.1 Sustainable forestry and 5.3.2 Sustainable agriculture it seems that data coverage is better for the 5.3.2 Sustainable agriculture. However, all responding countries are currently reporting e.g. data on 5.3.1.1 Ratio of annual increment and fellings in forests (%) to FOREST EUROPE, UNECE and FAO. This data should therefore be available.

Table 9. Results of the online-survey on existing and needed bioeconomy key indicators and related indicators, as well as their respective data availability, under the bioeconomy objective “Managing natural resources sustainably”.

Bioeconomy key indicators and related indicators as identified under the bioeconomy objective “Managing natural resources sustainably”	Key indicator	Related indicator	Demand			Supply
			SUM countries that answered "included" at national level	SUM countries that answered "not included, but needed" at national level	SUM countries that answered "not needed"	Data availability in countries
5.1 Land cover (share of total area, %)	x		8	1	0	9
5.1.1 Forest area		x	7	2	0	8
5.1.2 Agricultural area incl. cropland and grassland		x	7	1	0	8
5.1.3 Surface water		x	3	3	1	6
5.2 Resource availability	x		8	2	0	6
5.2.1 Growing stock on forests available for wood supply (1000 m3)		x	8	1	0	9
5.2.2 Freshwater resources (billion m3)		x	5	2	1	7
5.2.3 Fish resources (tonnes)		x	4	2	1	5
5.3 Sustainable resource use	x		5	3	0	3
5.3.1 Sustainable forestry		x	6	2	1	4
5.3.1.1 Ratio of annual increment and fellings in forests (%)		x	4	3	2	5
5.3.1.2 Ratio of fellings and estimated maximum sustainable level of cuttings in forests (%)		x	3	2	2	4
5.3.2 Sustainable agriculture		x	7	2	1	8
5.3.2.1 Nitrogen balance (kg/ha)		x	5	3	1	8
5.3.2.2 Phosphorus balance (kg/ha)		x	4	3	1	7
5.3.2.3 Soil erosion (tonnes/ha)		x	4	3	2	7
5.3.2.4 Ammonia, NOx and SOx emissions (ktonnes)		x	5	3	1	7
5.3.2.5 Pesticides sales (tonnes)		x	4	3	0	7
5.4 Environmental protection	x		6	0	1	6
5.4.1 Protected forest areas (1000 ha)		x	6	2	1	6
5.4.2 Standing and lying dead wood in forests (m3/ha)		x	4	3	2	2
5.4.3 Agricultural areas under Natura 2000 (1000 ha)		x	6	2	1	8
5.4.4 Area under agri-environmental commitments (1000 ha)			7	2	0	8
5.4.5 Number of threatened species			4	2	2	6
5.5 Public financial support and private investments for ecosystem services (1000 EUR)	x		2	4	2	3
5.5.1 Public payment for ecosystem services		x	1	4	3	2
5.5.1.1 Forest management		x	1	4	3	2
5.5.1.2 Agriculture management		x	1	5	2	1
5.5.1.3 Water management		x	1	4	3	1
5.5.2 Private payment for ecosystem services		x	1	4	2	1
5.5.2.1 Forest management		x	1	3	3	1
5.5.2.2 Agriculture management		x	1	3	3	1
5.5.2.3 Water management		x	0	3	2	1

4. Discussions

The results of the conducted online-survey produced an overview of existing bioeconomy strategies, policies or related initiative and existing national bioeconomy indicator sets to monitor and assess the progress of the bioeconomy strategies, policies or related initiative. In addition, results on existing and/or needed bioeconomy key indicators and related indicators for assessing and monitoring a bioeconomy strategy, a policy, and/or a related initiative at national level were presented. Further, the report presents the data availability for the key indicators and related indicators at national level. Although the online-survey was answered by 13 out of 21 countries, the results present a good overview on the current situation in the EU MS.

This section will focus on how the gained results and their use in the further discussions on a commonly agreed set of indicators to measure the bioeconomy at EU level.

4.1. Existing bioeconomy strategies, policies or related initiatives, and existing bioeconomy indicator sets

The results of the online survey show that bioeconomy strategies, policies or related initiatives exist or are under development in most of the responding countries. National bioeconomy indicator sets to monitor and assess the progress of the bioeconomy strategies, policies and/or related initiatives exist in some of the responding countries, or are under development in parallel to the development of a national bioeconomy strategy, policy or related initiative. Although the online-survey did not receive responses from Eastern and South-Eastern EU MS it can be assumed that in all of the EU MS at least bioeconomy related initiatives have been established. This hypothesis is supported by the review report of the EU Bioeconomy strategy (EC 2017). The report (EC 2017) states further that the *“2012 Bioeconomy Strategy is that it has brought the bioeconomy principles and cross-cutting objectives to the attention of national and regional policy-makers...”*

Our results support the assumption that the main drivers for the transition towards a bioeconomy varies from EU MS to EU MS not only depending on the country-specific socio-economic and ecological settings, legal framework, and social demands, but also on e.g. a long history of using natural resources and strong developed bioeconomy sectors.

4.2. Bioeconomy sectors included in a bioeconomy at national level

The results show that the sectors that are mostly included in the bioeconomy at national level are the traditional bioeconomy sectors focusing on primary production of biomass (agriculture, aquaculture, fisheries and forestry) and the traditional sectors using the biomass (food industry, wood products and pulp and paper industry). However, sectors currently only partly included (e.g. the construction sector, pharmaceutical industry and chemical industry) may gain of importance in the future.

The country specific social-economic and ecological settings are well reflected in the responses, e.g. nature tourism is considered as included or partly included mostly in Northern European countries. Other country specific sectors that were currently seen by a few countries as part of bioeconomy are the textile industry and biotechnology sector with its related services. A cross-sectoral cooperation at national level between all above-mentioned sectors is crucial to avoid competition for primary biomass resources. In this light it is evident that all bioeconomy sectors need to be innovative, productive and competitive whilst using fewer resources and reducing its environmental impact.

4.3. Identified most suitable bioeconomy key indicators and related indicators at national level

The results of this study show that the EU bioeconomy strategy objectives (EC 2012) *Creating jobs and maintaining competitiveness, Reducing dependence on non-renewable resources, Mitigating and adapting climate change, Ensuring food security, Managing natural resources sustainably* are included in almost all responding countries in their respective bioeconomy strategy, policy or related initiatives. This applies also for countries where a bioeconomy strategies, policies and/or related initiative are currently under development. Therefore, the results of Section 3.2.4 on suitable indicators under each EU bioeconomy strategy objective, could contribute to the further discussions when setting the frame for the development of a national and respectively a common EU bioeconomy monitoring system.

Considering the results on the relevance of suitable key indicators and related indicators at national level, the suggested five key indicators (Table 10) and 90 related indicators (Annex 3) under the objective **Creating jobs and maintaining competitiveness** could contribute to the further discussions when setting the frame for the development of a common EU bioeconomy monitoring system. At the time of the online-survey development, no key indicator and related indicators on imports have been suggested. However, the fact that EU MS also import biomass and bioeconomy goods (e.g. wooden biomass into industrial processes and energy generation), and taken into account the correspondents' comments that a key indicator on imports is needed, we recommend to include such a key indicator. In addition, we recommend to consider additional related indicators for textile, industrial biotechnology and synthetic biology under the indicator "1.x.x bioeconomy goods". Further research is needed for those key indicators and related indicators where the data and high-quality statistical information are currently not available or are based primarily on expert opinions.

Considering the results on the relevance of key indicators and related indicators at national level, the suggested six key indicators (Table 10) and 15 related indicators (Annex 3) under the objective **Reducing dependence on non-renewable resources** could contribute to the further discussions when setting the frame for the development of a common EU bioeconomy monitoring system. The recycling option (cascading use) of biobased materials is currently not taken into account in the list of key indicators and related indicators on the objective reducing dependence on non-renewable resources. However, this should be taken into consideration in the further discussions. In addition, further discussions are needed on the issue if solar, wind, geothermal energy and hydropower can be considered as renewable energy sources. Although, these related indicators have received high rating in *not needed*, the country specific social-economic and ecological settings should be taken into account when deciding on key indicators and related indicators in the future. This applies also to the related indicator on wood based-constructions and bio-based textiles. Further research is needed for those key indicators and related indicators where the data and high-quality statistical information are currently not available or are based primarily on expert opinions.

Considering the results on the relevance of key indicators and related indicators at national level, the suggested six key indicators (Table 10) and eight related indicators (Annex 3) under the objective **Mitigating and adapting climate change** could contribute to the further discussions when setting the frame for the development of a common EU bioeconomy monitoring system. However, the relatively low response rate for some of the key indicators and related indicators can be partly explained by the ecological settings of a country (e.g. 3.1.3 Water area carbon emissions/sinks). It is evident that *"ecosystems such as forests, oceans and soils are crucial carbon sinks"* (EC 2017) and therefore further discussions are needed on how to include the suggested key indicators and related indicators to the further discussions. In addition, the reported relatively low data availability for some of the key indicators might not reflect the current situation, as most of the respondent countries do report annually data under the UNFCCC (United Nations Framework Convention on Climate Change) and Kyoto

Protocol on LULUCF (Land Use, Land-Use Change and Forestry). Further research is needed for those key indicators and related indicators where the data and high-quality statistical information are currently not available or are based primarily on expert opinions.

Considering the results on the relevance of key indicators and related indicators at national level, the suggested seven key indicators (Table 10) and 26 related indicators (Annex 3) under the objective **Ensuring food security** could contribute to the further discussions when setting the frame for the development of a common EU bioeconomy monitoring system. However, it should be further discussed if the related indicators are presenting a comprehensive picture of the pattern of a country's food supply. When it comes to the indicators related to 4.1.3 Non-wood forest products and 4.1.4 New food products (insects), the relevance for food security is not recognised by countries, but seen as important for the development of value added products in bioeconomy. Low responses on the related indicators for agricultural products like olives and grapes reflect the country specific social-economic and ecological settings. Currently there is no key indicator and related indicators on food imports. Nevertheless, a comparison of the quantities of food available for human consumption with those imported would indicate the extent to which a country depends upon imports (import dependency ratio). In addition, the amount of food waste on farms during distribution and processing has to be taken into consideration in the further discussions. Further research is needed for those key indicators and related indicators where the data and high-quality statistical information are currently not available or are based primarily on expert opinions.

Considering the results on the relevance of key indicators and related indicators at national level, the suggested five key indicators (Table 10) and twenty-six related indicators (Annex 3) under the objective **Managing natural resources sustainably** could contribute to the further discussions when setting the frame for the development of a common EU bioeconomy monitoring system. When comparing the responses given for the data availability under the key indicators and related indicators under 5.3.1 Sustainable forestry and 5.3.2 Sustainable agriculture it seems that data coverage is better for the 5.3.2 Sustainable agriculture. However, all responding countries are currently reporting e.g. data on 5.3.1.1 Ratio of annual increment and fellings in forests (%) to FOREST EUROPE, UNECE and FAO. This data should therefore be available. The modern concept of sustainable resource use has gone beyond the original meaning of sustainable yield of forest resource mentioned in year 1713 (Carlowitz). Nowadays the concept has to fulfil simultaneous the ecological, economic, social and cultural functions of ecosystems. This has also been recognised in the EU Bioeconomy Strategy (Innovating for sustainable growth) (2012 a) which aims *"to pave the way to a more innovative, resource efficient and competitive society that reconciles food security with the sustainable use of biotic renewable resources for industrial purposes, while ensuring environmental protection"*. Existing processes that measure progress toward sustainability (e.g. FOREST EUROPE) should be taken in the further discussions when setting the frame for the development of a common EU bioeconomy monitoring system. Further research is needed for those key indicators and related indicators where the data and high-quality statistical information are currently not available or are based primarily on expert opinions.

Table 10. Identified most suitable key indicators under the bioeconomy objective

EU bioeconomy strategy objective	Identified most suitable key indicators
Creating jobs and maintaining competitiveness	Number of employed persons in rural and urban areas
	Value added
	Contribution to the GDP
	Investment in research and innovation
	Exports
	<i>+ Import (identified by the correspondents after the online-survey)</i>
Reducing dependence on non-renewable resources	Production of renewable energy <i>and</i> Production of biofuels and biogas <i>combined</i>
	Material and waste recycling and recovery rates
	Material replacing non-renewable resources
	Public financial support and private
	Investment in research and innovation
Mitigating and adapting climate change	Carbon sequestration
	Forest carbon emissions/sinks
	Greenhouse gas emissions from agriculture
	Water area carbon emissions/sinks
	Public financial support and private investments
	Investment in research and innovation
Ensuring food security	Domestic food supply of food commodities in terms of production, import/ stock change
	Agricultural products
	Fish products
	Non-wood forest products
	New food products
	Public financial support and private
	Investment in research and innovation
Managing natural resources sustainably	Land cover
	Resource availability
	Sustainable resource use
	Environmental protection
	Public financial support and private investments for ecosystem services
	<i>+ Investment in research and innovation (identified by the correspondents after the online-survey)</i>

4.4. Data comparability

To reach consistent and comparable results across all EU MS, harmonized statistical systems need to be utilized when reporting data concerning the most suitable key indicators and related indicators. The system of national accounts (NA) will definitely play a decisive role in future harmonized data deliveries to bioeconomy monitoring. National accounts are a statistical system that describes national economies comprehensively, systematically and precisely. National accounting systems are based on the European System of Accounts ESA2010, which complies with the global SNA2008 (System of National Accounts) recommendations. National accounts can be regarded as a basis when developing a common EU bioeconomy monitoring system. In addition to NA, other well-established and agreed statistical systems need to be exploited as well. For example, regarding labour force, foreign trade or industrial statistics, the methodologies and concepts are based on EU legislation, resulting to comparable country figures. The industrial division in bioeconomy monitoring is based on the harmonized classification of economic activities in the European Union (NACE, Rev. 2). Other important economic classifications include CPA (Products by Activity) and Prodcom, which provides statistics on manufactured goods. There is also a need for regional statistics on the bioeconomy. To that purpose, the nomenclature of territorial units in the EU (NUTS) need to be introduced when appropriate.

5. Conclusions

This report presents an overview of existing bioeconomy strategies, policies or related initiatives and indicators to monitor and assess these at national level, and the importance of existing bioeconomy sectors at national level. Furthermore, it presents the existing or needed most suitable bioeconomy key indicators and related indicators, and their respective data availability, for assessing and monitoring the progress of a bioeconomy at national level.

Because the main drivers for the transition towards a bioeconomy often strongly vary from between the EU MS depending on the country-specific economic and ecological settings, legal framework, and social demands, also the national or regional bioeconomy strategies vary in their goals and measures. Consequently, indicators used to measure the development of a national bioeconomy or the success of a bioeconomy strategy depends on the national goals. Nevertheless, synchronizing the national bioeconomy monitoring activities is necessary to ensure comparability of the results of the national monitoring systems.

The identified most suitable bioeconomy key indicators important and feasible at the national context, can contribute to the further discussions when setting the frame for the development of a common EU bioeconomy monitoring system.

To reach consistent and comparable country results across all EU MS, standardized statistical sources need to be utilized when reporting data under the most suitable key indicators and related indicators. Nevertheless the proposed indicator set needs to be further developed, including several rounds of testing their feasibility. To avoid an overlapping in the development of bioeconomy monitoring ,co-operation is needed between EU MS and actors active in this field, such as the EC, Eurostat, FAO, FOREST EUROPE, and the JRC Bioeconomy Observatory.

Appendices

Annex 1 Glossary

Agriculture Activities concerned with cultivating land, raising crops, and feeding, breeding, and raising livestock; farming. Source: NACE Rev. 2, Statistical classification of economic activities in the European Community. Eurostat, European Commission.

Ammonia emissions (Agriculture) Annual atmospheric emissions of ammonia. Source: EUROSTAT

Aquaculture The cultivation (including harvesting) of aquatic animals and plants, especially fish, shellfish, and seaweed, in natural or controlled marine or freshwater environments; underwater agriculture. Source: NACE Rev. 2, Statistical classification of economic activities in the European Community. Eurostat, European Commission.

Area under agri-environmental commitments Agricultural area which is covered by agri-environmental measures (and shows the implementation over time of this rural development scheme).

Bio-based textiles Bio-based products are wholly or partly derived from materials of biological origin, excluding materials embedded in geological formations and/or fossilised. In industrial processes, enzymes are used in the production of chemical building blocks, detergents, pulp and paper, textiles, etc. Source: EUROSTAT

Biodegradable plastics Biodegradable plastics that are produced from renewable resources (e.g. sugar, starch or cellulose). Source: European-bioplastics.org

Biofuels Biofuels are liquid fuels from a non-fossil biological origin and also represent a renewable energy resource. Biofuels can be divided into biogasoline and biodiesel depending on the material of origin used. Source: EUROSTAT

Biogas Biogas, primarily methane and carbon dioxide, is produced through the bacterial decomposition of organic matter like sewage, manure, organic household waste and plant crops. Source: EUROSTAT

Carbon emissions "Emissions" means the release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time. Source: UNFCC

Carbon sinks "Sink" means any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere. Source: UNFCC

Chemical industry Includes the transformation of organic and inorganic raw materials by a chemical process and the formation of products. Information is only needed on the use of bio-based raw materials. Source: NACE Rev. 2, Statistical classification of economic activities in the European Community. Eurostat, European Commission.

Construction Includes general construction and specialised construction activities for buildings and civil engineering works. Information is only needed on the use of wood and other biomaterials in construction activities. Source: NACE Rev. 2, Statistical classification of economic activities in the European Community. Eurostat, European Commission.

Fish resources The living resources in the community or population. Use of the term fish stock usually implies that the particular population is more or less isolated from other stocks of the same species and hence self-sustaining. Source: OECD

Fisheries Include the hunting, collecting and gathering activities directed at removing or collecting live wild aquatic organisms. Source: NACE Rev. 2, Statistical classification of economic activities in the European Community. Eurostat, European Commission.

Food industry Processing of the products of agriculture, forestry and fishing into food for humans or animals. The manufacture of beverages and tobacco are also included. Source: NACE Rev. 2, Statistical classification of economic activities in the European Community. Eurostat, European Commission.

Forest area Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use.

Forestry Includes the process of establishing and managing forests, wood harvesting (incl. energy wood), as well as the extraction of wild growing non-wood forest products. Source: NACE Rev. 2, Statistical classification of economic activities in the European Community. Eurostat, European Commission.

Freshwater resources Freshwater resources refers to the total volume of water available in a territory, resulting from internal flow (water from precipitation minus evapotranspiration in a territory) as well as external inflow (water inflow from neighboring territories). Source: Eurostat

Geothermal energy Geothermal energy is present in the earth in the form of heat, and stored in rocks, trapped vapour, water or brines. This heat energy can be used directly for heating or to generate electricity. Source: EUROSTAT

Growing stock on forests available for wood supply Volume over bark of all living trees with a height of 1.3 m or more and includes the stem from ground level up to a top diameter of 0 cm, excluding branches. Includes only trees growing on forest land available for wood supply. Source: TBFRA 2000

Hunting Include trapping and hunting on a commercial basis. Included is also taking of animals (dead or alive) for food, fur, skin, or for use in research, in zoos or as pets. Source: NACE Rev. 2, Statistical classification of economic activities in the European Community. Eurostat, European Commission.

Hydro power Hydropower is generated by first converting the potential energy stored in water into the kinetic energy of running water, which is then converted into electrical energy via turbines. Source: EUROSTAT

Nature tourism, green care and recreation In nature-based tourism, the attraction to nature is the decisive factor for tourists to choose a destination. The recreational use of nature refers to various leisure activities outdoors, such as hiking, cross-country skiing, walking or just spending time in nature e.g. enjoying scenery. Green care encompasses nature-linked activities that maintain and improve human health and well-being and quality of life through active interventions. Source: NACE Rev. 2, Statistical classification of economic activities in the European Community. Eurostat, European Commission.

Nitrogen balance (Agriculture) The difference between the nitrogen inputs entering a farming system (mainly livestock manure and fertilisers) and the nitrogen outputs leaving the system (the uptake of nitrogen for crop and pasture production). Source: OECD

Pesticides sales (Agriculture) The active substance contained in the pesticides. Source: EUROSTAT

Pharmaceutical industry Includes the manufacture of basic pharmaceutical products and pharmaceutical preparations. Information is only needed on the use of bio-based raw materials. Source: NACE Rev. 2, Statistical classification of economic activities in the European Community. Eurostat, European Commission.

Phosphorus balance (Agriculture) The difference between the phosphorus inputs entering a farming system (mainly livestock manure and fertilisers) and the phosphorus outputs leaving the system (the uptake of phosphorus for crop and pasture production). Source: OECD

Proportion of fish stocks within biological limits Percentage of fish stocks exploited within their level of maximum biological productivity. Source: UN

Pulp and paper industry Include the manufacture of pulp, paper and converted paper products. Source: NACE Rev. 2, Statistical classification of economic activities in the European Community. Eurostat, European Commission.

Ratio of fellings and estimated maximum sustainable level of cuttings (forestry) Fellings: volume of trees felled during the reference period. Source: TBFRA 2000. Estimated maximum sustainable level of cuttings: no standard definition available.

Ratio of fellings and increment (forestry). Fellings: volume of trees felled during the reference period. Net annual increment: Annual volume increment of trees minus volume of annual natural losses. Source: TBFRA 2000

Renewable energy Any naturally occurring source of energy, as biomass, solar, wind, tidal, wave, and hydroelectric power, that is not derived from fossil or nuclear fuels. Source: NACE Rev. 2, Statistical classification of economic activities in the European Community. Eurostat, European Commission.

Soil erosion (Agriculture) Estimated soil loss by water erosion. Source: EUROSTAT

Solar energy Solar energy is used for generation of electricity and heat. Source: EUROSTAT

Surface water Surface water is all water naturally open to the atmosphere, including rivers, lakes, reservoirs, streams, impoundment's, seas, estuaries and so on. Source: OECD

Threatened species Numbers of known species and threatened species with the aim of indicating the state of mammals, birds, freshwater fish, reptiles, amphibians and vascular plants. Source: OECD

Total forest protected areas Areas especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means Source: IUCN 2015, FRA 2015

Transportation of bio-based raw materials and products Includes both the transportation of bio-based raw materials to industrial and energy generating plants, and the domestic transportation of processed bio-based products. Export deliveries are excluded. Source: NACE Rev. 2, Statistical classification of economic activities in the European Community. Eurostat, European Commission.

Water purification and distribution Include the collection, treatment and distribution of water for domestic and industrial needs. Source: NACE Rev. 2, Statistical classification of economic activities in the European Community. Eurostat, European Commission.

Wind energy The kinetic energy of the wind is converted into electricity by using wind turbines. Turbines can be located either on land or offshore. Source: EUROSTAT

Volume of standing and lying dead wood in forests standing, lying on the ground All non-living woody biomass not contained in the litter, either standing, lying on the ground. Dead wood includes wood lying on the surface, dead roots, and stumps larger than or equal to 10 cm in diameter or any other diameter used by the country. Source: FOREST EUROPE

Wood based constructions Wood-based construction - wood is naturally heterogeneous so it has variable properties. This can be overcome by using standardised engineered wood products (EWP) that have predictable and consistent performance. One EWP, cross-laminated timber (CLT), allows strong but light multi-storey construction. Source: EUROSTAT

Wood fuels Wood fuels are used for generation of electricity and heat, and include firewood, charcoal, chips, pellet, black liquor and sawdust. Source: EUROSTAT

Wood products industry Include the manufacture of sawnwood, veneer sheets, wood-based panels (i.e. plywood, fibreboard and particle board), pellets, builders' carpentry and joinery products, wooden houses etc.

Annex 2 Online-survey

1 (Does your country have a) <i>Yes, Under preparation, NO</i>	Bioeconomy strate- gy/policy/related initiatives	If your country have the bioeconomy strate- gy/policy/related initiative, please add the link (Does your country have a)	
	Indicators to monitor and assess above mentioned		

1 (Is one of the EU bioecon- omy objectives included in your country's bioeconomy strategy/policy/related ini- tiatives?) Categories: <i>yes; not included, but needed; not included, and not needed</i>	Creating jobs and maintaining competitiveness	What is or would be the national rele- vance(1=poor ... 10=excellent) (Is one of the EU bioecon- omy objectives included in your country's bioecon- omy strate- gy/policy/related initiatives?)	Comments (Is one of the EU bioe- cono- my objectives included in your country's bioe- conomy strate- gy/policy/related initiatives?)	
	Reducing dependence on non- renewable resources			
	Mitigating and adapting climate change			
	Ensuring food security			
	Managing natural resources sus- tainably			
	Other objectives, please specify in the comment field			

Indicator already included at national level Categories: <i>yes; not included, but need- ed; not included, and not needed</i>	Creating jobs and maintaining competitiveness	1.1 Number of employed persons in rural and urban areas (1000 persons)	What is or would be the national rele- vance(1=poor ... 10=excellent)	Data source for this indicator available at na- tional level (exist- ing, not existing, I do not know)	
		1.1.1 Food sector			
		1.1.1.1 Agriculture			
		1.1.1.2 Food industry			
		1.1.1.3 Aquaculture			
		1.1.2 Bioeconomy goods			
		1.1.2.1 Forestry			
		1.1.2.2 Wood products industry			
		1.1.2.3 Pulp and paper industry			
		1.1.2.4 Construction			
		1.1.2.5 Chemical industry			
		1.1.2.6 Pharmaceutical industry			
		1.1.3 Renewable energy			
		1.1.4 Water purification and distri- bution			
		1.1.5 Transportation of bio-based raw materials and products			
		1.1.6 Bioeconomy services			
		1.1.6.1 Nature tourism, green care and recreation			
1.1.6.2 Hunting					
1.1.6.3 Fisheries					
Others, please specify in the com- ment field					
Indicator already included at national level (...continues (indicators related to the objective "Creating jobs and	Creating jobs	1.2. Value added (1000 EUR)	What is or would be the national rele- vance?(1=poor... 10=excellent)	Data source for this indicator available at national level	
		1.2.1 Food sector			
		1.2.1.1 Agriculture			

<p>maintaining competitive-ness"))</p>	<p>1.2.1.2 Food industry</p> <p>1.2.1.3 Aquaculture</p> <p>1.2.2 Bioeconomy goods</p> <p>1.2.2.1 Forestry</p> <p>1.2.2.2 Wood products industry</p> <p>1.2.2.3 Pulp and paper industry</p> <p>1.2.2.4 Construction</p> <p>1.2.2.5 Chemical industry</p> <p>1.2.2.6 Pharmaceutical industry</p> <p>1.2.3 Renewable energy</p> <p>1.2.4 Water purification and distribution</p> <p>1.2.5 Transportation of bio-based raw materials products</p> <p>1.2.6 Bioeconomy services</p> <p>1.2.6.1 Nature tourism, green care and recreation</p> <p>1.2.6.2 Hunting</p> <p>1.2.6.3 Fisheries</p> <p>Others, please specify in the comment field</p>	<p>(...continues (indicators related to the objective "Creating jobs and maintaining competitive-ness"))</p>	<p>(...continues (indicators related to the objective "Creating jobs and maintaining competitiveness"))</p>	
<p>Indicator already included at national level (...continues (indicators related to the objective "Creating jobs and maintaining competitive-ness"))</p>	<p>1.3. Contribution to the GDP (%)</p> <p>1.3.1 Food sector</p> <p>1.3.1.1 Agriculture</p> <p>1.3.1.2 Food industry</p> <p>1.3.1.3 Aquaculture</p> <p>1.3.2 Bioeconomy goods</p> <p>1.3.2.1 Forestry</p> <p>1.3.2.2 Wood products industry</p> <p>1.3.2.3 Pulp and paper industry</p> <p>1.3.2.4 Construction</p> <p>1.3.2.5 Chemical industry</p> <p>1.3.2.6 Pharmaceutical industry</p> <p>1.3.3 Renewable energy</p> <p>1.3.4 Water purification and distribution</p> <p>1.3.5 Transportation of bio-based raw materials and products</p> <p>1.3.6 Bioeconomy services</p> <p>1.3.6.1 Nature tourism, green care and recreation</p> <p>1.3.6.2 Hunting</p> <p>1.3.6.3 Fisheries</p> <p>Others, please specify in the comment field</p>	<p>What is or would be the national relevance?(1=poor... 10=excellent) (...continues (indicators related to the objective "Creating jobs and maintaining competitive-ness"))</p>	<p>Data source for this indicator available at national level (...continues (indicators related to the objective "Creating jobs and maintaining competitiveness"))</p>	
<p>Indicator already included at national level (...continues (indicators related to the objective "Creating jobs and</p>	<p>Creating jobs and maintaining competitiveness</p> <p>1.4 Investment in research and innovation (1000 EUR)</p> <p>1.4.1 Food sector</p> <p>1.4.1.1 Agriculture</p>	<p>What is or would be the national relevance?(1=poor... 10=excellent)</p>	<p>Data source for this indicator available at national level</p>	

maintaining competitive-ness"))	1.4.1.2 Food industry	(...continues (indicators related to the objective "Creating jobs and maintaining competitive-ness"))	(...continues (indicators related to the objective "Creating jobs and maintaining competitive-ness"))		
	1.4.1.3 Aquaculture				
	1.4.2 Bioeconomy goods				
	1.4.2.1 Forestry				
	1.4.2.2 Wood products industry				
	1.4.2.3 Pulp and paper industry				
	1.4.2.4 Construction				
	1.4.2.5 Chemical industry				
	1.4.2.6 Pharmaceutical industry				
	1.4.3 Renewable energy				
	1.4.4 Water purification and distribution				
	1.4.5 Transportation of bio-based raw materials and products				
	1.4.6 Bioeconomy services				
	1.4.6.1 Nature tourism, green care and recreation				
	1.4.6.2 Hunting				
	1.4.6.3 Fisheries				
	Others, please specify in the comment field				
Indicator already included at national level (...continues (indicators related to the objective "Creating jobs and maintaining competitive-ness"))	1.5 Export (1000 EUR)	What is or would be the national relevance?(1=poor... 10=excellent) (...continues (indicators related to the objective "Creating jobs and maintaining competitive-ness"))	Data source for this indicator available at national level (...continues (indicators related to the objective "Creating jobs and maintaining competitive-ness"))		
	1.5.1 Food sector				
	1.5.1.1 Agriculture				
	1.5.1.2 Food industry				
	1.5.1.3 Aquaculture				
	1.5.2 Bioeconomy goods				
	1.5.2.1 Forestry				
	1.5.2.2 Wood products industry				
	1.5.2.3 Pulp and paper industry				
	1.5.2.4 Construction				
	1.5.2.5 Chemical industry				
	1.5.2.6 Pharmaceutical industry				
	1.5.3 Renewable energy				
	1.5.4 Water purification and distribution				
	1.5.5 Transportation of bio-based raw materials and products				
	1.5.6 Bioeconomy services				
	1.5.6.1 Nature tourism, green care and recreation				
1.5.6.2 Hunting					
1.5.6.3 Fisheries					
Others, please specify in the comment field					
Indicator already included at national level (Which are the most relevant indicators from the national viewpoint to monitor and assess the objective Reducing dependence on non-renewable resources?)	Reducing dependence on	2.1 Production of renewable energy (share of renewable resources on the total energy production, %)	What is or would be the national relevance?(1=poor ... 10=excellent) (Which are the most relevant indicators from the national viewpoint to monitor and assess the objective Reducing dependence on non-renewable resources?)	Data source for this indicator available at national level (Which are the most relevant indicators from the national viewpoint to monitor and assess the objective Reducing dependence on non-renewable resources?)	
		2.1.1 Wood fuels			
		2.1.2 Solar energy			
		2.1.3 Wind energy			
		2.1.4 Geothermal energy			

		2.1.5 Hydropower		tor and assess the objective Reducing dependence on non-renewable resources?)	viewpoint to monitor and assess the objective Reducing dependence on non-renewable resources?)	
		Others, please specify in the comment field				
Indicator already included at national level (...continues (indicators related to the objective "Reducing dependence on non-renewable resources"))		2.2 Production of biofuels and biogas (toe)		What is or would be the national relevance(1=poor ... 10=excellent) (...continues (indicators related to the objective "Reducing dependence on non-renewable resources"))	Data source for this indicator available on national level (...continues (indicators related to the objective "Reducing dependence on non-renewable resources"))	
		2.2.1 Forest biomass				
		2.2.1.1 Biofuels				
		2.2.1.2 Biogas				
		2.2.2 Agriculture biomass				
		2.2.2.1 Biofuels				
		2.2.2.2 Biogas				
		Others, please specify in the comment field				
Indicator already included at national level (...continues (indicators related to the objective "Reducing dependence on non-renewable resources"))		2.3 Material and waste recycling and recovery rates (toe)		What is or would be the national relevance(1=poor ... 10=excellent) (...continues (indicators related to the objective "Reducing dependence on non-renewable resources"))	Data source for this indicator available at national level (...continues (indicators related to the objective "Reducing dependence on non-renewable resources"))	
		2.3.1 Wood products				
		2.3.2 Organic waste				
		Others, please specify in the comment field				
Indicator already included at national level (...continues (indicators related to the objective "Reducing dependence on non-renewable resources"))		2.4 Material replacing non-renewable resources (Bio-materials)		What is or would be the national relevance(1=poor ... 10=excellent) (...continues (indicators related to the objective "Reducing dependence on non-renewable resources"))	Data source for this indicator available at national level (...continues (indicators related to the objective "Reducing dependence on non-renewable resources"))	
		2.4.1 Wood-based constructions (m3)				
		2.4.2 Bio-based textiles (tonnes)				
		2.4.3 Biodegradable plastics (toe)				
		Others, please specify in the comment field				
Indicator already included at national level (...continues (indicators related to the objective "Reducing dependence on non-renewable resources"))		2.5 Public financial support and private investments for reducing dependence on non-renewable resources (1000 EUR)		What is or would be the national relevance(1=poor ... 10=excellent) (...continues (indicators related to the objective "Reducing dependence on non-renewable resources"))	Data source for this indicator available at national level (...continues (indicators related to the objective "Reducing dependence on non-renewable resources"))	
		2.5.1 Public investments				
		2.5.2 Private investments				
		2.6 Investment in research and innovation (1000 EUR)				
		Others, please specify in the comment field				
Indicator already included at national level (Which are the most relevant indicators from the national viewpoint to monitor and assess the objective Mitigating and adapting to climate change?)	Mitigating and adapting to	3.1 Carbon sequestration (CO2 eq. tonnes)		What is or would be the national relevance(1=poor ... 10=excellent) (Which are the most relevant indicators from the national viewpoint to monitor and assess the objective Mitigating and adapting to	Data source for this indicator available at national level (Which are the most relevant indicators from the national viewpoint to monitor and assess the objec-	
		3.1.1 Forest carbon emissions/sinks				
		3.1.1.1 Forest carbon emissions				
		3.1.1.2 Forest carbon sinks				
		3.1.2 Agricultural emissions/sinks				
		3.1.2.1 Greenhouse gas emissions from agriculture				
		3.1.2.2 Agricultural soils as sinks				

	3.1.3 Water area carbon emissions/sinks		climate change?)	ative Mitigating and adapting to climate change?)	
	3.1.3.1 Water area carbon emissions				
	3.1.3.2 Water area sinks				
	Others, please specify in the comment field				
Indicator already included at national level (...continues (indicators related to the objective "Mitigating and adapting to climate change").)	3.2 Public financial support and private investments for mitigating and adaptation (1000 EUR)		What is or would be the national relevance(1=poor ... 10=excellent) (...continues (indicators related to the objective "Mitigating and adapting to climate change").)	Data source for this indicator available at national level (...continues (indicators related to the objective "Mitigating and adapting to climate change").)	
	3.2.1 Public investments				
	3.2.2 Private investments				
	3.3 Investment in research and innovation (1000 EUR)				
	Others, please specify in the comment field				

Indicator already included at national level (Which are the most relevant indicators from the national viewpoint to monitor and assess the objective Ensuring food security?)	Ensuring food security	4.1 Domestic food supply of the food commodities in terms of production, import and stock change	What is or would be the national relevance?(1=poor ... 10=excellent) (Which are the most relevant indicators from the national viewpoint to monitor and assess the objective Ensuring food security?)	Data source for this indicator available at national level (Which are the most relevant indicators from the national viewpoint to monitor and assess the objective Ensuring food security?)	
		4.1.1 Agricultural products (1000 EUR)			
		4.1.1.1 Crops			
		4.1.1.1.1 Potatoes			
		4.1.1.1.2 Cereals			
		4.1.1.1.3 Sugar beets			
		4.1.1.1.4 Vegetables			
		4.1.1.1.5 Fruit			
		4.1.1.1.6 Grapes			
		4.1.1.1.7 Olives			
Others, please specify in the comment field					
Indicator already included at national level (...continues (indicators related to the objective "Ensuring food security"))	Ensuring food security	4.1.1.2 Meat (1000 EUR)	What is or would be the national relevance(1=poor ... 10=excellent) (...continues (indicators related to the objective "Ensuring food security"))	Data source for this indicator available at national level (...continues (indicators related to the objective "Ensuring food security"))	
		4.1.1.2.1 Veal and beef			
		4.1.1.2.2 Pig meat			
		4.1.1.2.3 Sheep and goat meat			
		4.1.1.2.4 Poultry			
		4.1.1.3 Milk products			
Others, please specify in the comment field					
Indicator already included at national level (...continues (indicators related to the objective "Ensuring food security"))	Ensuring food security	4.1.2. Fish products (1000 EUR)	What is or would be the national relevance(1=poor ... 10=excellent) (...continues (indicators related to the objective "Ensuring food security"))	Data source for this indicator available at national level (...continues (indicators related to the objective "Ensuring food security"))	
		4.1.2.1 From aquaculture			
		4.1.2.2 From capture			
		4.1.3. Non-wood forest products (1000 EUR)			
		4.1.3.1 Mushrooms			
		4.1.3.2 Fruits, berries and edible nuts			
		4.1.4. New food products (1000 EUR)			
		4.1.4.1 Insects			
4.1.4.2 Wood-based ingredients					

		Others, please specify in the comments field				
Indicator already included at national level (... continues (indicators related to the objective "Ensuring food security"))		4.2 Public financial support and private investments for reducing dependence on non-renewable resources (1000 EUR)	What is or would be the national relevance(1=poor ... 10=excellent) (... continues (indicators related to the objective "Ensuring food security"))		Data source for this indicator available on national level (... continues (indicators related to the objective "Ensuring food security"))	
		4.2.1 Public investments				
		4.2.2 Private investments				
		4.3 Investment in research and innovation (1000 EUR)				
		Others, please specify in the comment field				

Indicator already included at national level (Which are the most relevant indicators from the national viewpoint to monitor and assess the objective Managing natural resources sustainably?)	Managing natural resources sustainably	5.1 Land cover (share of total area, %)	What is or would be the national relevance(1=poor ... 10=excellent) (Which are the most relevant indicators from the national viewpoint to monitor and assess the objective Managing natural resources sustainably?)		Data source for this indicator available at national level (Which are the most relevant indicators from the national viewpoint to monitor and assess the objective Managing natural resources sustainably?)	
		5.1.1 Forest area				
		5.1.2 Agricultural area incl. cropland and grassland				
		5.1.3 Surface water				
		Others, please specify in the comment field				
Indicator already included at national level (ne... continues (indicators related to the objective "Managing natural resources sustainably"))	Managing natural resources sustainably	5.2 Resource availability	What is or would be the national relevance(1=poor ... 10=excellent) (ne... continues (indicators related to the objective "Managing natural resources sustainably"))		Data source for this indicator available at national level (ne... continues (indicators related to the objective "Managing natural resources sustainably"))	
		5.2.1 Growing stock on forests available for wood supply (1000 m3)				
		5.2.2 Freshwater resources (billion m3)				
		5.2.3 Fish resources (tonnes)				
		Others, please specify in the comment field				
Indicator already included at national level (...continues (indicators related to the objective "Managing natural resources sustainably"))	Managing natural resources sustainably	5.3 Sustainable resource use	What is or would be the national relevance(1=poor ... 10=excellent) (...continues (indicators related to the objective "Managing natural resources sustainably"))		Data source for this indicator available at national level (...continues (indicators related to the objective "Managing natural resources sustainably"))	
		5.3.1 Sustainable forestry				
		5.3.1.1 Ratio of annual increment and fellings in forests (%)				
		5.3.1.2 Ratio of fellings and estimated maximum sustainable level of cuttings in forests (%)				
		5.3.2 Sustainable agriculture				
		5.3.2.1 Nitrogen balance (kg/ha)				
		5.3.2.2 Phosphorus balance (kg/ha)				
		5.3.2.3 Soil erosion (tonnes/ha)				
		5.3.2.4 Ammonia, NOx and SOx emissions (ktonnes)				
		5.3.2.5 Pesticides sales (tonnes)				
		5.3.3 Proportion of fish stocks within biological limits				
		Others, please specify in the comment field				
Indicator already included at national level (...continues (indicators related to the	Managing natural resources sustainably	5.4 Environmental protection	What is or would be the national relevance(1=poor ...		Data source for this indicator available at na-	
		5.4.1 Protected forest areas (1000 ha)				

objective "Managing natural resources sustainably")	5.4.2 Standing and lying dead wood in forests (m3/ha)	10=excellent) (...continues (indicators related to the objective "Managing natural resources sustainably"))	tional level (...continues (indicators related to the objective "Managing natural resources sustainably"))
	5.4.3 Agricultural areas under Natura 2000 (1000 ha)		
	5.4.4 Area under agri-environmental commitments (1000 ha)		
	5.4.5 Number of threatened species		
	Others, please specify in the comment field		
Indicator already included at national level (...continues (indicators related to the objective "Managing natural resources sustainably"))	5.5 Public financial support and private investments for ecosystem services (1000 EUR)	What is or would be the national relevance(1=poor ... 10=excellent) (...continues (indicators related to the objective "Managing natural resources sustainably"))	Data source for this indicator available at national level (...continues (indicators related to the objective "Managing natural resources sustainably"))
	5.5.1 Public payment for ecosystem services		
	5.5.1.1 Forest management		
	5.5.1.2 Agriculture management		
	5.5.1.3 Water management		
	5.5.2 Private payment for ecosystem services		
	5.5.2.1 Forest management		
	5.5.2.2 Agriculture management		
	5.5.2.3 Water management		
	Others, please specify in the comment field		

Annex 3 Identified most suitable key indicators and related indicators

Most suitable bioeconomy key indicators and related indicators as identified under the bioeconomy objective “Creating jobs and maintaining competitiveness”	Key indicator	Related indicator
1.1 Number of employed persons in rural and urban areas (1000 persons)	x	
1.1.1 Food sector		x
1.1.1.1 Agriculture		x
1.1.1.2 Food industry		x
1.1.1.3 Aquaculture		x
1.1.2 Bioeconomy goods		x
1.1.2.1 Forestry		x
1.1.2.2 Wood products industry		x
1.1.2.3 Pulp and paper industry		x
1.1.2.4 Construction		x
1.1.2.5 Chemical industry		x
1.1.2.6 Pharmaceutical industry		x
1.1.3 Renewable energy		x
1.1.4 Water purification and distribution		x
1.1.5 Transportation of bio-based raw materials/products		x
1.1.6 Bioeconomy services		x
1.1.6.1 Nature tourism, green care and recreation		x
1.1.6.2 Hunting		x
1.1.6.3 Fisheries		x
1.2. Value added (1000 EUR)	x	
1.2.1 Food sector		x
1.2.1.1 Agriculture		x
1.2.1.2 Food industry		x
1.2.1.3 Aquaculture		x
1.2.2 Bioeconomy goods		x
1.2.2.1 Forestry		x
1.2.2.2 Wood products industry		x
1.2.2.3 Pulp and paper industry		x
1.2.2.4 Construction		x
1.2.2.5 Chemical industry		x
1.2.2.6 Pharmaceutical industry		x
1.2.3 Renewable energy		x
1.2.4 Water purification and distribution		x
1.2.5 Transportation of bio-based raw materials/products		x
1.2.6 Bioeconomy services		x
1.2.6.1 Nature tourism, green care and recreation		x
1.2.6.2 Hunting		x
1.2.6.3 Fisheries		x

Most suitable bioeconomy key indicators and related indicators as identified under the bioeconomy objective “Creating jobs and maintaining competitiveness”	Key indicator	Related indicator
1.3. Contribution to the GDP (%)	x	
1.3.1 Food sector		x
1.3.1.1 Agriculture		x
1.3.1.2 Food industry		x
1.3.1.3 Aquaculture		x
1.3.2 Bioeconomy goods		x
1.3.2.1 Forestry		x
1.3.2.2 Wood products industry		x
1.3.2.3 Pulp and paper industry		x
1.3.2.4 Construction		x
1.3.2.5 Chemical industry		x
1.3.2.6 Pharmaceutical industry		x
1.3.3 Renewable energy		x
1.3.4 Water purification and distribution		x
1.3.5 Transportation of bio-based raw materials/products		x
1.3.6 Bioeconomy services		x
1.3.6.1 Nature tourism, green care and recreation		x
1.3.6.2 Hunting		x
1.3.6.3 Fisheries		x
1.4 Investment in research and innovation (1000 EUR)	x	
1.4.1 Food sector		x
1.4.1.1 Agriculture		x
1.4.1.2 Food industry		x
1.4.1.3 Aquaculture		x
1.4.2 Bioeconomy goods		x
1.4.2.1 Forestry		x
1.4.2.2 Wood products industry		x
1.4.2.3 Pulp and paper industry		x
1.4.2.4 Construction		x
1.4.2.5 Chemical industry		x
1.4.2.6 Pharmaceutical industry		x
1.4.3 Renewable energy		x
1.4.4 Water purification and distribution		x
1.4.5 Transportation of bio-based raw materials/products		x
1.4.6 Bioeconomy services		x
1.4.6.1 Nature tourism, green care and recreation		x
1.4.6.2 Hunting		x
1.4.6.3 Fisheries		x

Most suitable bioeconomy key indicators and related indicators as identified under the bioeconomy objective “Creating jobs and maintaining competitiveness”	Key indicator	Related indicator
1.5 Export (1000 EUR)	x	
1.5.1 Food sector		x
1.5.1.1 Agriculture		x
1.5.1.2 Food industry		x
1.5.1.3 Aquaculture		x
1.5.2 Bioeconomy goods		x
1.5.2.1 Forestry		x
1.5.2.2 Wood products industry		x
1.5.2.3 Pulp and paper industry		x
1.5.2.4 Construction		x
1.5.2.5 Chemical industry		x
1.5.2.6 Pharmaceutical industry		x
1.5.3 Renewable energy		x
1.5.4 Water purification and distribution		x
1.5.5 Transportation of bio-based raw materials/products		x
1.5.6 Bioeconomy services		x
1.5.6.1 Nature tourism, green care and recreation		x
1.5.6.2 Hunting		x
1.5.6.3 Fisheries		x

Most suitable bioeconomy key indicators and related indicators as identified under the bioeconomy objective “Reducing dependence on non-renewable resources”	Key indicator	Related indicator
2.1 Production of renewable energy (share of renewable resources on the total energy production, %)	x	
2.1.1 Wood fuels		x
2.1.2 Solar energy		x
2.1.3 Wind energy		x
2.1.4 Geothermal energy		x
2.1.5 Hydropower		x
2.2 Production of biofuels and biogas (toe)	x	
2.2.1 Forest biomass		x
2.2.1.1 Biofuels		x
2.2.1.2 Biogas		x
2.3 Material and waste recycling and recovery rates (toe)	x	
2.3.1 Wood products		x
2.3.2 Organic waste		x
2.4 Material replacing non-renewable resources (bio-materials)	x	
2.4.1 Wood-based constructions (m3)		x
2.4.2 Bio-based textiles (tonnes)		x
2.4.3 Biodegradable plastics (toe)		x
2.5 Public financial support and private investments for reducing dependence on non-renewable resources (1000 EUR)	x	
2.5.1 Public investments		x
2.5.2 Private investments		x
2.6 Investment in research and innovation (1000 EUR)	x	

Most suitable bioeconomy key indicators and related indicators as identified under the bioeconomy objective "Mitigating and adapting climate change"	Key indicator	Related indicator
3.1 Carbon sequestration (CO2 eq. tonnes)	x	
3.1.1 Forest carbon emissions/sinks	x	
3.1.1.1 Forest carbon emissions		x
3.1.1.2 Forest carbon sinks		x
3.1.2 Agricultural emissions/sinks		x
3.1.2.1 Greenhouse gas emissions from agriculture	x	
3.1.2.2 Agricultural soils as sinks		x
3.1.3 Water area carbon emissions/sinks	x	
3.1.3.1 Water area carbon emissions		x
3.1.3.2 Water area sinks		x
3.2 Public financial support and private investments for mitigating and adaptation (1000 EUR)	x	
3.2.1 Public investments		x
3.2.2 Private investments		x
3.3 Investment in research and innovation (1000 EUR)	x	

Most suitable bioeconomy key indicators and related indicators as identified under the bioeconomy objective "Ensuring food security"	Key indicator	Related indicator
4.1 Domestic food supply of the food commodities in terms of production, import and stock change	x	
4.1.1 Agricultural products (1000 EUR)	x	
4.1.1.1 Crops		x
4.1.1.1.1 Potatoes		x
4.1.1.1.2 Cereals		x
4.1.1.1.3 Sugar beets		x
4.1.1.1.4 Vegetables		x
4.1.1.1.5 Fruit		x
4.1.1.1.6 Grapes		x
4.1.1.1.7 Olives		x
4.1.1.2 Meat (1000 EUR)		x
4.1.1.2.1 Veal and beef		x
4.1.1.2.2 Pig meat		x
4.1.1.2.3 Sheep and goat meat		x
4.1.1.2.4 Poultry		x
4.1.1.3 Milk products		x
4.1.2. Fish products (1000 EUR)	x	
4.1.2.1 From aquaculture		x
4.1.2.2 From capture		x
4.1.3. Non-wood forest products (1000 EUR)	x	
4.1.3.1 Mushrooms		x
4.1.3.2 Fruits, berries and edible nuts		x
4.1.4. New food products (1000 EUR)	x	
4.1.4.1 Insects		x
4.1.4.2 Wood-based ingredients		x
4.2 Public financial support and private investments for reducing dependence on	x	

non-renewable resources (1000 EUR)		
4.2.1 Public investments		X
4.2.2 Private investments		X
4.3 Investment in research and innovation (1000 EUR)	X	

Most suitable bioeconomy key indicators and related indicators as identified under the bioeconomy objective “Managing natural resources sustainably”	Key indicator	Related indicator
5.1 Land cover (share of total area, %)	X	
5.1.1 Forest area		X
5.1.2 Agricultural area incl. cropland and grassland		X
5.1.3 Surface water		X
5.2 Resource availability	X	
5.2.1 Growing stock on forests available for wood supply (1000 m3)		X
5.2.2 Freshwater resources (billion m3)		X
5.2.3 Fish resources (tonnes)		X
5.3 Sustainable resource use	X	
5.3.1 Sustainable forestry		X
5.3.1.1 Ratio of annual increment and fellings in forests (%)		X
5.3.1.2 Ratio of fellings and estimated maximum sustainable level of cuttings in forests (%)		X
5.3.2 Sustainable agriculture		X
5.3.2.1 Nitrogen balance (kg/ha)		X
5.3.2.2 Phosphorus balance (kg/ha)		X
5.3.2.3 Soil erosion (tonnes/ha)		X
5.3.2.4 Ammonia, NOx and SOx emissions (ktonnes)		X
5.3.2.5 Pesticides sales (tonnes)		X
5.4 Environmental protection	X	
5.4.1 Protected forest areas (1000 ha)		X
5.4.2 Standing and lying dead wood in forests (m3/ha)		X
5.4.3 Agricultural areas under Natura 2000 (1000 ha)		X
5.4.4 Area under agri-environmental commitments (1000 ha)		
5.4.5 Number of threatened species		
5.5 Public financial support and private investments for ecosystem services (1000 EUR)	X	
5.5.1 Public payment for ecosystem services		X
5.5.1.1 Forest management		X
5.5.1.2 Agriculture management		X
5.5.1.3 Water management		X
5.5.2 Private payment for ecosystem services		X
5.5.2.1 Forest management		X
5.5.2.2 Agriculture management		X
5.5.2.3 Water management		X

References

- Blumberga, D., Muizniece, I., Zihare, L., Sniega, L. 2017. Bioeconomy mapping indicators and methodology. Case study about forest sector in Latvia. *Energy Procedia* 128: 363-367.
- Carlowitz, H. C. v. ,1713. *Sylvicultura oeconomica*. Leipzig.
- EUROSTAT European Classification of Economic Activities (NACE, Rev. 2)
- EC 2017. Review of the 2012 European Bioeconomy Strategy
https://ec.europa.eu/research/bioeconomy/pdf/review_of_2012_eu_bes.pdf Last assessed 17.5.2018.
- EC 2012a. COMMISSION STAFF WORKING DOCUMENT /* SWD/2012/0011 final <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52012SC0011> Last assessed 17.5.2018.
- EC 2012b. The Bioeconomy Strategy
<https://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy&lib=strategy> Last assessed 17.5.2018.
- Fritsche, U.R., Iriarte, L. 2014. Sustainability criteria and indicators for the bio-based economy in Europe: State of discussion and way forward. *Energies* 7: 6825-6836.
- FOREST EUROPE, 2018. SFM Criteria & Indicators. <http://foresteurope.org/sfm-criteria-indicators2/> Last assessed 17.5.2018.
- JRC Bioeconomy Report, 2016. <https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/bioeconomy-report-2016> Last assessed 17.5.2018.
- Karvonen, J., Halder, P., Kangas, J., Leskinen, P. 2017. Indicators and tools for assessing sustainability impacts of the forest bioeconomy. *Forest Ecosystems* 4:2.
- Muizniece, I., Timma, L., Blumberga, A., Blumberga, D. 2016. The methodology for assessment of bioeconomy efficiency. *Energy Procedia* 95: 482-486.
- Pfau, S.P., Hagens, J.E., Dankbaar, B., Smits, A.J.M. 2014. Visions of sustainability in bioeconomy research. *Sustainability* 6(3): 1222-1249
- Ronzon, T., Piotrowski, S., M'Barek, R., Carus, M. 2017. A systematic approach to understanding and quantifying the EU's bioeconomy. *Bio-based and Applied Economics* 6(1): 1-17.
- Talavyria, M.P., Lyman, V.V., Baidala, V.V. 2017. Indicators for analysis of the bioeconomy in Ukraine. *Ekonomika*, No 3.
- Trydeman Knudsen, M., Hermansen, J.E., Thostrup, L.B. 2015. Mapping sustainability Criteria for the Bioeconomy. Aarhus University, Department of Agroecology.
- OECD Green Growth Studies 2017. <http://www.oecd.org/env/green-growth-indicators-2017-9789264268586-en.htm> Last assessed 17.5.2018.
- Van de Pas, J. 2015. The bio-economy: definitions and measurement. Wageningen UR.
- Wolfslehner, B., Linser, S., Pülzl, H., Bastrup-Birk, A., Camia, A., Marchetti, M., 2016. Forest bioeconomy – a new scope for sustainability indicators. *From Science to Policy* 4, European Forest Institute



luke.fi

Natural Resources Institute Finland
Latokartanonkaari 9
FI-00790 Helsinki, Finland
tel. +358 29 532 6000