BE-Rural | Note on the development of a sustainability screening for regional bioeconomy strategies

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Introduction

The European Commission (EC) sees great promise in the bioeconomy (BE) for achieving various policy aims related to sustainability, such as climate change mitigation, security of energy supply, rural development (Gawel et al. 2019), biodiversity (Lindqvist et al. 2019) and the achievement of the Sustainable Development Goals (SDGs) (Peterson and Kaaret 2020). Concretely, the EU Bioeconomy Strategy lists as its main goals: i) ensuring food and nutrition security; ii) managing natural resources sustainably; iii) reducing dependence on non-renewable, unsustainable resources whether sourced domestically or from abroad; iv) mitigating and adapting to climate change; and v) strengthening European competitiveness and creating jobs (EC, 2018a). However, sustainability is not an intrinsic characteristic of the BE, but a potential it could achieve (Zeug et al. 2020). Thus, improving our capacity to assess the environmental impacts of bioeconomy development is of great importance for ensuring the sustainability of the transition at hand. This could be significantly challenging for regions who lack established structures and consistent instances for collaboration on the topic, and depend largely on project-based impulses.

The issue of sustainability of and in the BE has been the subject of wide discussion in academic and civil society circles. One known phenomenon is that, under certain circumstances, policy support and investments on BE can elicit undesired challenges and trade-offs in terms of sustainability, as additional, politically driven demand for biomass and land resources emerges (Gawel et al. 2019). As a result, conflicting goals need to be considered holistically to balance social, economic and environmental impacts. Therefore, various authors argue that the development of a sustainable BE is only possible if it is embedded within overarching socio-economic-ecological transformation pathways, e.g. the ones related to the achievement of the SDGs (Jarosch et al. 2020; Peterson and Kaaret 2020).

In the updated EU BE Strategy, the EC outlines the action „understanding the ecological boundaries of the bioeconomy" (EC, 2018), filling a gap in the previous strategy from 2012. Several initiatives are now underway that aim to improve the monitoring and understanding of the bioeconomy's effects on Europe's social, economic and environmental systems[1]. This reflects the priority and commitment given to establish a bioeconomy based on solid knowledge foundations.

The regional dimension

As postulated in the EU Bioeconomy Strategy and acknowledged by EU Committee of the Regions, regions are the most appropriate territorial level at which to implement bioeconomy strategies. In the present

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[11] For instance, the European Commission's Bioeconomy Knowledge Centre and the Data-Modelling platform of agro-economics research, the Horizon 2020 project Biomonitor, the SYMOBIO project sponsored by the German Federal Ministry of Education and Research.

note, our understanding of regions is guided by the EU Nomenclature of Territorial Units for Statistics (NUTS) classification for 2021, more specifically at NUTS3 level, the smallest standardized territorial unit type in this system. To this respect, the effects of implementing the BE can be best observed at a regional scale, particularly in terms of social and environmental impact (Jarosch et al. 2020). As Reinhard et al. (2021, p.12) argue for agricultural production:

> *"[T]he type and amount of resources used (water, land, etc.), the inputs required (the application of fertilizers and crop protection agents, the use of machinery, etc.) and the corresponding emissions into soil, air and water (carbon dioxide, nitrate, dinitrogen monoxide, phosphate, etc.) are determined by small-scale spatial parameters (precipitation, soil properties, slope, etc.) and therefore highly context dependent."*

Each region has a specific BE potential that depends on a variety of factors such as the locally existing environmental resources like water, soil, and biodiversity. Moreover, this potential is influenced by the existence of other enabling socio-economic factors such as policies, finance, knowledge and infrastructure. To maintain the proper functioning of natural systems and the contingent economic and social well-being, it is fundamental to understand the extent to which this potential can be exploited sustainably and how future changes in conditions could affect it. Notwithstanding, the consideration of the environmental dimension of sustainability tends to receive limited attention in relation to its counterparts when discussing the development of the BE (Lindqvist et al. 2019). This can be observed in regions where the BE is a relatively new concept. For instance, in most of BE-Rural's OIP regions there is no dedicated BE strategy in place and the development of the BE is mostly associated with regional development and economic policies, putting the potential social and economic benefits of the BE in the foreground (see BE-Rural D2.2 Anzaldúa et al. 2019). Here, we see the understanding of ecological limits and their consideration in the development of regional BE strategies as prerequisites for their sustainability. Hence, a sustainable BE potential shall be one that takes in first line the environmental sustainability into consideration and includes these limits under which the BE can operate so that resources are conserved for future generations. In our understanding, this means that the inputs and outputs of bio-based enterprises – in terms of used, consumed or degraded resources and emitted pollutants – shall not be as high as to hamper the regeneration of the regional ecosystem.

Available methods for assessing regional bioeconomy potential

Assessing the overall sustainability of a regional bioeconomy, for instance, in terms of its contribution to the achievement of the SDGs, will require comprehensive and holistic assessments. Such assessments will need to consider environmental, social and economic impacts of the bioeconomy, as well as resulting goal conflicts that may arise between them. In this context, Life Cycle Assessment (LCA) is a well-established method that can be used to determine the environmental impacts of entire value chains. In fact, it is the (only) guiding methodology considered for assessing the environmental impacts of the bioeconomy found in the EU Knowledge Centre for Bioeconomy2. However, there are several challenges for the LCA methodology (see EC 2018b) and conducting LCAs often requires substantial effort and a certain pool of resources (time, personnel, etc.). In addition, in certain contexts, the necessary data is often not available to conduct a valid LCA.

[2] https://knowledge4policy.ec.europa.eu/bioeconomy/topic/environment_en

There are several variations of the methodology which differ from each other according to specific foci, such as economic (e.g. Life cycle costing LCC), social (S-LCA) and Environmental (E-LCA). There are also newer methodologies, which are more holistic, such as the Life Cycle Sustainability Assessment (LCSA), but these are still in their infancy and under development (Zeug et al. 2020). Further, these life cycle oriented methodologies are still not proven for their application at regional level, even though some regionalized forms of LCA do exist (Pfister 2020). This can represent both a barrier and a missed opportunity in regions whose decision-makers are keen to develop and implement sustainable bioeconomy strategies, but who have limited resources and for which data availability is scarce (e.g. rural areas). Optimally, communities would be able to map and evaluate bio-based value chains in their regions as well as the ecosystems underpinning them and their changes in as much detail as possible, and to guarantee a certain degree of flexibility (e.g. with regard to the data situation) at the same time. In reality, regions with limited resources and data are strongly dependent on project-based collaborations bringing authorities, experts from various research fields, and other stakeholders together with actors holding local ecological knowledge to help filling data gaps to a certain degree.

In previous activities, the BE-Rural project team has assessed the bioeconomy potential of the OIP regions using the Self-Assessment Tool (SAT) of the European Commission3 in D2.3 "The bioeconomy potential of BE-Rural's OIP regions"4. However, while this procedure offers some insights on specific topics related to environmental sustainability, such as the long-term stability and availability of feedstocks, this tool still has some limitations to this respect. For instance, it only analyses the status quo and not the impact of biomass use in the future, which is a key element in a sustainability assessment.

An alternative framework to incorporate considerations of ecological limits into regional bioeconomy strategies

Rationale

As previously mentioned, practical applications of sustainability assessments vary in their balance of environmental, social and economic dimensions. The former often appears to be comparatively more elusive, as methodological frameworks for its analysis are less numerous, underdeveloped, and less known. We think this can increase the risk of planners, facilitators, project consortia, etc. failing to consider the environmental dimension of sustainability adequately when developing a regional bioeconomy strategy/roadmap, especially in rural areas. Therefore, we argue that an important first step is to estimate the proportion of a region's bioeconomy potential that can be attained within safe ecological limits. For this, we propose developing a methodology that is easily accessible and replicable in regions with relatively low financial resources and expertise in the field, i.e. that would not have the capacities to carry out an LCA.

Focusing on a selection of relevant natural resources, this could be addressed with two different scenarios: *baseline scenario*, composed of the economic baseline and the environmental baseline. The former refers to the status quo of biomass production and use (obtained through the SAT tool). The latter refers to the state of environmental conditions expressed in key indicators which reflect for instance

[3] https://ec.europa.eu/growth/tools-databases/escss_en
[4] https://be-rural.eu/wp-content/uploads/2019/11/BE-Rural_D2.3_Bioeconomy_potential_analysis.pdf

vulnerability to soil degradation, depletion of water resources o reduction of biodiversity. Both these components of these scenario are compared against a *target scenario* which considers the change in the environmental status caused by new or expanded economic activities with the respective consequences for yields and processes. The approach to sustainability can be structured as the analysis of the difference in impacts caused by the two reference scenario projections: baseline vs target projections. These analyses will serve as an important basis for strategy/roadmap development as it will help to identify whenever there are vulnerabilities in specific environmental parameters in the region, as well as the expected impacts that selected sectors and their practices may have on them. Through this, it will be possible to identify which sectors or practices should be more or less encouraged in the strategies/roadmaps.

Some methodological considerations and foreseeable limitations

As ecosystems do not necessarily overlap with political units, the assessment would have to consider the set of ecosystems within which the region is embedded. Moreover, processing companies do not always necessarily use feedstock that originate from the same region, nor necessarily use only bio-based feedstocks for their production. These aspects increase the difficulty of analysing the regional environmental impact of all kinds of bio-based businesses operating in the region to ensure that these do so within safe ecological limits. Therefore, a first sustainability screening like the one we are proposing and which, by nature, needs to be easy to apply, should focus first on the biomass that is generated within the region, be it as primary raw material/feedstock or as waste. While the impact of processing and manufacturing companies is also relevant, its regional distribution is much more difficult to assess and allocate and more complex methodologies such as LCA are more suitable for this purpose. This is also the case because there is no clear cut regarding which sectors belong to the bioeconomy nor is the "bio-based" share of sectors that are only partially bio-based clearly determined (Jander et al. 2020). Furthermore, the environmental impact of products and services that are located further downstream in the value chain occurs can occur in the various regions that their feedstocks come from or where they are processed. This makes it more difficult to allocate the environmental impacts to a specific region and increases the risk of counting impacts that are actually located somewhere else. Therefore, focusing on the primary sector at first instance also facilitates the regional specificity of the estimated impacts. Operating within safe ecological limits from a regional perspective depends on a variety of factors: for instance on the volumes of the most relevant biomass streams that are produced in the region, as well as on the general practices used by the companies involved in them (in production, processing and end-of-life phase). Additionally, the limited scope of the SAT (focusing on chemicals) could result in shortcomings in the initial characterization of the regional bioeconomy potential. Ultimately, the selection of assessment indicators and the foundation of these indicators on valid data in high resolution are of great importance for the regional ecological assessment. Our proposed approach reaches here its limits in terms of offering high-resolution data(sets) related to quantities from the forestry and fishery sectors. One way to address this problem would be to obtain statistics and data from local institutions (e.g. state offices) through local partners on site. These efforts could be aligned to contribute to the previously mentioned monitoring initiatives at EU and national level, to increase their coverage and exploit synergies.

Description of the proposed methodology

In essence, the sustainability screening approach proposed would be based on a rough appraisal of a) the available capacity of the regional ecosystems to underpin bioeconomic activities, and b) the expected *ecological burden* that a range of bioeconomic activities deemed relevant for the region would place on the ecosystems. The latter is broadly understood as the cumulative contribution of the relevant activities towards reaching the ecological limits in the region, and would be mainly based on expected levels of use, consumption and/or degradation of resources like soil, water and biodiversity.

We propose developing a first assessment methodology that can be applied with relatively modest resources and effort to:

- Estimate the "maximum level of production" of particularly relevant biomass streams (identified in SAT) in the region (with business as usual practices) that could be sustained over long term regarding impacts on a series of indicators.
- Offer pointers on the benefits of changes in practices or combination of activities/diversification of biomass streams to achieve a total higher biomass production within the safe ecological limits.
- Focus on the regionally available resources and impact to the ecosystems that the region is embedded into (it is understood that ecosystems are not correlated with political divisions, so a way to delineate this scope of environmental impact will have to be found).

The target audience for this would be regional authorities, policy and decision makers interested or already engaged in developing a bioeconomy strategy/roadmap or improving the environmental sustainability considerations of their existing one. Moreover, the assessment can also create a link to businesses as well, for instance through the involvement of clusters or sectoral business associations in a joint development of these strategies/roadmaps. Such strategies and roadmaps would ideally provide potential pathways for the private sector to go through in order to improve the sustainability of their activities, for instance by favouring certain economic sectors that include best practices in terms of sustainability.

As said, while an LCA would be the most adequate assessment method to do this, it is not an easy access option for the appraisal of environmental sustainability for regional authorities, facilitators and project consortia in specific contexts. The proposed BE-Rural screening method does not intend to replace the LCA, but rather to set the groundwork for a more streamlined effort ("warm up") where the LCA is indeed possible; and to provide an entry level option to incorporate environmental sustainability considerations into decision making in cases where the lack of capacity to conduct an LCA would result in them being neglected ("safeguard").

The ultimate goal of this exercise will be to develop a methodological concept, which can be tested in one of the BE-Rural OIPs for its further refinement. This comes as a response to a potential shortcoming in the project, identified during its first periodic review. BE-Rural's conceptual framework establishes that project activities should consider the notion of 'safe ecological limits' in relation to the further development of regional bio-based systems. However, no clear task or activity is outlined in the DoA that illustrates how this could be done in practice. Moreover, this new effort would lay the foundations for further applications in future projects and initiatives that in turn generate experiences and information, and contribute to increase the method's replicability in different contexts and regions.

Structure of the methodology

The screening is split into five main parts that will be conducted sequentially as follows:

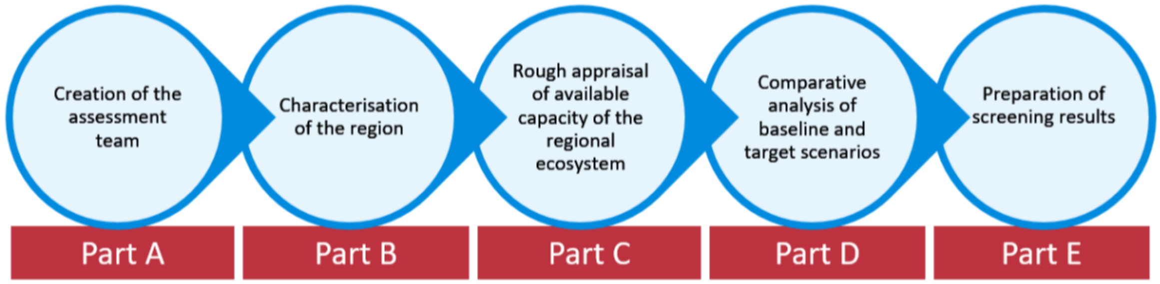

Figure 1 – Structure of the BE-Rural sustainability screening

Part A – Creation of the assessment team

The screening will be conducted by the interested parties (regional authorities, decision-makers, planners and stakeholders) with guidance from a team made up of both local and foreign experts. This could take the shape of a European Technical Group on Bioeconomy Sustainability, similar to those under the Common Implementation Strategy of the EU's Water Framework Directive, that could keep the discussion going and support as ad-hoc advisory group for the regions. The EU Expert Group linked to the Bioeconomy Policy Support Facility[5], the recently launched European Bioeconomy Policy Forum (EBPF), the Thematic Group Bioeconomy and Climate Action in Rural Areas of the European Network for Rural Development (ENRD)[6], and the FAO's International Sustainable Bioeconomy Working Group (ISBWG)[7] could eventually host this regional advisory group or be invited to pick up its mandate.

Part B – Characterisation of the region using the SAT

The first task of the team will be to produce a general outline of environmental conditions (climate, land cover, etc.) and run an assessment using the SAT to define biomass availability and bioeconomy potential in the region. The BE-Rural team considers it feasible to use the information collected through the SAT tool and other project results, e.g. the PESTEL analysis[8] carried out in D2.2, to then set the bases of the screening. The key outputs of Part A are the consolidated assessment team and a selection of bioeconomy activities deemed relevant for the region.

Part C – Rough appraisal of available capacity of the regional ecosystem

Using existing indicators (see Table 1) and expert opinion from within and beyond the assessment team, this part of the screening will yield a qualitative (ordinal) categorization of the capacity of the ecosystems in the region to underpin bioeconomy activities. Thus, the key output of Part B is a baseline scenario from which the development of the regional bioeconomy strategy/roadmap would part.

Part D – Comparative analysis of baseline and target scenarios

Based on pre-defined ranges indicating the level of resource consumption associated to major activity types (following the NACE classification) at certain intensities, the assessment team will project the expected ecological burden (i.e. foreseeable levels of resource demand) of the relevant bioeconomy

[5] https://ec.europa.eu/transparency/expert-groups-register/screen/expert-groups/consult?do=groupDetail.groupDetail&groupID=3726&news=1&mod_groups=1&month=03&year=2021
[6] https://enrd.ec.europa.eu/enrd-thematic-work/greening-rural-economy/bioeconomy_en
[7] http://www.fao.org/in-action/sustainable-and-circular-bioeconomy/international-sustainable-bioeconomy-working-group/en/
[8] PESTEL stands for political, economic, social, technical, environmental and legal assessment (see Anzaldúa et al. 2019)

activities shortlisted in Part B (representing the target scenario). This will then be overlaid against the appraisal of available ecosystem capacity in the region from Part C (representing the baseline scenario).

Part E – Preparation of screening results

Based on the results of Part D, the team will draft a presentation of results indicating which ecosystems and natural resources could be at risk or vulnerability using an ordinal scale. This will be supplemented with recommendations on bioeconomic activities to avoid or incorporate with reserve into the regional bioeconomy strategy/roadmap.

Box 1 – Example of the "characterisation of the region" for the Stara Zagora region in Bulgaria and the "rough appraisal of available capacity" of surface and groundwater bodies in the East Aegean Sea River Basin District. These are partial and preliminary results of an ongoing pilot conducted by the authors of this note. They are included exclusively for illustrating the type of information that the sustainability screening could yield and how a resulting dossier could be formatted.

Stara Zagora Region, Bulgaria

The Stara Zagora region (bulgarian "oblast" comply with the NUTS 3 administrative level) is situated in the Thracian valley, in central Bulgaria. With a total area is 5,151 km^2, it consists of 11 municipalities and has a population of over 300,000 inhabitants. The region's geographical position is one of the competitive advantages for enterprises who have established their operations here, as highways, first class roads and railway lines run across the region and connect it with a number of international destinations.

Figure 2 – Map of Bulgaria with approximate location of the Stara Zagora region. Source: Abhold et al., 2019.

Stara Zagora has numerous valuable natural resources that are favourable to the development of agriculture, energy and industry. The climate is moderate continental, with relatively mild winters. The soils in the area are flat for the most part and fertile. The cultivated area occupies more than 56% of the farmland. Cereals, sunflowers, cotton, and vegetables, as well as fruit orchards and grapevines are grown mainly in the southern plains. The region is abundant with herbs that are used for the cosmetic, pharmaceutical, and food processing industry. Nowadays the region has a diverse economy and lots of unexplored business potential – especially with regard to the circular economy. The potential lies in the better use of the available resources as well as developing or applying new technologies. The OIP Stara Zagora will focus on seeking new technologies for the processing of herbs and production of essential oils for the cosmetics and pharmaceutical industry. The small-scale production in this area will be combined with tourism-related activities to expand the existing business status quo and potential (Anzaldúa et al., 2019).

In Bulgaria, water management is coordinated at the national and river basin level. Since 2002, the country follows the requirements of the EU Water Framework Directive (WFD) and through the Bulgarian Water Act of 2006 it has aligned itself with EU water legislation. Stara Zagora lies in the East Aegean River Basin District (RBD code: BG3000).

Figure 3 – Location of the four river basin districts in Bulgaria (East Aegean RBD shown in color). Source: Tuntova, n.d.

To run the rough appraisal of the capacity of surface and groundwater bodies in this River Basin District (RBD), the authors of this note have reviewed the data reported in its 2nd River Basin Management Plan under the WFD. These data were accessed on 02.06.2021 from the WISE WFD data viewer (Tableau dashboard) hosted on the European Environment Agency's website.[9] The data reviewed included the reported ecological and chemical status of rivers and lakes as well as the quantitative and chemical status of groundwater bodies in the RBD. Data on significant pressures and significant impacts on rivers, lakes and groundwater bodies in the RBD was also reviewed as part of the exercise. This pilot screening of the water environment associated to the Stara Zagora region yielded the following baseline context:

Surface water bodies: according to the officially reported data from the 2nd management cycle of the WFD, almost two thirds of rivers and lakes in the East Aegean RBD fail to achieve Good Ecological Status or are in unknown ecological conditions. Economic activities that could have substantial negative impacts on river and lake ecology should thus be avoided in the region. Further, there is a high proportion of surface water bodies under unknown chemical conditions. Economic activities that could result in significant changes in the chemical properties of water resources should thus be considered with reserve or avoided

[9] https://www.eea.europa.eu/data-and-maps/dashboards/wise-wfd

until more information is collected. The main pressures on rivers are point sources of pollution, abstraction and hydromorphology alterations. The main pressures on lakes are unknown anthropogenic pressures. Nutrient pollution is the most recurrent impact on rivers and is important in lakes as well. Economic activities associated to moderate or high nutrient discharges to the environment should thus be avoided. Almost half of the lakes in the RBD are affected by unknown impacts. Further information on pressures and impacts on the region's lakes should be collected as part of the bioeconomy strategy development process.

Groundwater bodies: almost half of the groundwater bodies in the RBD are in poor chemical status. Economic activities that could have substantial negative impacts on groundwater should thus be considered with reserve. Diffuse sources of pollution are the most recurrent pressures on groundwater bodies in the RBD. Economic activities classified under this category should thus be avoided. Nutrient pollution is the most recurrent impact on groundwater bodies in the RBD. Economic activities associated to moderate or high nutrient discharges to the environment should thus be avoided.

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Annex – Indicators under consideration for Part C of the BE-Rural sustainability screening framework

Table 1 - Indicators under consideration for inclusion in Part C of the BE-Rural sustainability screening framework

Category	Indicator Family	Indicator	Spatial level	Unit of measure	Comments/Reference
Soil	Soil health	Estimated mean soil erosion rate (all lands)	NUTS0 - 3	t / (ha*yr)	Combined indicator developed to cover both the CAP's (environmental) context indicator #42 and the EU SDG progress monitoring indicator "soil erosion by water". It has been developed using the RUSLE2015[10, 11] model, which is applied to the EU (data for 2016). Its underlying purpose is to assess the impact of conservation practices on mitigating soil erosion and the role of agri-environmental policies. The team behind the development of this indicator (see Panagos et al. 2020) also consider their approach to be the most suitable for measuring and evaluating soil governance instruments, for instance those to be introduced in the proposed 2021 – 2027 CAP Regulation, e.g. the "Good Agricultural and Environmental Conditions" (GAEC).
		Soil erosion by water	NUTS0 - 3	ha, %	CAP context indicator #42 – it assesses the "Estimated agricultural area affected by severe water erosion (>11 t ha-1 yr-1)" expressed either as area (ha) or as percentage of the total arable area in the respective geographic unit.
		Mean erosion rates (only in arable lands)	NUTS0 - 3	t / (ha*yr)	Also developed by Panagos et al. (see 2020) using RUSLE2015 (see "estimate mean erosion rate" above), but only applied to arable lands as defined by CORINE Land Cover (CLC) classes 21X (or Raster codes: 12, 13, 14)
		Wind erosion and global soil erosion (by water)	National	t / (ha*yr)	Soil Loss by water erosion (t ha-1 yr-1) - mean values per country calculated through RUSLE model (global)
		Soil organic matter in arable land	National	Mt, g/Kg	CAP context indicator #42 expressed through the total estimates of organic carbon content in arable land (in Mt, differentiated between croplands, grasslands and permanent crops) and mean organic carbon content (in g per Kg of soil)

[10] https://esdac.jrc.ec.europa.eu/themes/rusle2015
[11] https://esdac.jrc.ec.europa.eu/themes/indicators-soil-erosion

Water	Water quality	Status of water bodies according to the EU Water Framework Directive	River Basin District	Number of water bodies in high, good, moderate, poor, bad or unknown status	WISE WFD Data Viewer[12] Disaggregated data for ecological and chemical status of surface water bodies; quantitative and chemical status of groundwater bodies, per River Basin District
	Water quantity	Water Exploitation Index + (WEI+)	National	Total fresh water use as % of the renewable fresh water resources (groundwater and surface water) at a given time and place	Illustrates the pressure on renewable freshwater resources due to water demand. Values above 20% are generally considered as an indication of water scarcity, while values equal or bigger than 40% indicate situations of severe water scarcity, i.e. the use of freshwater resources is clearly unsustainable. Annual calculations at national level, however, cannot reflect uneven spatial and seasonal distribution of resources and may therefore mask water scarcity that occurs on a seasonal or regional basis.
	Burden on water bodies	Significant pressures on water bodies	River Basin District	No. and % of water bodies under significant pressures per pressure type	WISE WFD Data Viewer[7]
	Burden on water bodies	Significant impacts on water bodies	River Basin District	No. and % of water bodies under significant impacts per impact type	WISE WFD Data Viewer[7]
Biodiversity	High Nature Value Farmland	Loss of High Nature Value Farmland by agriculture intensification	NUTS3	% loss of HNV farmland	EU indicator of the conservation value of an agricultural area. Comprises hot spots of biodiversity in rural areas and is usually characterised by extensive farming practices.
Biomass	Biomass quantity	Crop production in EU standard humidity	NUTS2	Harvested production in EU standard humidity (1000 t)	Agricultural production per NUTS2 unit. The data is provided by Eurostat and covers EU27/28
	Biomass quantity	Roundwood, fuelwood and other basic products	National level	1000 t or cubic meters	Production of roundwood, fuelwood and other basic products on national level. The data is provided by Eurostat and covers EU27/28
	Biomass quantity	Catches by fishing area Aquaculture production	Fishing areas, national level	Tons live weight	Catches in different European fishing areas and production from aquaculture excluding hatcheries and nurseries on national level. The data is provided by Eurostat and covers EU27/28

[12] WISE WFD Data Viewer (https://www.eea.europa.eu/data-and-maps/dashboards/wise-wfd)

Initial considerations on the selection of indicators

Soil degradation

The two most relevant indicators for soil degradation are soil erosion (mainly through water) and soil organic carbon (SOC). Both are the only CAP context indicators related to soil. Two indicators are the ones that are potentially the most relevant. First of all the "estimated mean soil erosion" (all lands) developed by Panagos et al. (2020). However, there are major data gaps regarding to SOC and data is currently only available at national level.

According to Panagos et al (2020) soil organic carbon does not change so quickly and therefore is not so sensitive to human influence on short term. Therefore, they recommend using just a sole indicator for monitoring impact of policies: "estimated mean soil erosion rate". We also consider this to be one of the two most relevant indicators next to the CAP context indicator "Soil erosion by water".

We favour the former one (estimated mean soil erosion rate) because it provides a solid baseline that factors land-cover management and support of specific good environmental practices to estimate the actual erosion rate in the NUTS3 regions. This indicator is based on RUSLE2015, which is a model that takes into account various aspects, including cover-management and support of good practices (both related to human activities) (Panagos et al. 2020). The mean soil erosion value refers to water erosion only, but it is argued that this is the most relevant at least in terms of policy action. This value thus is considered a viable estimation for erosion vulnerability at a relatively small geographic scale. Moreover, changes in specific practices can alter the overall erosion, increasing the vulnerability/risk. In cases where the mean soil erosion exceeds the 11 t ha^{-1} yr^{-1}, erosion is considered severe and activities that can generate a high erosion impact shall be discouraged.

There is also a version of this indicator that uses the same methodology exclusively for arable land. However, as bioeconomy also considers other land uses than strictly arable land, we consider this to be slightly less relevant.

On the other hand, the CAP context indicator evaluates the share of the arable land (in NUTS0 – 3 level) that is already affected by severe erosion (>11 t ha-1 yr-1). While this indicator is indeed focused only on arable land, it is also very relevant since it is the one that is officially used by the EC and it already provides an indication of the areas that are vulnerable to practices that could increase erosion. The former aspect is advantageous considering the interplay with other indicators to be used (e.g. for water or biodiversity).

Nonetheless, the comprehensiveness of the "estimated mean soil erosion" and the fact that it already considers aspects that are foreseen for the next CAP (good agricultural environmental conditions) makes it a more robust baseline and is our preferred option at the moment.

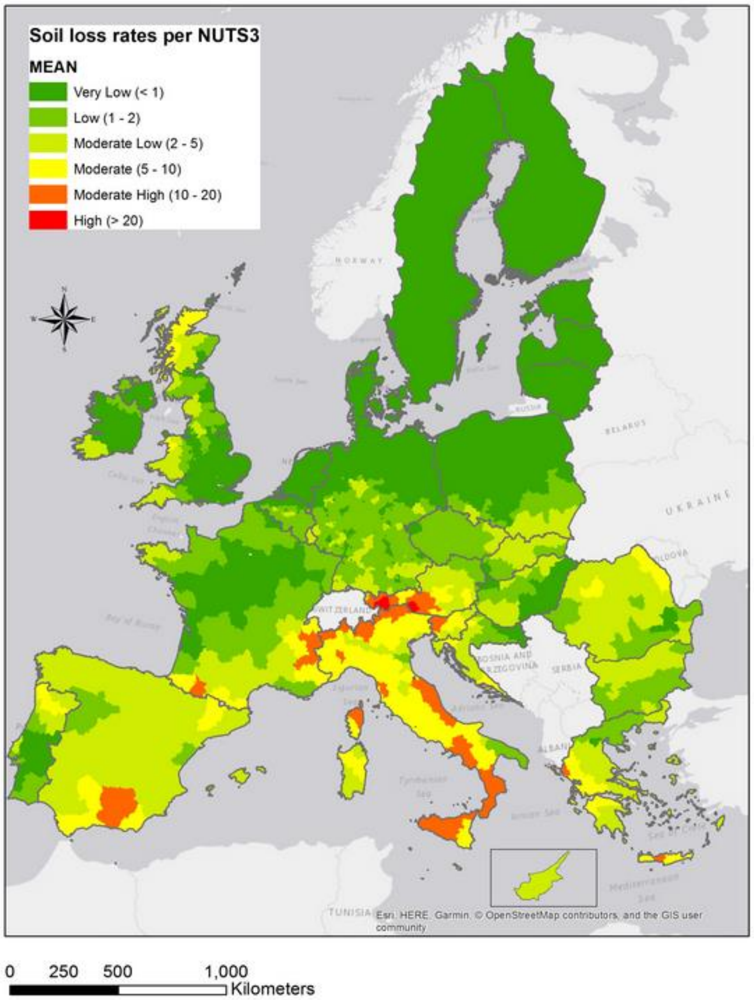

Figure 2: Mean soil erosion rate per NUTS3 (JRC, n.d.)

Water use and burden on water bodies

Based on Ecologic Institute's previous contributions to the European Environment Agency work on the development and assessment of indicators on water use intensity for agriculture[13] and the Water Exploitation Index plus in agriculture (Agri-WEI+), our initial consideration was that a good fit for the screening would be a regionalized version of the WEI+. This indicator compares the total fresh water used in a country per year against the renewable fresh water resources (groundwater and surface water) it has available in the same period. While there is no explicit agreement on this, values above 20% for this ration are generally considered as an indication of water scarcity, while values equal or bigger than 40% indicate situations of severe water scarcity, i.e. unsustainable water use. Some limitations are that annual calculations at national level cannot reflect uneven spatial and seasonal distribution of resources and may therefore mask water scarcity that occurs on a seasonal or regional basis. The calculation of the WEI+ at regional level is currently not conducted and would entail a large effort that falls beyond the scope of the task in BE-Rural.

[13] https://www.eea.europa.eu/data-and-maps/indicators/economic-water-productivity-of-irrigated-2/assessment

As a second option, we have looked into the reporting of the Water Framework Directive. Here, the benefits are that data availability for potentially applicable indicators like the status of water bodies in a river basin district, as well as substantial pressures and impacts on them are largely available and updated periodically. The status of water bodies is split into categories, and it incorporates ecological and chemical or quantitative and chemical conditions for surface and groundwater bodies, respectively. This would potentially be a good fit for the ordinal description of the regional systems' capacity that we envision for in Part C of the screening. The drawback with these data is that the spatial level is the river basin district, which often does not match the demarcations of regional political units. Nonetheless, we do not think it will be possible to find a better option that provides such wide EU coverage with direct reporting from the Member States.

Biodiversity

Understanding how the biodiversity in a region will respond to and/or is affected by bioeconomy expansion is critical. This issue is particularly pronounced considering the bioeconomy's potential role as a driver of land-use change, the variety of biomass being considered, and the diversity of ecosystems that can potentially supply the biomass for regional bioeconomies.

In order to understand and evaluate the sustainability of biomass production, it is therefore necessary to look at how biomass production affects the environment and ecosystems. This can be done through different lenses/indicators, which can be used to examine certain characteristics of the environment and ecosystems. One way to assess the sustainability of biomass production is its impact on biodiversity in a region. This in turn can be investigated with biodiversity indicators. One of these indicators is the High Nature Value Farmland-Indicator (HNV Farmland-Indicator). The HNV is an EU indicator of the conservation value of an agricultural area. The High nature Value Farmland (HNV) comprises hot spots of biodiversity in rural areas and is usually characterised by extensive farming practices.

When it comes to scaling up regional biomass production, which can go hand in hand with intensifying agriculture in a region, for example, the risk intensified agriculture might have on the regional biodiversity could be assessed with the HNV Farmland-Indicator and in our case though the loss of HNV farmland due to agricultural intensification per NUTS3. This can be explained by the fact that increased biomass production through intensification of agriculture directly influences the loss of HNV farmland. Another reason for choosing this indicator was the availability of data. The scaling (see figure below) could be summarised into three scales for our exercise.

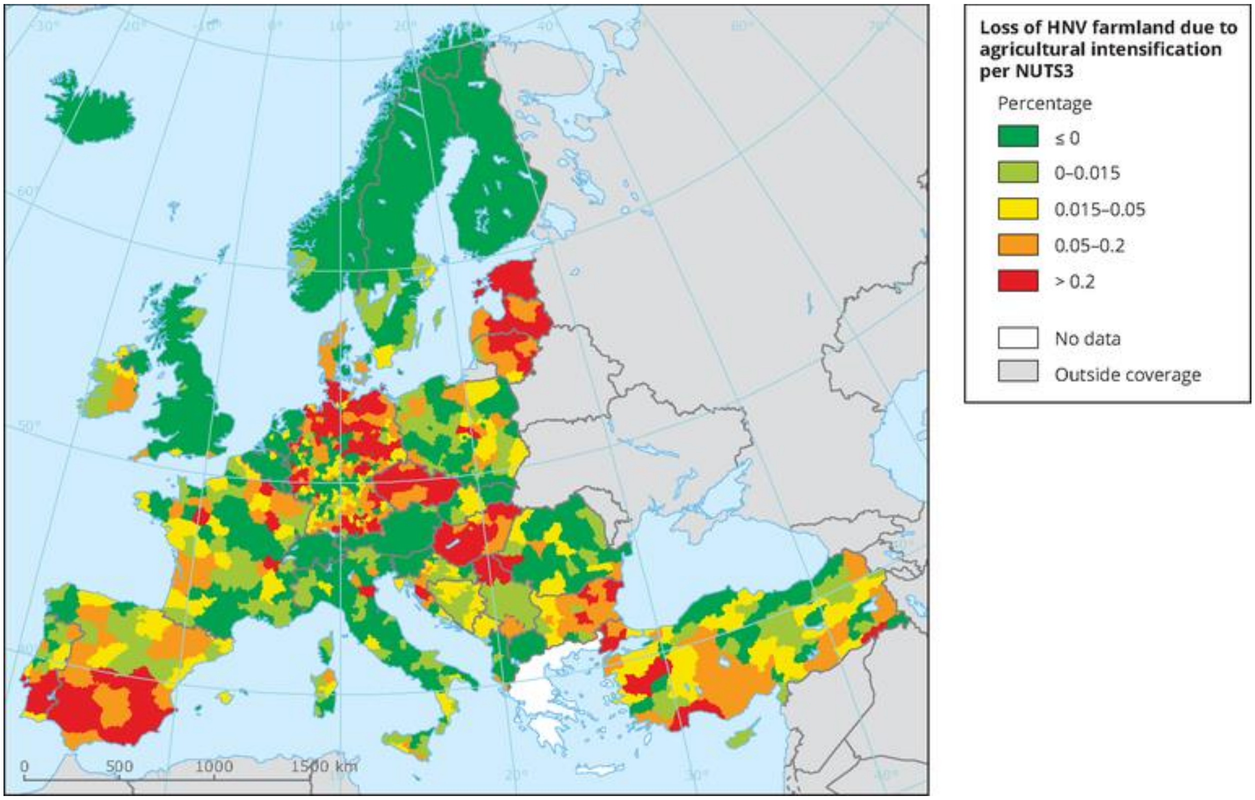

Figure 3: Loss of HNV farmland due to agricultural intensification per NUTS3 (EEA 2017)

Biomass

In order to be able to develop bioeconomy strategies and roadmaps or even business models in a region, it is important to be able to estimate the potential of the required raw materials, the biomass potential. Biomass potential is a term used to estimate possible contributions of biomass to the energy or raw material market. As a target figure, the biomass potential indicates which cultivated areas or raw material quantities are available in a region for use as renewable raw materials. These raw materials can come from the biomass sources mentioned above. It is therefore important to know about the biomass quantities from the respective sources. Eurostat provides the quantities of agricultural raw materials at NUTS2 level for agriculture. These give a general impression of the sectoral biomass capacities for this sector. It is important to mention that these capacities are not only biomass for energy and material use, but also for food.

To carry out a holistic biomass potential assessment, the quantities from forestry, fisheries and the waste sector would also have to be taken into account in this methodology.