Building a monitoring system for the EU bioeconomy

Progress Report 2019: Description of framework

2020

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Abstract

The new EU Bioeconomy Strategy, adopted in 2018 is more relevant within the actual political, environmental and social context than ever before. In these times of acute awareness of global climate change impacts and related challenges for sustainable development, the EU Bioeconomy is perceived a crucial stepping stone to changing our whole development paradigm and to trigger systemic change. Bioeconomy is intended to contribute to the decarbonisation of our economy, to catalyse changes in consumer habits and will modernise our industries throughout the value chain. But is it all good? At what cost to primary productions systems? Can the bioeconomy really deliver on its promises while ensuring biodiversity enhancement and the improvement of our planet's overall health? To what extent will societies benefit from a transition from a fossil-based to a bio-based economy?

This document describes the first year of the development of the EU Bioeconomy Monitoring System by the European Commission's Joint Research Centre (JRC) in collaboration with experts throughout European and International organisations, EU Member States, Commission Services and other stakeholders to assess questions such as those posed above. The framework is designed to house several basic indicators that are, analogous to the instruments of a symphony, in themselves useful and meaningful but whose value is enhanced once they are placed within an orchestra. Only when the indicators interplay jointly the ensemble is capable of estimating the progress of EU bioeconomy and its contribution towards the Sustainable Development Goals, highlighting related trade-offs and synergies.

In this first year, the development of the monitoring system has focused on structuring the framework, thus creating a better understanding of the bioeconomy as it is presented in various sources at national, EU and international levels. Criteria have been established to assess indicator quality, which is relevant to the final decision on indicator inclusion.

This document represents a status report on the development of the EU-wide monitoring system for the Bioeconomy and by no means does it constitute the finished work. Comments are always welcome, please write to: JRC-Bioeconomy-Monitoring@ec.europa.eu.

1 Introduction

1.1 The EU Bioeconomy within the political agenda of the new European Commission

The updated EU Bioeconomy strategy [EC, 2018a] contributes directly to the political agenda of the new European Commission (2019-2024). A sustainable and circular EU Bioeconomy would effectively contribute to a European Green Deal that aims for the EU to be the first climate-neutral continent by 2050, by supporting the development of renewable products and energy to substitute fossil fuels and other carbon-intensive materials. The New Circular Economy Action Plan has the ambition to consolidate the EU role as world leader in circular economy and clean technologies, including bio-based industries. Furthermore, the European Green Deal Communication [EC,2019], with its proposal for a new Biodiversity Strategy due in March 2020, places the protection of our planet and of the shared environment among the top priorities of the new Commission, a priority that is also clearly shared in the EU Bioeconomy Strategy and Action Plan. The Green Deal also foresees a "Farm to Fork" strategy, whereby food availability along a sustainable value chain must be ensured; as well as specific reference to the preservation of rural areas and to the importance of investing in these, all values sustained in the Bioeconomy Strategy.

The EU Bioeconomy Strategy intends to encourage local bio-based innovation as well as to facilitate the modernisation of EU industries within the bioeconomy sectors. Primary producers should benefit from the EU Bioeconomy, fully integrating them in value creation. Social rights are also part of the package, and a sustainable bioeconomy would entail sustainable trade with third countries to minimize the social and environmental footprint of imported bio-based goods. These aspects are reflected in the second ambition on the political agenda of the new Commission "An economy that works for people". This ambition contains a strong element of supporting small business, referring to the desire to make it easier for small business to grow.

1.2 Why monitor?

It is because of its inherent complexity and the very high level of ambition of the Bioeconomy strategy itself that the progress towards a truly sustainable bioeconomy must be closely monitored with reliable data and robust analysis to provide a holistic view of all the dimensions of sustainability and to highlight eventual trade-offs among them. Further, monitoring is essential to identify areas in need of policy intervention as well as to assess the coherence and the impacts of existing legislation. The Action Plan of the 2018 EU Bioeconomy Strategy includes a specific action for the development of an EU-wide, internationally coherent monitoring system to track economic, social and environmental progress towards a circular and sustainable bioeconomy. The European Commission's Joint Research Centre is leading this action, in collaboration with several Commission Services, Member States and stakeholders. The monitoring system will be made publicly available through the European Commission's Knowledge Centre for Bioeconomy[2] (KCB).

1.3 What to include in the EU Bioeconomy Monitoring System?

According to the EU Bioeconomy Strategy, the bioeconomy "covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. It includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services". The ambition of a sustainable bioeconomy is further framed in the 2018 Strategy by five objectives carried over from the previous Strategy (Figure 1). While the first EU Bioeconomy Strategy of 2012 [EC, 2012] followed a strong utilitarian view of nature and a weak sustainability approach

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[2] https://ec.europa.eu/knowledge4policy/bioeconomy_en

[Ramcilovic-Suominen & Pülzl, 2018], the 2018 Strategy has a more balanced approach in which the promotion of growth for bio-based industries is placed at the same level of importance as protecting the health of ecosystems and understanding their boundaries. What the Monitoring System should monitor exactly is the basis of the conceptual framework that has been developed for this purpose, as is described in the following chapter.

The monitoring system is put in place to monitor sustainability across the economic, social and environmental pillars, and not to monitor the implementation of the Bioeconomy Strategy Action Plan, although, as we describe in section 4.1.6, there are elements of effective governance within this monitoring system that are drawn from the Action Plan itself.

1.4 Vision of a "sustainable" bioeconomy

Concepts of sustainable development are deeply embedded in many EU policy ambitions, including within the 2018 EU Bioeconomy Strategy. Especially the five objectives of the strategy, provide a broad vision for a sustainable bioeconomy (Figure 1).

Figure 1. The five objectives of the EU Bioeconomy Strategy.

Ensuring food and nutrition security

Managing natural resources sustainably

Strengthening European competitiveness and creating jobs

Mitigating and adapting to climate change

Reducing dependence on non-renewable, unsustainable resources

Economic prosperity depends on healthy and productive ecosystems and over-exploitation can damage the same ecosystems upon which the economy depends [Folke et al., 2018]. This is all the more true when we consider the bioeconomy. The bioeconomy sectors entail many direct and indirect interactions between human well-being and the biosphere, being completely dependent on renewable resources compared to other sectors of the economy. A sustainable EU Bioeconomy will contribute to reaching climate-neutrality in the EU, promoting a circular economy, and encouraging a transition towards sustainable food, farming and fishing systems as well as towards sustainable forestry and the development of bio-based sectors. Preserving Europe's natural capital for future generations, restoring our ecosystems and enhancing their functions while conserving biodiversity are core pillars of the EU bioeconomy strategy. Furthermore, a sustainable and circular bioeconomy is foreseen to create economic opportunities for rural, coastal and urban communities through local bio-based innovation, the integration of primary producers in value chains, the diversification of supply chains and the modernisation of EU industries. Finally, a sustainable EU bioeconomy must look beyond EU borders and promote sustainable trade conditions, social fairness, economic growth, and environmental protection within trading countries. It is clear, thus, that it is crucial to carefully monitor

the progress of bioeconomy to be able to steer socio-ecological systems towards a sustainable future. Achieving a sustainable bioeconomy, thus, may well be the crucial stepping stone to changing our whole development paradigm and trigger systemic change.

The EU bioeconomy is clearly linked to the international sustainability agenda. According to the Rio declaration on the Environment and Development (UN 1992), a sustainable development is development which meets the needs of the current generation without compromising the ability of future generations to meet their own. The UN 2030 Agenda with its list of 17 Sustainable Development Goals constitutes a global normative exercise through which the international community operationalised these ambitions. Through the SDGs, thus, "Sustainability" is not merely an aspirational concept anymore, but a blueprint to achieve a fair, inclusive, prosperous growth within the boundaries of our planet [Costanza et al., 2016].

2 Design and conceptual framework

The goal for this monitoring system is to inform policy-making through the provision of meaningful and robust indicators. To do this, the system should be designed so that it is capable of highlighting synergies and trade-offs across multiple scales and levels: geographical (global, EU, national and regional); across pillars of sustainability; across economic sectors and across the strategy objectives themselves. The monitoring system should furthermore provide basic information to enable further analyses and interpretation by third parties, thus contributing to the involvement, dialogue and debate between the EC, stakeholders and citizens.

The 2018 EU Bioeconomy Strategy outlines five objectives, as well as an overarching goal to reach a 'Circular and Sustainable Bioeconomy'. These represent normative prescriptions of a desirable bioeconomy within general guidelines. The EU Bioeconomy Strategy in itself does not quantify targets. Targets, and subsequently progress measurement, can be defined in a relative or absolute way. In other words, a target can define a desired trend which is considered positive, or define a specific numerical target to be achieved. In turn, the numerical target can represent an aspirational or symbolic one, usually employed for social targets, or a firm biophysical threshold, such as in the case of the planetary boundaries [Rockstrom et al., 2009]. Since the EU bioeconomy strategy encompasses many EU policies with their own targets (qualitative or quantitative), our definition and its normative criteria reflect only aspirational trends, while specific targets may be embedded implicitly within the indicators chosen.

Nevertheless, to facilitate the choice of indicators, it is essential to define which trends represent progress towards the bioeconomy envisaged by the Strategy, and which are instead detrimental trends. Defining clear normative criteria allows us to establish a link between the chosen indicators and their broader meaning. It further allows a clear qualification of the directionality of trends of the indicators: a 'positive' trend on the long run will be a trend that moves the bioeconomy closer to the desired outcome, a 'negative' trend on the long run will be a trend that pushes it further away. This is the role of the framework described in details in Section 4 which operationalizes the principles described in section 1.2.

In line with the criteria described in the Staff Working Document that accompanies the Strategy [EC, 2018], namely to minimise reporting burden and to coordinate with other monitoring initiatives; and the need to design a monitoring system for the EU Bioeconomy that is capable of capturing variations within that specific domain, we propose a multi-tier monitoring system to both cater to an audience who wishes an interpreted set of indicators; and to audiences who wish to have the underlying indicators and data available to them for their own analysis. With this design, the level of detail and number of indicators is tailored to the needs of the users. Egenolf & Bringezu [2019] state that a small number of indicators is more appropriate to provide overviews and general statements, while a large number of indicators is more appropriate to illustrate and highlight details. This concept fits well with this monitoring system design, in which we wish to offer a large number of indicators for detailed interpretation by users; yet we also wish to give meaning and interpretation to indicators within the bioeconomy context, thus producing few but expressive indexes at a more aggregated level.

2.1 Users and audience

This action was introduced in the updated Strategy following the 2017 review of the 2012 strategy, in which it was recommended to better monitor and assess progress in order to provide scientific evidence for policy-making. The primary users of the monitoring system are policy makers at EU level. This category of users might benefit from information which is aggregated and interpreted using the scientific knowledge and familiarity of EU policy in the JRC. Other users are EU Agencies and researchers, national and regional-level policy makers and bio-based industry; these categories may also benefit from more detailed and disaggregated information. The monitoring system should also cater to EU citizens by providing useful information on consumer footprint and the life cycle

assessment of selected products in order to help citizens ponder the choices they make. The monitoring system should provide useful information for each of these categories of users.

2.2 Categories of indicators in the framework

An indicator is a 'measure based on verifiable data that conveys information about more than itself' and indicators are purpose-dependent, meaning that the interpretation given to the data actually depends on the purpose [BIP, 2019]. The proposed framework is multi-level, multi-dimensional and multi-scale and should also encompass the systems' level thinking, which surrounds, summarises and makes sense of individual indicators through a holistic approach.

The framework is designed to contain different types of indicators, whose level of aggregation and complexity is defined by the criteria the indicator is meant to measure. At the foundation of the pyramid in Figure 2 are underlying statistical data that can be measured, followed by three tiers of indicators differing in complexity, and thus increasingly subject to interpretation. The indicator(s) are chosen based on their suitability to address the particular normative criteria that needs to be assessed (detailed in 4.1). In some cases it is appropriate to use basic indicators whereas in other cases it is appropriate to use processed or system level indicators. In some cases, the system level indicators make use of basic or processed indicators, but not always.
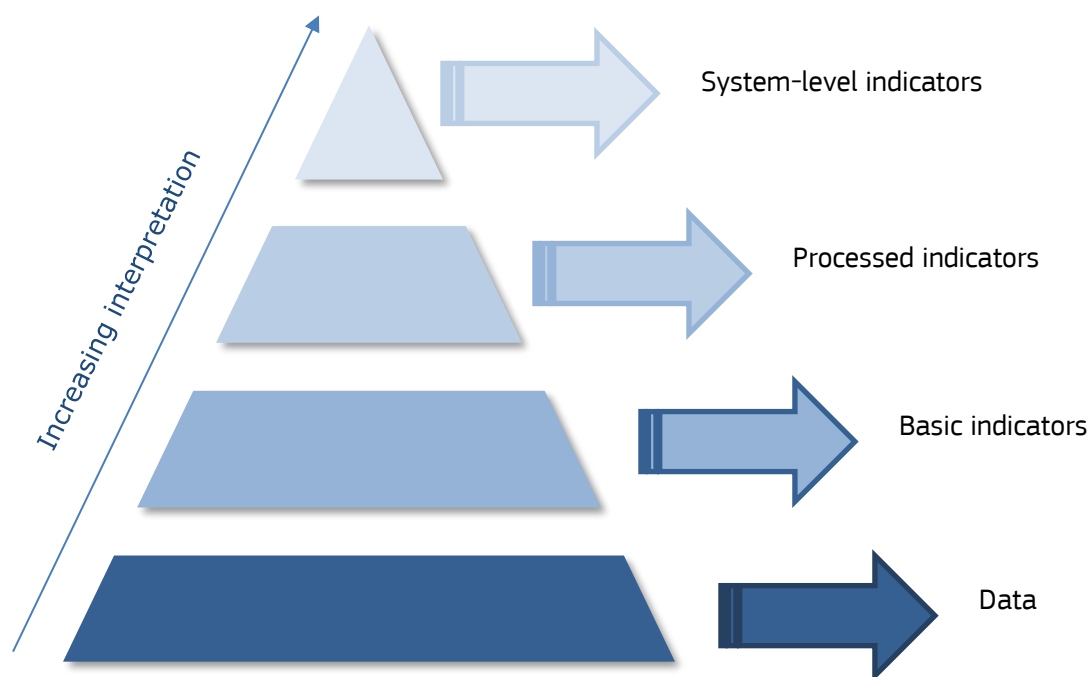
Figure 2. Illustration of the pyramid of information applied to the conceptual framework

Basic indicators are a collection of indicators that are not necessarily harmonised among themselves. Each indicator in this group has its own specific purpose. The basic indicators are often borrowed from reporting systems that are used to gauge EU policy, used in the framework of European and international reporting, or may be produced ad hoc to monitor a specific facet of the EU Bioeconomy.

Processed indicators are more sophisticated in that a certain level of harmonisation, computation and interpretation is made to generate these indicators. These are more useful indicators with respect to basic indicators because although they may be sector-specific, value-chain specific, objective specific etc., their meaning is interpreted within the context of the EU Bioeconomy.

System-level indicators are those that require a higher level of value-judgement in their compilation given the higher level of complexity of the questions the indicators are addressing.

To ensure that a full picture of sustainability is portrayed the set of indicators are structured around the following main dimensions:

1. Each indicator is related to one of the five objectives of the EU Bioeconomy Strategy.

2. Each indicator is mapped to the addressed sustainability pillar: economic, social or environmental. Another underlying "pillar" is added for the physical accounting of the changes in state of the natural resources.

3. Where possible, each indicator is defined according to the relevant biomass source it refers to: agriculture, forestry, fisheries, aquaculture.

4. Where relevant, each indicator will be mapped according to the relevant step in the value chain: from the natural capital stock, to supply steps such as production and harvesting (primary sectors), to the processing and use steps including cascading (e.g. in manufacturing sectors), until the end of life including recycling and disposal.

Further to each of these four main dimensions, each indicator is assessed within the context of the Sustainable Development Goal(s).

The first two points, the Strategy objectives and the three pillars of sustainability consist of a "minimum basic coverage". This means that at the very minimum, the monitoring system must contain one indicator per objective per pillar, so if we consider these two criteria on an orthogonal axis and map the indicators within the space, there should be no gaps. The third, sectoral dimension is considered as a crucial detail in identifying the sectoral contribution to the sustainability of the bioeconomy. The concept of the value chain is an additional dimension that is necessary in order to identify vulnerabilities, or hot spots along the value chain for any given sustainability dimension or strategy objective, concepts that are further developed in section 2.2.3.1 on Life Cycle Analysis.

2.2.1   Basic indicators

According to recent work on the SDGs monitoring framework [UN SDSN, 2015], "indicators need to be simple to compile and easy to interpret and communicate". The UN framework for global monitoring of SDGs progress explicitly recommends the use of simple and mono-variable indicators. Following this lesson learned, basic indicators will be included in the monitoring framework. These are usually indicators that already exist, are recognized for their significance and their quality and are already reported regularly at the international level, in the context of an existing monitoring framework or to meet policy requirements. In many cases, basic statistical data can be given a precise interpretation and thus be used directly as indicators, functioning as proxies of more complex processes and trends.

Important data gaps will have to be addressed when monitoring the bioeconomy because data collection may be scarce and difficult to obtain. This is particularly true for the monitoring of hybrid sectors of activity (i.e. sectors combining bio-based and fossil-based activities), not least the bio-based industries [Spekreijse et al., 2019] and biorefineries [Parisi, 2018]. Similarly, there may be gaps in geographical availability. In this framework, therefore, we favour data and basic indicators that are available and acceptable proxies of the information required if they can be found in existing monitoring frameworks; are already related to monitoring existing policies; and are based on well-established data.

The reason for "labelling" the basic indicators is to be able to identify the indicators with multiple purposes and to be able to construct the composite indicators accordingly.

2.2.2   Processed indicators

Processed indicators either ensure harmonisation across countries or sectors; or ensure that the directionality of the indicator is in line with reaching specific strategy objectives. This is important

when aggregating indicators in, for example, composite indicators, as described in further detail in Section 5.1.1. Whereas basic indicators are often available from sources outside of the JRC, processed indicators are indicators usually developed within the JRC and may be produced using basic indicators to describe the progress or impact of the EU bioeconomy in a more meaningful way using modelling, normalisation and harmonisation techniques.

For example, some basic indicators (e.g. employment, turnover and value added) are currently reported according to the official classification of activity sectors or products (NACE, CPA, HS, Comext, NAICS) that sometimes mix bio-based activities with non bio-based ones [Ronzon & M'barek, 2018]. Thus, the monitoring of these indicators for the solely bio-based activities/products requires the elaboration and application of ad-hoc methodologies. Such a methodology has been established by Ronzon et al. [2017a] for the estimation of bioeconomy jobs, turnover and value added.

Processing may encompass the use of techniques to fill in gaps in time series, the assembly of various data sources representing the same indicator with different definitions and units. For example, the quantity of wood available for wood supply is reported at the state level based considering different factors for the availability for wood supply [Alberdi et al. 2016] as well as different thresholds to estimate the biomass [Gschwantner et al. 2009]. Estimation methods were developed and applied thanks to harmonization work performed by Member States in interaction with the JRC.

Processed indicators include the estimation of intensive variables for the sake of comparison between countries or regions. This requires not only the identification of the appropriate data sources for the main (extensive) variable used in the numerator, but also the choice of a denominator depending on the message that the indicator should carry on. For example, the number of people employed in bio-based sectors in a country can be divided by the total number of people employed or the total active population. This data harmonisation suggests aligning the concepts used and their measurement across the different parts of the bioeconomy system monitored. First, it requires the adoption of clear and common definitions. As an example, the concept of biomass potential can refer to technical potential, economic potential, implementation potential or sustainable potential [JRC, 2015]. A monitoring framework relies on the application of a same definition across the Member States and the biomass sources (agriculture, forestry and aquatic biomass) monitored. Second, the harmonisation of the unit of measurement is also a requisite for data comparison and aggregation. It is for example common rule to convert monetary indicators in Euros for the sake of cross-country comparisons, although not all Member States are part of the euro zone. Conversion to a common unit is also needed before aggregating heterogeneous items like volumes of biomass from vegetables, from fish and from wood logs. Naturally, the common unit can differ according to the policy question the monitoring framework answers to (protein content unit to address nutritional issues vs. carbon-content unit for climate issues).

2.2.3 System level indicators

It is sometimes necessary to select rather complex indicators to assess particular aspects of the EU bioeconomy. An example is the assessment of the impact of the EU Bioeconomy-related products on the land use footprint in exporting countries, or the impact of those products on water resources. To produce such an indicator requires a look at the value chain as a whole, and thus a life cycle assessment approach. The tools to develop system level indicators identified so far within the context of the EU Bioeconomy Monitoring System are consumer-based Life Cycle Assessment indicators [Sala et al., 2019], footprint indicators [Egenolf & Bringezu, 2019], and natural capital accounting [La Notte et al. 2017a].

2.2.3.1 Product-based Life cycle analysis and environmental footprints

LCA is a quantitative method relating all emissions and impacts to a service or function provided, and is recalled in the European Bioeconomy Strategy (already in 2012, and with a clear mandate in 2018). LCA is explicitly mentioned as a method to support the calculation of the environmental

footprint [EC 2013a, EC 2013b] and to support comparison between bio-based and fossil-based materials. LCA follows four main phases: (i) defining goal and scope (ii) life cycle inventory, detailing data on resources used for each stage of the product lifecycle and emissions into the environment (iii) life cycle impact assessment, based on 16 key components (Table 1), covering impacts on the environment and human health due to emissions and resource use and (iv) interpretation of the results (including the possibility of visualising either the 16 impacts or their aggregation in terms of areas of protection: human health, ecosystem health and natural resources). These phases correspond to the elements of the "Driver Pressure State Impact Response" (DPSIR framework) developed by the European Environment Agency. Work carried out in the JRC [Sala et al., 2019] show that this approach helps put in perspective the impacts of the EU bioeconomy versus global impacts, versus planetary boundaries and versus the Sustainable Development Goals, to monitor the evolution of bioeconomy compared to other sectors, and to identify bioeconomy-related environmental hotspots (which may become more relevant in the future). However, some methodological challenges remain to be explored, such as the criteria for the selection of representative products for bioeconomy.

In the Product-based LCA produces results over 16 environmental key components (described in Annex III):

Table 1. Sixteen impact categories of life system assessment.

1. Climate change	2. Particulate matter
3. Photochemical ozone formation	4. Ozone depletion
5. Ionising radiation	6. Acidification
7. Marine eutrophication	8. Freshwater eutrophication
9. Terrestrial eutrophication	10. Freshwater ecotoxity
11. Human toxicity, cancer	12. Human toxicity, non-cancer
13. Water use	14. Land use
15. Resource use, minerals and metals	16. Resource use, fossil

2.2.3.2 Consumption and consumer footprints

Two sets of life cycle assessment-based indicators are used in the JRC for measuring the environmental impact of EU consumption[3]: consumption footprint and consumer footprint, which have a complementary role in assessing the impacts. The consumption footprint assesses impacts at country scale. The indicator (either as single score or for distinct 16 impact categories, Table 1.) adopts a top-down approach, aiming to assess the potential environmental impact of apparent consumption in the EU, and accounting for both domestic impacts (production and consumption at country level with a territorial approach) and trade-related impacts. The impacts are assigned to the country where the final consumer is located.

The consumer footprint adopts a bottom-up approach, and aims to assess the potential environmental impact of an average EU citizen by means of the impacts associated with representative products. Currently the JRC is applying LCA to more than 130 representative products purchased and used in one year by an EU citizen in 5 areas of consumption (food, mobility, housing, household goods, appliances) . For this monitoring activity, we will focus on specific products. The

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[3] https://eplca.jrc.ec.europa.eu/ConsumptionFootprint/

consumer footprint assesses environmental impacts along each step of the product's life cycle (raw material extraction, production, use phase, re-use/recycling and disposal).

2.2.3.3 *Natural capital accounting*

Natural capital accounting (NCA) is a satellite system meant to integrate official economic accounts by using their same framework and methodological rules. This process guarantees consistency with tools and models used by economists and thus allows integrated analysis [UN et al. 2014, 2017].

DG Environment, DG RTD, Eurostat and the Europe Environment Agency are working together with the JRC at the Knowledge Innovation Project on an Integrated system of Natural Capital and ecosystem services Accounting (KIP-INCA). The methodology developed within INCA considers the intersection between the ecosystem service potential and the service demand deriving from the socioeconomic systems, to obtain the actual flow of ecosystem service use, in form of "accounting tables" [La Notte et al. 2017a]. Although there could be different levels of complexity, for most ecosystem services the starting point is a biophysical model that assesses a spatially explicit representation of the ecosystem potential interacting with the actual demand. This is then translated in monetary terms, and reported in the accounting tables for the ecosystem services. So far, accounts have been completed for the following ecosystem services: crop and timber provision, crop pollination, water purification, flood control, global climate regulation and nature based recreation [La Notte et al. 2017b; Vallecillo et al. 2018; Vallecillo et al., 2019]. At the end of 2020, accounts will be available also for soil retention and habitat maintenance.

Following several proof of concept reports and the consolidation of the proposed methodology within the scientific community, the JRC will endeavour to include Natural Capital Accounting as a set of indicators towards monitoring:

— ecosystem services in physical and monetary terms (supply and use);

— capacity of ecosystems to provide services in monetary terms (virtual stock);

— overuse or unmet demand of ecosystem services in physical terms (mismatch between supply and use).

To have systematic and continuous accounts, a standardized methodology needs to be finalized, based on the outcomes of the experimental accounts. For those ecosystem services that need modelling, GIS-tools need to be set to replicate the assessment over time.

The present and future work on NCA at JRC considers (i) expanding the list of ecosystem services to include additional strategic services, (ii) bridging with economic tools such as multi-regional input-output analysis and partial and general equilibrium models.

2.2.4 Aggregating indicators

Due to the inter-sectorial, multi-disciplinary and multi-dimension character of the bioeconomy, a high number of basic, processed and system-level indicators are expected to be put together. This will produce a scoreboard that may be complex to navigate (see section 5.1.1 on 'Scoreboards'), and may not necessarily be effective at communicating information about the status and progress of the bioeconomy. Although it is necessary to report the basic and processed indicators to enable targeted analysis by third parties, the JRC has the scientific knowledge to interpret the system as a whole in order to produce a more concise overview of how the EU Bioeconomy is performing. Techniques to deliver the key messages in a limited number of indicators will be used in order to develop a comprehensive dashboard. These techniques include the development of composite indicators.

Considering that the overarching goal of the EU Bioeconomy Strategy is to achieve a sustainable circular bioeconomy, and that this is founded on other EU strategies such as the strategies for a circular economy, for a sustainable European future [EC, 2016] and the long term strategy of development to achieve the Paris Climate agreement [EC, 2018b], bioeconomy trends cannot be analysed in isolation. The EU Bioeconomy will be assessed in relation to the overall transformation of the European and global socio-ecological-economic systems. Aggregate indicators aim thus to

produce more holistic indexes, possibly representing information closer to the object of the monitoring, to answer higher-level questions such as highlighting the trade-offs among the bioeconomy strategy objectives, assess the contribution of EU Bioeconomy within a planetary boundaries framework [Rockstrom et al., 2009; O'Neill et al., 2018], and eventually to assess the contribution of the EU Bioeconomy to the EU citizens' well-being (see for example, Sala et al, 2015; Pelletier et al. 2016; Mancini & Sala, 2018). Tools for aggregate indicators include composite indicators, and other overall concepts from the safe and just operating space framework [Raworth, 2017], including the impact of the EU Bioeconomy within the planet's carrying capacity.

3 Monitoring at different geographical scales

Geographical scale is expressly taken into consideration in the monitoring framework in order to capture the EU regional and national-level interactions, as well as impacts of EU consumption on extra-EU regions. Geography cannot be considered a dimension in the monitoring framework given the EU-centric nature of this particular framework because it is not always possible or desirable to assess each indicator at regional, national, EU and global scales. What is logical and desirable however, is to:

● Prefer EU level harmonised national data. When EU-level data is required but not available, it should be processed using national level data as the source data;

● Agree with Member States (MS) on which indicators are meaningful at national level;

● Compute processed indicators used at EU-level for national and sub-national scales in the same way (i.e. use the same algorithms but with relevant data scale);

● Compute meaningful indicators at global scale;

● Agree with international organisations on which indicators are meaningful in an international context.

3.1 National and regional-scale indicators

The main drivers for transition towards a sustainable bioeconomy often vary between EU Member States because of country-specific economic, social and environmental contexts as well as differing definitions of bioeconomy. Furthermore, national bioeconomy strategies may vary in their goals and measures.

As of November 2019, 10 Member States (MS) have implemented dedicated bioeconomy strategies at national level, namely Finland and Germany (2010), Spain (2016), France, Italy and Latvia (2017), Ireland, the Netherlands and the UK (2018) and Austria (2019) (Figure 3). Some of these countries have developed, or are in the process of developing instruments and indicators to monitor the level of implementation of their national strategies and action plans, as well as monitoring frameworks to assess the national progress towards a sustainable and circular bioeconomy.

Regarding the implementation of the national strategies, the assessment is mainly conducted by working groups that regularly meet and assess the execution of the action plans and roadmaps. Some examples are the Irish Bioeconomy Implementation Group, the Spanish Bioeconomy Strategy Monitoring Group, the Italian Bioeconomy Coordination Group and the German Inter-Ministerial Working Group on the Bioeconomy. They base their assessments on direct measurable indicators on the actions to be accomplished, e.g. number of funding measures, number of nationally funded R&I projects, number of awareness campaigns, etc. Concerning the bioeconomy monitoring frameworks, some have a strong focus on socioeconomic indicators, such as Finland [LUKE, 2019].

The UK specifies in the national strategy, as main metrics to measure the success of its national bioeconomy, three main socio-economic indicators, i.e. Gross Value Added (GVA), jobs and productivity. Yet, it is also mentioned that additional metrics to assess more comprehensively the impacts of the national bioeconomy on the UKs economy will be considered [UK, 2018].

The biophysical and technology dimensions are also covered in other national frameworks that are being developed. Germany structures the monitoring framework along 3 topic areas: (1) monitoring of resources and their sustainability (data on agrarian products, by-products, waste, and organic materials in general; (2) monitoring of the economic effects and the economic development of the bio-economy (key economic indicators, including indicators on R&D&I and on trends of technological development); (3) systemic monitoring which integrates the data and develops comprehensive indicators and models in a systemic, holistic way (with a special focus on sustainability and SDGs) [Wackerbauer et al. 2019].

As for Italy, its revised national strategy selected, as part of a continuously updating and evolutionary process, a set of Key Performance Indicators (KPIs) to monitor the bioeconomy developments on the supply and demand side. This set includes, at the time of this report, 30 indicators grouped along 8 areas: biomass availability, productive and employment structure, human capacity, innovation, investment, demographics and markets. Furthermore, the Italian strategy also considers the five EU Bioeconomy Strategy objectives [Italy, 2019].

The EU-wide monitoring system will build on the national monitoring frameworks in a bi-directional and mutual-learning approach. Thus, some MS, *inter alia* Ireland [2019] and Italy [2019], explicitly state in their action plans the willingness to "liaise and be consistent with the EU Commission on the EU-wide, internationally coherent monitoring system to track the progress towards a sustainable, circular bioeconomy in Europe and to underpin related policy areas".

Figure 3. Map of status of national level bioeconomy strategies
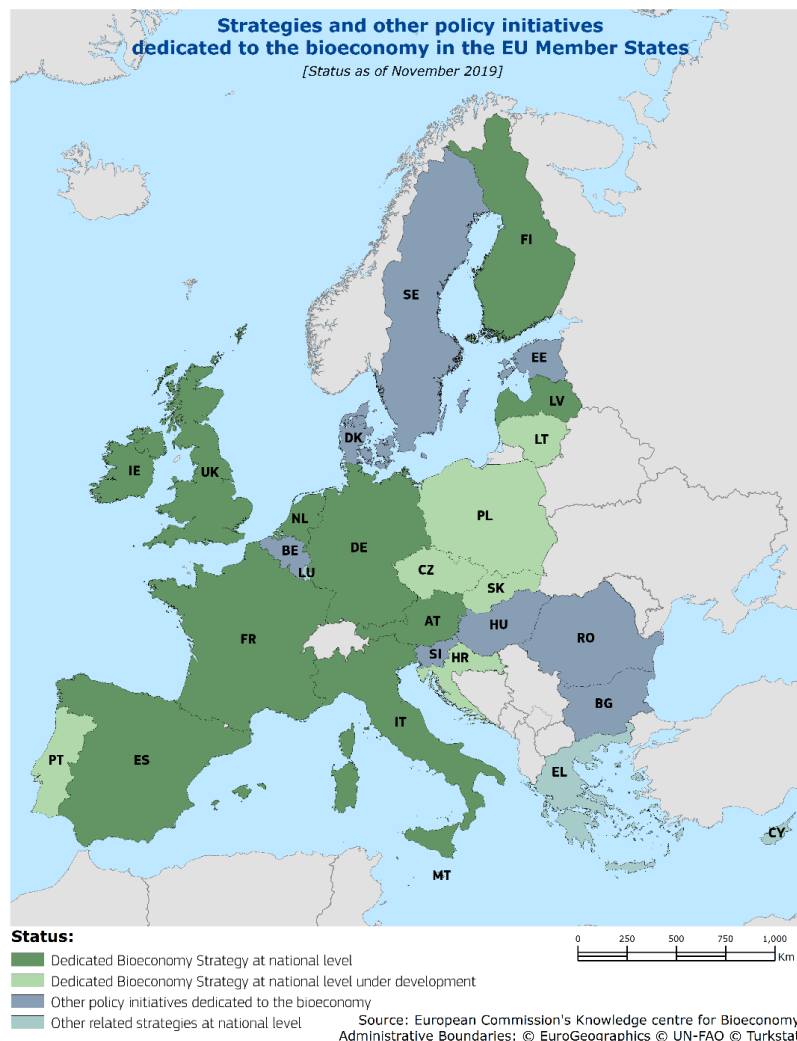
Lier et al. [2018] conducted a study whereby the indicators that were prioritized by Member States at that time were compared within the context of the MontBioeco project[4]. The MS were approached through the Standing Committee on Agricultural Research Bioeconomy Strategic Working Group (SCAR-BSW) members. Thirteen countries, represented by different ministries, responded. Respondents confirmed that aquaculture, fisheries, food industry, agriculture and forestry were

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[4] https://www.luke.fi/en/projects/montbioeco/

always considered as part of the bioeconomy sector. Transport, water purification and distribution and construction were considered by some countries as being partially or not at all part of the bioeconomy, and the share of bio-based in pharmaceutical industry and chemical industry processes was difficult to calculate. The indicators identified as most suitable at MS level, categorised by EU Bioeconomy objective, is shown in Table 2.

Table 2. Results of indicators from MontBioeco survey conducted in 2017-2018.

EU bioeconomy strategy objective	Identified most suitable key indicators
Creating jobs and maintaining competitiveness	Number of employed persons in rural and urban areas (number)
	Value added (EUR)
	Contribution to the GDP (EUR)
	Investment in research and innovation (EUR)
	Exports (EUR)
	Import (EUR)
Reducing dependence on non-renewable resources	Production of renewable energy and Production of biofuels and biogas combined (%)
	Material and waste recycling and recovery rates (tonnes)
	Material replacing non-renewable resources (tonnes)
	Public financial support and private (EUR)
	Investment in research and innovation(EUR)
Mitigating and adapting climate change	Carbon sequestration (CO2 eq. tonnes)
	Forest carbon emissions/sinks
	Greenhouse gas emissions from agriculture
	Water area carbon emissions/sinks
	Public financial support and private investments (EUR)
	Investment in research and innovation (EUR)
Ensuring food security	Domestic food supply of food commodities in terms of production, import/ stock change (EUR)
	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 (ha)
	Resource availability (unit defined by the resource)
	Sustainable resource use (unit defined by the resource)
	Environmental protection (unit defined by the resource)
	Public financial support and private investments for ecosystem services (EUR)
	Investment in research and innovation (EUR)

This table represents a first draft of the indicators that are of interest to EU Member States. The indicators reported by countries are included in the EU-wide mapping exercise, albeit they were flagged within the MontBioEco according to whether or not there was availability across MS, thus there is sometimes an issue of seamless EU coverage. Furthermore, the H2020 project BioMonitor has identified 30 key indicators in collaboration with stakeholders, adding to the above list indicators related to innovation and policy [BioMonitor, 2019].

The updated Bioeconomy Strategy has a very strong local (national, regional, urban) component. Other actions of the bioeconomy strategy are entirely devoted to this aspect. The monitoring system is no exception: the system should be built in collaboration with Member States in order to ensure that its principles can be transposed at different geographical levels and represent valid aspects of the national bioeconomies, considering the variety of potentials, opportunities and risk.

Putting this in practice is not simple, given the sometimes divergent priorities between countries, however there are mechanisms to ensure the harmonisation and transparency between EU-level monitoring and national-level monitoring. These are:

(a) Favouring MS-level indicators for EU-scale monitoring system. The indicators collected within other policy frameworks as the result of obligatory reporting; Eurostat data; and voluntary schemes.

(b) Offering a framework that defines objectives and criteria for a 'desirable' bioeconomy. These can be directly transposed at national level even though the specific indicators to describe progress towards the criteria may be different based on specific national strategies.

(c) Another action of the EU Bioeconomy Strategy Action Plan, the European National Bioeconomy Forum of Member States. Scheduled to be launched in 2020, the forum's principle aim is to facilitate networking of Member States and regions, but may also provide a formal framework by which MS may interact with the EC for the development of new indicators;

(d) Workshops and meetings. Face-to-face interactions provide the opportunity to learn about the evaluation priorities in the different countries, the methods developed to produce the indicators and the attempts to fill the gaps.

3.2 Global scale indicators

The EU monitoring system should take responsibility for monitoring impacts of EU bio-based consumption and trade on the rest of the world. The impacts of EU consumption may be much more far-reaching than what we capture if looking only at internal production indicators. While indicators typically available for EU conditions refer to European-based supply, European consumption has both positive and negative effects outside of EU borders that must be captured (i.e. export of impacts). The growing access to third-country markets to satisfy the EU demand for biocommodities could lead to cross-border spill overs and carbon leakage. Thus our overall responsibility for global climate change may be missed or not captured and therefore our policy makers are not informed to take action. For example, the EU demand for meat or palm oil could fuel tropical deforestation in Brazil and Malaysia, contributing to the increase in their Land Use Land Use Change and Forestry (LULUCF) emissions (Figure 4).

Figure 4. Europe imports bio-based products from third countries (e.g., Brazil and Malaysia) and "exports" several externalities in the place of origin, such as GHG emissions from direct and indirect land use changes and loss of biodiversity.
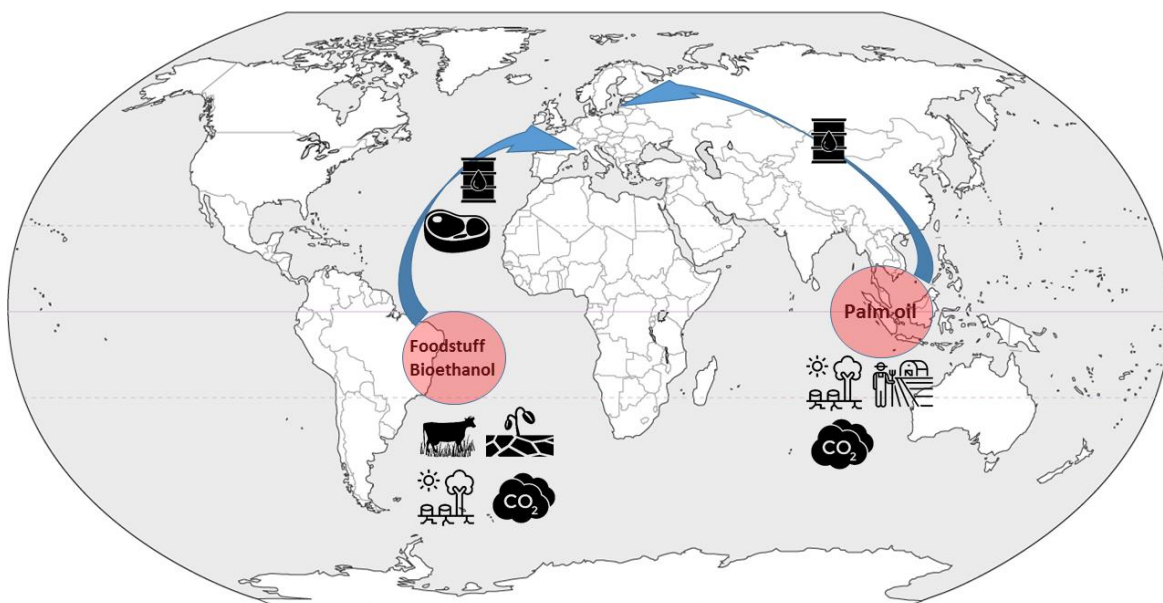
Positive and negative externalities must be understood in a global context to align the EU bioeconomy with world-wide sustainable development goals. Unfortunately, due to their cross-border nature, data

on spill overs are sparse and incomplete, demanding the definition of a robust framework for their measurement. Trade statistics about EU imports of biomass should be linked to information on land use changes, natural resource use and socioeconomic trends in the place of origin, to provide internationally comparable indicators on spill overs. The cause-effect relationships between EU biomass demand and observed impacts in countries outside of Europe is not trivial and must be studied before a sound selection of key-sectors and impact indicators can be made. Assessing biophysical impacts requires the integration of different data sources and scale of analysis (e.g., national agriculture databases, regional deforestation observatories, and global trade dynamics, among others). Relying only on global monitoring systems leads to a very broad picture of the consequences of EU Bioeconomy on the rest of the world, hiding the causal links between productive systems and their impacts in a site-specific context. Therefore, for critical hotspots or key-exporting countries to EU market, a specific set of indicators at subnational level should be considered.

The main tools that will be used to assess the impact of the EU Bioeconomy on the rest of the world are consumer-based life cycle analysis to assess the footprints of our actions (see section 2.2.3.2). This approach will provide a broad overview on the spill overs of EU trade in the place of origin. The results could be subsequently calibrated with national and subnational statistics to reduce the uncertainty of the LCA analysis in selected hotspots (key-trading partners) and for specific commodities (Figure 5).

Figure 5: Step-by-step approach to assess environmental spill overs of EU demand for bio-commodities in third countries.
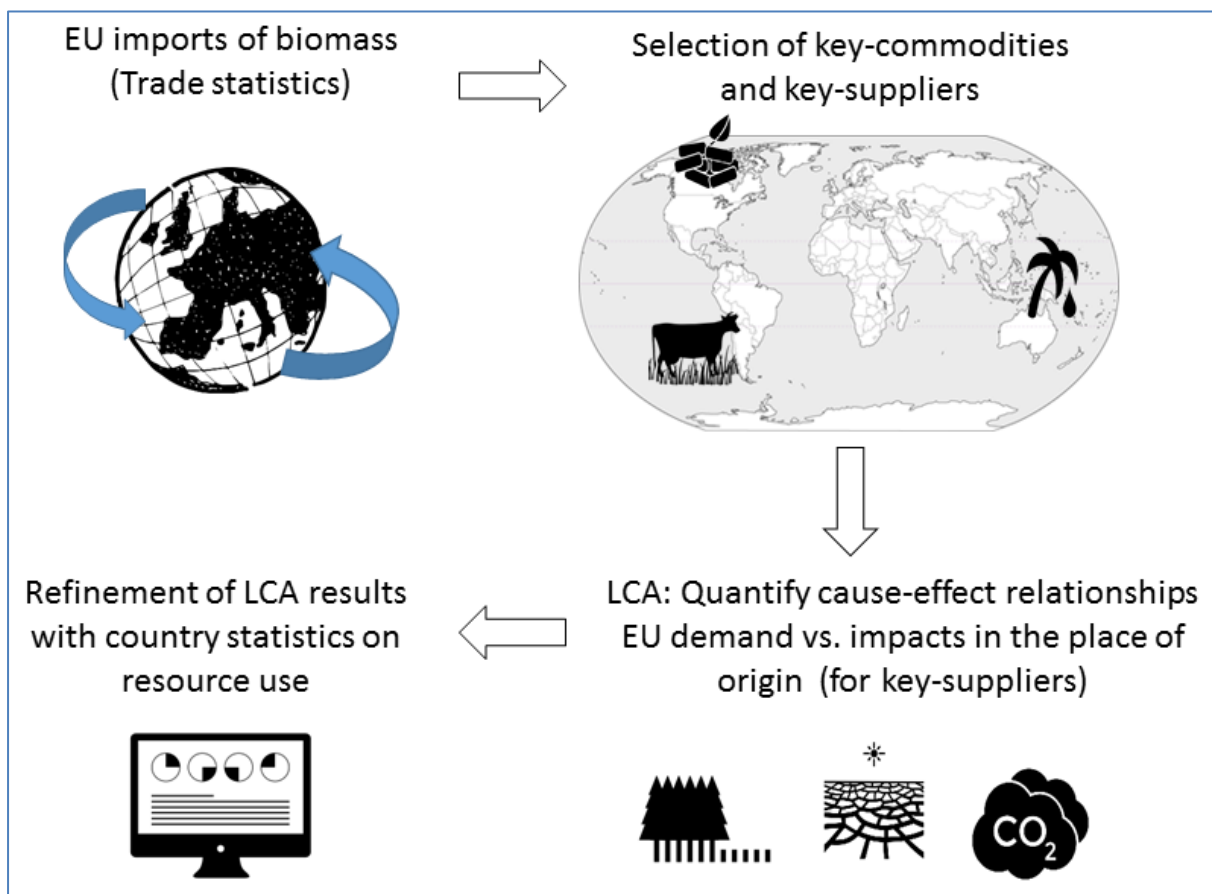
Information about EU international trade statistics (e.g., from Eurostat Comext[5] and Comtrade[6]) will be used to select biocommodities according to their share in the EU imports (volume or value, see

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[5] https://ec.europa.eu/eurostat/web/international-trade-in-goods/data/database
[6] https://comtrade.un.org/

for example Figure 6) and the relevance of their environmental impacts in the place of origin. Oilseeds, fibres (cotton) and rubber are examples of non-food products imported by the EU with high global cropland footprint [Bruckner et al., 2019]. Meat and livestock feed are EU imported food/feed products associated with deforestation trends in tropical regions, like Brazil [Kehoe et al., 2019].

Figure 6: EU-28 exports and imports of raw materials. For our purposes, we consider only the imports of bio commodities.
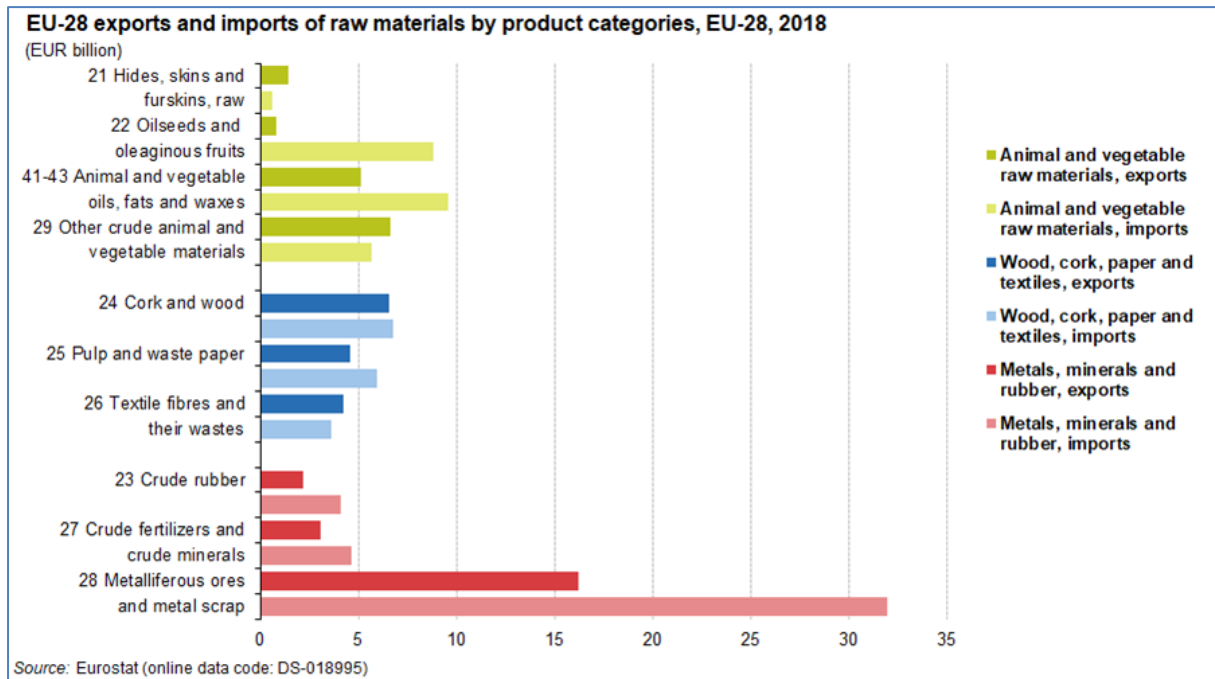
Understanding if, how and to what extent the production of a traded biocommodity is threatening natural resources outside the EU is not trivial and will demand a careful assessment of the cause-effect relationships based on literature review, expert judgments and statistical analysis of demand-supply datasets vs. observed impacts.

Other sources of information about sustainability of traded bio-commodities that could be used *ad hoc* to refine our results are:

- The GRAS Project[7] aims to support the establishment and monitoring of sustainable and deforestation-free supply chains of agricultural products. It provides information about land use changes, biodiversity, carbon stock and social indices with varying resolutions for 16 countries and regions. Some indices are coarsely aggregated at country level (e.g., social indices) and can be useful only for inter-country or inter-regional comparison, without allowing for a subnational assessment. Georeferenced raster data on biophysical attributes are provided with a better resolution (e.g., biomass carbon, pixel 1x1 Km^2) according to the quality of publicly available datasets

- The TRASE[8] platform seeks to describe the links between agricultural commodities supply chains and environmental and social risks in tropical forest regions. TRASE uses publicly available data to map trade flows (via trading companies) from the place of production to the consumer and provide a picture of potential impacts, offering a knowledge base to move towards a more sustainable production, trade and consumption for the major forest-risk agricultural commodities. TRASE covers only Latin America soy, beef in Argentina, Brazil and Paraguay, palm oil in Indonesia and Colombia and coffee in Colombia. The scale of analysis is defined by the availability of country's production data; trade volumes of commodities and

financial flows are quantified at national level, whilst only information about Brazil and Paraguay soy production are disaggregated at municipality level. Flows of traded commodities and their environmental impacts – from production to final destination – are described in sankey diagrams.

- The ATLAS[9] of Economic Complexity is a visualization tool that allows one to explore global trade flows over time for 250 countries and territories, classified into 20 categories of goods and 5 categories of services (covering ca. 6000 products). Raw trade data on goods are derived from COMTRADE[10] (UN Statistical division), whilst raw data on services are from the international Monetary Fund[11]. It should be noted, however, that ATLAS does not assess any kind of environmental and socioeconomic impact due to trade flows.

- The EORA[12] global supply chain database consists of a multi-region Input-Output table (MRIO) model working with a common 26-sector classification across 190 countries. It provides high-resolution IO tables and environmental satellite accounts, covering a 1990–2015 time window. EORA produces spatially explicit environmental and carbon footprints associated with the consumption in a given country (domestic resource use, resources embodied in imports and exports) and allows for linking consumers to the upstream hotspots of their purchases.

- Within the BioMonitor[13] project, a database for biomass flows that links these data with input-output tables has been developed. This allows to identify the availability and use of biomass for further development of the bioeconomy at regional (EU member state level and for selected countries at NUTS2-level) as well as product based level (420 products).

- Among the activities of the JRC that are related to monitoring at global level is the development of an EU Observatory on deforestation, forest degradation, changes in the world's forest cover and associated drivers, pursuant to the Deforestation Communication [EC, 2019]. Monitoring EU imports of tropical timber and other commodities potentially associated with tropical deforestation and forest degradation, such as palm oil, meat, soy, cocoa, maize and rubber, will be a critical part of the Observatory. Furthermore, the JRC is co-chair of the International Bioeconomy Forum working group on Monitoring the Bioeconomy with the FAO (further described in Annex II).

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[9] http://atlas.cid.harvard.edu/
[10] https://comtrade.un.org/
[11] http://data.imf.org/?sk=9D6028D4-F14A-464C-A2F2-59B2CD424B85
[12] https://www.worldmrio.com/
[13] http://biomonitor.eu/

4 Using international criteria to frame the EU Monitoring System

What has been described so far is a breakdown of the requirements of a monitoring system that is able to capture the different facets of a sustainable EU Bioeconomy. These notions are made more concrete by attributing further details to the scheme. In order to effectively choose the indicators with which to monitor the progress, impact and sustainability of the EU Bioeconomy, we must add further details to the strategy objectives thus making their prescriptions more explicit.

There are two internationally-recognised frameworks that may be used to further refine the EU Bioeconomy Monitoring Framework. The first is the UN Sustainable Development Goals (SDGs). As highlighted in section 1, the pathway to a sustainable bioeconomy is an essential step to achieve the SDGs, and thus mapping the indicators in the monitoring framework to the seventeen goals and their specific targets may be used as a "checklist" of the progress of the EU bioeconomy towards sustainable development. Additionally, specific indicators used to monitor SDGs at International and at EU level may be directly used within the EU Bioeconomy Monitoring System. Work is ongoing to map the contribution of the EU Bioeconomy Strategy to Sustainable Development Goals and to understand the synergies between the two monitoring systems. The bioeconomy domains are varied, from the bio-based sectors of activities (SDG 2, 8 and 9); the use and recycling of natural resources (SDG 6, 11 and 12); the conservation of biodiversity and the restoration of healthy ecosystems (SDG14 and 15); education (SDG 4); the production of energy (SDG 7); climate action (SDG 13); and partnerships for the implementation of the action plan (SDG 17). The SDGs are mapped within the Bioeconomy Monitoring Framework in section 4.1.7.

The second internationally-recognised framework is the list of 10 aspirational principles and 24 criteria (henceforth P&C) that were agreed to by the International Sustainable Bioeconomy Working Group (ISBWG) as representative of a sustainable bioeconomy (Table 3)[14].

Table 3. ISBWG Principles and Criteria.

ISBWG Principles	ISBWG Criteria
Principle 1. Sustainable bioeconomy development should support food security and nutrition at all levels	Criterion 1.1. Food security and nutrition are supported
	Criterion 1.2. Sustainable intensification of biomass production is promoted
	Criterion 1.3. Adequate land rights and rights to other natural resources are guaranteed
	Criterion 1.4. Food safety, disease prevention and human health are ensured
Principle 2. Sustainable bioeconomy should ensure that natural resources are conserved, protected and enhanced	Criterion 2.1. Biodiversity conservation is ensured
	Criterion 2.2. Climate change mitigation and adaptation are pursued
	Criterion 2.3. Water quality and quantity are maintained, and, in as much as possible, enhanced
	Criterion 2.4. The degradation of land, soil, forests and marine environments is prevented, stopped or reversed
Principle 3. Sustainable bioeconomy should support competitive and inclusive economic growth	Criterion 3.1. Economic development is fostered
	Criterion 3.2. Inclusive economic growth is strengthened

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[14] http://www.fao.org/3/ca5145en/CA5145EN.pdf

	Criterion 3.3. Resilience of the rural and urban economy is enhanced
Principle 4. Sustainable bioeconomy should make communities healthier, more sustainable, and harness social and ecosystem resilience	**Criterion 4.1. The sustainability of urban centres is enhanced**
	Criterion 4.2. Resilience of biomass producers, rural communities and ecosystems is developed and/or strengthened
Principle 5. Sustainable bioeconomy should rely on improved efficiency in the use of resources and biomass	**Criterion 5.1. Resource efficiency, waste prevention and waste re-use along the whole bioeconomy value chain is improved**
	Criterion 5.2. Food loss and waste is minimized and, when unavoidable, its biomass is reused or recycled
Principle 6. Responsible and effective governance mechanisms should underpin sustainable bioeconomy	**Criterion 6.1. Policies, regulations and institutional set up relevant to bioeconomy sectors are adequately harmonized**
	Criterion 6.2. Inclusive consultation processes and engagement of all relevant sectors of society are adequate and based on transparent sharing of information
	Criterion 6.3. Appropriate risk assessment and management, monitoring and accountability systems are put in place and implemented
Principle 7. Sustainable bioeconomy should make good use of existing relevant knowledge and proven sound technologies and good practices, and, where appropriate, promote research and innovation	**Criterion 7.1. Existing knowledge is adequately valued and proven sound technologies are fostered**
	Criterion 7.2. Knowledge generation and innovation are promoted
Principle 8. Sustainable bioeconomy should use and promote sustainable trade and market practices	**Criterion 8.1. Local economies are not hampered but rather harnessed by the trade of raw and processed biomass, and related technologies**
Principle 9. Sustainable bioeconomy should address societal needs and encourage sustainable consumption	**Criterion 9.1. Consumption patterns of bioeconomy goods match sustainable supply levels of biomass**
	Criterion 9.2. Demand and supply- side market mechanisms and policy coherence between supply and demand of food and non-food goods are enhanced
Principle 10. Sustainable bioeconomy should promote cooperation, collaboration and sharing between interested and concerned stakeholders in all relevant domains and at all relevant levels	**Criterion 10.1. Cooperation, collaboration and sharing of resources, skills and technologies are enhanced when and where appropriate**

The aspirations driving the definition of P&C, as well as the values and worldviews reflected, are very much in line with the vision for a sustainable bioeconomy (Section 1.4) emerging from the EU Bioeconomy Strategy and the political guidelines of the 2019-2024 Commission. We therefore use the established P&C as a tool to disaggregate further the EU objectives and operationalize them for our monitoring effort, in line with the FAO as described in Bracco et al [2019].

In many cases, the EU Bioeconomy Strategy objectives are broader than the ISBWG Principles, making it necessary to aggregate more than one Principle. For instance, Principles 3 and 7 are reflected in the EU objective of 'Strengthening European competitiveness and creating jobs', with Principle 7 reflecting Innovation-related concepts while Principle 3 tackles economic and employment aspects (incl. rural development). In other cases, the EU Objective is narrower and more specific: the objective of 'mitigating and adapting to climate change' is covered by a single criterion in the P&C list.

There is the specific case where the Principles and Criteria fit across all Objectives. This is the case of Principle 6 "Responsible and effective governance mechanisms should underpin sustainable bioeconomy". The monitoring system is put in place to monitor sustainability across the economic,

social and environmental pillars and not to monitor the implementation of the EU Bioeconomy Strategy Action Plan, however the notion of policy coherence is extremely relevant, especially since the bioeconomy sectors are regulated under many different legislative tools. The monitoring system, thus, can be complemented with indicators tracking policies pertaining to different Strategy objectives, which are still in the process of being mapped and are therefore not included in this document (section 4.1.6).

In the following chapters, the EU strategy objectives are used as an overall grouping of the P&Cs. The P&C's are then mirrored into EU-relevant criteria in a one-to-one relationship where possible. Specific headings, called 'key components', are given to further disaggregate the different criteria into components considered to be key to the measurement of progress within the criteria and create a coherent picture of what a sustainable bioeconomy should look like. Each objective, EU normative criterion, and key component is identified by a specific ID that is used throughout the text to cross-reference items.

4.1 Conceptual framework for monitoring the EU bioeconomy

4.1.1 EU Strategy objective 1: Ensuring food and nutrition security

EU Strategy Objective 1 mirrors ISBWG Principle 1, however the criteria are simplified in this EU framework to reflect European priorities. EU Criterion 1.1 is broken down into four key components using the FAO's definition of Food Security[15] with its four dimensions: Availability, Access, Utilisation, and Stability.

- Availability: includes indicators concerning supply of food resources, food production and storage.

- Access: includes concepts of physical and economic access to food.

- Utilisation: indicators for both sufficient quality and quantity of food (concepts of nutrition safety and nutrition quality are included here).

- Stability: Indicators of stability of the above components.

According to FAO's definition, in order to ensure food and nutrition security, all of the core components must exist in a state such that no one factor can detrimentally influence another. For example, an individual may have sufficient economic status but may be at risk of being food insecure if an event occurs that reduces availability of food resources or restricts physical access to them. The overall food and nutrition security could therefore probably best be assessed with an overview of the four individual components, for instance through the use of composite indicators.

The P&C list presents additional criteria on sustainable intensification of food production (ISBWG 1.2). Within our framework, these aspects are spread across various EU Objectives: several components related to the production of food may be mirrored in the 'availability' key component of EU objective 1, on the other hand of the environmental pressures deriving from agriculture intensification are now considered in EU objective 2, together with the delivery of various ecosystem services; finally, economic aspects related to rural development are captured in EU objective 3. Additionally, ISBWG presents a criterion (ISBWG 1.3) on land rights. The socio-economic aspects of rural production within the EU are included in EU objective 3, while those concerning countries exporting food and feed to the EU are captured in criterion EU 1.2. Finally, the contribution of bioeconomy to concepts of domestic food safety (ISBWG 1.4) are included in criteria EU 1.1.c for EU Member States, while eventual impacts on food safety and other aspects of food security in countries exporting food and feed to the EU are included in criterion EU 1.2.

In addition to Criterion ISBWG 1.1, criterion ISBWG 8.1 has been made more specific and added to this EU objective. It includes the specific notion of assessing the impact of EU imports of food and feed stuff on the local economies of exporting countries. Even though some aspects of this criterion may be considered as part of the "stability" key component of criterion 1.1 when viewed from an EU perspective (e.g. aspects of security of supply and import dependency), social, environmental and economic impacts on exporting countries are captured in the new criterion EU 1.2. To be noted that aspects of sustainable trade of non-foodstuff biomass are included in EU Objective 5. Furthermore, this new criterion, together with other aspects of sustainable trade, support EC President von der Leyen in her engagement to ensure that "new trade agreements concluded [with non EU countries] will have a dedicated sustainable-development chapter and the highest standards of climate, environmental and labour protection".

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[15] http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.XUrnxOqzaUk

EU Strategy Objective	ISBWG criteria	EU criteria	Key component	EU ID
Ensuring Food and Nutrition Security				1
	1.1 Food security and nutrition are supported	Food security and nutrition are supported		1.1
			Availability	1.1.a
			Access	1.1.b
			Utilisation	1.1.c
			Stability	1.1.d
	8.1 Local economies are not hampered but rather harnessed by the trade of raw and processed biomass and related technologies	Sustainable trade of biomass for food uses is promoted		1.2
			Economic impact of trade in exporting countries (to EU)	1.2.a
			Environmental footprints in exporting countries (to EU)	1.2.b
			Social impact of trade in exporting countries (to EU)	1.2.c
	1.2.Sustainable intensification of biomass production is promoted			Objective 2
	1.3. Adequate land rights and rights to natural resources are guaranteed			1.2.c
	1.4.Food safety, disease prevention and human health are ensured			1.1.b; 1.1.c; 1.2c

4.1.2 EU Strategy objective 2: Managing natural resources sustainably

The second EU Strategy objective refers to the conservation, protection and restoration of ecosystems, as well as to the sustainable management of primary production systems, with the goal to maintain healthy and resilient ecosystems. The 2018 EU Bioeconomy strategy states that managing natural resources sustainably is more important than ever in the current context of increasing environmental pressures and biodiversity loss. Furthermore, action is needed to avoid ecosystem degradation, protect natural capital, restore, value and enhance ecosystem functions, which in turn can increase food and water security, and contribute substantially to the adaptation and mitigation of climate change through "negative emissions" and carbon sinks. Given the shared concepts with the effort towards Mapping and Assessment of Ecosystems and their Services (MAES[16]), this objective's normative criteria and key components have been designed to reflect the MAES concepts rather closely.

Figure 7: Conceptual framework for an EU-wide ecosystem assessment.
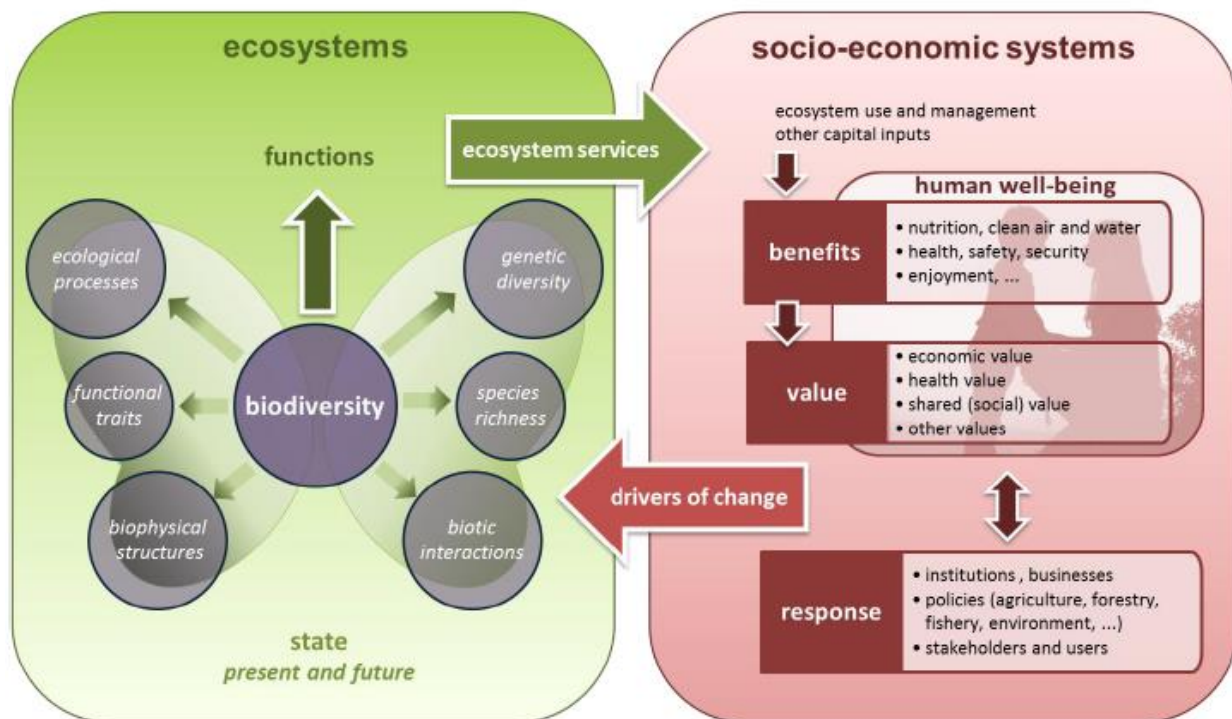
Source: *MAES 1st report (2013), pag. 17.*

According to the 1st MAES report (Maes et al, 2013), "The full conceptual model highlights the underpinning role of biodiversity. (The) Figure elaborates on the different roles of biodiversity in supporting ecosystem functions and ecosystem services. The butterfly depicts six dimensions of biodiversity (Figure 7), three on each wing, which connect biodiversity to ecosystem functioning and ecosystem services". This statement captures the concept that biodiversity and its attributes are underpinning healthy ecosystems and ergo their capacity to deliver E.S. and contribute to human well-being. For this reason, biodiversity indicators are not separated but rather included in 'Condition' indicators, which deviates from the ISBWG P&C.

The 5th MAES report (Maes et al, 2018) goes further to make a causal link between biodiversity, ecosystem condition, ecosystem services and their impact on human well-being. On the other hand,

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[16] https://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/index_en.htm

human actions (negative or positive) can affect biodiversity and ecosystem conditions and thus affect the long-term capacity of ecosystems to provide ecosystem services, and goes on to state that "*The relation between ecosystem condition and regulating ecosystem services is usually positive (Smith et al., 2017). However, for provisioning or cultural ecosystem services such as recreation in nature reserves a non-linear relationship is often observed. A moderate use of ecosystem services is positively related to ecosystem condition but intensive use of provisioning ecosystem services has mostly a negative impact on ecosystem condition and results in ecosystem degradation. Provisioning services such as fish and timber, if overused, can effectively act as a pressure on ecosystems. To avoid over-exploitation of provisioning services, safe thresholds need to be set and well-designed indicators could reflect these limits.*" Thus there is a main distinction made in the MAES framework that is carried over to the EU Bieoconomy Monitoring System, and that is the concept of pressures and condition. Ecosystem condition refers to the physical, chemical and biological condition or quality of an ecosystem at a particular point in time. Pressure refers to a human induced process that alters the condition of ecosystems.

Criterion 2.1 reflects the state of ecosystems in a single criterion "Ecosystem capacity is maintained or enhanced". As argued above, biodiversity underpins ecosystems' health, thus ISBWG criteria 2.1 and 2.4 are combined. Key components of this criterion include environmental quality, structural and functional ecosystem attributes, soil, species abundance and diversity, and conservation status of habitats and species. Many indicators under criterion 2.1 are MAES indicators, covering different types of ecosystems (including urban area, hence the link to ISBWG 4.1, "the sustainability of urban centres is enhanced"). Key component 2.1.e includes indicators on the extent of protected areas and type of ecosystems protected. Criterion ISBWG 2.3 focusses on water quality and quantity and remains in the bioeconomy monitoring system, however these concepts are captured under both the state (EU 2.1) and pressures (EU 2.2) criteria. The normative criterion EU 2.2 aggregates several concepts of the P&C. It is a broad criterion, which expresses the pressures caused by primary production sectors on various ecosystems and the environment in general terms. Key component 2.2.b and 2.2.c (freshwater and marine) are kept separate by differentiating between freshwater and marine ecosystems. Quantities of biomass supplied and supply capacity are addressed in EU 2.3, but in a way that reflects the provisional ecosystems services and the capacity of the ecosystems to supply services in the three main classes of ecosystem services: provisional, recreational and cultural. This is measured through Natural Capital Accounting (NCA, see section 2.2.3.3), whereby the NCA can be used to monitor ecosystem services (in monetary and physical terms); the capacity of the ecosystems to provide services (virtual stock); and the overexploitation or the unmet demand of ecosystem services. More detail is devoted to provisional services in order to analyse the consumption patterns of bioeconomy goods. Criterion EU 2.3 therefore considers the balance between the supply and demand of biomass. For this reason key components cover notions of sustainable consumption but also of the supply capacity of the system. In Objective 2 we are concerned with the biophysical capacity to supply biomass in general but not per sector, which means we are focussing on the provisional side of the value chain and not on transformation or use. This is covered in Objective 5.

The original ISBWG Criterion 2.2 is moved to the objective 4, mitigating and adapting to climate change.

EU Strategy Objective	ISBWG criteria	EU criteria	Key component	EU ID
Managing Natural Resources Sustainably				2
	2.1 Biodiversity conservation is ensured	Ecosystem capacity is maintained or enhanced		2.1
	2.4 The degradation of land, soil, forests and marine environments is		Environmental quality	2.1.a

prevented, stopped or reversed 2.3 Water quality and quantity are maintained, and, in as much as possible, enhanced 4.1 The sustainability of urban centres is enhanced		Structural and functional ecosystem attributes	2.1.b
		Soil	2.1.c
		Species diversity and abundance	2.1.d
		Conservation status of habitats and species	2.1.e
1.2.Sustainable intensification of biomass production is promoted 2.3 Water quality and quantity are maintained, and, in as much as possible, enhanced	Primary production sectors are managed sustainably		2.2
		Pressures from Forest Management	2.2.a
		Pressures from marine / coastal fisheries & aquaculture management	2.2.b
		Pressures from freshwater fisheries & aquaculture management	2.2.c
		Pressures on Agro-ecosystems	2.2.d
9.1 Consumption patterns of bioeconomy goods match sustainable supply levels of biomass 4.2 Resilience of biomass producers, rural communities and ecosystems is developed and / or strengthened	Ecosystem services contribution to human well-being is maintained or enhanced		2.3
		Provisioning services	2.3.a
		Cultural services	2.3.b
		Regulating services	2.2.c
2.2 Climate change mitigation and adaptation are pursued	Objective 4		

4.1.3 EU Strategy objective 3: Strengthening European competitiveness and creating jobs

This objective encompasses several of the criteria in the P&C list. This objective is refined by the criteria into quantitative aspects of economic development; qualitative aspects of policy instruments; notions of resilience in both community and governance levels; and specific focus on rural areas and economies.

Criterion EU 3.1 addresses the capacity of bioeconomy activities to produce wealth and thereby to participate to economic development in Member States. It also relates to the basic question of how much the bioeconomy is contributing to the whole economy, indicators in key component EU 3.1.a will express the infiltration of bioeconomy in the whole economy. EU 3.1.b and 3.1.c will contain indicators that monitor the changes in the prices of raw biomass and processed biomass. While EU 3.1.d monitors exports of EU biomass and derived products, EU 3.1.e was introduced in the BioMonitor project to monitor the comparative advantage of the EU with respect to other regions, and is proposed for this system as well.

Criterion EU 3.2 reflects the quality of economic development, with the goal to have an inclusive economic growth for the bioeconomy, which fosters employment, gender equality and improving working conditions. In this criterion we focus on the EU situation. Issues of responsible and fair trade monitoring equalities and inclusiveness abroad, are included in Criterion EU 1.2 for food and feed-related imports, and in Objective 5, criterion 5.4, for non-food, non-feed imports.

Criterion 3.3 highlights the need for resilient urban and rural regions in order to ensure the success and competitiveness of the bioeconomy, a focal point in the EU Bioeconomy Strategy. This criterion also contains a key component to highlight the economic link between urban and rural areas in order to monitor the synergies between the two, as well as bioeconomy investments in rural and coastal areas. The resilience of biomass producers and rural communities (now including coastal communities given the emphasis in the Strategy) is considered here in its socio-economic terms and it is thus separated from concepts of ecological resilience which instead fall under objective 2, key component 2.4. Under criterion 3.3, the income of primary producers and the diversification of their income are also taken into consideration.

Criteria 3.4-3.5 encompass Principle 7 of the P&C ("Sustainable bioeconomy should make good use of existing relevant knowledge and proven sound technologies"), thus the goal for improved innovation in the bioeconomy, whether this is through valuation of existing knowledge (3.4) or through generation of new knowledge through research and development (3.5).

Criterion 3.6 has a focus on demand and supply side market mechanisms affecting these. The policy coherence aspects will be dealt with separately (see section 4.1.6). Market mechanisms, such as those to promote consumer awareness, influence consumer behaviours and resource competition among sectors are covered in this criterion under key component 3.6.a. Aspects of consumer awareness and education leading to consumer behaviour are included in key component 3.6.b. For instance it could include indicators about the self-perceived role of bioeconomy on citizen's health & well-being (psychological and physical). It could also include indicators on information about bioeconomy (e.g. number of times 'bioeconomy' appears on newspapers or it is shared on social media). Key component 3.6.c captures the resource competition among sectors of the bioeconomy. The indicators belonging to this key component are those showing the biomass uses. This is placed in this specific objective, although it is quite transversal, because the split in biomass uses is mainly associated to markets mechanisms and policy.

EU Strategy Objective	ISBWG criteria	EU criteria	Key component	EU ID
Strengthening European competitiveness and creating jobs				3
	3.1 Economic development is fostered	Economic development is fostered		3.1
			Contribution of bioeconomy to economic development	3.1.a
			Value of raw biomass	3.1.b
			Value added of processed biomass	3.1.c
			Exports of EU food and non-food biomass, processed goods and/or related technologies	3.1.d
			Comparative advantage	3.1.e
	3.2 Inclusive economic growth is strengthened	Inclusive economic growth is strengthened		3.2
			Employment in bioeconomy	3.2.a
			Working conditions related to bioeconomy	3.2.b
			Equality & inclusiveness in bioeconomy sectors	3.2.c

3.3 Resilience of the rural and urban economy is enhanced	Resilience of the rural, **coastal** and urban economy is enhanced		3.3
		Physical infrastructure (accessibility, services)	3.3.a
		Financial stability (household; region)	3.3.b
		Economic dependencies between urban and rural areas	3.3.c
		Bioeconomy investments in rural & coastal areas	3.3.d
		Rural income diversification	3.3.e
		Income, primary producers	3.3.f
		Biomass demand for new value chains	3.3.g
7.1 Existing knowledge is adequately valued and proven sound technologies are fostered	Existing knowledge is adequately valued and proven sound technologies are fostered		3.4
		Existing knowledge on bioeconomy technologies	3.4.a
		Proven sound bio-technologies	3.4.b
		Capacity development (extension services)	3.4.c
7.2 Knowledge generation and innovation are promoted	Knowledge generation and innovation are promoted		3.5
		Knowledge generation/ (high level) education	3.5.a
		Research and innovation	3.5.b

				3.6
9.2 Demand and supply-side market mechanisms and policy coherence between supply and demand of food and non-food goods are enhanced	Demand and supply-side market mechanisms ~~and policy coherence~~ between supply and demand of food and non-food goods are enhanced			3.6
			Market mechanisms (e.g. prices, consumer awareness)	3.6.a
			Consumer behaviour	3.6.b
			Resource competition among sectors of the bioeconomy	3.6.c

4.1.4 EU Strategy objective 4: Mitigating and adapting to climate change

This fourth objective is well defined and well-understood. Many indicators will fall into the key components because of the importance in assessing climate change mitigation and adaptation along all steps of the value chain and across all sectors. The main criteria headings remain unchanged, as they are described in the P&C as criterion 2.2 within Principle 2:

- Key component 4.1.a includes indicators dealing with climate change mitigation efforts, e.g. carbon offset due to the bioeconomy sectors, LULUCF accounting etc.

- Key component 4.1.b includes indicators dealing to adaptation to climate change, in natural ecosystems through specific management measures (e.g. species/crop selection as a function of the upcoming environmental constraints),

- Key component 4.2.a refers to resilience and adaptation in the built environment if it involves biomass components (e.g. urban trees, green roofs etc…)

EU Strategy Objective	ISBWG criteria	EU criteria	Key component	EU ID
Mitigating and adapting to climate change				4
	2.2 Climate change mitigation and adaptation are pursued	Climate change mitigation and adaptation are pursued		4.1
			Climate change mitigation	4.1.a
			Climate change adaptation	4.1.b
	4.1 The sustainability of urban centres is enhanced	The sustainability of urban centres is enhanced		4.2
			Enhanced resilience/adaptation to climate change for urban areas	4.2.a

4.1.5 EU Strategy objective 5: Reducing dependence on non-renewable, unsustainable resources, whether sourced domestically or from abroad

This objective is expanded and detailed using a range of impact of the P&C list. It reflects the goal for a bioeconomy that follows sustainable production and consumption ideals along the value chain as well as circular economy principles. Criterion EU 5.1 is taken from the P&C list (Criterion ISBWG 5.1) and has a focus on the efficient use of resources along the value chain. This is broken down further to facilitate the choice of indicators. While key component 5.1.a focusses on resource efficiency, key component 5.1.b has a focus on energy efficiency along the supply chain of bio-based products. Key components 5.1.c – 5.1.d include measurable concepts of waste re-use and waste treatment of non-food biomass resources. A special focus on urban areas is included under key component 5.1.e to reflect the ISBWG criterion Criterion 4.1 "The sustainability of urban centres is enhanced". This Criterion is repeated and used in EU criterion 5.6. as well to emphasise urban dweller well-being. EU 5.2 focusses on food waste reduction and food waste re-use and recycling. This key component may complement information in 1.2.d and 5.4.d.

Criterion EU 5.3 "Bioeconomy should promote sustainable production and consumption of biomass and bio-based products" is an addition to this framework with respect to the ISBWG P&C. It effectively describes the sustainability of EU bio-based products and consumption choices. Key component 5.2.a contains indicators for environmental impacts of production and consumption of the bioeconomy, benefitting from the experience within JRC on Life Cycle Assessment and its application to assessing the consumer footprint of EU citizens. This differs from key components in EU Criterion 5.5, which focus on extra-EU impacts because these will focus on domestic (or total) impacts. Key component 5.3.b is a consumer-based angle. Although the actual technique to assess key category 5.3.a will be the same, the perspective will differ (and so the variables used and sums etc).

Criterion EU 5.4 considers the consumption of bio-based products, and not of biomass. The production and consumption of biomass is taken care of in Objective 2 under key component 2.3.a "provisional services", where the supply capacity of the system is considered. In Objective 5 we are concerned with the sector-specific uses of biomass. Thus we are assessing the overall consumption patterns of bioeconomy products. Key component 5.4.a reflects on changes in demand for various biomass products. Key component 5.4.b focusses on the production of bio-based products, which is linked to Objective 2 in that 2.3.a is providing the biomass for those products, but in this case we focus on more advanced steps along the value chain. What remains in a grey area is the production of biomass in closed settings, for example micro-algal production plants. Key component 5.4.c is taken directly from the ISBWG P&C and contains indicators to highlight the penetration of bio-based products at the expenses of fossil sources, especially for bioenergy penetration, but it could also include indicators on bio-based materials substituting non-renewable materials in construction, furniture, plastics etc. Thus this key component contains indicators of share of penetration. This is useful because bio-based products will increment but if overall consumption increments as well, the actual penetration of the new products may remain stable.

Criterion 5.5 is analogous to criterion EU 1.2 but for non-food commodities, capturing aspects of responsible trade. The environmental impacts of bioeconomy on 3rd countries for non-food products, is assessed in 5.5.b. The key component 5.5.c reflects (an aspect) of social impacts of bioeconomy trade on extra-EU countries; P&Cs focus on land rights and rights to resources, but other aspects of social impacts could be included, for instance on labour rights and working conditions.

EU Strategy Objective	ISBWG criteria	EU criteria	Key component	EU ID
Reducing dependence on non-renewable unsustainable resources, whether sourced domestically or from abroad				5
	5.1 Resource efficiency, waste prevention and waste-re-use along the whole bioeconomy value chain is improved	Resource efficiency, waste prevention and waste-re-use along the whole bioeconomy value chain is improved		5.1
			Resource efficiency (Material footprint (secondary resources))	5.1.a
			Energy efficiency	5.1.b
			Non-food waste re-use	5.1.c
			Non-food waste treatment and hazardous waste	5.1.d
	4.1 The sustainability of urban centres is enhanced		Improving waste collection and waste-water systems in urban areas	5.1.e
	5.2 Food loss and waste is minimised and, when unavoidable, its biomass is reused or recycled	Food loss and waste is minimised and, when unavoidable, its biomass is reused or recycled		5.2
			Food loss and waste minimization	5.2.a
			Food waste re-use or recycling	5.2.b
	9.1 Consumption patterns of bioeconomy goods match sustainable supply levels of biomass	Sustainable production and consumption of ~~biomass and~~ bio-based products (within EU) is promoted		5.3
			Bio-based products environmental impacts	5.3.a
			Consumer footprints	5.3.b
		Consumption patterns of **bioeconomy goods** match sustainable supply levels of biomass		5.4
			Consumption and demand for bio-based products	5.4.a
			Production of bio-based products	5.4.b
			Reduced dependence on non-renewable resources	5.4.c

	8.1 Local economies are not hampered but rather harnessed by the trade of raw and processed biomass and related technologies	Bioeconomy should promote sustainable trade of biomass for non-food uses		5.5
			Economic impact of trade in exporting countries (to EU)	5.5.a
			Environmental footprints in exporting countries (to EU)	5.5.b
			Social impact of trade in exporting countries (to EU)	5.5.c
	4.1 The sustainability of urban centres is enhanced	The sustainability of urban centres is enhanced		5.6
			Enhanced wellbeing and health of urban dwellers	5.6.a

4.1.6 Policy coherence

Most P&C are integrated into the different Strategy objectives as described in the previous sections. The exception however is the cross-cutting Principle 6 "Responsible and effective governance mechanisms should underpin sustainable bioeconomy". The ISBWG criteria to consider under this heading, although not necessarily explicitly monitored are

- ISBWG 6.1 Policies, regulations and institutional set up relevant to bioeconomy sectors are adequately harmonised

- ISBWG 6.2 inclusive consultation process and engagement of all relevant sectors of society are adequate and based on transparent sharing of information

- ISBWG 6.3 Appropriate risk assessment and management, monitoring and accountability systems are put in place and implemented
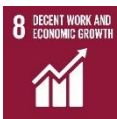
Policy coherence is a *sin qua non* for the success of the EU bioeconomy, both across sectors and policies and across geographical scales. The indicators associated to ISBWG Principle 6.1 within the EU context pertain to the sectorial policies. In this way, we capture the element so fundamental to the objectives of the monitoring system: policy coherence. Many of the indicators proposed for this monitoring system are directly taken from, or are derived from obligatory reporting under policies that are currently in place. In this way, we may track the relevant indicators coming from other policies. More work is needed to assess the synergies and trade-offs between these basic indicators. Composite indicators (section 5.1.1) will be a useful tool for this purpose (among others), and new indicators will also have to be developed. A possible source for ISBWG 6.3 is the monitoring of the 2018 Bioeconomy Strategy Action plan itself. The Commission has pledged to monitor the implementation of the Strategy, thus providing useful input to this specific Criterion.

4.1.7 Conceptual framework and SDGs

The tables below provide a link between the conceptual framework proposed in this report and the UN SDGs and their targets. The mapping is provided at different hierarchical levels, starting from the link between the EU Objective and SDGs, down to the link between key components and SDGs specific targets. In some cases, a whole criterion can be mapped to one or multiple SDG targets. The SDG codes used in the following tables can be deciphered using Annex I.
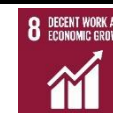
EU Strategy Objective	EU ID	EU criteria	Key component	SDG / Targets
Ensuring Food and Nutrition Security	1			
	1.1	Food security and nutrition are supported		
	1.1.a		Availability	2.3
	1.1.b		Access	2.1
	1.1.c		Utilisation	2.2
	1.1.d		Stability	2.a; 2.b; 2.c
	1.2	Sustainable trade of biomass for food uses is promoted		10.a; 17.10; 17.11; 17.12
	1.2.a		Economic impact of trade in exporting countries (to EU)	2.3; 2.a; 2.b; 2.c
	1.2.b		Environmental footprints in exporting countries (to EU)	2.4; 15.a
	1.2.c		Social impact of trade in exporting countries (to EU)	1.4; 2.1; 2.2; 8.7

EU Strategy Objective	EU ID	EU criteria	Key component	SDG / Targets
Managing Natural Resources Sustainably	2			
	2.1	Ecosystem capacity is maintained or enhanced		6.6; 15.3
	2.1.a		Environmental quality	
	2.1.b		Structural and functional ecosystem attributes	6.3; 15.1
	2.1.c		Soil	
	2.1.d		Species diversity and abundance	2.5; 15.5
	2.1.e		Conservation status of habitats and species	14.5; 15.1; 15.4
	2.2	Primary production sectors are managed sustainably		15.a
	2.2.a		Pressures from Forest Management	15.2; 15.b
	2.2.b		Pressures from marine / coastal fisheries & aquaculture management	14.2; 14.4; 14.6
	2.2.c		Pressures from freshwater fisheries & aquaculture management	6.4
	2.2.d		Pressures on Agro-ecosystems	2.4; 6.4; 14.1
	2.3	Ecosystem services contribution to human well-being is maintained or enhanced		
	2.3.a		Provisioning services	
	2.3.b		Cultural services	
	2.2.c		Regulating services	6.6; 13.1

EU Strategy Objective	EU ID	EU criteria	Key component	ID
Strengthening European competitiveness and creating jobs	3			
	3.1	Economic development is fostered		
	3.1.a		Contribution of bioeconomy to economic development	8.1
	3.1.b		Value of raw biomass	
	3.1.c		Value added of processed biomass	8.2
	3.1.d		Exports of EU food and non-food biomass, processed goods and/or related technologies	
	3.1.e		Comparative advantage	
	3.2	Inclusive economic growth is strengthened		4.4; 8.5
	3.2.a		Employment in bioeconomy	
	3.2.b		Working conditions related to bioeconomy	8.8
	3.2.c		Equality & inclusiveness in bioeconomy sectors	
	3.3	Resilience of the rural, coastal and urban economy is enhanced		
	3.3.a		Physical infrastructure (accessibility, services)	9.1
	3.3.b		Financial stability (household; region)	
	3.3.c		Economic dependencies between urban and rural areas	11.a
	3.3.d		Bioeconomy investments in rural & coastal areas	
	3.3.e		Rural income diversification	
	3.3.f		Income, primary producers	
	3.3.g		Biomass demand for new value chains	

3.4	Existing knowledge is adequately valued and proven sound technologies are fostered		
3.4.a		Existing knowledge on bioeconomy technologies	
3.4.b		Proven sound bio-technologies	
3.4.c		Capacity development (extension services)	
3.5	Knowledge generation and innovation are promoted		9.5
3.5.a		Knowledge generation/ (high level) education	
3.5.b		Research and innovation	14.a
3.6	Demand and supply-side market mechanisms between supply and demand of food and non-food goods are enhanced		
3.6.a		Market mechanisms (e.g. prices, consumer awareness)	12.8
3.6.b		Consumer behaviour	12.8
3.6.c		Resource competition among sectors of the bioeconomy	

EU Strategy Objective	EU ID	EU criteria	Key component	SDG / Target
Mitigating and adapting to climate change	4			
	4.1	Climate change mitigation and adaptation are pursued		
	4.1.a		Climate change mitigation	
	4.1.b		Climate change adaptation	13.1
	4.2	The sustainability of urban centres is enhanced		
	4.2.a		Enhanced resilience/adaptation to climate change for urban areas	11.5; 13.1

EU Strategy Objective	EU ID	EU criteria	Key component	SDG / Targets
Reducing dependence on non-renewable unsustainable resources, whether sourced domestically or from abroad	5			
	5.1	Resource efficiency, waste prevention and waste-re-use along the whole bioeconomy value chain is improved		
	5.1.a		Resource efficiency (Material footprint (secondary resources))	8.4; 12.2
	5.1.b		Energy efficiency	7.3
	5.1.c		Non-food waste re-use	12.5
	5.1.d		Non-food waste treatment and hazardous waste	12.5
	5.1.e		Improving waste collection and waste-water systems in urban areas	6.3
	5.2	Food loss and waste is minimised and, when unavoidable, its biomass is reused or recycled		12.5
	5.2.a		Food loss and waste minimization	
	5.2.b		Food waste re-use or recycling	
	5.3	Sustainable production and consumption of bio-based products (within EU) is promoted		12.2
	5.3.a		Bio-based products environmental impacts	
	5.3.b		Consumer footprints	
	5.4	Consumption patterns of bioeconomy goods match sustainable supply levels of biomass		
	5.4.a		Consumption and demand for bio-based products	
	5.4.b		Production of bio-based products	
	5.4.c		Reduced dependence on non-renewable resources	7.2
	5.5	Bioeconomy should promote sustainable trade of biomass for non-food uses		10.a; 17.10; 17.11; 17.12

5.5.a		Economic impact of trade in exporting countries (to EU)	2.a; 2.b; 2.c
5.5.b		Environmental footprints in exporting countries (to EU)	15.a
5.5.c		Social impact of trade in exporting countries (to EU)	1.4; 2.1; 2.2; 8.7
5.6	The sustainability of urban centers is enhanced		
5.6.a		Enhanced wellbeing and health of urban dwellers	11.6; 11.7

5 Proposed indicators

Over one hundred indicators have been so far proposed by various experts from both within and outside of the JRC and consolidated in a single database. Each indicator is accompanied by attributes defining the main dimensions and indicator quality (see section 6.2) to facilitate queries and for gap analysis.

Many indicators so-far proposed for the EU Bioeconomy Monitoring Framework are the result of other international efforts such as the Biomonitor project, pioneering work such as MontBioEco, or ongoing work at the JRC which has led to specific knowledge of relevant indicators given the political context in which the JRC is working (Annex II).

The indicators are divided by the Strategy objective, normative criteria and key component they address. The indicators and their full sets of attributes are stored in a database.

At the time of writing, the indicators have not been finalised and are therefore not published here.

5.1 Aggregating indicators

5.1.1 Scoreboards and composite indicators

The EC JRC Competence Centre on Composite Indicators and Scoreboards is at the forefront of the development of composite indicators and scoreboards for almost 15 years and has contributed to half of the 150+ composite indicators and scoreboards used within a range of EU institutions.

Scoreboards are collections of indicators that aim to monitor or represent a common concept, such as the proposed scoreboard for bioeconomy. Scoreboards are information-rich, however they are complex and much data is presented at once, making comparisons difficult and overall performance unclear.

A composite indicator is an aggregation of observable indicators that aims to quantify a variable that cannot be directly measured. Given that the objectives are the same or very similar to those of scoreboards, it can be regarded as a mathematical summary of a scoreboard. In this sense it is very much complementary to a scoreboard, and can serve as a tool for identifying high-level trends, making simple comparisons, as well as an access point for exploring the underlying data.

The key to developing composite indicators is to have relevant indicators assembled within a logical and structured framework (scoreboard), such the framework discussed in this document. The added value of composite indicators is that they aggregate a large number of variables and allow for simplified comparisons – although the aggregation of the indicators requires some methodological decisions, and some information will inevitably be lost when aggregating many indicators into one. This latter point emphasises why composite indicators and scoreboards should usually be presented together.

Composite indicators will be valuable in summarising the trends of combined groups of indicators relating to, for example, the Strategy objectives. A participatory approach will be adopted in order to develop these for the EU Bioeconomy Monitoring System because they require a lengthy process of interpretation and debate before they are agreed upon, not to mention a pool of carefully-selected indicators to work with. We expect therefore, that once the inventory of basic and processed indicators are sufficient to describe the sustainability of the EU Bioeconomy, we may proceed with the steps that are required to configure composite indicators.

The steps to building a composite indicator are typically as follows:

1. Clearly identifying the concept to be measured and building a conceptual framework (possibly as a hierarchical framework with dimensions and sub-dimensions of the concept) as well as the objectives and end-users of the index.

2. Selecting indicators based on e.g. value added, relevance, data quality/reliability, etc.

3. Data treatment, consisting of data imputation (if needed and appropriate), multivariate analysis and normalisation.

4. Weighting and aggregating indicators according to the conceptual framework and the relative importance of indicators and dimensions.

5. Robustness and sensitivity analysis

6. Visualisation, analysis and communication of the results, including linking to other relevant indexes and quantities (e.g. perhaps on sustainable development).

These steps are usually followed in an iterative process, and stakeholder consultation should be sought in every step, if possible.

6   Implementation technicalities

6.1   Prioritizing key questions and users' needs

Indicators are purpose-led, the exact goal and objectives of the monitoring framework need to be tuned and refined to the audience interests. Indeed indicators are best designed to help answer stakeholders' key questions. The conceptual framework is designed to be able to answer questions at different levels of aggregation. Nonetheless, the final monitoring system will need to present the key information tailored to the needs of various stakeholders. Therefore, three types of interactions with stakeholders have been used so far: online survey, workshops and discussions (with DGs and national experts).

Survey. A survey of "user's stories" was conducted in April/May 2019 using a snowballing sampling technique[17], which made it possible to collect feedback from 76 participants, mostly from governmental institutions. Most respondents expect to enhance their knowledge and to understand the trends of the bioeconomy from a monitoring system for the purpose of prioritising actions and to inform their own stakeholders.

User Stories is a concept that is borrowed from software development. It is powerful because it allows the developers to gauge the expectations at the onset, as well as update the user stories throughout the development of the product (Figure 8)

Figure 8. Expectations of the EU Bioeconomy Monitoring System will change over time as both the bioeconomy and our knowledge evolves
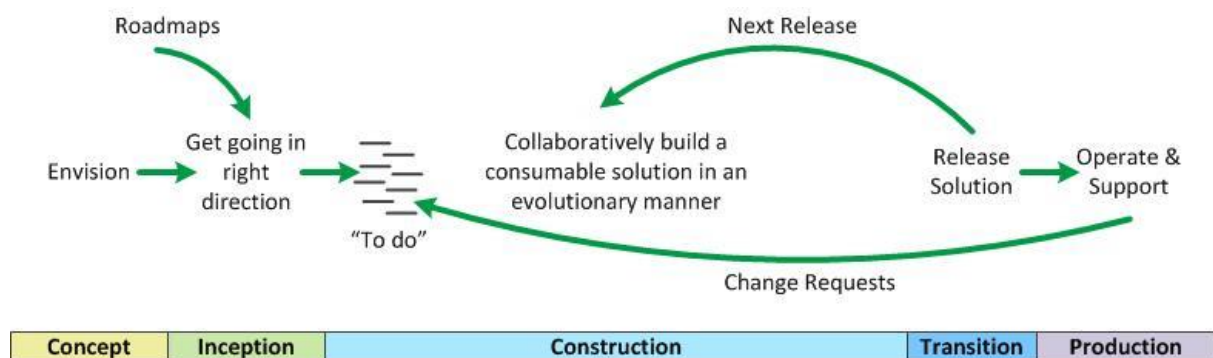
Copyright 2014 Disciplined Agile Consortium

We asked people three basic questions: Who are you? What do you need? Why do you need a Bioeconomy Monitoring System? Four recurring themes emerged from an assessment of verbatim comments by mining key phrases and words. These are attached to labels. Four main labels were identified and qualities attributed to each of these (Table 4).

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[17] In sociology and statistics research, snowball sampling (or chain-referral sampling) is a nonprobability sampling technique where primary data sources nominating another potential primary data sources to be used in the research. Thus the sample group is said to grow like a rolling snowball. Source: https://research-methodology.net/sampling-in-primary-data-collection/snowball-sampling/

Table 4. Labels and attributes of labels retrieved from user story survey (2019).

Research		Bioeconomy	
Research	Products	Bioeconomy	Trends
	Science		Contributions
	Technology		Development
	University		Cross-sectoral
	Business		Policy
Data	Accurate	Monitoring System	Evaluate
	Statistics		Track
	Services		Maps
	Accounts		Strategies
	Comparable		Assessment
			Charts
			Update

The survey was not anonymous. Profiles of the users were divided into the following five groups:

- MS policy officers (39%);
- EU policy officers (8%);
- Researchers (31%);
- Cooperatives, lobby groups and industry (18%);
- Other (4%).

The geographical coverage was reasonable, answers came from 18 different countries.

The interest categories were assessed. Potential users were interested in one of four broad categories:

- To compare between MS (12%);
- For knowledge and trends (65%);
- For rural and regional development (12%);
- Trade-offs and synergies (6%).

The purpose for using the monitoring system, as stated by potential users, was cited as:

- To prioritize (42%);
- To inform (23%);
- To persuade (19%);
- To network (12%);
- To give back to the monitoring system (4%).

Figure 9. Overlap of responses for interest categories and purpose foreseen for using the EU Bioeconomy Monitoring System.
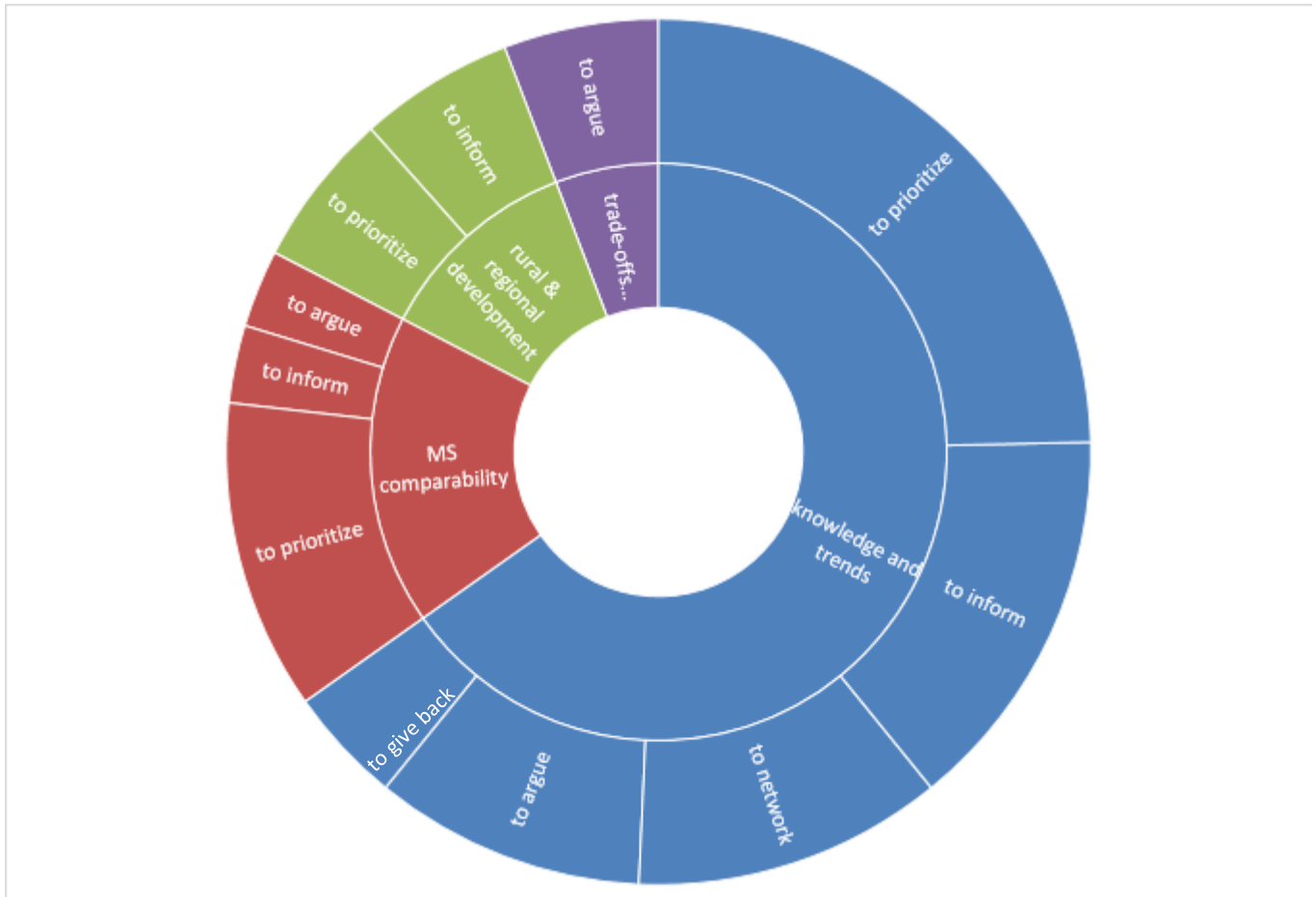
Figure 9 shows the overlap in responses on how and why the monitoring system would be used. The majority of potential users declared that they would use the monitoring system to gain insight on knowledge and trends. The applications are subdivided by five main categories of uses, with the majority being to prioritize their work. The second most common use of the monitoring system is declared to be the MS comparability.

Workshops. A workshop involving external stakeholders took place in 2019. The first –a follow up of the workshop in November 2018[18] and organised on June 18, 2019 in Ispra Italy, brought together experts from different organisations on essentially monitoring systems. The draft structure and a first list of indicators was presented and discussed with academic experts from different bioeconomy fields and European Member States[19].

Other means. Exchanges with relevant Policy DGs is encouraged for JRC staff working on the project, particularly where gaps have been identified and consultation with other services would be beneficial. Also, networking is key, contributors are encouraged to attend meetings and report back to the group.

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[18] The workshop that took place in November 2018 provide the opportunity to review existing monitoring frameworks and explore existing approached in EU Member States, and to start the discussion about next steps to develop the EU bioeconomy monitoring system

[19] A summary of the workshop is available at: https://ec.europa.eu/knowledge4policy/publication/report-community-practice-workshop-shaping-eu-bioeconomy-monitoring-system-first_en

6.2   Principles for indicators inclusion

Figure 10. Process for the definition of a core set of indicators. represents an abstract illustration of the process that will lead to a core set of basic and processed indicators for the monitoring action, which will be complemented by aggregate indicators once ready and defined. Given the existing knowledge and expertise on monitoring EU policies involving several aspects of the bioeconomy, we foresee the following steps that will lead to the compilation of a final list of indicators:

- Mapping existing basic data and indicators into the conceptual framework.

- Evaluate eventual limitations of the framework (iterative process);

- Compile an exhaustive preliminary list of available indicators and compare with existing international and EU MS frameworks;

- Highlight main gaps in available data;

- Apply the principles for inclusion (see section below) to filter the preliminary list;

- Evaluate each indicator against these principles and rank them to define a core set of indicators;

- Prepare a detailed 'passport' for each indicator in the core set;

- The conceptual framework can be modified along the process to better suit the goal and scope of the monitoring exercise.

Figure 10. Process for the definition of a core set of indicators.
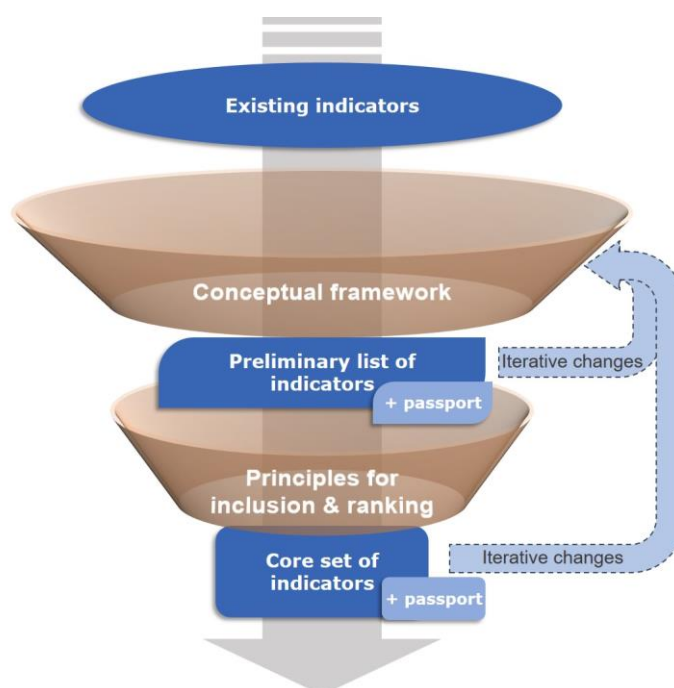
Based on the experience gathered by existing monitoring frameworks [BIP, 2019; EEA, 2005; EUROSTAT, 2016; UN SDSN, 2015; Forest Europe, 2015] and based on the recommendations received at the JRC workshop in November 2018 [JRC, 2018], we propose the following principles for the inclusion of indicators in the core set:

- Outcome-focused (if possible) and/or clear directionality (whether or not the indicator follows the direction of the target) identifiable with one or more strategy's objectives;

- Validity and Clarity: clear relationship with the monitored quantity (clear and accepted cause-effect chain).

- Policy relevance: indicators with either direct connection to policy objectives or already agreed as meaningful indicator to monitor a policy development. This includes indicators that are used to monitor other Actions within the Strategy. Some are relevant to monitor the whole EU Bioeconomy.

- Timely: the indicator should be based on data reflecting recent conditions.

- Frequent dissemination of underlying data.

- Established: sufficient length of time series.

- Geographical coverage: EU aggregate, MS level, Global.

- Methodologically well-founded and well-documented.

- Based on well-established data sources.

- Based on routinely and frequently collected data, for instance through reporting obligations.

- Comparable across countries: homogeneously defined across countries.

- Comparable over time: no methodological breaks in the data series.

- Accessible: data openly available and clearly documented.

6.2.1 Indicators' passports and ranking criteria for selection of core set of indicators

Each indicator will be accompanied by a passport containing all relevant information concerning the indicator itself, the measure composing it, and how it compares with the principles mentioned above.

While carrying out the initial mapping exercise, experts will be required to compile a simple passport. At the end of the mapping, all indicators will be ranked based on specific ranking criteria to define the core set of indicators. At that time, a maximum number of indicators will also be defined. According to existing monitoring frameworks, it is important to limit the number of the core indicators for both clarity and efforts in populating the set.

The passport will be composed of three sections: data about the author and owner of the indicator; the second section will collect specific information on the indicator's characteristics; the third section will apply a quality scoreboard that will be utilized to rank the indicators.

Concerning the ranking method, the initial proposal is to utilize the same scoreboard as used by Eurostat for the selection of SDG indicators framework [EUROSTAT, 2016], as reported in Table 5.

Table 5: Criteria to be applied to preliminary list of indicators for quality ranking and inclusion in core set. Source: EUROSTAT, 2017

	Rating			
Criterion	**High (= 3 points)**	**Medium (= 2 points)**	**Low (= 1 point)**	**not accepted (= 0 points)**
Frequency of dissemination	every year	every 2 years	every 3 years	longer than every 3 years or a-periodic
Timeliness	T-1 year	T-2 years	T-3 years	> T-3 years

(release year - reference year)				
Geographical coverage	Data for all MS and EU aggregate available	MS data represents at least 75% of EU total and EU aggregate available	MS data represents at least 50% of EU total and EU aggregate available	MS data represents less than 50% of EU total or no EU aggregate available
Comparability between countries	Data for all countries comparable	Data comparable for MS representing at least 75% of EU total	Data comparable for MS representing at least 50% of EU total	Data comparable for MS representing less than 50% of EU total
Length of time series	>10 years	5 - 10 years	2 - 5 years	1 year only
Comparability over time	At least 5 data points without method-logical break	At least 3 data points without method-logical break	At least 2 data points without method-logical break	No data points without method-logical break
Data accessibility	Data openly available, in a clearly documented format, in a homogeneous file, served through data exchange formats, accessible through automated procedures with minimum human intervention (e.g. APIs that serve data in json/xml file formats or links to files in csv/xls formats).	Data openly available, in an undocumented format and / or in a heterogeneous file, served through data exchange formats, accessible through automated procedures with minimum human intervention (e.g. xls spreadsheets with multiple and heterogeneous sheets).	Data openly available, in an undocumented format and / or in a heterogeneous file and / or served through formats that require massive human intervention (e.g. web scraping of html pages).	Data available only through manual intervention (e.g. to be requested through e-mails), in not editable format (e.g. pdf files), through tools that don't allow automated download (e.g. web interfaces with filtering capabilities based on user sessions), in an undocumented format that don't seem to respect a scheme.

6.3   Data management Infrastructure

The monitoring system will be made public through the Knowledge Centre for the Bioeconomy platform (https://ec.europa.eu/knowledge4policy/bioeconomy).

During the entire process of indicators collection analysis, a data management plan and an associated data infrastructure need to be put in place to allow, inter alia, retrieving, harmonising, storing and sharing the data. Potentially (if agreed) an API to allow the user to download the underlying indicators data could be developed. Other possible web-based dissemination features will be explored (e.g. embedding code, dashboard-downloading button, etc.) to obtain a user interface which respond to the need of the users.

Figure 11 shows the infrastructure and data management tools needed in the project. As these are now the early stages of the project, there is uncertainty associated to the number and nature of

datasets as well as on the availability of APIs from the original data sources to fetch the data, this data workflow and ICT infrastructure may need to be updated/further developed.

Figure 11. Data flow and ICT infrastructure for the data management and dissemination and communication activities in the project.

https://ec.europa.eu/knowledge4policy/bioeconomy_en
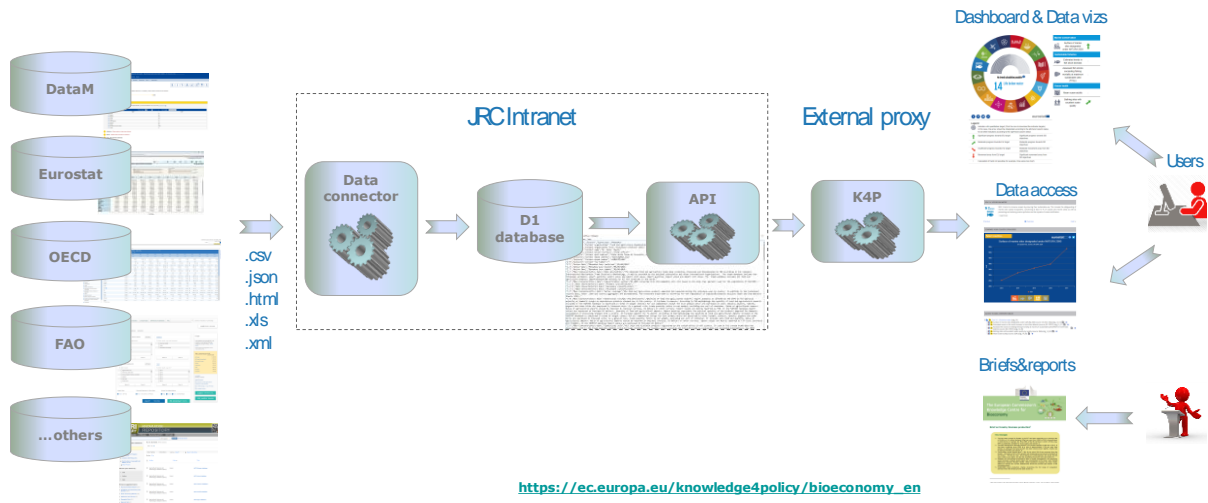
6.4 Dashboards

Dashboards are the window of the monitoring system to the public. As described in section 2.1, the main target users of the dashboards are policy officers at EU level, followed by MS and regional level policy makers. Although these represent the principal target audience, the monitoring system should aim to satisfy the needs of many different users. The entry points to the system should therefore be multi-purpose. For example while some users may prefer to access the data through a map view, others may prefer to access by selecting specific products. This year the focus has not been on developing dashboards, but rather on building the theoretical framework. Nonetheless, thought has gone into this process with the development of a first beta tool in Q3 and Q4 2019.

7 Way forward in 2020

This document represents a snapshot of the status of the EU Bioeconomy Monitoring System in its first year since inception. The main focus has been on developing a framework, while in parallel launching a survey on user expectations and a collection of both robust and established indicators; as well as indicators that should be included but do not exist yet ("hopeful").

The work planned for 2020 towards the development of the Monitoring System for the EU Bioeconomy will prioritize four main fronts: 1) Continued collection of basic indicators and the further processing of processed and system-level indicators; 2) development of aggregate indicators; 3) dashboard web development; 4) reinforcement of presence in International and MS contexts (Table 6).

Table 6. Summary of workplan for 2020

Basic, processed and system-level indicators	Aggregate indicators	Web development	Reinforce bridges with MS & International efforts
• Stakeholder consultation • Identification of gaps • Expert contracts to fill gaps + institutional work	• Definition of objectives • Institutional work • Intensive stakeholder consultation process	• Management of expectations and prioritization of tools to develop • Stakeholder consultation	• Work within guidelines developed jointly with FAO for IBF • Work within SDGs context • Collaboration with MS

7.1 Basic, processed and system-level indicators

Basic, processed and system-level indicators will be the foundation of the monitoring system and will be made publically available, data sources, where possible, included. In some cases basic indicators may be misleading, or may indicate the same information as other basic indicators. A consultative process with a wide range of stakeholders will therefore take place to narrow down and identify the most useful indicators.

Just as individual instruments cannot represent the richness of a symphony, basic, processed and system-level indicators cannot offer the full picture of the progress of the EU Bioeconomy towards the normative criteria we have described here. However they will be the building blocks of the so-called aggregate indicators that will be used for this final purpose. Efforts were made in 2019 to collect basic indicators, however there are still several gaps in the indicator set proposed. Gaps also exist within the dimensions described in Section 2.2; they represent gaps either along the value chain, for specific sectors or for sustainability pillars. The gap analysis will be fundamental to ensure completeness of an indicator set that may be used to generate meaningful aggregate indicators. The JRC plans to engage the services of thematic experts to fill these gaps in order of priority.

7.2 Aggregate indicators

Aggregate indicators are subject to an increasing level of interpretation and therefore assumptions, but they are necessary to understand the big picture, just as the symphony as a whole is capable of transmitting a fuller range of emotion with respect to individual instruments. Aggregate indicators are complex to compute and should address specific questions. Given the wide range of questions possible within the scope of the EU Bioeconomy, the development of salient aggregate indicators will first require a process of prioritization, based on expectations of the key end users of the monitoring

system. Once the first questions are prioritized, and ensuring the basic data and indicators required to produce the aggregates are available, the aggregate indicators may be designed and computed.

7.3 Web development

One mock up dashboard was developed in 2019 to test the logic of the Monitoring System framework. This practical test was helpful to identify specific data and technology challenges. The dashboards will be hosted by the Knowledge Centre of Bioeconomy, and must therefore comply with Commission web rules. This ground breaking work has given us the opportunity to explore the confines of the web tools, as well as the data itself, helping us to identify needs such as metadata harmonisation. In 2020 the dashboard that has been developed will be further refined, a database will be structured and new tools will be built, again in order to prioritization. We plan to use an agile approach whereby stakeholders will be consulted at every development round.

7.4 Reinforce bridges with national and international initiatives

The JRC will continue to work with the FAO, co-chairing the working group on monitoring within the context of the International Bioeconomy Forum. With this link, the JRC will continue to maintain the links with the International community in following guidelines and standards. There are other initiatives that should also be further explored for synergies, namely Task 45 "Climate and Sustainability Effects of Bioenergy within the broader Bioeconomy" of the International Energy Agency (IEA).

The bridge with EU Member States is crucial to ensure relevance of the EU-wide monitoring system. In this case the bridge may be two-way. On the one hand MS will provide guidance to the Commission for the EU system and on the other hand, the Commission may provide a framework within which MS may include indicators that are most relevant to their national situation.

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Annexes

Annex I. Sustainable Development Goals: UN Targets, ESTAT indicators and UN indicators

Goal 1	End poverty in all its forms everywhere
Goal 2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Goal 3	Ensure healthy lives and promote well-being for all at all ages
Goal 4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal 5	Achieve gender equality and empower all women and girls
Goal 6	Ensure availability and sustainable management of water and sanitation for all
Goal 7	Ensure access to affordable, reliable, sustainable and modern energy for all
Goal 8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Goal 9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
Goal 10	Reduce inequality within and among countries
Goal 11	Make cities and human settlements inclusive, safe, resilient and sustainable
Goal 12	Ensure sustainable consumption and production patterns
Goal 13	Take urgent action to combat climate change and its impacts
Goal 14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal 16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Goal 17	Strengthen the means of implementation and revitalize the global partnership for sustainable development

UN TARGETS	1.1	By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day
	1.2	1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions
	1.3	1.3 Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable
	1.4	1.4 By 2030 ensure that all men and women, particularly the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership, and control over land and other forms of property, inheritance, natural resources, appropriate new technology, and financial services including microfinance
	1.5	1.5 By 2030 build the resilience of the poor and those in vulnerable situations, and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters
	1.a	1.a Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation to provide adequate and predictable means for developing countries, in particular LDCs, to implement programmes and policies to end poverty in all its dimensions

	1.b	1.b Create sound policy frameworks, at national, regional and international levels, based on pro-poor and gender-sensitive development strategies to support accelerated investments in poverty eradication actions
EUSTAT EU Indicators	sdg_01_10	People at risk of poverty or social exclusion
	sdg_01_20	People at risk of income poverty after social transfers
	sdg_01_30	Severely materially deprived people
	sdg_01_40	People living in households with very low work intensity
	sdg_01_41	In work at-risk-of-poverty rate
	sdg_01_60	Population living in a dwelling with a leaking roof, damp walls, floors or foundation or rot in window frames of floor by poverty status
UN Global Indicators	1.1.1	1.1.1 Proportion of population below the international poverty line, by sex, age, employment status and geographical location (urban/rural)
	1.2.1	1.2.1 Proportion of population living below the national poverty line, by sex and age
	1.2.2	1.2.2 Proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions
	1.3.1	1.3.1 Proportion of population covered by social protection floors/systems, by sex, distinguishing children, unemployed persons, older persons, persons with disabilities, pregnant women, newborns, work-injury victims and the poor and the vulnerable
	1.4.1	1.4.1 Proportion of population living in households with access to basic services
	1.4.2	1.4.2 Proportion of total adult population with secure tenure rights to land, (a) with legally recognized documentation, and (b) who perceive their rights to land as secure, by sex and type of tenure
	1.5.1	1.5.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population
	1.5.2	1.5.2 Direct economic loss attributed to disasters in relation to global gross domestic product (GDP)
	1.5.3	1.5.3 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030
	1.5.4	1.5.4 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies
	1.a.1	1.a.1 Proportion of domestically generated resources allocated by the government directly to poverty reduction programmes
	1.a.2	1.a.2 Proportion of total government spending on essential services (education, health and social protection)
	1.a.3	1.a.3 Sum of total grants and non-debt-creating inflows directly allocated to poverty reduction programmes as a proportion of GDP
	1.b.1	1.b.1 Proportion of government recurrent and capital spending to sectors that disproportionately benefit women, the poor and vulnerable groups

UN TARGETS		
	2.1	By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations including infants, to safe, nutritious and sufficient food all year round
	2.2	By 2030, end all forms of malnutrition, including achieving by 2025 the internationally agreed targets on stunting and wasting in children under five years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women, and older persons
	2.3	By 2030, double the agricultural productivity and the incomes of small-scale food producers, particularly women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets, and opportunities for value addition and non-farm employment
	2.4	By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and that progressively improve land and soil quality

	2.5	By 2020 maintain genetic diversity of seeds, cultivated plants, farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at national, regional and international levels, and ensure access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge as internationally agreed
	2.a	Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development, and plant and livestock gene banks to enhance agricultural productive capacity in developing countries, in particular in least developed countries
	2.b	Correct and prevent trade restrictions and distortions in world agricultural markets including by the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round
	2.c	Adopt measures to ensure the proper functioning of food commodity markets and their derivatives, and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility
EUSTAT EU Indicators	sdg_02_10	Obesity rate by body mass index (BMI)
	sdg_02_20	Agricultural factor income per annual work unit (AWU) (source: Eurostat, DG AGRI)
	sdg_02_30	Government support to agricultural research and development
	sdg_02_40	Area under organic farming
	sdg_02_50	Gross nutrient balance on agricultural land by nutrient
	sdg_02_60	Ammonia emissions from agriculture (source: EEA)
UN Global Indicators	2.1.1	2.1.1 Prevalence of undernourishment
	2.1.2	2.1.2 Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)
	2.2.1	2.2.1 Prevalence of stunting (height for age <-2 standard deviation from the median of the World Health Organization (WHO) Child Growth Standards) among children under 5 years of age
	2.2.2	2.2.2 Prevalence of malnutrition (weight for height >+2 or <-2 standard deviation from the median of the WHO Child Growth Standards) among children under 5 years of age, by type (wasting and overweight)
	2.3.1	2.3.1 Volume of production per labour unit by classes of farming/pastoral/forestry enterprise size
	2.3.2	2.3.2 Average income of small-scale food producers, by sex and indigenous status
	2.4.1	2.4.1 Proportion of agricultural area under productive and sustainable agriculture
	2.5.1	2.5.1 Number of plant and animal genetic resources for food and agriculture secured in either medium- or long-term conservation facilities
	2.5.2	2.5.2 Proportion of local breeds classified as being at risk, not at risk or at unknown level of risk of extinction
	2.a.1	2.a.1 The agriculture orientation index for government expenditures
	2.z.2	2.a.2 Total official flows (official development assistance plus other official flows) to the agriculture sector
	2.b.1	2.b.1 Agricultural export subsidies
	2.c.1	2.c.1 Indicator of food price anomalies

UN TARGETS		
	3.1	By 2030 reduce the global maternal mortality ratio to less than 70 per 100,000 live births
	3.2	By 2030 end preventable deaths of newborns and under-five children
	3.3	By 2030 end the epidemics of AIDS, tuberculosis, malaria, and neglected tropical diseases and combat hepatitis, water-borne diseases, and other communicable diseases
	3.4	By 2030 reduce by one-third pre-mature mortality from non-communicable diseases (NCDs) through prevention and treatment, and promote mental health and wellbeing
	3.5	Strengthen prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol
	3.6	By 2020 halve global deaths and injuries from road traffic accidents

	3.7	By 2030 ensure universal access to sexual and reproductive health care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes
	3.8	Achieve universal health coverage (UHC), including financial risk protection, access to quality essential health care services, and access to safe, effective, quality, and affordable essential medicines and vaccines for all
	3.9	By 2030 substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination
	3.a	Strengthen implementation of the Framework Convention on Tobacco Control in all countries as appropriate
	3.b	Support research and development of vaccines and medicines for the communicable and non-communicable diseases that primarily affect developing countries, provide access to affordable essential medicines and vaccines, in accordance with the Doha Declaration which affirms the right of developing countries to use to the full the provisions in the TRIPS agreement regarding flexibilities to protect public health and, in particular, provide access to medicines for all
	3.c	Increase substantially health financing and the recruitment, development and training and retention of the health workforce in developing countries, especially in LDCs and SIDS
	3.d	Strengthen the capacity of all countries, particularly developing countries, for early warning, risk reduction, and management of national and global health risks
EUSTAT EU Indicators	sdg_03_10	Life expectancy at birth by sex
	sdg_03_20	Share of people with good or very good perceived health by sex
	sdg_03_30	Smoking prevalence by sex (source: DG SANTE)
	sdg_03_40	Death rate due to chronic diseases by sex
	sdg_03_41	Death rate due to tuberculosis, HIV and hepatitis by sex
	sdg_03_60	Self-reported unmet need for medical examination and care by sex
UN Global Indicators	3.1.1	Maternal mortality ratio
	3.1.2	Proportion of births attended by skilled health personnel
	3.2.1	Under-5 mortality rate
	3.2.2	Neonatal mortality rate
	3.3.1	Number of new HIV infections per 1,000 uninfected population, by sex, age and key populations
	3.3.2	Tuberculosis incidence per 100,000 population
	3.3.3	Malaria incidence per 1,000 population
	3.3.4	Hepatitis B incidence per 100,000 population
	3.3.5	Number of people requiring interventions against neglected tropical diseases
	3.4.1	Mortality rate attributed to cardiovascular disease, cancer, diabetes or chronic respiratory disease
	3.4.2	Suicide mortality rate
	3.5.1	Coverage of treatment interventions (pharmacological, psychosocial and rehabilitation and aftercare services) for substance use disorders
	3.5.2	Harmful use of alcohol, defined according to the national context as alcohol per capita consumption (aged 15 years and older) within a calendar year in litres of pure alcohol
	3.6.1	Death rate due to road traffic injuries
	3.7.1	Proportion of women of reproductive age (aged 15–49 years) who have their need for family planning satisfied with modern methods
	3.7.2	Adolescent birth rate (aged 10–14 years; aged 15–19 years) per 1,000 women in that age group

UN TARGETS		
	4.1	By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes
	4.2	By 2030 ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education

	4.3	By 2030 ensure equal access for all women and men to affordable quality technical, vocational and tertiary education, including university
	4.4	By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship
	4.5	By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples, and children in vulnerable situations
	4.6	By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy
	4.7	By 2030 ensure all learners acquire knowledge and skills needed to promote sustainable development, including among others through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship, and appreciation of cultural diversity and of culture's contribution to sustainable development
	4.a	Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all
	4.b	By 2020, substantially expand globally the number of scholarships available to developing countries, in particular least developed countries, small island developing States and African countries, for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes, in developed countries and other developing countries
	4.c	By 2030, substantially increase the supply of qualified teachers, including through international cooperation for teacher training in developing countries, especially least developed countries and small island developing states
EUSTAT EU Indicators	sdg_04_10	Early leavers from education and training by sex
	sdg_04_20	Tertiary educational attainment by sex
	sdg_04_30	Participation in early childhood education by sex
	sdg_04_40	Underachievement in reading, maths or science (source: OECD)
	sdg_04_50	Employment rates of recent graduates by sex
	sdg_04_60	Adult participation in learning by sex
UN Global Indicators	4.1.1	Proportion of children and young people (a) in grades 2/3; (b) at the end of primary; and (c) at the end of lower secondary achieving at least a minimum proficiency level in (i) reading and (ii) mathematics, by sex
	4.2.1	Proportion of children under 5 years of age who are developmentally on track in health, learning and psychosocial well-being, by sex
	4.2.2	Participation rate in organized learning (one year before the official primary entry age), by sex
	4.3.1	Participation rate of youth and adults in formal and non-formal education and training in the previous 12 months, by sex
	4.4.1	Proportion of youth and adults with information and communications technology (ICT) skills, by type of skill
	4.5.1	Parity indices (female/male, rural/urban, bottom/top wealth quintile and others such as disability status, indigenous peoples and conflict-affected, as data become available) for all education indicators on this list that can be disaggregated
	4.6.1	Proportion of population in a given age group achieving at least a fixed level of proficiency in functional (a) literacy and (b) numeracy skills, by sex
	4.7.1	Extent to which (i) global citizenship education and (ii) education for sustainable development, including gender equality and human rights, are mainstreamed at all levels in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment
	4.a.1	Proportion of schools with access to (a) electricity; (b) the Internet for pedagogical purposes; (c) computers for pedagogical purposes; (d) adapted infrastructure and materials for students with disabilities; (e) basic drinking water; (f) single-sex basic sanitation facilities; and (g) basic handwashing facilities (as per the WASH indicator definitions)
	4.b.1	Volume of official development assistance flows for scholarships by sector and type of study
	4.c.1	Proportion of teachers in: (a) pre-primary; (b) primary; (c) lower secondary; and (d) upper secondary education who have received at least the minimum organized teacher training (e.g. pedagogical training) pre-service or in-service required for teaching at the relevant level in a given country

UN TARGETS		
	5.1	End all forms of discrimination against all women and girls everywhere
	5.2	Eliminate all forms of violence against all women and girls in public and private spheres, including trafficking and sexual and other types of exploitation
	5.3	Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilations
	5.4	Recognize and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies, and the promotion of shared responsibility within the household and the family as nationally appropriate
	5.5	Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic, and public life
	5.6	Ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the Programme of Action of the International Conference on Population and Development and the Beijing Platform for Action and the outcome documents of their review conferences
	5.a	Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance, and natural resources in accordance with national laws
	5.b	Enhance the use of enabling technologies, information and communications technology, to promote the empowerment of women
	5.c	Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls at all levels
EUSTAT EU Indicators	sdg_05_10	Physical and sexual violence to women experienced within 12 months prior to the interview by age group (2012 data) (source: FRA)
	sdg_05_20	Gender pay gap in unadjusted form
	sdg_05_30	Gender employment gap
	sdg_05_40	Inactive population due to caring responsibilities by sex
	sdg_05_50	Seats held by women in national parliaments and governments (source: EIGE)
	sdg_05_60	Positions held by women in senior management positions (source: EIGE)
UN Global Indicators	5.1.1	Whether or not legal frameworks are in place to promote, enforce and monitor equality and non-discrimination on the basis of sex
	5.2.1	Proportion of ever-partnered women and girls aged 15 years and older subjected to physical, sexual or psychological violence by a current or former intimate partner in the previous 12 months, by form of violence and by age
	5.2.2	Proportion of women and girls aged 15 years and older subjected to sexual violence by persons other than an intimate partner in the previous 12 months, by age and place of occurrence
	5.3.1	Proportion of women aged 20–24 years who were married or in a union before age 15 and before age 18
	5.3.2	Proportion of girls and women aged 15–49 years who have undergone female genital mutilation/cutting, by age
	5.4.1	Proportion of time spent on unpaid domestic and care work, by sex, age and location
	5.5.1	Proportion of seats held by women in (a) national parliaments and (b) local governments
	5.5.2	Proportion of women in managerial positions
	5.6.1	Proportion of women aged 15–49 years who make their own informed decisions regarding sexual relations, contraceptive use and reproductive health care
	5.6.2	Number of countries with laws and regulations that guarantee full and equal access to women and men aged 15 years and older to sexual and reproductive health care, information and education
	5.a.1	(a) Proportion of total agricultural population with ownership or secure rights over agricultural land, by sex; and (b) share of women among owners or rights-bearers of agricultural land, by type of tenure
	5.a.2	Proportion of countries where the legal framework (including customary law) guarantees women's equal rights to land ownership and/or control
	5.b.1	Proportion of individuals who own a mobile telephone, by sex

	5.c.1	Proportion of countries with systems to track and make public allocations for gender equality and women's empowerment

UN TARGETS		
	6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all
	6.2	By 2030, achieve access to adequate and equitable sanitation and hygiene for all, and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
	6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and substantially increasing recycling and safe reuse globally
	6.4	By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity, and substantially reduce the number of people suffering from water scarcity
	6.5	By 2030 implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
	6.6	By 2020 protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes
	6.a	By 2030, expand international cooperation and capacity-building support to developing countries in water and sanitation related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies
	6.b	Support and strengthen the participation of local communities for improving water and sanitation management
ESTAT EU Indicators	sdg_06_10	Population having neither a bath, nor a shower, nor indoor flushing toilet in their household by poverty status
	sdg_06_20	Population connected to at least secondary wastewater treatment
	sdg_06_30	Biochemical oxygen demand in rivers
	sdg_06_40	Nitrate in groundwater
	sdg_06_50	Phosphate in rivers
	sdg_06_60	Water exploitation index by type of water source
UN Global Indicators	6.1.1	Proportion of population using safely managed drinking water services
	6.2.1	Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water
	6.3.1	Proportion of wastewater safely treated
	6.3.2	Proportion of bodies of water with good ambient water quality
	6.4.1	Change in water-use efficiency over time
	6.4.2	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
	6.5.1	Degree of integrated water resources management implementation (0–100)
	6.5.2	Proportion of transboundary basin area with an operational arrangement for water cooperation
	6.6.1	Change in the extent of water-related ecosystems over time
	6.a.1	Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan
	6.b.1	Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management

UN TARGETS		
	7.1	By 2030 ensure universal access to affordable, reliable, and modern energy services
	7.2	Increase substantially the share of renewable energy in the global energy mix by 2030
	7.3	Double the global rate of improvement in energy efficiency by 2030

	7.a	By 2030 enhance international cooperation to facilitate access to clean energy research and technologies, including renewable energy, energy efficiency, and advanced and cleaner fossil fuel technologies, and promote investment in energy infrastructure and clean energy technologies
	7.b	By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support
EUSTAT EU Indicators	sdg_07_10	Primary energy consumption
	sdg_07_11	Final energy consumption
	sdg_07_20	Final energy consumption in households per capita
	sdg_07_30	Energy productivity
	sdg_07_40	Share of renewable energy in gross final energy consumption by sector
	sdg_07_50	Energy import dependency by products
	sdg_07_60	Population unable to keep home adequately warm by poverty status
UN Global Indicators	7.1.1	Proportion of population with access to electricity
	7.1.2	Proportion of population with primary reliance on clean fuels and technology
	7.2.1	Renewable energy share in the total final energy consumption
	7.3.1	Energy intensity measured in terms of primary energy and GDP
	7.a.1	International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems
	7.b.1	Investments in energy efficiency as a proportion of GDP and the amount of foreign direct investment in financial transfer for infrastructure and technology to sustainable development services

UN TARGETS		
	8.1	Sustain per capita economic growth in accordance with national circumstances, and in particular at least 7% per annum GDP growth in the least-developed countries
	8.2	Achieve higher levels of productivity of economies through diversification, technological upgrading and innovation, including through a focus on high value added and labour-intensive sectors
	8.3	Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage formalization and growth of micro-, small- and medium-sized enterprises including through access to financial services
	8.4	Improve progressively through 2030 global resource efficiency in consumption and production, and endeavour to decouple economic growth from environmental degradation in accordance with the 10-year framework of programmes on sustainable consumption and production with developed countries taking the lead
	8.5	By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value
	8.6	By 2020, substantially reduce the proportion of youth not in employment, education or training
	8.7	Take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking and secure the prohibition and elimination of the worst forms of child labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms
	8.8	Protect labour rights and promote safe and secure working environments of all workers, including migrant workers, particularly women migrants, and those in precarious employment
	8.9	By 2030, devise and implement policies to promote sustainable tourism which creates jobs, promotes local culture and products
	8.10	Strengthen the capacity of domestic financial institutions to encourage and to expand access to banking, insurance and financial services for all
	8.a	Increase Aid for Trade support for developing countries, in particular least developed countries, including through the Enhanced Integrated Framework for Trade-Related Technical Assistance to Least Developed Countries
	8.b	By 2020 develop and operationalize a global strategy for youth employment and implement the Global Jobs Pact of the International Labour Organization
	sdg_08_10	Real GDP per capita

ESTAT EU Indicators	sdg_08_11	Investment share of GDP by institutional sectors
	sdg_08_20	Young people neither in employment nor in education and training by sex
	sdg_08_30	Employment rate by sex
	sdg_08_40	Long-term unemployment rate by sex
	sdg_08_60	People killed in accidents at work
UN Global Indicators	8.1.1	Annual growth rate of real GDP per capita
	8.2.1	Annual growth rate of real GDP per employed person
	8.3.1	Proportion of informal employment in non-agriculture employment, by sex
	8.4.1	Material footprint, material footprint per capita, and material footprint per GDP
	8.4.2	Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
	8.5.1	Average hourly earnings of female and male employees, by occupation, age and persons with disabilities
	8.5.2	Unemployment rate, by sex, age and persons with disabilities
	8.6.1	Proportion of youth (aged 15–24 years) not in education, employment or training
	8.7.1	Proportion and number of children aged 5–17 years engaged in child labour, by sex and age
	8.8.1	Frequency rates of fatal and non-fatal occupational injuries, by sex and migrant status
	8.8.2	Level of national compliance with labour rights (freedom of association and collective bargaining) based on International Labour Organization (ILO) textual sources and national legislation, by sex and migrant status
	8.9.1	Tourism direct GDP as a proportion of total GDP and in growth rate
	8.9.2	Proportion of jobs in sustainable tourism industries out of total tourism jobs
	8.10.1	Number of commercial bank branches per 100,000 adults and (b) number of automated teller machines (ATMs) per 100,000 adults
	8.10.2	Proportion of adults (15 years and older) with an account at a bank or other financial institution or with a mobile-money-service provider
	8.a.1	Aid for Trade commitments and disbursements
	8.b.1	Existence of a developed and operationalized national strategy for youth employment, as a distinct strategy or as part of a national employment strategy

UN TARGETS		
	9.1	Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all
	9.2	Promote inclusive and sustainable industrialization, and by 2030 raise significantly industry's share of employment and GDP in line with national circumstances, and double its share in Least Developed Countries
	9.3	Increase the access of small-scale industrial and other enterprises, particularly in developing countries, to financial services including affordable credit and their integration into value chains and markets
	9.4	By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, all countries taking action in accordance with their respective capabilities
	9.5	Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, particularly developing countries, including, by 2030, encouraging innovation and substantially increasing the number of R&D workers per one million people and public and private R&D spending
	9.a	Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, Least Developed Countries, landlocked developing countries and small island developing states
	9.b	Support domestic technology development, research and innovation in developing countries including by ensuring a conducive policy environment for inter alia industrial diversification and value addition to commodities

	9.c	Significantly increase access to ICT and strive to provide universal and affordable access to internet in Least Developed Countries by 2020
EUSTAT EU Indicators	sdg_09_10	Gross domestic expenditure on R&D by sector
	sdg_09_20	Employment in high- and medium-high technology manufacturing and knowledge-intensive services
	sdg_09_30	R&D personnel by sector (sdg_09_30)
	sdg_09_40	Patent applications to the European Patent Office (source: EPO)
	sdg_09_50	Share of busses and trains in total passenger transport
	sdg_09_60	Share of rail and inland waterways in total freight transport
UN Global Indicators	9.1.1	Proportion of the rural population who live within 2 km of an all-season road
	9.1.2	Passenger and freight volumes, by mode of transport
	9.2.1	Manufacturing value added as a proportion of GDP and per capita
	9.2.2	Manufacturing employment as a proportion of total employment
	9.3.1	Proportion of small-scale industries in total industry value added
	9.3.2	Proportion of small-scale industries with a loan or line of credit
	9.4.1	CO2 emission per unit of value added
	9.5.1	Research and development expenditure as a proportion of GDP
	9.5.2	Researchers (in full-time equivalent) per million inhabitants
	9.a.1	Total official international support (official development assistance plus other official flows) to infrastructure
	9.b.1	Proportion of medium and high-tech industry value added in total value added
	9.c.1	Proportion of population covered by a mobile network, by technology

UN TARGETS		
	10.1	By 2030 progressively achieve and sustain income growth of the bottom 40% of the population at a rate higher than the national average
	10.2	By 2030 empower and promote the social, economic and political inclusion of all irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status
	10.3	Ensure equal opportunity and reduce inequalities of outcome, including through eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and actions in this regard
	10.4	Adopt policies especially fiscal, wage, and social protection policies and progressively achieve greater equality
	10.5	Improve regulation and monitoring of global financial markets and institutions and strengthen implementation of such regulations
	10.6	Ensure enhanced representation and voice of developing countries in decision making in global international economic and financial institutions in order to deliver more effective, credible, accountable and legitimate institutions
	10.7	Facilitate orderly, safe, regular and responsible migration and mobility of people, including through implementation of planned and well-managed migration policies
	10.a	Implement the principle of special and differential treatment for developing countries, in particular least developed countries, in accordance with WTO agreements
	10.b	Encourage official development assistance and financial flows, including foreign direct investment, to States where the need is greatest, in particular least developed countries, African countries, small island developing States and landlocked developing countries, in accordance with their national plans and programmes
	10.c	By 2030, reduce to less than 3% the transaction costs of migrant remittances and eliminate remittance corridors with costs higher than 5%
EUSTAT EU Indicators	sdg_10_10	Purchasing power adjusted GDP per capita
	sdg_10_20	Adjusted gross disposable income of households per capita
	sdg_10_30	Relative median at-risk-of-poverty gap

	sdg_10_41	Income distribution
	sdg_10_50	Income share of the bottom 40 % of the population
	sdg_10_60	Asylum applications by state of procedure
UN Global Indicators	10.1.1	Growth rates of household expenditure or income per capita among the bottom 40 per cent of the population and the total population
	10.2.1	Proportion of people living below 50 per cent of median income, by sex, age and persons with disabilities
	10.3.1	Proportion of population reporting having personally felt discriminated against or harassed in the previous 12 months on the basis of a ground of discrimination prohibited under international human rights law
	10.4.1	Labour share of GDP, comprising wages and social protection transfers
	10.5.1	Financial Soundness Indicators
	10.6.1	Proportion of members and voting rights of developing countries in international organizations
	10.7.1	Recruitment cost borne by employee as a proportion of monthly income earned in country of destination
	10.7.2	Number of countries with migration policies that facilitate orderly, safe, regular and responsible migration and mobility of people
	10.a.1	Proportion of tariff lines applied to imports from least developed countries and developing countries with zero-tariff
	10.b.1	Total resource flows for development, by recipient and donor countries and type of flow (e.g. official development assistance, foreign direct investment and other flows)
	10.c.1	Remittance costs as a proportion of the amount remitted

UN TARGETS		
	11.1	By 2030, ensure access for all to adequate, safe and affordable housing and basic services, and upgrade slums
	11.2	By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons
	11.3	By 2030 enhance inclusive and sustainable urbanization and capacities for participatory, integrated and sustainable human settlement planning and management in all countries
	11.4	Strengthen efforts to protect and safeguard the world's cultural and natural heritage
	11.5	By 2030 significantly reduce the number of deaths and the number of affected people and substantially decrease the economic losses relative to GDP caused by disasters, including water-related disasters, with the focus on protecting the poor and people in vulnerable situations
	11.6	By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality, municipal and other waste management
	11.7	By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, particularly for women and children, older persons and persons with disabilities
	11.a	Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning
	11.b	By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels
	11.c	Support least developed countries, including through financial and technical assistance, for sustainable and resilient buildings utilizing local materials
EUSTAT EU Indicators	sdg_11_10	Overcrowding rate by poverty status
	sdg_11_20	Population living in households considering that they suffer from noise, by poverty status
	sdg_11_30	Difficulty in accessing public transport by level of difficulty and degree of urbanisation
	sdg_11_40	People killed in road accidents (source: DG MOVE)

	sdg_11_50	Exposure to air pollution by particulate matter (source: EEA)
	sdg_11_60	Recycling rate of municipal waste
UN Global Indicators	11.1.1	Proportion of urban population living in slums, informal settlements or inadequate housing
	11.2.1	Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities
	11.3.1	Ratio of land consumption rate to population growth rate
	11.3.2	Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically
	11.4.1	Total expenditure (public and private) per capita spent on the preservation, protection and conservation of all cultural and natural heritage, by type of heritage (cultural, natural, mixed and World Heritage Centre designation), level of government (national, regional and local/municipal), type of expenditure (operating expenditure/investment) and type of private funding (donations in kind, private non-profit sector and sponsorship)
	11.5.1	Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population
	11.5.2	Direct economic loss in relation to global GDP, damage to critical infrastructure and number of disruptions to basic services, attributed to disasters
	11.6.1	Proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated, by cities
	11.6.2	Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)
	11.7.1	Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities
	11.7.2	Proportion of persons victim of physical or sexual harassment, by sex, age, disability status and place of occurrence, in the previous 12 months
	11.a.1	Proportion of population living in cities that implement urban and regional development plans integrating population projections and resource needs, by size of city
	11.b.1	Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030
	11.b.2	Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies
	11.c.1	Proportion of financial support to the least developed countries that is allocated to the construction and retrofitting of sustainable, resilient and resource-efficient buildings utilizing local materials

UN TARGETS		
	12.1	Implement the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries
	12.2	By 2030, achieve the sustainable management and efficient use of natural resources
	12.3	By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses
	12.4	By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment
	12.5	By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse
	12.6	Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle
	12.7	Promote public procurement practices that are sustainable, in accordance with national policies and priorities
	12.8	By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature
	12.a	Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production

	12.b	Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products
	12.c	Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities
EUSTAT EU Indicators	sdg_12_10	Consumption of chemicals by hazardousness - EU aggregate
	sdg_12_20	Resource productivity and domestic material consumption (DMC)
	sdg_12_30	Average CO2 emissions per km from new passenger cars (source: EEA, DG CLIMA)
	sdg_12_41	Circular material use rate
	sdg_12_50	Generation of waste excluding major mineral wastes by hazardousness
	sdg_12_60	Recycling rate of waste excluding major mineral wastes
UN Global Indicators	12.1.1	Number of countries with sustainable consumption and production (SCP) national action plans or SCP mainstreamed as a priority or a target into national policies
	12.2.1	Material footprint, material footprint per capita, and material footprint per GDP
	12.2.2	Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
	12.3.1	Food loss index and (b) food waste index
	12.4.1	Number of parties to international multilateral environmental agreements on hazardous waste, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement
	12.4.2	Hazardous waste generated per capita and proportion of hazardous waste treated, by type of treatment
	12.5.1	National recycling rate, tons of material recycled
	12.6.1	Number of companies publishing sustainability reports
	12.7.1	Number of countries implementing sustainable public procurement policies and action plans
	12.8.1	Extent to which (i) global citizenship education and (ii) education for sustainable development (including climate change education) are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment
	12.a.1	Amount of support to developing countries on research and development for sustainable consumption and production and environmentally sound technologies
	12.b.1	Number of sustainable tourism strategies or policies and implemented action plans with agreed monitoring and evaluation tools
	12.c.1	Amount of fossil-fuel subsidies per unit of GDP (production and consumption) and as a proportion of total national expenditure on fossil fuels

UN TARGETS		
	13.1	Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
	13.2	Integrate climate change measures into national policies, strategies and planning
	13.3	Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
	13.a	Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible
	13.b	Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities
ESTAT EU Indicators	sdg_13_10	Greenhouse gas emissions (source: EEA)
	sdg_13_20	Greenhouse gas emissions intensity of energy consumption (source: EEA and Eurostat)

	sdg_13_30	Mean near surface temperature deviation (source: EEA)
	sdg_13_40	Climate related economic losses by type of event (source: EEA)
	sdg_13_50	Contribution to the international 100bn USD commitment on climate related expending (source: DG CLIMA, EIONET)
	sdg_13_60	Population covered by the Covenant of Mayors for Climate & Energy signatories (source: Covenant of Mayors)
UN Global Indicators	13.1.1	Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population
	13.1.2	Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030
	13..1.3	Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies
	13.2.1	Number of countries that have communicated the establishment or operationalization of an integrated policy/strategy/plan which increases their ability to adapt to the adverse impacts of climate change, and foster climate resilience and low greenhouse gas emissions development in a manner that does not threaten food production (including a national adaptation plan, nationally determined contribution, national communication, biennial update report or other)
	13.3.1	Number of countries that have integrated mitigation, adaptation, impact reduction and early warning into primary, secondary and tertiary curricula
	13.3.2	Number of countries that have communicated the strengthening of institutional, systemic and individual capacity-building to implement adaptation, mitigation and technology transfer, and development actions
	13.a.1	Mobilized amount of United States dollars per year between 2020 and 2025 accountable towards the $100 billion commitment
	13.b.1	Number of least developed countries and small island developing States that are receiving specialized support, and amount of support, including finance, technology and capacity-building, for mechanisms for raising capacities for effective climate change-related planning and management, including focusing on women, youth and local and marginalized communities

UN TARGETS		
	14.1	By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution
	14.2	By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans
	14.3	Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels
	14.4	By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics
	14.5	By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information
	14.6	By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation
	14.7	By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism
	14.a	Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries
	14.b	Provide access for small-scale artisanal fishers to marine resources and markets

	14.c	Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in the United Nations Convention on the Law of the Sea, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of "The future we want"
ESTAT EU Indicators	sdg_14_10	Surface of marine sites designated under NATURA 2000 (source: DG ENV, EEA)
	sdg_14_21	Estimated trends in fish stock biomass in North East Atlantic (source: JRC-STECF)
	sdg_14_30	Assessed fish stocks exceeding fishing mortality at maximum sustainable yield (FMSY) in North East Atlantic (source: JRC, STECF)
	sdg_14_40	Bathing sites with excellent water quality by locality (source: EEA)
	sdg_14_50	Mean ocean acidity (source: EEA)
UN Global Indicators	14.1.1	Index of coastal eutrophication and floating plastic debris density
	14.2.1	Proportion of national exclusive economic zones managed using ecosystem-based approaches
	14.3.1	Average marine acidity (pH) measured at agreed suite of representative sampling stations
	14.4.1	Proportion of fish stocks within biologically sustainable levels
	14.5.1	Coverage of protected areas in relation to marine areas
	14.6.1	Degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing
	14.7.1	Sustainable fisheries as a proportion of GDP in small island developing States, least developed countries and all countries
	14.a.1	Proportion of total research budget allocated to research in the field of marine technology
	14.b.1	Degree of application of a legal/regulatory/ policy/institutional framework which recognizes and protects access rights for small-scale fisheries
	14.c.1	Number of countries making progress in ratifying, accepting and implementing through legal, policy and institutional frameworks, ocean-related instruments that implement international law, as reflected in the United Nations Convention on the Law of the Sea, for the conservation and sustainable use of the oceans and their resources

UN TARGETS		
	15.1	By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements
	15.2	By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally
	15.3	By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world
	15.4	By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development
	15.5	Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species
	15.6	Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed
	15.7	Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products
	15.8	By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species
	15.9	By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts
	15.a	Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems
	15.b	Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation

	15.c	Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities
ESTAT EU Indicators	sdg_15_10	Share of forest area
	sdg_15_20	Surface of terrestrial sites designated under NATURA 2000 (source: DG ENV, EEA)
	sdg_15_30	Artificial land cover
	sdg_15_50	Estimated soil erosion by water – area affected by severe erosion rate (source: JRC)
	sdg_15_60	Common bird index by type of species – EU aggregate (source: EBCC)
	sdg_15_61	Grassland butterfly index – EU aggregate (source: EEA, BCE)
UN Global Indicators	15.1.1	Forest area as a proportion of total land area
	15.1.2	Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type
	15.2.1	Progress towards sustainable forest management
	15.3.1	Proportion of land that is degraded over total land area
	15.4.1	Coverage by protected areas of important sites for mountain biodiversity
	15.4.2	Mountain Green Cover Index
	15.5.1	Red List Index
	15.6.1	Number of countries that have adopted legislative, administrative and policy frameworks to ensure fair and equitable sharing of benefits
	15.7.1	Proportion of traded wildlife that was poached or illicitly trafficked
	15.8.1	Proportion of countries adopting relevant national legislation and adequately resourcing the prevention or control of invasive alien species
	15.9.1	Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011–2020
	15.a.1	Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems
	15.b.1	Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems
	15.c.1	Proportion of traded wildlife that was poached or illicitly trafficked

UN TARGETS		
	16.1	Significantly reduce all forms of violence and related death rates everywhere
	16.2	End abuse, exploitation, trafficking and all forms of violence against and torture of children
	16.3	Promote the rule of law at the national and international levels and ensure equal access to justice for all
	16.4	By 2030, significantly reduce illicit financial and arms flows, strengthen the recovery and return of stolen assets and combat all forms of organized crime
	16.5	Substantially reduce corruption and bribery in all their forms
	16.6	Develop effective, accountable and transparent institutions at all levels
	16.7	Ensure responsive, inclusive, participatory and representative decision-making at all levels
	16.8	Broaden and strengthen the participation of developing countries in the institutions of global governance
	16.9	By 2030, provide legal identity for all, including birth registration
	16.10	Ensure public access to information and protect fundamental freedoms, in accordance with national legislation and international agreements
	16.a	Strengthen relevant national institutions, including through international cooperation, for building capacity at all levels, in particular in developing countries, to prevent violence and combat terrorism and crime
	16.b	Promote and enforce non-discriminatory laws and policies for sustainable development
	sdg_16_10	Death rate due to homicide by sex

EUSTAT EU Indicators	sdg_16_20	Population reporting occurrence of crime, violence or vandalism in their area by poverty status
	sdg_16_30	General government total expenditure on law courts
	sdg_16_40	Perceived independence of the justice system (source: DG COMM)
	sdg_16_50	Corruption Perceptions Index (source: Transparency International)
	sdg_16_60	Population with confidence in EU institutions by institution (source: DG COMM)
UN Global Indicators	16.1.1	Number of victims of intentional homicide per 100,000 population, by sex and age
	16.1.2	Conflict-related deaths per 100,000 population, by sex, age and cause
	16.1.3	Proportion of population subjected to (a) physical violence, (b) psychological violence and (c) sexual violence in the previous 12 months
	16.1.4	Proportion of population that feel safe walking alone around the area they live
	16.2.1	Proportion of children aged 1–17 years who experienced any physical punishment and/or psychological aggression by caregivers in the past month
	16.2.2	Number of victims of human trafficking per 100,000 population, by sex, age and form of exploitation
	16.2.3	Proportion of young women and men aged 18–29 years who experienced sexual violence by age 18
	16.3.1	Proportion of victims of violence in the previous 12 months who reported their victimization to competent authorities or other officially recognized conflict resolution mechanisms
	16.3.2	Unsentenced detainees as a proportion of overall prison population
	16.4.1	Total value of inward and outward illicit financial flows (in current United States dollars)
	16.4.2	Proportion of seized, found or surrendered arms whose illicit origin or context has been traced or established by a competent authority in line with international instruments
	16.5.1	Proportion of persons who had at least one contact with a public official and who paid a bribe to a public official, or were asked for a bribe by those public officials, during the previous 12 months
	16.5.2	Proportion of businesses that had at least one contact with a public official and that paid a bribe to a public official, or were asked for a bribe by those public officials during the previous 12 months
	16.6.1	Primary government expenditures as a proportion of original approved budget, by sector (or by budget codes or similar)
	16.6.2	Proportion of population satisfied with their last experience of public services
	16.7.1	Proportions of positions in national and local institutions, including (a) the legislatures; (b) the public service; and (c) the judiciary, compared to national distributions, by sex, age, persons with disabilities and population groups
	16.7.2	Proportion of population who believe decision-making is inclusive and responsive, by sex, age, disability and population group
	16.8.1	Proportion of members and voting rights of developing countries in international organizations
	16.9.1	Proportion of children under 5 years of age whose births have been registered with a civil authority, by age
	16.10.1	Number of verified cases of killing, kidnapping, enforced disappearance, arbitrary detention and torture of journalists, associated media personnel, trade unionists and human rights advocates in the previous 12 months
	16.10.2	Number of countries that adopt and implement constitutional, statutory and/or policy guarantees for public access to information
	16.a.1	Existence of independent national human rights institutions in compliance with the Paris Principles
	16.b.1	Proportion of population reporting having personally felt discriminated against or harassed in the previous 12 months on the basis of a ground of discrimination prohibited under international human rights law

UN TARGETS		
	17.1	Strengthen domestic resource mobilization, including through international support to developing countries, to improve domestic capacity for tax and other revenue collection
	17.2	Developed countries to implement fully their official development assistance commitments, including the commitment by many developed countries to achieve the target of 0.7 per cent of gross national income for official development assistance (ODA/GNI) to developing countries and 0.15 to 0.20 per cent

		of ODA/GNI to least developed countries; ODA providers are encouraged to consider setting a target to provide at least 0.20 per cent of ODA/GNI to least developed countries
	17.3	Mobilize additional financial resources for developing countries from multiple sources
	17.4	Assist developing countries in attaining long-term debt sustainability through coordinated policies aimed at fostering debt financing, debt relief and debt restructuring, as appropriate, and address the external debt of highly indebted poor countries to reduce debt distress
	17.5	Adopt and implement investment promotion regimes for least developed countries
	17.6	Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge-sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism
	17.7	Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed
	17.8	Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology
	17.9	Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the Sustainable Development Goals, including through North-South, South-South and triangular cooperation
	17.10	Promote a universal, rules-based, open, non-discriminatory and equitable multilateral trading system under the World Trade Organization, including through the conclusion of negotiations under its Doha Development Agenda
	17.11	Significantly increase the exports of developing countries, in particular with a view to doubling the least developed countries' share of global exports by 2020
	17.12	Realize timely implementation of duty-free and quota-free market access on a lasting basis for all least developed countries, consistent with World Trade Organization decisions, including by ensuring that preferential rules of origin applicable to imports from least developed countries are transparent and simple, and contribute to facilitating market access
	17.13	Enhance global macroeconomic stability, including through policy coordination and policy coherence
	17.14	Enhance policy coherence for sustainable development
	17.15	Respect each country's policy space and leadership to establish and implement policies for poverty eradication and sustainable development
	17.16	Enhance the Global Partnership for Sustainable Development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the Sustainable Development Goals in all countries, in particular developing countries
	17.17	Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships
	17.18	By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts
	17.19	By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product, and support statistical capacity-building in developing countries
EUSTAT EU Indicators	sdg_17_10	Official development assistance as share of gross national income (source: OECD)
	sdg_17_20	EU financing to developing countries by financing source (source: OECD)
	sdg_17_30	EU imports from developing countries by country income groups
	sdg_17_40	General government gross debt
	sdg_17_50	Shares of environmental and labour taxes in total tax revenues
UN Global Indicators		Finance
	17.1.1	Total government revenue as a proportion of GDP, by source
	17.1.2	Proportion of domestic budget funded by domestic taxes

17.2.1	Net official development assistance, total and to least developed countries, as a proportion of the Organization for Economic Cooperation and Development (OECD) Development Assistance Committee donors' gross national income (GNI)
17.3.1	Foreign direct investment (FDI), official development assistance and South-South cooperation as a proportion of total domestic budget
17.3.2	Volume of remittances (in United States dollars) as a proportion of total GDP
17.4.1	Debt service as a proportion of exports of goods and services
17.5.1	Number of countries that adopt and implement investment promotion regimes for least developed countries
	Technology
17.6.1	Number of science and/or technology cooperation agreements and programmes between countries, by type of cooperation
17.6.2	Fixed Internet broadband subscriptions per 100 inhabitants, by speed
17.7.1	Total amount of approved funding for developing countries to promote the development, transfer, dissemination and diffusion of environmentally sound technologies
17.8.1	Proportion of individuals using the Internet
	Capacity Building
17.9.1	Dollar value of financial and technical assistance (including through North-South, South-South and triangular cooperation) committed to developing countries
	Trade
17.10.1	Worldwide weighted tariff-average
17.11.1	Developing countries' and least developed countries' share of global exports
17.12.1	Average tariffs faced by developing countries, least developed countries and small island developing States
	Systems Issues
	Policy and Institutional Coherence
17.13.1	Macroeconomic Dashboard
17.14.1	Number of countries with mechanisms in place to enhance policy coherence of sustainable development
17.15.1	Extent of use of country-owned results frameworks and planning tools by providers of development cooperation
	Multi-stakeholder partnership
17.16.1	Number of countries reporting progress in multi-stakeholder development effectiveness monitoring frameworks that support the achievement of the sustainable development goals
17.17.1	Amount of United States dollars committed to (a) public-private partnerships and (b) civil society partnerships
	Data, monitoring, and accountability
17.18.1	Proportion of sustainable development indicators produced at the national level with full disaggregation when relevant to the target, in accordance with the Fundamental Principles of Official Statistics
17.18.2	Number of countries that have national statistical legislation that complies with the Fundamental Principles of Official Statistics
17.18.3	Number of countries with a national statistical plan that is fully funded and under implementation, by source of funding
17.19.1	Dollar value of all resources made available to strengthen statistical capacity in developing countries
17.19.2	Proportion of countries that (a) have conducted at least one population and housing census in the last 10 years; and (b) have achieved 100 per cent birth registration and 80 per cent death registration

Annex II. Background on JRC work related to Bioeconomy

The JRC is the Commission's science and knowledge service. Throughout the years it has supported EU policies through independent research in many different thematic fields. The increasing abundance of relevant data and information from sources beyond the JRC, requires also an ability to map, review, analyse and condense the best available knowledge in support of EU policies. This is why the JRC, through its 2030 Strategy, is transforming itself from a traditional research-producing organisation into a manager of knowledge for EU policies: making sense, filtering and distilling the vast amount of information to communicate relevant evidence for the Commission's policy needs.

One of the initiatives it has taken to this end is to set up and coordinate Knowledge Centres in specific policy areas. Those are virtual entities that bring together knowledge and expertise from different locations (both within and outside of the European Commission) to inform policymakers in a transparent, tailored and concise manner about the status and findings of the latest scientific evidence.

The European Commission's Knowledge Centre for Bioeconomy (KCB) is one of them. It was launched in July 2017, to pull together the knowledge and expertise needed to assess the status, progress and impact of the bioeconomy. Considering the complexity of the bioeconomy (cross-sectorial and cross-policy), bringing together the extensive scientific competences and the excellent research work undertaken by the JRC in bioeconomy-related topics over many years can be extremely valuable. In particular, this diverse knowledge and expertise will be necessary for developing and producing data for the monitoring system. Here we list some of the JRC work on which the development of a monitoring system for the EU bioeconomy is building upon.

History of bioeconomy monitoring at JRC

The first European Bioeconomy Strategy released in 2012 addressed the need for monitoring the Bioeconomy in its Action 6 of the Action Plan, which specified that a Bioeconomy Observatory should be established with the following mission: "To supply policy-makers and stakeholders with reference data and analyses on the bioeconomy, allowing to regularly assess the progress and impact of the bioeconomy and providing a solid basis for policy development and decision-making on the bioeconomy". Hence, in 2013 the JRC was entrusted to establish the Bioeconomy Information System Observatory (BISO) which structured the scarce and scattered information available at the time around three pillars of the bioeconomy "Policy", "Research" and "Markets". It also made available results and reports from studies specifically carried out by the JRC as contributions to the Observatory such as Life Cycle Assessment (LCA) analyses to describe different bioeconomy value chains and their environmental performance [EC, 2015], macroeconomic modelling and socio-economic indicators, and studies on the bio-based industries [Nattrass et al, 2016] were made available.

In 2017, BISO was integrated into the European Commission's Knowledge Centre for Bioeconomy (KCB) that follows the concept set out in the JRC 2030 strategy. It manages the complex and abundant expertise and knowledge available by bringing together experts and knowledge from inside and outside the European Commission to inform policymakers in a transparent, tailored and concise manner about the status and findings of the latest scientific evidence took over BISO, broadening the scope of its activities and strengthening the outreach of its target groups.

JRC has been addressing the monitoring of the EU bioeconomy prior to the new Bioeconomy Strategy and Action Plan and the new mandate to formally set up a monitoring system. Since 2014, the JRC has published peer-reviewed articles and scientific reports directly related to set-up of a Bioeconomy Observatory [M'barek et al., 2014], Facts and figures on biomass, turnover and employment [Ronzon et al., 2015], the estimation of key socioeconomic indicators for the bioeconomy [M'barek et al. 2018; Ronzon et al. 2017b; Ronzon et al. 2018] and the representation of biomass flows [Gurria et al. 2017]. Furthermore, the JRC has been active in bio-based product market analysis for many years and published several studies related to the bio-based chemical industry and biorefineries [Natrass et al. 2016; Parisi and Ronzon 2016; Spekreijse et al. 2019]. It has also refined the representation of bioeconomy sectors in Social Accounting Matrices [Mainar-Causapé, A.J. et al. 2017; Mainar-Causapé,

A.J. et al., 2018) and performed several ex-ante studies on the possible global implications of the development of bioeconomy markets in the EU [Philippidis et al. 2018a,b,c; Philippidis et al. 2019a,b). The existing network includes key stakeholders from industry and academia. The knowledge produced has been communicated to a larger public through research briefs and the data produced has been published and updated on line at https://datam.jrc.ec.europa.eu. The variety of communication channels has permitted these outcomes to be used in many official documents of the EC, including different Communications (e.g., COM(2018) 673), stakeholder communications (Member States, industry, academia, associations, etc.) and on euronews[20].

Biomass mandate

A "Mandate on the provision of data and analysis on biomass supply and demand by the JRC on a long-term basis" has been agreed at Directors' level by the SG and 11 DGs (AGRI, CLIMA, DEVCO, ENER, ENV, GROW, JRC, MARE, MOVE, REGIO, TRADE) in October 2014. Following the mandate, JRC initiated in 2015 the overarching study on biomass with institutional resources. Within the scope of the mandate, the JRC is tasked to provide on a long-term basis data, models and analysis on EU and global biomass potential, supply, demand and related sustainability. The JRC biomass study is meant to support coherent policy making, aligning and harmonizing input data, assumptions, models and scenarios regarding biomass, transparently highlighting knowledge and data gaps and uncertainties. A harmonised database of biomass in EU countries is being maintained, integrating data and information from ground surveys, statistical services and remote sensing techniques. Advanced modelling techniques are being used to simulate possible future scenarios of EU and global biomass supply and uses across different sectors. Within this activity, a harmonised evaluation of forest resources in EU member states with the contribution of national forest inventories. JRC also produces a map of forest available for wood supply and a map of growing stocks in the EU28. Wood balance sheets and specific wood flow charts highlighting the interconnections between transformation sectors and the circularity have been developed.

International Bioeconomy Forum

The JRC is active in the International Bioeconomy Forum through two working groups, Forest and Bioeconomy. Within the Forest Bioeconomy Working Group, there is a focus area on data and monitoring. The decision for JRC to co-chair this focus area with the European Forest Institute was taken in the IBF Second Plenary Meeting in Vancouver Canada on May 27-28, 2019. At that same meeting it was decided that the JRC would co-chair the working group on monitoring the bioeconomy with the FAO.

H2020 BioMonitor

The BioMonitor project aims to establish a sustainable and robust framework different stakeholders can use to monitor and measure the bioeconomy and its various impacts in relation to the EU and its Member States. It has a focus on the provision of a comprehensive database and statistics for bio-based industries, missing transparent methodology for bio-based data collection and a lack of integrated value chain data and indicators that illustrate the flows of different bio-based materials' processing system. JRC.D4 is scientific partner in the consortium. (http://biomonitor.eu/).

The BioMonitor project organised a first stakeholder workshop on October 23rd, 2018 in Brussels, gathering 31 participants. The workshop aimed at identifying main challenges and indicators, serving as a basis for the further development of the BioMonitor system of objectives, criteria and indicators for an EU bioeconomy monitoring system. The outcome is available und this link: http://biomonitor.eu/wp-content/uploads/2019/01/D7.2_First-Stakeholder-Workshop.pdf

A comprehensive report on the "Framework for measuring the size and development of the bioeconomy" was published in October 2019. The proposed framework measuring developments will in particular focus on the bio-based sectors, given that the traditional part of the bioeconomy can already be monitored.

BioMonitor defines the bioeconomy according to the relevant sectors in the Statistical Classification of Economic Activities in the European Community (NACE), broadly assigning bioeconomy industries need to three different kinds of economic activities to be linked with NACE:

- Natural-resource based activities that directly exploit a biological resource (agriculture, forestry, fisheries) and provide biomass as input for other industries

- Conventional activities to further process the biomass from 1. (food, feed, tobacco, beverages, wood and wood products, textiles, wearing apparel, leather, paper and pulp, furniture)

- Novel activities to further process the biomass and/or biomass residues from 1 or use processing residues from 2. (biorefineries, biofuels, bio-based chemicals, bio-based plastics, biogas)

BioMonitor proposes the use of two types of indicators, on the one hand those monitoring the evolution (ex-post) of the bioeconomy and on the other hand those evaluating the impact of the bioeconomy on for example targets (often ex-ante and provided as model outcomes).

Details can be found in the report:

http://biomonitor.eu/wp-content/uploads/2019/10/BioMonitor_Deliverable_1.1_Update_1.pdf

BBI- JU

The Bio-based Industries Joint Undertaking (BBI JU[21]) was officially established under EU Council Regulation No 560/2014 of 6 May 2014. It is an independent legal entity that manages the public-private partnership (PPP) between the European Commission and the Bio-based Industries Consortium (BIC). BBI JU is responsible for the implementation under the Horizon 2020 programme of open Call for proposals for R&I, innovation and coordination & support actions. The BBI JU is driven by the Strategic Innovation and Research Agenda (SIRA) and aims at increasing investment in the development of a sustainable bio-based industry sector in Europe, including the creation of new bio-based value chains and products and first-of-the-kind biorefineries in Europe based on a sustainable biomass supply .BBI-JU provides on a yearly basis Key Performance Indicators described in the SIRA related to specific research and innovation objectives of BBI JU. An analysis of the BBI JU projects to the BBI JU KPIs can be found in the BBI JU Annual Activity Report 2018[22].

JRC is in contact with the coordinators of BBI-JU and is following their actions since the beginning in 2014. A cooperative approach is being planned in the sector of biorefineries (to integrate the JRC databases with BBI-JU input) and in the collection of market data in the bio-based industry.

Life cycle thinking and life cycle assessment

The JRC has a consolidated experience in the development of life cycle-based indicators and in the application of life cycle assessment to quantify the environmental performance of products and services and identify environmental trade-offs, in support to decision-making.

JRC is leading and participating to several projects based on the evaluation of environmental impacts through a life cycle thinking approach (https://eplca.jrc.ec.europa.eu/a_projects.html?pageIdOpen=project5).

Among them, JRC is leading the Consumption Footprint project aimed to analyse the environmental impacts of consumption in EU, building on the outcomes of the LC-IND2 project [Sala et al. 2019].

Two sets of indicators based on life cycle assessment methodology are developed and quantified, i.e. the Consumption Footprint (at EU and member state level) and the Consumer Footprint (referred to an average EU citizen). The project encompasses the analysis of decupling of policy-relevant scenarios, and consumers' behaviour and is complemented by the assessment of environmental impacts and pressures not traditionally captured by life cycle assessment, e.g. biodiversity loss (e.g. Crenna et al. 2019) and generation of marine litter.

In addition, JRC has lead the technical and scientific development of the Product Environmental Footprint (PEF) and the Organisation Environmental Footprint (OEF) methods, established by Communication from the Commission Building the Single Market for Green Products (COM/2013/196). The compliance of environmental information to the PEF method is a key element of the updated Bioeconomy Strategy.

MAES

The DG-ENV's initiative on Mapping and Assessment of Ecosystems and their Services (MAES) is working in a joint MAES INCA EU wide ecosystem assessment using an array of spatially explicit indicators on ecosystem condition and accounts on ecosystem services. The aim of this study is to ensure a consistent quantitative reporting of the condition of Europe's ecosystems and ecosystem services.

The MAES assessment serves two main policy requests, 1) provide an evaluation of the headline biodiversity target of the EU Biodiversity Strategy to 2020 in general and of Target 2 in particular, and 2) provide a baseline as well as support to the definition of smarter targets for the post-2020 biodiversity policy in the framework of the European Green Deal. The assessment also needs to provide an evidence base and baseline for the post 2020 biodiversity policy. Such an evidence base will be far more prominent than before when setting new biodiversity targets. It is expected that the assessment will provide the data (indicators) to test a framework that describes for different ecosystem types (forest, agricultural, urban, freshwaters, marine) how pressures and resource use can affect the condition of ecosystems.

Agri-environmental monitoring for CAP

The JRC contributes to the assessment of the agri-environmental conditions in Europe. This covers the development of methods and tools for the evaluation of environmental agricultural impacts of the food and farming sector including the provision of sustainability indicators at different levels (from farm to regional and national levels), mostly related to the Performance Monitoring and Evaluation Framework (PMEF) developed by DG AGRI with the Member States.

In addition, the JRC covers the assessment of the nitrogen cycle and the environmental impacts of nitrogen losses, the assessment of ecosystem services and provision delivered by agriculture. Linkages to other agriculture related policies such as nature resources, climate and food systems are also considered. This work prepares tools, collects and synthetizes knowledge on the effectiveness of CAP interventions and assists policy DGs with analysis in support to the CAP2020+. Other part of the work contributes to the Task Force on Reactive Nitrogen (UN-ECE CLRTAP), the International Nitrogen Initiative INI, and support to the EU Biodiversity strategy.

Data portal of agro-economics research - DataM

The data portal DataM (https://datam.jrc.ec.europa.eu/datam/) gives access to the data underlying the scientific production of the European Commission and partners about the economics aspects of agriculture, bioeconomy, climate change, food and nutrition security and related sustainability.

Data of this portal consists mainly in processed data, models' outcomes and estimates. These can be outlooks about future scenarios as well as calculations concerning the past to overcome the lack of official statistical data.

Data is presented in terms of raw datasets ready to download, and as interactive dashboards or infographics for the self-analysis of data.

Related to the bioeconomy, the following data sets are available and regularly updated:

- Biomass uses and flows

- BioSAMs EU Member States – 2010 ; Online jobs calculator

- Jobs and wealth in the EU bioeconomy / JRC- Bioeconomics

- DG AGRI-JRC - Production, trade and apparent use

Common Fisheries Programme

The JRC is regularly contributing to the Monitoring of the Common Fisheries Policy, as established in art. 50 of Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013. In fact, the Commission is obliged to annually report to the European Parliament and to the Council on the progress on achieving maximum sustainable yield and on the situation of fish stocks. Such assessment takes place by looking at a number of indicators of a predefined sampling frame. In particular, those indicators are a) the number of stocks where fishing mortality exceeds Fmsy, b) the number of stocks where fishing mortality is equal or less tan Fmsy, c) the number of stocks outside the biological limits, d) the number of stocks inside the biological limits, e) the number of stocks outside the CFP requirements, f) the number of stocks inside the CFP requirements and the annual value of F/Fmsy and SSB. By performing such exercise (ensured by JRC and the Scientific Technical and Economic Committee for Fisheries), it is possible to verify if, and to what extent, the implementation of the legislation (i.e. the CFP and related provisions) has resulted in improving the state of the fish stock, and in which fishing area. All relevant assessment are published at https://stecf.jrc.ec.europa.eu/reports/cfp-monitoring.

Sector dialogues with Brazil

The JRC is supporting the development of the Brazilian Platform for Monitoring and Observation of climate change impacts (SISMOI) within the 2018 Sector Dialogue EU-Brazil initiative (MCTIC-JRC Work programme 2018-2020; JRC thematic lead: Follador, M., D1). The collaboration between the Brazilian Ministry of Science, Technology and Innovation and JRC formally started in 2016 with a visit at Ispra site of Brazilian delegation to discuss about the theoretical framework of SISMOI, key sectors and indicators, and the policy relevance for the national and international climate agenda. The project aims at fostering the knowledge and technology transfer between the parties on monitoring climate change impacts on biophysical, social and economic dimensions. The first case study is the Brazilian semiarid region and the studied key-sectors are water, energy and agriculture. The city of Campina Grande hosted the expert meeting on climate change impact indicators in June 2019. The 3 day event brought together sectoral experts from academy, public and private sectors to validate the proposed set of indicators (Tables 6, 7 and 8). A Brazilian Delegation will visit the JRC-Ispra from 11th to 13th November to present the final version of SISMOI platform, gather feedback and discuss about future collaborations, including data sharing and synergies between ongoing initiative (e.g., SISMOI and the Monitoring system for Bioeconomy) Brazil is the largest exporter of agriculture products to the EU; indicators on food security, agriculture productivity, bioenergy, among many others, could be easily linked to the BE goals and included into the global component of the Monitoring system of EU Bioeconomy. This information could also provide a broad understanding of the resilience of our trading partners in the face of climate change.

Figure 6 Indicators selected to assess impacts and vulnerability in the water sector

Dimension		Thematic indicator	Indicator
Vulnerability	Sensibility	Water resources supply and demand	Deficit water balance
			Water production per capita
		Water use efficiency	Water losses in the supply distribution system
			Water consumption per capita
		Saneamento Básico e Acesso aos Recursos Hídricos	Population with water supply system
			Population with sanitary sewage supply system
			Households with water supply from cisterns, wells or springs
		Human Health Risks	Diseases related to inadequate environmental sanitation
			Households unsuitable for housing
			Water quality
	Adaptative Capacity	Emergency or structural plans and actions	Public policies for water supply alternatives
			Contingency plans for environmental disasters
			Resilient city program
			Federal priority for natural disasters monitoring
		Water resource plann	Implementation level of water management plans
			Municipal sanitation plan
		Capacidade Socioeconômica Familiar	Wealth inequality
			Payment for water acces
			Low income households
Exposure		Natural exposure	Vegetation cover in Water Drainage Permanent Preservation Area (WPPA)
			Anthropized or impermeable areas
			Natural cover in high slope areas
			Soil water conent
		People location	Population living
			population living isolated to water and roads
Climate Perturbation		Climate Perturbation index - Dry	Consecutive dry days
			Coefficient of variation of precipitation
			Total rainfall
			Standardized Precipitation Index
		Climate Perturbation index - Rainfall intensity	Highest precipitation in 1 day
			Highest precipitation in 5 days
			Total rainfall
			Consecutive rainfall days

Figure 7: Indicators selected to assess impacts and vulnerability in the agriculture sector

Dimension		Thematic indicator	Indicator
Vulnerability	Sensibility	Agricultural production and economic profitable	Staple foods agricultural yield
			Landowners structure of staple food agriculture
			Staple foods economic profitable
			livestock stocking and pasture condition
		Agricultural Practice and Management	Agrochemicals uses
			Water use for large scale irrigation
			Sustainable agricultural practices
		Farmer and agricultural establishments features	Electricity in agricultural establishments
			Pastures in poor condition
			Water resources protection in agricultural establishments
			Economic activities farmer diversity
			Machines and agricultural yield
		Nutrition and Human Health Risks	Nutrition pattern
			Food insufficiency
			Level of food and nutrition insecurity
			Malnourished children under 2 years old
	Adaptative Capacity	Maintenance of agricultural production	National Program for Strengthening Family Farming (PRONAF) cover
			Economic profitability farmer supported by Food Acquisition Program (PAA)
			Food Acquisition Program (PAA) receiving units
			Cistern Program cover
			Families benefited by community seed storages
			Associativisme level
			Public technical orientation level
		Crisis Emergency Aid Programs	Harvest Guarantee Program cover
			Financial Emegency Aid for family farmers in drought situations
			Agricultural Activity Guarantee Program cover
		Food Safety Management	National School Feeding Program (PNAE) cover
			Resilient city program
			Food safety digest and planning instruments
		Capacidade socioeconômica familiar	Wealth inequality
			Responsible Analphabetism of land properties
			Low income households
			Family Grant Program cover
			Unemployment tendency
			People growth in households
			Growth of staple foods prices with income household
Exposure		Natural exposure	Vegetation cover in Water Drainage Permanent Preservation Area (WPPA)
			Agricultural area in unsuitable land slope
			Land degradated or in desertification land processess
			Soil water conent
			Agriculture low suitable land
		People location	Population living
			Land ownership structure
			Population living isolated to water and roads
Climate Perturbation		Climate Perturbatio index – Dry	Consecutive dry days
			Coefficient of variation of precipitation
			Total rainfall
			Standardized Precipitation Index
		Climate Perturbatio index – Rainfall intensity	Highest precipitation in 1 day
			Highest precipitation in 5 days
			Total rainfall
			Consecutive rainfall days

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Figure 8: Indicators selected to assess impacts and vulnerability in the energy sector

Dimension		Thematic indicator	Indicator
Vulnerability	Sensibility	Access and Consumption	Househols without electricity
			Agricultural establishments without electricity
			Charcoal and firewood extraction per capita
			Continuity of Electricity Supply
			Electricity consumption household
		Electricity production by different sources	Electricity production from renewable and clean sources per capita
			Electricity production diversification
	Adaptative Capacity	Continuity of Access	Installed capacity of mini and micro power generation
			Installed capacity of power self-generators
		Microeconomic capacity	Household electricity tariff increase with household income
			Low income households
		Macroeconomic capacity	Municipality gross domestic product (MGDP)
			State gross domestic product (SGDP)
		Disaster management	Resilient city program
			Federal priority for natural disasters monitoring
Exposure		Natural exposure	lightning strikes
			Burned areas
		People location	Population living
			Population living isolated to National Interconnect System Electricity
			Population living isolated to water and roads
Índice de Perturbaç ão Climática		Climate Perturbation index - Dry	Consecutive dry days
			Coefficient of variation of precipitation
			Total rainfall
			Standardized Precipitation Index
		Climate Perturbation index - Rainfall intensity	Highest precipitation in 1 day
			Highest precipitation in 5 days
			Total rainfall
			Consecutive rainfall days

Forest Europe

JRC actively contributes to the debates on criteria and indicators for sustainable forest management in the framework of Forest Europe, and it also contributes to the related reporting efforts. In particular, the chapters on criteria 1 (forest resources and carbon cycles) and 4 (biological diversity in forest ecosystems) of the State of European Forest Report 2015 were co-led by JRC authors. In addition, JRC provided support to the reporting obligations calculating some European level indicators such as forest fragmentation {Vogt et al., 2019a].

Collaboration with the European Forest Institute (EFI)

A Collaboration Research Agreement (CRA) is currently in place between JRC and EFI, aimed at improving the co-ordination and effectiveness of co-operation efforts between EFI and the JRC in the field of forest sector and forest resources modelling, and promoting joint co-operation for an enhanced understanding of forest disturbances and related risks in Europe. In the context of this CRA, in 2017 JRC worked jointly with EFI in a study on Monitoring and assessing the sustainable forest-based bioeconomy, coordinated by the European Forest Institute [Wolfslehner et al 2016]. This work included an in-depth review of existing indicators of interest to monitor the forest-based bioeconomy. Relevant indicators to inform the first version of the EU Bioeconomy Strategy [2012] were identified. Gaps were highlighted and ways forward were proposed. Collaboration with the European Forest Institute on indicators and the forest-based bioeconomy continues.

Food and Agricultural Organisation

The Joint Research Centre is supporting the development and implementation of FAO's global forest analysis for the thematic topics Accounting and Fragmentation. The analysis scheme and data products have been designed to support the indicator Forest Fragmentation in the State of the World's Forests (SOFO) report 2020 (see Vogt et al. 2019b). Furthermore, the JRC is co-chairing the IBF working group on Monitoring the Bioeconomy with FAO.

Sustainability of biofuels, bioenergy and alternative fuels (ALFA) project

The JRC has extensive experience in monitoring the progress of bioenergy in the EU and on evaluating environmental impacts of biofuels, bioenergy and alternative fuels pathways through life cycle assessment [Marelli et al., 2015; Giuntoli et al., 2017; Edwards et al., 2017]. The ALFA project supports European Commission in achieving the objective of decarbonising transport via techno-economic analysis of alternative fuels at European and global scale, in different transport modes. It assesses the environmental sustainability and climate impact of biofuels, bioenergy and alternative fuels; the technological development of bioenergy and biofuels pathways and other fuels or energy carriers for road transport, and the costs of associated savings on GHG and pollutant emissions.

In more details the ALFA project:

- provides support to the EC in fulfilling its legal obligations regarding biofuels with respect to the implementation and reporting requirements of the Renewable Energy Directive-RED (2009/28/EC) and its recast (2018/2001/EU), and of the Fuel Quality Directive – FQD (Directive 2009/30/EC).

- Identifies and characterises sustainability aspects of biofuels, bioenergy and other alternative fuels and monitors their environmental performance,

- Develops, upgrades and improves methodological and analytical tools based on real-world input data to calculate and assess GHG emissions balances of conventional and alternative fuel pathways, including 'well-to-wheels' analyses,

- Develops life-cycle assessment methodologies for recycled carbon fuels and renewable fuels of non-biological origin, supports the Commission's work on alternative fuels for aviation at UN-ICAO.

Climate change

This indicator refers to the increase in the average global temperatures as result of greenhouse gas (GHG) emissions. The greatest contributor is generally the combustion of fossil fuels such as coal, oil, and natural gas. The global warming potential of all GHG emissions is measured in kilogram of carbon dioxide equivalent (kg CO_2 eq), namely all GHG are compared to the amount of the global warming potential of 1 kg of CO_2.

Particulate Matter

This indicator measures the adverse impacts on human health caused by emissions of Particulate Matter (PM) and its precursors (e.g. NO_x, SO_2). Usually, the smaller the particles, the more dangerous they are, as they can go deeper into the lungs. The potential impact of is measured as the change in mortality due to PM emissions, expressed as disease incidence per kg of $PM_{2.5}$ emitted.

Ionising radiation

The exposure to ionising radiation (radioactivity) can have impacts on human health. The Environmental Footprint only considers emissions under normal operating conditions (no accidents in nuclear plants are considered). The potential impact on human health of different ionising radiations is converted to the equivalent of kilobequerels of Uranium 235 (kg U235 eq).

Photochemical ozone formation

Ozone (O_3) on the ground (in the troposphere) is harmful: it attacks organic compounds in animals and plants, it increases the frequency of respiratory problems when photochemical smog ("summer smog") is present in cities. The potential impact of substances contributing to photochemical ozone formation is converted into the equivalent of kilograms of Non-Methane Volatile Organic Compounds (e.g. alcohols, aromatics, etc.; kg NMVOC eq).

Eutrophication, terrestrial

Eutrophication impacts ecosystems due to substances containing nitrogen (N) or phosphorus (P). These nutrients cause a growth of algae or specific plants and limit growth in the original ecosystem. The potential impact of substances contributing to terrestrial eutrophication is converted to the equivalent of moles of nitrogen (mol N eq).

Ozone depletion

The stratospheric ozone (O_3) layer protects us from hazardous ultraviolet radiation (UV-B). Its depletion increases skin cancer cases in humans and damage to plants. The potential impacts of all relevant substances for ozone depletion are converted to their equivalent of kilograms of trichlorofluoromethane (also called Freon-11 and R-11), hence the unit of measurement is in kilogram of CFC-11 equivalent (kg CFC-11 eq).

LCA and environmental impacts

With LCA, different environmental impacts may be assessed. The Environmental Footprint method allows assessing 16 impact categories.

Acidification

Acidification has contributed to a decline of coniferous forests and an increase in fish mortality. Acidification can be caused by emissions getting into the air, water and soil. The most significant sources are combustion processes in electricity, heating production, and transport. The contribution to acidification is greatest when the fuels contain a high level of sulphur. The potential impact of substances contributing to acidification is converted to the equivalent of moles of hydron (general name for a cationic form of atomic hydrogen, mol H^+ eq).

Eutrophication, freshwater

Eutrophication impacts ecosystems due to substances containing nitrogen (N) or phosphorus (P). If algae grows too rapidly, it can leave water without enough oxygen for fish to survive. Nitrogen emissions into the aquatic environment are caused largely by fertilizers used in agriculture, but also by combustion processes. The most significant sources of phosphorus emissions are sewage treatment plants for urban and industrial effluents and leaching from agricultural land. The potential impact of substances contributing to freshwater eutrophication is converted to the equivalent of kilograms of phosphorus (kg P eq).

Eutrophication, marine

Eutrophication impacts ecosystems due to substances containing nitrogen (N) or phosphorus (P). As a rule, the availability of one of these nutrients will be a limiting factor for growth in the ecosystem, and if this nutrient is added, the growth of algae or specific plants will be increased. For the marine environment this will be mainly due to an increase of nitrogen (N). Nitrogen emissions are caused largely by the agricultural use of fertilisers, but also by combustion processes. The potential impact of substances contributing to marine eutrophication is converted to the equivalent of kilograms of nitrogen (kg N eq).

Human toxicity, non-cancer

This indicator refers to potential impacts on human health caused by absorbing substances through the air, water, and soil. Direct effects of products on humans are currently not measured. The unit of measurement is Comparative Toxic Unit for humans (CTUh). This is based on a model called USEtox.

Water use

The withdrawal of water from lakes, rivers or groundwater can contribute to the 'depletion' of available water. The impact category considers the availability or scarcity of water in the regions where the activity takes place, if this information is known. The potential impact is expressed in cubic metres (m³) of water use related to the local scarcity of water.

Resource use, minerals and metals

The basic idea behind this impact category is the same as the one behind the impact category resource use, fossils (namely, extracting a high concentration of resources today will force future generations to extract lower concentration or lower value resources). The amount of materials contributing to resource depletion are converted into equivalents of kilograms of antimony (kg Sb eq).

Ecotoxicity, freshwater

This indicator refers to potential toxic impacts on an ecosystem, which may damage individual species as well as the functioning of the ecosystem. Some substances have a tendency to accumulate in living organisms. The unit of measurement is Comparative Toxic Unit for ecosystems (CTUe). This is based on a model called USEtox.

Human toxicity, cancer

This indicator refers to potential impacts on human health caused by absorbing substances through the air, water and soil. Direct effects of products on humans are currently not measured. The unit of measurement is Comparative Toxic Unit for humans (CTUh). This is based on a model called USEtox.

Land Use

Use and transformation of land for agriculture, roads, housing, mining or other purposes. The impacts can vary and include loss of species, of the organic matter content of soil, or loss of the soil itself (erosion). This is an indicator of loss of soil organic matter content, expressed in kilograms of carbon deficit (kg C deficit).

Resource use, fossils

The earth contains a finite amount of non-renewable resources, such as fossil fuels like coal, oil and gas. The basic idea behind this impact category is that extracting resources today will force future generations to extract less or different resources. For example, the depletion of fossil fuels may lead to the non-availability of fossil fuels for future generations. The amount of materials contributing to resource use, fossils, are converted into MJ.

Impact affecting the environment on a global scale

Impact affecting the environment mainly at local/regional scale

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