BE-Rural

Bio-based strategies and roadmaps for enhanced rural and regional development in the EU

Note on the development of a sustainability screening for regional bioeconomy strategies

July 2022

Gerardo Anzaldúa, Ariel Araujo, John Tarpey, Levin Scholl, Rebecca Noebel, Oleksandra Tryboi, Chuan Ma

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818478.

Document information	
Project name:	BE-Rural
Project title:	Bio-based strategies and roadmaps for enhanced rural and regional development in the EU
Project number:	818478
Start date:	1st April 2019
Duration:	40 months

Report:	D5.4: Note on the development of a sustainability screening for regional bioeconomy strategies
Work Package:	WP5: Regional strategies & roadmaps
Work Package leader:	ECO
Task:	Subtask 5.3.2: Developing a sustainability screening tool to facilitate the consideration of ecological limits at the regional level
Task leader:	ECO
Responsible author(s):	Gerardo Anzaldúa, Ariel Araujo, John Tarpey, Levin Scholl, Rebecca Noebel (ECO); Oleksandra Tryboi (SECB); Chuan Ma (WIP)
Internal peer review:	Zoritza Kiresiewa, Holger Gerdes (ECO)
Planned delivery date:	M39
Actual delivery date:	M40
Reporting period:	RP2

Dissemination level of this report		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

ACKNOWLEDGMENT & DISCLAIMER

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818478.

EXECUTIVE SUMMARY

The bioeconomy carries great potential for achieving various policy aims related to sustainability. However, sustainability is not an intrinsic characteristic of the bioeconomy, but a potential it could achieve. For this reason, improving our capacity to assess the environmental impacts of bioeconomy development is of great importance if we are to ensure the sustainability of the transition at hand. This could be significantly challenging for regions which lack established structures and consistent instances for collaboration on the topic and depend largely on project-based impulses.

Regions are agreed to be the most appropriate territorial level at which to implement bioeconomy strategies. Similarly, the effects of bioeconomic activities can be best observed at a regional scale, particularly in terms of social and environmental impact. Yet, the available and favoured methods for assessing bioeconomy potential and environmental impact are rarely framed within the regional scale. Further, 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.

The aim of the BE-Rural Sustainability Screening is to support decision-makers to incorporate considerations of ecological limits into their regional bioeconomy strategies and roadmaps, and with this to contribute to Action 3 of EU Bioeconomy Strategy: "Understand the ecological boundaries of the bioeconomy". As an initial and exploratory task to be taken up in future initiatives (e.g. the upcoming Horizon Europe project SCALE-UP), the main purpose of this work has been to investigate the following research questions:

a) To what extent is it possible to combine openly accessible, regularly updated regional data (i.e. NUTS3 or similar) on water, land, biodiversity and biomass into a structured framework to draw broad indications of what potential ecological limits are in a given region?
b) To what extent would it possible to compare these indicative “baseline” results with state-of-the-art research on the environmental impacts of particular bioeconomic activities and management practices?
c) How much effort would it require to extract meaningful information from this that could inform decision-making and participatory processes?
d) What are the main gaps and barriers that users of this framework would encounter?

To do so, a working concept of the sustainability screening has been formulated and piloted in two BE-Rural OIPs: Stara Zagora, Bulgaria and in Vidzeme, Latvia. The development process employed has been an iterative and incremental one, with a broad outline of the approach defined at the start of the task and further shaped and refined as practical experiences were gathered during the pilots.

This report provides the context and justification for the development of BE-Rural’s Sustainability Screening, a description of its methodological procedure, and the syntheses of results from the two experimental implementations of the approach in the Stara Zagora and Vidzeme, which are included in full as annexes to this report. The last chapters present the main lessons learned from these two pilots and the overall conclusions of the task.

Table of contents

Figures

Tables

Abbreviations

BE	Bioeconomy
EBPF	European Bioeconomy Policy Forum
EC	European Commission
ENRD	European Network for Rural Development
EU	European Union
FAO	Food and Agriculture Organisation
ISBWG	International Sustainable Bioeconomy Working Group
LCA	Life Cycle Analysis
OIP	Open Innovation Platform
RSuDS	Rural Sustainable Drainage Systems
SAT	Self-Assessment Tool to promote sustainable chemical production in all regions
SDGs	Sustainable Development Goals
WFD	Water Framework Directive
WISE	Water Information Service for Europe

1 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 which 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, 2018a), 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. Following the EU Nomenclature of Territorial Units for Statistics (NUTS), regions are categorized under the 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

[1] 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.

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 should 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 burden of bioeconomic activities – in terms of used, consumed or degraded resources and emitted pollutants – should not be as high as to destabilize the ecological systems upon which regions depend.

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 Bioeconomy[2]. 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, skilled personnel, etc.). In addition, in certain contexts, the necessary data is often not available to conduct a valid LCA.

There are several variations of the methodology which differ from each other according to specific foci, such as 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 et al., 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 ecological systems 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 Commission[3] in Deliverable 2.3 "The bioeconomy potential of BE-Rural's OIP regions"[4]. 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 would be a key element in a sustainability assessment.

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

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

2.1 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[5], this could be addressed in two different stages: *baseline setting*, composed of the environmental conditions baseline and the biomass potential baseline. The former refers to the state of environmental conditions expressed in key indicators which reflect, for instance, vulnerability to soil degradation, depletion of water resources or reduction of biodiversity. The latter refers to the status quo of biomass production and use (obtained through the SAT tool and refined with regional statistics). Both components of the baseline can then be compared against an evaluation of the *potential ecological burden* of regionally relevant bioeconomic activities. This considers the change in the environmental conditions estimated previously caused by new or expanded economic activities, with the respective consequences for yields and processes. The approach to sustainability could theoretically then be structured as the overlay and comparison of the available capacity of the region's ecological system and the potential ecological burden of the relevant bioeconomic activities. The result of such a an exercise could serve as an important basis for

---

[5] According to the literature review conducted in the preparatory phase of this task, there is not a standard or generally accepted set of natural resource categories considered essential for bioeconomic activities. Different studies mention or cover various resource types. The authors have thus made a practical choice based on considerations of resource types that would provide a wide range of lessons during the piloting of the sustainability screening approach. These are:

- **Water:** there is a longstanding EU-level Directive in place (the Water Framework Directive) which entails regular reporting by Member States at sub-national level (River Basin District) and for which data is readily available and accessible via the Water Information Service for Europe (WISE). Using this to conduct Part B of the screening was expected to be a relatively straight-forward procedure, yet it would entail moderate data processing, a definition of a methodology, thresholds for the ordinal rating and an understanding of uncertainty levels associated with the methodology and thresholds chosen.
- **Soil:** no EU-level directive or common regulation exists for this resource, but relatively good coverage via accessible data and indicators on certain descriptors (e.g. soil erosion risk) are available from previous research.
- **Biodiversity:** EU-level Directives are in place (Birds and Habitats Directives) for which Member States regularly report data, and thus the experience handling this element was expected to be similar to the case of water. However, due to its own nature, biodiversity is a very different and difficult "item" to monitor at the regional level (the commonly used scale for data reporting is the biogeographical region). This was thus expected to necessitate additional processing and exploration.
- **Biomass: this provided the direct** link to the SAT results and an opportunity to elaborate on this using well-developed methodologies and regional statistics, for which we expected to encounter a moderate data capacity.

bioeconomy strategy/roadmap development as it would help to identify vulnerabilities in specific environmental parameters in the region, as well as the expected impacts that selected activities and management practices may have on them. Through this, it would be possible to identify which sectors or practices should be encouraged and/or avoided in the strategies/roadmaps.

2.2 Some methodological considerations and foreseeable limitations

As ecological systems do not necessarily overlap with political demarcations, the assessment would have to consider the set of ecological systems 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 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, collection, 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 screening. 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.

3 Methodology underpinning the BE-Rural Sustainability Screening

3.1 General description

In essence, the sustainability screening approach proposed is based on a rough appraisal[6] of a) the available capacity of the regional ecological systems 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 ecological systems. 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.

[6] A rough appraisal here refers to a high-level approximation and analysis based on readily available data and indicators and entailing only limited additional handling and processing. This is meant to keep the efforts and resources necessary for the exercise manageable.

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 providing structural support to certain economic activities or best management 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.

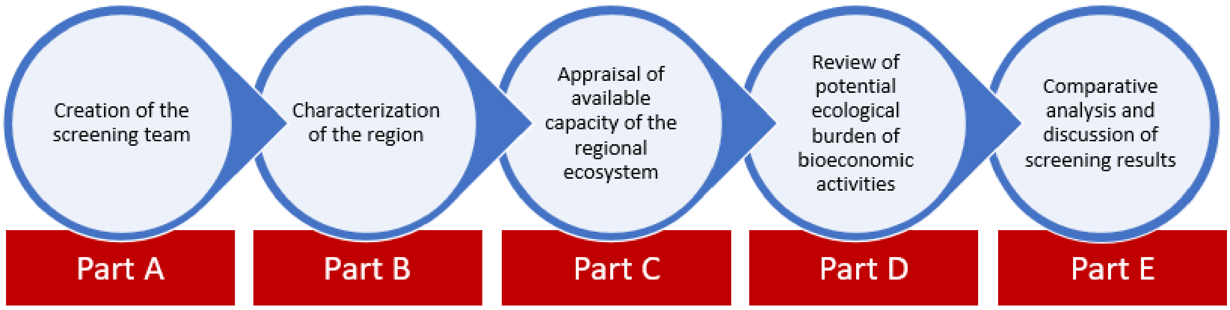
The BE-Rural Sustainability Screening is not intended as a replacement of the LCA, but rather as a way to set the groundwork for a more streamlined effort where the LCA is indeed possible ("warm up"); and to provide an entry level option to incorporate environmental sustainability considerations into 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 task was to develop a methodological concept and test it in two of the BE-Rural OIPs for its further refinement. This comes as a response to a shortcoming in the BE-Rural project identified during its first periodic review. The project'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 project's work plan 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 can contribute to increase the method's replicability in different contexts and regions.

3.2 Structure

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 screening team

The screening will be conducted by a team made up of interested parties (regional authorities, decision-makers, planners and stakeholders) with guidance from a technical group made up of both local and foreign bioeconomy sustainability experts. The approach aims to bring businesses, universities and civil society representatives on board, for instance through the involvement of clusters or sectoral business associations, research units and civil associations in a joint development of these strategies/roadmaps. The mentioned technical group that would accompany the screening team and provide support could take the shape of a European Technical Group on Bioeconomy Sustainability, similar to those under the Common Implementation Strategy of the EU Water Framework Directive, that could keep the discussion of key concepts and terms evolving and support as ad-hoc advisory group for the regions. The EU Expert Group linked to the Bioeconomy Policy Support Facility[7], 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)[8], and the FAO's International Sustainable Bioeconomy Working Group (ISBWG)[9] could eventually host this regional advisory group or be invited to pick up its mandate. The main output of Part A is the consolidated screening team.

Part B – Characterization of the region

Once the screening team has been formed, its first task is to produce a general outline of environmental conditions (climate, land cover, etc.) and run an assessment using the SAT (Self-Assessment Tool to promote sustainable chemical production in all regions)[10] to define biomass availability and bioeconomy potential in the region. In addition, the team is to discuss and produce a list of relevant bioeconomic activities that would be pursued/promoted as part of the region's bioeconomy strategy. 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[11] documented in Deliverable 2.2, to set the basis for the screening. Similarly, the broad categories of bioeconomic activities that the OIP facilitators defined as relevant in their regional strategy and roadmap documents (Deliverable 5.3) are relevant inputs. The key outputs of Part B are the outline on regional conditions and bioeconomy potential (including an appraisal of biomass availability) and a shortlist of bioeconomy activities deemed relevant for the region.

Part C – Appraisal of available capacity of the regional ecosystem

Using existing indicators and expert opinion from within and beyond the screening team, this part of the screening will yield a qualitative (ordinal) categorization of the capacity of the ecological systems in the region to underpin bioeconomy activities. Thus, the key output of Part C is the baseline setting from which the development or update of the regional bioeconomy strategy/roadmap would part.

Part D – Review of the potential ecological burden of regionally relevant bioeconomic activities

Based on available data and information indicating the level of resource consumption associated to economic activity types (following the NACE classification) and management practices, the screening team will review the potential ecological burden (i.e. foreseeable levels of resource use, consumption or degradation) of the relevant bioeconomy activities shortlisted in Part B. Metadata and contextual information from any datasets, indicators and reference studies used should also be compiled. This is to ensure transparency as regards aspects of comparability and uncertainty. The key output of Part D is the synthesis of the potential ecological burden of relevant bioeconomy activities.

Part E – Overview of screening results and recommendations

Based on the results of Parts C and D, the team will overlay and compare the available capacity of the region's ecological system and potential ecological burden of the relevant bioeconomic activities, discuss the results and prepare a synthesis table indicating the natural resources that could be at risk or vulnerability, or, alternatively, could benefit from the adoption of specific management practices. This will be supplemented with recommendations on bioeconomic activities and practices to avoid or incorporate with reserve into the regional bioeconomy strategy/roadmap.

---

[7] 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

[8] https://enrd.ec.europa.eu/enrd-thematic-work/greening-rural-economy/bioeconomy_en

[9] See: http://www.fao.org/in-action/sustainable-and-circular-bioeconomy/international-sustainable-bioeconomy-working-group/en/

[10] See: https://ecrn.net/self-assessment-tool-to-promote-sustainable-chemical-production-in-all-regions/

[11] PESTEL stands for political, economic, social, technical, environmental and legal assessment (see Anzaldúa et al. 2019)

4 Screening results and main lessons from the application of the method in the case study regions

4.1 Overview of screening results

This section presents excerpts of the screening reports of the Stara Zagora and Vidzeme regions which in turn resulted from the piloting of the concept described in previous chapters. They are included here to provide the reader with more concrete examples of what the screening can yield and how the resulting information can be presented. The full screening reports for both pilots, including a regional characterisation and descriptions of datasets, indicators, methodologies, uncertainties and information on potential ecological burden are found in the annex to this document.

4.1.1 Stara Zagora, BG

The pilot screening conducted for the Stara Zagora region yielded the appraisal of available capacity of the regional ecological system shown in the third and fourth columns of Table 1 below. The OIP selected forestry as one of the priority bioeconomic activities in their regional bioeconomy strategy. Based on this and a review of scientific literature on environmental impacts of forestry, the fifth and sixth columns list potentially beneficial and potentially detrimental forestry management practices. These results may carry considerable uncertainty and in some cases may be limited in scope. Thus, they are intended here merely as an exercise to show what the pilot of the sustainability screening for the region was capable of generating.

Table 1 Overview of results of the sustainability screening for the Stara Zagora region

Resources screened		**Ordinal Baseline Rating**	**Appraisal of available ecological capacity**	**Forestry Management Practices**	
Category	**Sub-Category**			**Potentially beneficial to the baseline status**	**Potentially detrimental to the baseline status**
Water	**Surface water bodies**	(red)	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. Further, there is a	**Filter strips** around point sources of pollution to capture and transpire part of the pollutant load. **Afforestation** with species that can effectively bind the nutrients that cause the pollution without	**Reforestation / afforestation** with species of high water demand in areas subject to water abstraction pressures could result in water scarcity problems which could subsequently exacerbate water quality issues.

			high proportion of surface water bodies under unknown chemical conditions. 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. Almost half of the lakes in the RBD are affected by unknown impacts.	generating new pressures and impacts (e.g. water scarcity). **Partial selection harvesting** to maintain stable conditions of substrate availability and light exposure, promoting nutrient cycling.	**Large-scale harvesting operations (e.g. clearcutting)** may interrupt nutrient cycling functions and cause nutrient enrichment of downstream water bodies.
	Ground-water bodies		Almost half of the groundwater bodies in the East Aegean RBD are in poor chemical status. Diffuse sources of pollution are the most recurrent pressures on groundwater bodies in the RBD. Nutrient pollution is the most recurrent impact on groundwater bodies in the RBD.		
Land Resour-ces	**-**		With a mean soil erosion rate in all lands of 1.4 t/ha per year in 2016 (latest available data), Stara Zagora is not considered vulnerable to erosion. Erosion in arable lands is 2.1 t/ha per year, which is still well below the European threshold for low erosion level (low < 5 t/ha per year). Only 0.82% of all land in	**Artificial regeneration** with various tree species (mixing hardwood and coniferous species) can increase the abundance of soil microflora and fauna, reduce acidity, as well as improve the moisture and nutrient contents of soils	**Site preparation** e.g. through raking, plowing, and bedding can all lead to soil compaction and the removal of topsoil, while the application of herbicides can lead to issues of toxicity in the soil **Understory cleaning** may cause soil compaction, which

			Stara Zagora surpasses the European threshold for severe erosion rate (severe >=10 t/ha per year). In this context, soil erosion does not pose a risk for the sustainability of the bioeconomy in the region.	**Afforestation** – particularly in the context of shelter belts for farmland– can potentially reduce soil erosion and increase soil moisture content. It can also improve the infiltrability of the soil and can lead to reduced salt inputs, which is beneficial for soil quality **Precommercial thinning** generally involves cutting trees and leaving them on the ground, which can enhance the soil quality	can have negative effects on soil moisture content and other soil features. Large-scale harvesting operations (e.g. **clearcut** and final harvest of **shelterwood**) can cause reduced soil porosity and water infiltration, leading to increased waterlogging on flat land, and soil runoff and erosion on slopes
Biodiver-sity	**Agricultural land**		Stara Zagora area, NUTS3 number BG344, has a rate of 0.406 regarding losing HNV farmland. This rate is rather high in comparison with other NUTS3 unit in Europe (as only 169 out of 1483 NUTS3 regions have loss rates higher than 0.2%).	**Artificial regeneration** with various tree species can generate a greater diversity of habitats to the benefit of native species. Moreover, mixed plantations tend to be more resistant and resilient to natural and human disturbances **Afforestation** of (particularly intensive) agricultural land can provide a comparably favourable habitat for forest species increase connectivity between patches of (semi) natural forest The species richness of forests **clearcut** in the past but that did not undergo a change in tree species (**natural or artificial**	An **artificial regeneration** that replaces already existing (semi)natural forest with plantation forest has a negative impact on species richness and diversity **clearcutting** causes large and intense disturbances and a subsequent change in the tree species (mainly **artificial regeneration**) can have a strong detrimental effect on species richness
	Forested land		Between 2012 and 2018, Stara Zagora experienced a gross forest cover increase of 25.875 ha. The majority of cover losses and gains can be attributed to changing broad-leaf cover, particularly to a change of previously non-forest land to new broadleaf forest cover. During the same period, the region accounted		

			for a relatively small gross forest cover loss of 2.157 ha, resulting in a net forest gain of 23.718 ha. The area of mixed forest cover has increased by a substantial extent over the observed period, explaining more than one third of the gross forest increase.	**regeneration**) is comparable to unmanaged references **Partial selective harvest** has generally no significant negative impact and is even beneficial for certain species such as lychens.	
Biomass	**-**		Screening of biomass resources in Stara Zagora showed that there is a potential of biomass resources from forest and agriculture that can be utilised by applying appropriate practices for collection of a sustainably available biomass. Other parts of potential are of theoretical origin and include biomethane, when produced from animal manure, and energy crops, when grown on marginal lands. Conservative assessment shows the availability of at least 105,423.2 t of dry matter of forest biomass. Further detailed assessment may increase this figure by considering a sustainable amount of primary and secondary forest residues.	**Applying a felling-over-increment ratio of 70%** to avoid over-maturing will help to decrease/prevent risks of diseases and forest fires. It may positively influence the net annual increment and increase the biomass potential over time.	**Increasing and staying much below the recommended felling-over-increment ratio of 70%** may decrease the biomass potential over time.

4.1.2 Vidzeme, LV

The pilot screening conducted for the Vidzeme region yielded the appraisal of available capacity of the regional ecological system shown in the third and fourth columns of Table 2 below. The OIP selected forestry as one of the priority bioeconomic activities in their regional bioeconomy strategy. Based on this and a review of scientific literature on environmental impacts of forestry, the fifth and sixth columns list potentially beneficial and potentially detrimental forestry management practices. <u>These results may carry considerable uncertainty and in some cases may be limited in scope. Thus, they are intended here merely as an exercise to show what the pilot of the sustainability screening for the region was capable of generating.</u>

Table 2 Overview of results of the sustainability screening for the Vidzeme region

Resources screened		**Ordinal Baseline Rating**	**Appraisal of available ecological capacity**	**Forestry Management Practices**	
Category	**Sub-Category**			**Potentially beneficial to the baseline status**	**Potentially detrimental to the baseline status**
Water	**Surface water bodies**		Only over one third (35%) of the rivers and lakes within the Gauja RBD are in Good Ecological Status or higher. Even more concerning is the proportion of rivers and lakes achieving Good Chemical Status, which is only 12% of the total. Significant pressures on rivers are quite varied, with point sources of pollution being the most recurrent ones, followed closely by diffuse sources of pollution, changes in hydromorphology and unknown anthropogenic pressures. The latter two are also important pressures on lakes in the RBD, but diffuse sources are substantially more recurrent for this water body	**Thinning** of- and measures to promote **mixed stands in riparian zones**, combined with establishment of **Rural Sustainable Drainage Systems** (RSuDS). **Buffer and filter strips** around point sources of pollution to capture and transpire part of the pollutant load. **Partial selection harvesting** to maintain stable conditions of substrate availability and light exposure, promoting nutrient cycling.	While currently not common practice in Latvia, **fertilisation** to increase forest productivity can result in excess nutrients reaching downstream water bodies. As new sites and marginal lands are developed in the future, adopting this practice could result in further deterioration of surface water bodies in the RBD, and eventually cause groundwater bodies to lose their currently Good Chemical status. **Large-scale harvesting operations (e.g. clearcutting)** may interrupt nutrient cycling functions and cause nutrient

			type. As regards significant impacts, both rivers and lakes in the Gauja RBD are affected most often by nutrient pollution, while habitat alterations due to morphological changes are also relevant for both water body types.		enrichment of downstream water bodies.
	Ground-water bodies		All five groundwater bodies within the Gauja RBD are reported to be in Good Quantitative and Good Chemical Status. Only one of the five is under pressure from point sources (contaminated sites or abandoned industrial sites), but the impact associated to this pressure has not been specified in the WFD reporting.		
Land Resour-ces	**-**		With a mean soil erosion rate in all lands of 0.3 t/ha per year in 2016 (latest available data), Vidzeme is not considered vulnerable to erosion. Erosion in agricultural areas and natural grasslands lands is 0.7 t/ha per year, which is still well below the European threshold for low erosion level (low < 5 t/ha per year). Only 0.01% of all lands in Vidzeme surpass the European threshold for severe erosion rate (severe >=10 t/ha per year). In this	**Artificial regeneration** with various tree species (mixing hardwood and coniferous species) can increase the abundance of soil microflora and fauna, reduce acidity, as well as improve the moisture and nutrient contents of soils **Afforestation** – particularly in the context of shelter belts for farmland– can potentially reduce soil erosion and increase soil moisture content. It can also improve the infiltrability of the	**Site preparation** e.g. through raking, plowing, and bedding can all lead to soil compaction and the removal of topsoil, while the application of herbicides can lead to issues of toxicity in the soil **Understory cleaning** may cause soil compaction, which can have negative effects on soil moisture content and other soil features.

			context, soil erosion does not pose a risk for the sustainability of the bioeconomy in the region.	soil and can lead to reduced salt inputs, which is beneficial for soil quality **Precommercial thinning** generally involves cutting trees and leaving them on the ground, which can enhance the soil quality	Large-scale harvesting operations (e.g. **clearcut** and final harvest of **shelterwood**) can cause reduced soil porosity and water infiltration, leading to increased waterlogging on flat land, and soil runoff and erosion on slopes
Biodiver-sity	**Agricultural land**		The Vidzeme region, NUTS3 number LV008, has a rate of 0.136 regarding losing HNV farmland. This rate is moderate in comparison with other NUTS3 unit in Europe.	**Artificial regeneration** with various tree species can generate a greater diversity of habitats to the benefit of native species. Moreover, mixed plantations tend to be more resistant and resilient to natural and human disturbances **Afforestation** of (particularly intensive) agricultural land can provide a comparably favourable habitat for forest species increase connectivity between patches of (semi) natural forest The species richness of forests **clearcut** in the past but that did not undergo a change in tree species (**natural or artificial regeneration**) is comparable to unmanaged references **Partial selective harvest** has generally no significant negative	An **artificial regeneration** that replaces already existing (semi)natural forest with plantation forest has a negative impact on species richness and diversity **clearcutting** causes large and intense disturbances and a subsequent change in the tree species (mainly **artificial regeneration**) can have a strong detrimental effect on species richness
	Forested land		Between 2012 and 2018, Vidzeme experienced a gross forest cover loss of 84.930 ha, roughly 60% of which derived from the conversion of broadleaf forests to non-forest areas. Elsewhere, however, the net forest gain accounted for 132.862 ha during the same time period with similar ratios of forest types, Changing broadleaf forest covers account for the majority of forest cover losses and forest cover gains. Most of the 105.991 ha net increase in broadleaf canopy cover stems from new forest growth on previous non-forest land.		

			Moreover, the conversion of 72.410 ha of broadleaf forests to mixed forests accounts for the largest share (80%) of conversions from one forest type to another. The area of mixed forest cover has increased by the largest extent.	impact and is even beneficial for certain species such as lychens.	
Biomass	**-**		Screening of biomass resources in Vidzeme region showed that there is a potential of biomass resources from forest and agriculture that can be utilised by applying appropriate practices for collection of a sustainably available biomass. Other parts of potential are of theoretical origin and include biomethane, when produced from animal manure, and energy crops, when grown on marginal lands. Conservative assessment shows the availability of at least 204,788.8 t of dry matter of forest biomass. Further detailed assessment may increase this figure by considering a sustainable amount of primary and secondary forest residues.	**Applying a felling-over-increment ratio of 70%** to avoid over-maturing will help to decrease/prevent risks of diseases and forest fires. It may positively influence the net annual increment and increase the biomass potential over time.	**Increasing and staying much below the recommended felling-over-increment ratio of 70%** may decrease the biomass potential over time.

4.2 Lessons on the operability of the methodology

The application of the methodology in the two case study regions highlighted, on the one hand, its potential if applied with suitable adjustments to the local context and considering the available data. On the other hand, a number of limitations to the approach also emerged.

A key challenge encountered during the screening was difficulty in finding relevant resource indicators at the NUTS3 (regional) level which were both readily available and regularly updated. This was the case for water and for specific items of biomass, where no such indicators or data could be found and, consequently, alternative information sources had to be reviewed and new procedures conceived. As this sometimes required resorting to more aggregated data (like in the case of Stara Zagora, where the area covered by the East Aegean RBD is still much larger than the territory of the oblast), some discrepancies between the results obtained and statements published in official reports were found. However, as these were mostly punctual items, overall the appraisal of baseline conditions in the regions with regards to these resources is considered acceptable for a first instance, even if the complexity of the analysis was slightly higher than expected.

On the other hand, for the case of land resources, it was possible to find an indicator that was available at the NUTS3 level and regularly updated. The selected indicator on soil (mean rate of soil erosion by water) however did not match up exactly with the information found in the literature regarding impacts of forestry practices on soil. The reviewed literature covered a wider variety of issues related to soil quality and its deterioration besides erosion, such as soil organic carbon, salinization and acidity. Thus, it was more difficult than expected to derive recommendations from the literature, even if the selected indicator can be considered a proxy for soil degradation as a whole (Panagos et al., 2020). At an early stage of the development of the methodology, we considered using the indicator "soil organic carbon" (SOC), but the lack of availability of centralized and regularly updated data at NUTS3 level for this indicator rendered it less suitable for the purposes of this screening. However, some information on this indicator and other parameters of soil quality in Bulgaria could be found through the involvement of the local partners from the OIP Stara Zagora. This allowed for some more specific recommendations from the literature which enriched the results of the assessment for the Stara Zagora region. Moreover, this highlights indispensable need to form a screening team early on in order to fill existing information gaps as much as possible with locally sourced information.

Regarding biodiversity, it was possible to find an indicator that is regularly updated and publicly available at the NUTS3 level, but it is only applicable for agricultural land. This presented a particular difficulty for the application of the methodology in the case study regions, which focused on the forestry sector. This issue highlights an overarching difficulty of assessing biodiversity. While there are various potential datasets for this at EU level, such as reporting under the Birds and Habitats Directives, their spatial scale is based on biogeographical and marine regions, making it difficult to use this data at a smaller regional scale such as NUTS3. Moreover, data for a specific region, especially regarding species, is very hard to obtain, for one because species are mostly mobile and not endemically encountered in single regions. Therefore, while such data would best match the information found in the literature on impacts, which focused on species richness, it was not possible to find an indicator that was openly available in this regard. Availability of this type of data is highly dependent on national efforts and resources and implementation by local authorities or active non-governmental engagement (e.g. monitoring by NGOs or crowd-sourced science). In this instance, it was still not possible to obtain relevant information or data through the partners in the OIPs. Nonetheless, it is still possible that such information does exist in some regions, but it was not possible to find it in the remit of this exercise, mostly due to language limitations.

With this in mind, it is important to highlight that because the project team carried out the application of the methodology in its entirety and received support from the OIPs on mostly concrete aspects, the language barrier presented a very substantial limitation in this iteration of the sustainability screening. However, in a practical setting, where an assessment team is set up that is proficient in the local language of the region where the screening is applied, this barrier should be overcome. Furthermore, such a team would likely have access not only to documents that are publicly available on the internet or on a centralized data portals such as Eurostat or the EEA, but also to those from regional and local authorities.

5 Conclusions

Overall, the authors consider that the efforts spent on this task have been fruitful as they have shed additional light on an angle of sustainability in bioeconomy which has received limited attention so far (high-level regional scale assessments). The representatives of the regional authorities who reviewed the two pilot screening reports considered these documents useful. The theoretical concept of the sustainability screening described in this report is highly ambitious. Not in terms of producing results with high resolutions or low uncertainty levels (as the aim is to produce a broad initial overview that informs subsequent work), but in terms of providing a structured approach to combine openly accessible, regularly updated regional data on water, land, biodiversity and biomass and to draw broad indications of what the potential ecological limits of a given region are. The practical implementation of the concept has clearly illustrated the range and level of challenges that those wishing to conduct a screening following this approach would encounter. While the baseline setting (Part C) was generally straight forward and required moderate efforts for processing of the data and interpreting the results, the estimation of the potential ecologic burden of bioeconomic activities (Part D) proved significantly more challenging. Here, the lack of quantitative data on the effects of specific economic activities and management practices on ecological systems was the biggest hurdle. While many LCA studies are indeed available, and while efforts are currently ongoing to compile and make accessible their results, data capacity and accessibility in this aspect will still require time until it reaches the level of the data sources used for the baseline setting. The knowledge that can be collected from academic literature e.g. on the impacts of specific forestry management practices, is useful and expected to grow as research initiatives exploring the topic of sustainability in the bioeconomy continue to emerge. For now though, the dependency on existing studies that often have been conducted in contexts that are different from that of the region where the screening is conducted generates important limitations. Only via the incorporation of local knowledge (e.g. via local or national experts involved in the screening team), can the more generic synthesis results and recommendations be placed in the region’s context and given further sharpness and relevance. As regards the effort required to extract meaningful information, the pilots showed that attaining useful results does require at least some members of the team to have good knowledge on the different elements that the screening explores to keep the necessary effort levels manageable. Here, the role of an international technical group on bioeconomy sustainability (resembling the working groups of the Common Implementation Strategy of the WFD) would also be highly valuable. In addition, the detailed descriptions of the methodologies used and the concrete examples and lessons learned that the two pilots conducted in BE-Rural yielded already provide good bases that future users can benefit from. As with similar assessment frameworks, further iterations and implementation of this approach would yield results that, if made openly accessible, would expand the available data from which future implementations could pull from. These future implementations and further refinement of the sustainability screening is already secured in the work plan of an upcoming Horizon Europe project, and it represents a promise for further exploration of bioeconomy sustainability at the regional level.

References

Anzaldúa, G., Abhold, K., Araujo, A., Chebotarev, A., Cosnita, D., Diaconescu, T., Dimov, L., Duic, N., Iorgulescu, R., Kiresiewa, Z., Lazdina, D., Makovskis, K., Markovska, M., Mihajloska, E., Mytlewski, A., Pauna, C., Pavlova, I., Rakowski, M., Schock, M., Szulecka, O., Tröltzsch, J., Zelljadt, E. (2019). D2.2 The macro-environment surrounding BE-Rural's Open Innovation Platforms. Deliverable D2.2 of the H2020 BE-Rural project. https://be-rural.eu/wp-content/uploads/2019/10/BE-Rural_D2.2_Macro-environment_OIPs.pdf

European Commission – EC (2018a). A sustainable Bioeconomy for Europe: strengthening the connection between economy, society and the environment – Updated Bioeconomy Strategy. Directorate-General for Research and Innovation, European Commission. Brussels

European Commission – EC (2018b): Environmental impact assessments of innovative bio-based products–Summary of methodology and conclusions. https://op.europa.eu/en/publication-detail/-/publication/9ab51539-2e79-11e9-8d04-01aa75ed71a1 (accessed 27.05.2021)

Gawel, E., Pannicke, N., & Hagemann, N. (2019). A Path Transition Towards a Bioeconomy—The Crucial Role of Sustainability. Sustainability, 11(11), 3005. MDPI AG. Retrieved from http://dx.doi.org/10.3390/su11113005

Jander, W., Wydra, S., Wackerbauer, J., Grundmann, P., & Piotrowski, S. (2020). Monitoring Bioeconomy Transitions with Economic–Environmental and Innovation Indicators: Addressing Data Gaps in the Short Term. Sustainability, 12(11), 4683. MDPI AG. Retrieved from http://dx.doi.org/10.3390/su12114683

Jarosch, L., Zeug, W., Bezama, A., Finkbeiner, M., & Thrän, D. (2020). A Regional Socio-Economic Life Cycle Assessment of a Bioeconomy Value Chain. Sustainability, 12(3), 1259. MDPI AG. Retrieved from http://dx.doi.org/10.3390/su12031259

Lindqvist, A. N., Broberg, S., Tufvesson, L., Khalil, S., & Prade, T. (2019). Bio-Based Production Systems: Why Environmental Assessment Needs to Include Supporting Systems. Sustainability, 11(17), 4678. MDPI AG. Retrieved from http://dx.doi.org/10.3390/su11174678

Panagos, P., Ballabio, C., Poesen, J., Lugato, E., Scarpa, S., Montanarella, L., & Borrelli, P. (2020). A Soil Erosion Indicator for Supporting Agricultural, Environmental and Climate Policies in the European Union. Remote Sensing, 12(9), 1365. MDPI AG. Retrieved from http://dx.doi.org/10.3390/rs12091365

Peterson, K. & Kaaret, K. (2020) Bioeconomy pathways at national and regional levels. SEI discussion brief February 2020. Stockholm Environment Institute. Stockholm, Sweden

Pfister, S., Oberschelp, C. & Sonderegger, T. (2020). Regionalized LCA in practice: the need for a universal shapefile to match LCI and LCIA. Int J Life Cycle Assess 25, 1867–1871. https://doi.org/10.1007/s11367-020-01816-7

Reinhard J., Bengoa X. & Liernur A. (2021): geoFootprint, Technical Documentation. Version 1, February 2021. Quantis, Lausanne, Switzerland.

Zeug, W., Bezama, A., Thrän, D. (2020). Towards a Holistic and Integrated Life Cycle Sustainability Assessment of the Bioeconomy – Background on Concepts, Visions and Measurements. UFZ Discussion Papers, Department of Bioenergy, 7/2020. Helmholtz-Zentrum für Umweltforschung GmbH – UFZ. Leipzig, Germany

Annex: Screening reports for the Stara Zagora and Vidzeme regions

Bio-based strategies and roadmaps for enhanced rural and regional development in the EU

BE-Rural Sustainability Screening Report: Stara Zagora Region

July 2022

Gerardo Anzaldúa, Ariel Araujo, John Tarpey, Oleksandra Tryboi, Levin Scholl, Rebecca Noebel, Chuan Ma

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818478.

Document information	
Project name:	BE-Rural
Project title:	Bio-based strategies and roadmaps for enhanced rural and regional development in the EU
Project number:	818478
Start date:	1st April 2019
Duration:	40 months

Report:	D5.4: Note on the development of a sustainability screening for regional bioeconomy strategies Annex 1: BE-Rural Sustainability Screening Report: Stara Zagora Region
Work Package:	WP5: Regional strategies & roadmaps
Work Package leader:	ECO
Task:	Subtask 5.3.2: Developing a sustainability screening tool to facilitate the consideration of ecological limits at the regional level
Task leader:	ECO
Responsible author(s):	Gerardo Anzaldua, Ariel Araujo, John Tarpey, Levin Scholl, Rebecca Noebel (ECO); Oleksandra Tryboi (SECB); Chuan Ma (WIP)
Internal peer review:	Martin Stoyanov, Iliana Pavlova (BIA); Elka Boneva (Agriculture Directorate of the Stara Zagora Oblast)
Planned delivery date:	M39
Actual delivery date:	M40
Reporting period:	RP2

Dissemination level of this report		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

ACKNOWLEDGMENT & DISCLAIMER

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818478.

EXECUTIVE SUMMARY

This synthesis report documents the pilot of the BE-Rural sustainability screening as implemented to examine the case of the Stara Zagora region in Bulgaria. The pilot was conducted as part of the BE-Rural project during the first semester of 2022. The main purpose of this task was to generate relevant insights for the further development and implementation of the sustainability screening beyond the project, while providing some initial indications and hopefully inspiration to the members of the Open Innovation Platform (OIP) Stara Zagora on some of the aspects to consider to build environmental sustainability into their bioeconomy strategy. The pilot was carried out by Ecologic Institute and WIP with support from BIA and was reviewed by a representative of the Stara Zagora Oblast.

The report introduces the sequence of steps carried out as part of the pilot and uses these as main structure for the document.

Stara Zagora is a region with great potential for the development of a bioeconomy, with numerous valuable natural resources, an advantageous geographical location, well-developed infrastructure, and unexplored business potential. In 2021, as part of the BE-Rural project, the OIP Stara Zagora drafted a bioeconomy strategy which, among others, listed agriculture and forestry as priority economic activities to develop in the future within a frame of sustainable resource management. The examination of the region's situation using BE-Rural's sustainability screening approach is an initial attempt to generate preliminary, yet concrete considerations of ecological limits as part of this process.

The pilot screening, building to the extent possible on openly accessible, regularly updated regional level data (e.g. from the EU Water Framework Directive reporting, European Statistics like the loss of High Nature Value Farmland, Copernicus Earth Observation data on forest cover, and from national and regional statistics on forest and agricultural biomass production), has illustrated potential concerns regarding the water resources and biodiversity that the Stara Zagora region depends on, while land resources and biomass potential appear to be in low risk of vulnerability from an environmental sustainability perspective.

Given the limited resources available for this task (not included or budgeted for in the original work plan), as well as its illustrative purpose, the pilot screening focused on one of the priority economic sectors from Stara Zagora's bioeconomy strategy: Forestry. On this basis, a literature review on the potential environmental impacts of various forestry management practices was carried out to illustrate the ecological burden that the establishment of new forestry operations or expansion of existing ones could have on the region's ecological systems.

Overlaying and comparing the appraisal of ecosystem and resource capacities with the potential ecological burden of the reviewed forestry activities, the screening team has been able to produce a broad diagnosis and general recommendations that could serve as initial considerations for decision-makers and other stakeholders of Stara Zagora's bioeconomy. While limited in its scope and extent, the results of this exercise will hopefully serve as groundwork for open, inclusive and transparent discussions on the sustainability of the region's future development.

Table of contents

Figures

Tables

Abbreviations

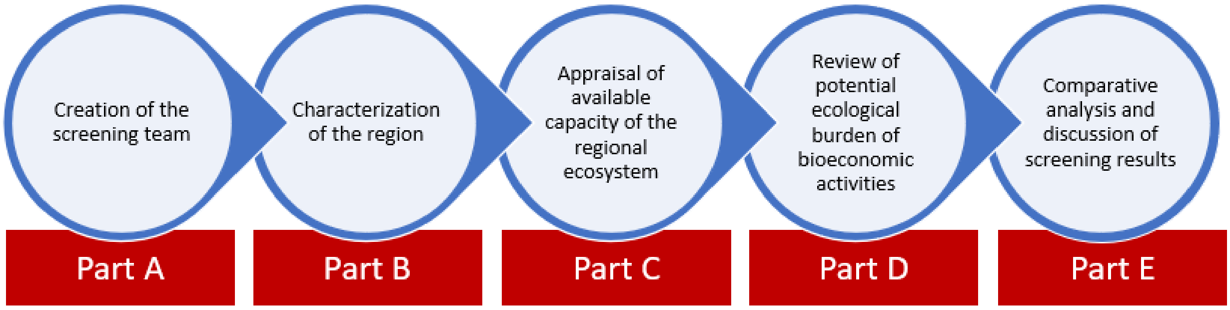
CAP	Common Agricultural Policy
CBD	Convention on Biological Diversity
CORINE Land Cover	Coordination of Information on the Environment, Land Cover
EC	European Commission
EEA	European Environment Agency
EU	European Union
JRC	Joint Research Centre
NUTS	Nomenclature des Unités Territoriales Statistiques
OIP	Open Innovation Platform
PESTEL Analysis	Political, economic, social, technical, environmental and legal analysis
RBA	River Basin Authority
RBD	River Basin District
RBMP	River Basin Management Plan
RES	Renewable Energy Source
SAT	Self-Assessment Tool to promote sustainable chemical production in all regions
WEI+	Water Exploitation Index +
WFD	Water Framework Directive
WISE	Water Information System for Europe
RES	Renewable Energy Source
SAT	Self-Assessment Tool to promote sustainable chemical production in all regions
WEI+	Water Exploitation Index +
WFD	Water Framework Directive
WISE	Water Information System for Europe

1 Introduction

The BE-Rural sustainability screening has been piloted during the first semester of 2022 to generate relevant insights for its further development and implementation beyond the project.

Figure 1 shows the structure (i.e. the sequence of steps) that has been ideated for the process. With the exception of Part A, all elements therein have been covered at least partly during the pilot, and the outcomes are documented in this screening report for Stara Zagora, Bulgaria. The structure is split into five main parts that are conducted sequentially as follows:

Figure 1 Structure of the BE-Rural sustainability screening



Part A – Creation of the screening team [Not covered in the pilot]

The BE-Rural sustainability screening is targeted to *authorities, policy and decision makers in regions with relatively low financial resources and/or expertise in environmental sustainability* who are interested or already engaged in developing a bioeconomy strategy/roadmap or in improving the environmental sustainability considerations of their existing one. Moreover, the approach aims to bring businesses, universities and civil society representatives on board, for instance through the involvement of clusters or sectoral business associations, research units and civil associations in a joint development of these strategies/roadmaps. To accompany the screening team and provide guidance, the authors' suggestion has been to establish a technical group with local and foreign experts on bioeconomy sustainability.

For piloting the approach within the project, the scientific partners of the consortium who have authored this report have taken over the role of the screening team for the most part. This was due to the lack of capacity and resources left in the project to get OIP members engaged in depth in an additional and elaborate activity (the sustainability screening was not included in the original workplan of the project and no additional resources were made available for its development and piloting). Nevertheless, the report has been reviewed by some of the OIP members, who have kindly contributed their views and provided data.

Part B – Characterisation of the region using the SAT [Partly covered in the pilot and in this document]

Once the screening team has been formed, its first task is to produce a general outline of environmental conditions (climate, land cover, etc.) and run an assessment using the SAT (Self-Assessment Tool to promote sustainable chemical production in all regions)[1] to define biomass availability and bioeconomy potential in the region. For the pilot, the authors used the information collected through the SAT tool in BE-Rural as well as other project results (e.g. the PESTEL analysis[2] documented in Deliverable 2.2) to set the bases of the screening. This was then supplemented with additional information from literary sources. This part of the screening also entails a shortlisting of bioeconomy activities deemed most relevant for the region. Since a screening team could not be formed (as mentioned above), the envisioned participatory process to conduct the shortlisting was not established. Instead, the authors

[1] See: https://ecrn.net/self-assessment-tool-to-promote-sustainable-chemical-production-in-all-regions/
[2] PESTEL stands for political, economic, social, technical, environmental and legal assessment (see Anzaldúa et al. 2019)

resorted to working with a selection of the broad categories of activities that the OIP facilitators have published in their regional strategy and roadmap documents (BE-Rural Deliverable 5.3).

Part C – Rough appraisal of available capacity of the regional ecosystem [Covered in the pilot and in this document]

Using existing indicators and expert opinion from within and beyond the screening team, this part of the screening yields a qualitative (ordinal) categorization of the capacity of the ecological systems in the region to underpin bioeconomy activities. Thus, the key output of Part C is setting a baseline from which the development or update of the regional bioeconomy strategy/roadmap would part.

Part D – Review of the potential ecological burden of regionally relevant bioeconomic activities [Covered in the pilot and in this document]

Based on the outcomes of a literature review conducted for the pilot, this part of the screening provides a synthesis of the potential ecological burden associated with the economic activities selected in Part B. The synthesis also compiles contextual information from the reference studies to ensure transparency as regards comparability issues, and where possible includes information collected on differences between specific management practices in terms of their potential burden on natural resources and ecological systems.

Part E – Overview of screening results and recommendations [Covered in the pilot and in this document]

Based on the results of Parts C and D, the team will overlay and compare the available capacity of the region's ecological system and potential ecological burden of the relevant bioeconomic activities, discuss the results and prepare a synthesis table indicating the natural resources that could be at risk or vulnerability, or, alternatively, could benefit from the adoption of specific management practices. This will be supplemented with recommendations on bioeconomic activities and practices to avoid or incorporate with reserve into the regional bioeconomy strategy/roadmap.

2 Part B: Characterisation of the Stara Zagora region

The Stara Zagora region (Bulgarian "oblasts" comply with the NUTS 3 administrative level) is situated in the Thracian valley, in central Bulgaria. With a total area of 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 (Anzaldúa et al. 2019)

Figure 2: Map of Bulgaria with approximate location of the Stara Zagora region

Source: Abhold et al., 2019

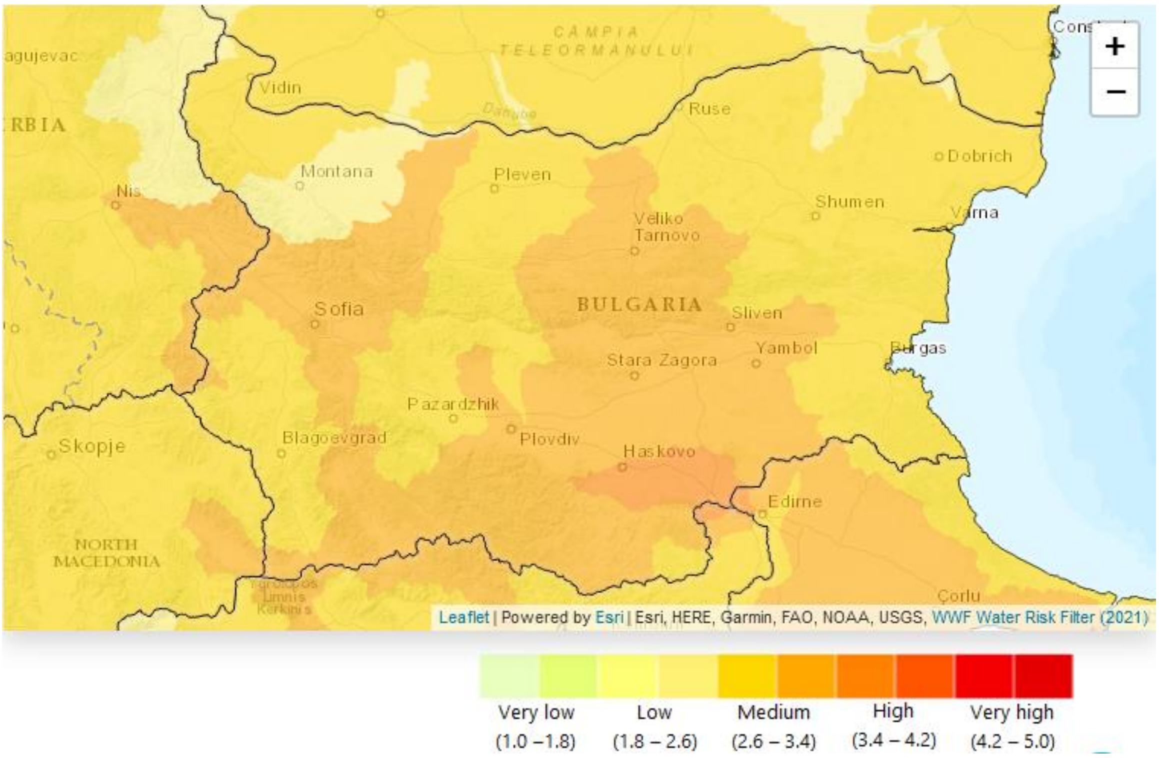
Stara Zagora has numerous valuable natural resources that are favourable to the development of agriculture, energy and industry. The climate is moderate continental, with relatively mild winters. The soils in the area are flat for the most part and fertile. The cultivated area occupies more than 56% 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. In BE-Rural, the Open Innovation Platform (OIP) created in the Stara Zagora region initially focused on seeking new technologies for the processing of herbs and production of essential oils for the cosmetics and pharmaceutical industries (Anzaldúa et al., 2019). Towards the end of the project, the OIP has formulated a bioeconomy strategy for the region whose priorities include the exploitation of its agricultural and forestry potential within a frame of sustainable resource management (Kiresiewa and Gerdes, 2021).

2.1 Resource availability and management profile

2.1.1 Water resources

Renewable water resources in Bulgaria are estimated at roughly 20 km^3 with variations from 10 to 30 km^3 in dry and wet years, respectively (Paskalev, n.d.). Of these, around 10.5 km^3 are abstracted each year, with 19% of water use assigned to agricultural activities, 3% to domestic use, and 78% to industry (Water Action Hub, n.d.). These resources are drawn mainly from the rivers that cross the country's territory, including the Danube and Maritza with their international basins. Seasonal variation is an important factor in the country, with areas prone to flooding during the snowmelt season and incidence of severe droughts during Summer and Autumn (Paskalev, n.d.). According to WWF's Water Risk Filter, the territory of Bulgaria exhibits an overall medium to high water risk, and ranks just above Spain on the country comparison for water risk (WWF, 2021).

Figure 3: Country profile for Bulgaria on the WWF Water Risk Filter



Source: WWF Water Risk Filter, 2021.

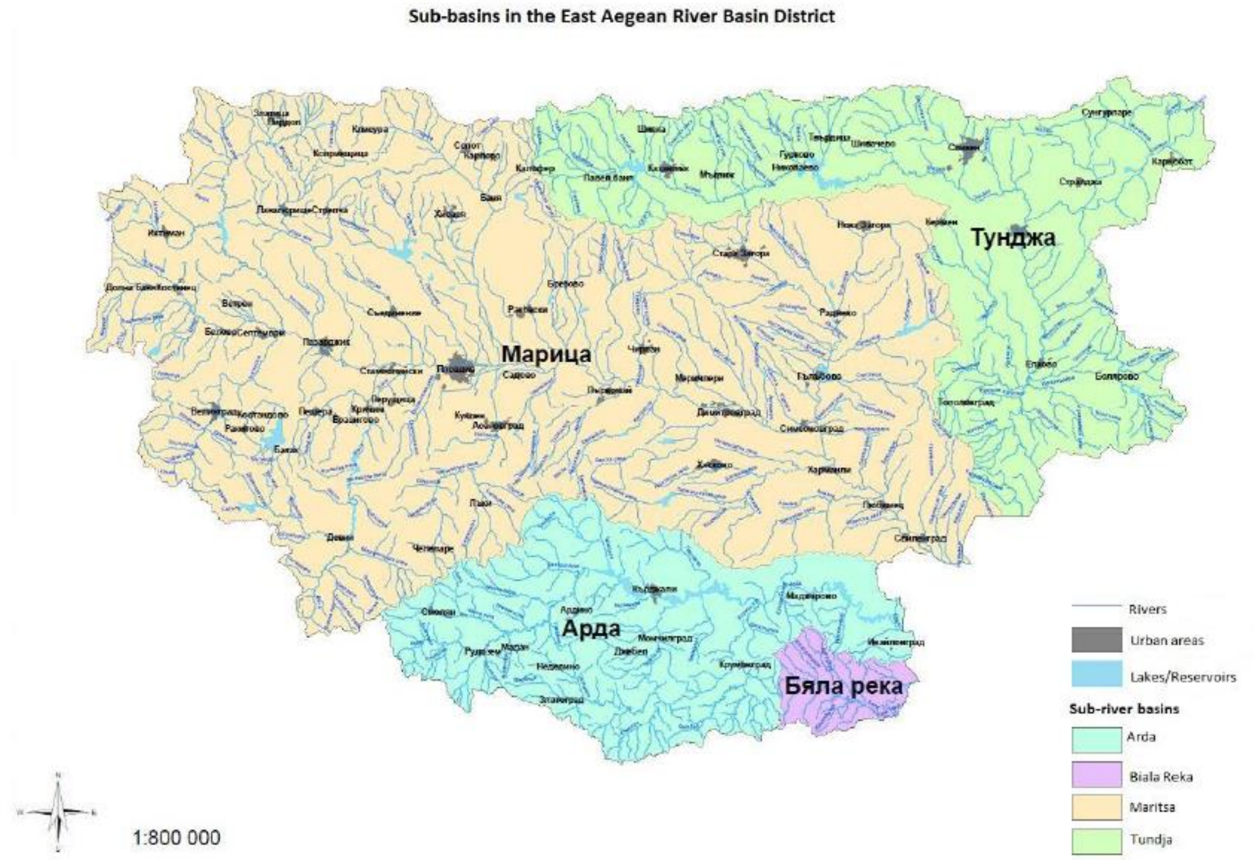
In Bulgaria, water management is coordinated at the national and river basin level. Since 2002, the country follows the requirements of the EU Water Framework Directive (WFD) and through the Bulgarian Water Act of 2006 it has aligned itself with EU water legislation. The country is split into four River Basin Districts (RBDs), with Stara Zagora lying in the East Aegean River Basin District (RBD code: BG3000) (see Figure 4). This RBD has seen an increase of around 12% in water use during the 2008-2013 period. During this time frame, average shares of water use were at 2.5% for the services sector, 8.9% for domestic water supply, 35.6% for agriculture, and 53,0% for industry. For the latter, in the year 2013 the largest share by far was dedicated to electricity production (44.5%), with manufacturing and mining following at 6.8% and 1.4%, respectively (Vladimirova, 2018).

Figure 4: Location of the four river basin districts in Bulgaria (East Aegean RBD shown in color)

Source: Tuntova, n.d.

With precipitation being highly variable and falling mostly in winter, the East Aegean RBD faces similar challenges as those described above for the entire country (seasonal flooding and drought), which are expected to be further undergirded by climate change. As regards the main anthropogenic pressures faced by the water bodies in the RBD, the 2nd River Basin Management Plan (2016) lists discharges from untreated or insufficiently treated waters, diffuse pollution sources (from agriculture, transport, air pollution and erosion) and changes in hydromorphology (Vladimirova, 2018). Within the RBD, the Stara Zagora region is largely located in the sub-basin of the Maritza River (see Figure 5). Several sections of the river and its tributaries are strongly polluted, for instance the Sazlijka river downstream of the town of Stara Zagora. Mining, manufacturing (metals, chemicals, cellulose pulp), and untreated domestic sewage and livestock wastewater have been flagged as the main sources of pollution (Paskalev, n.d.).

Figure 5: Location of the four sub-basins making up the East Aegean RBD (with the Maritza sub-basin shown in orange)



Source: East Aegean River Basin Management Plan 2014-2021, as cited in Vladimirova, 2018.

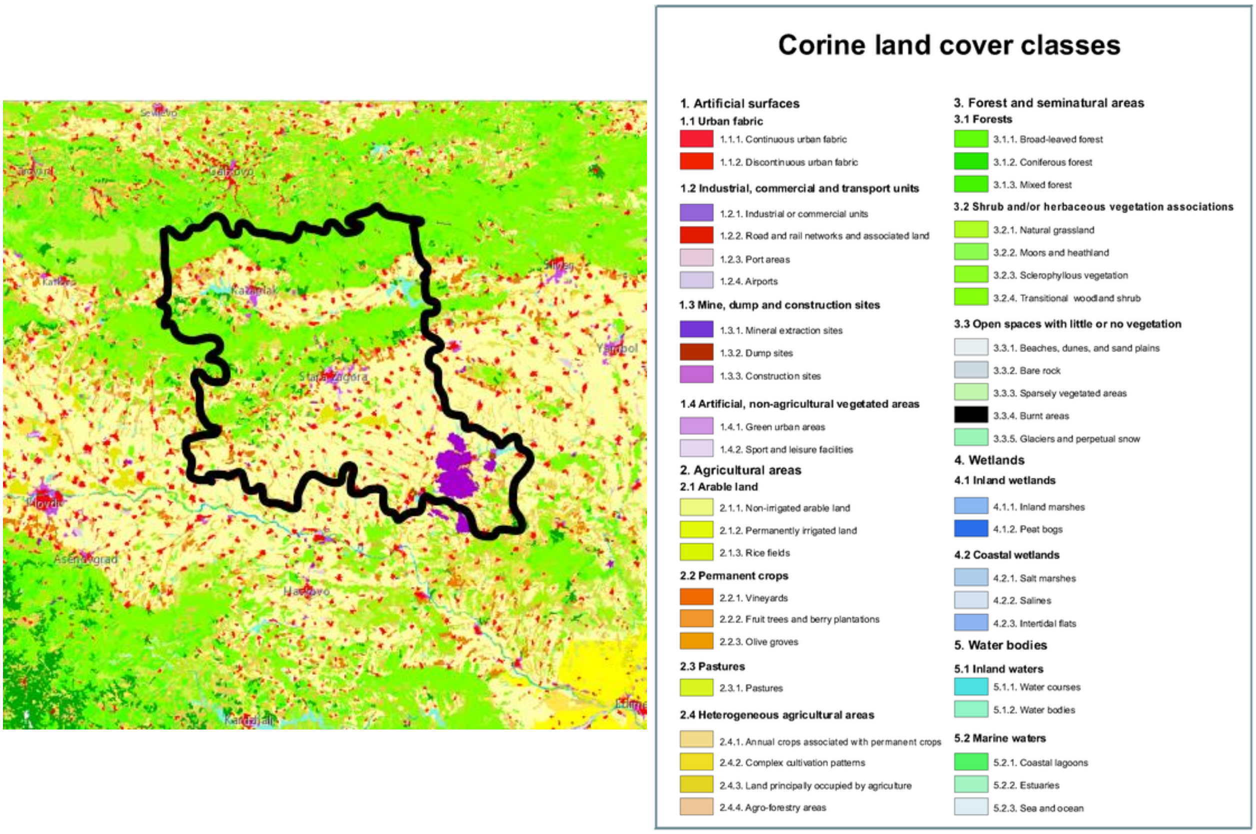
2.1.2 Land resources

According to the Bulgarian Ministry of Environment and Water (n.d):

> *"the land resources of Bulgaria, harmoniously complemented by a favorable physical and geographical location, are among the most valuable natural resources. The soil cover is characterized by great variety due to sufficient diversity of soil forming factors, including 42 types.*
>
> *The soil resources of Bulgaria generally have a high productive, regulatory and buffer functions potential and are subjected to natural and anthropogenic degradation, which adversely affects the functioning of ecosystems. The intensification of agricultural production can lead to accelerated degradation processes – erosion, salinization, acidification, water pollution, loss of biodiversity, to unfavorable for agriculture and environment extent. The damage of soil is a result of pollution with heavy metals and metalloids, plant protection products (pesticides), resistent organic pollutants, including petroleum products, unregulated waste disposal on soil surface, mining industry activities.*
>
> *[…] The sustainable soil management is a balance to jointly support functions of the land resources for the benefit of both environment and society"*

In terms of land-uses, agriculture is an important sector in the Stara Zagora region, with the area used for agriculture having grown by 25% between 2017 and 2018 (Anzaldúa et al., 2019). A broad overview from the CORINE land cover types of the Stara Zagora region (see Figure 6) reveals that roughly more than a half of the surface of the region is dedicated to agricultural activities, while a slightly smaller proportion of the land is covered by different types of forests. Organic agriculture is also growing rapidly in the region. Production is focused on seeds, cereals, leafy and stalked vegetables, as well as fruits, berries and nuts. However, there is a lack of policies to encourage the expansion of agriculture in Bulgaria, since policies are focused on preventing harm to ecosystems (Anzaldúa et al., 2019).

Figure 6: CORINE Land Cover Classes (CLC) 2018 for EU-27 with Stara Zagora Region (NUTS3 BG344) highlighted[3]



Source: EEA, 2020

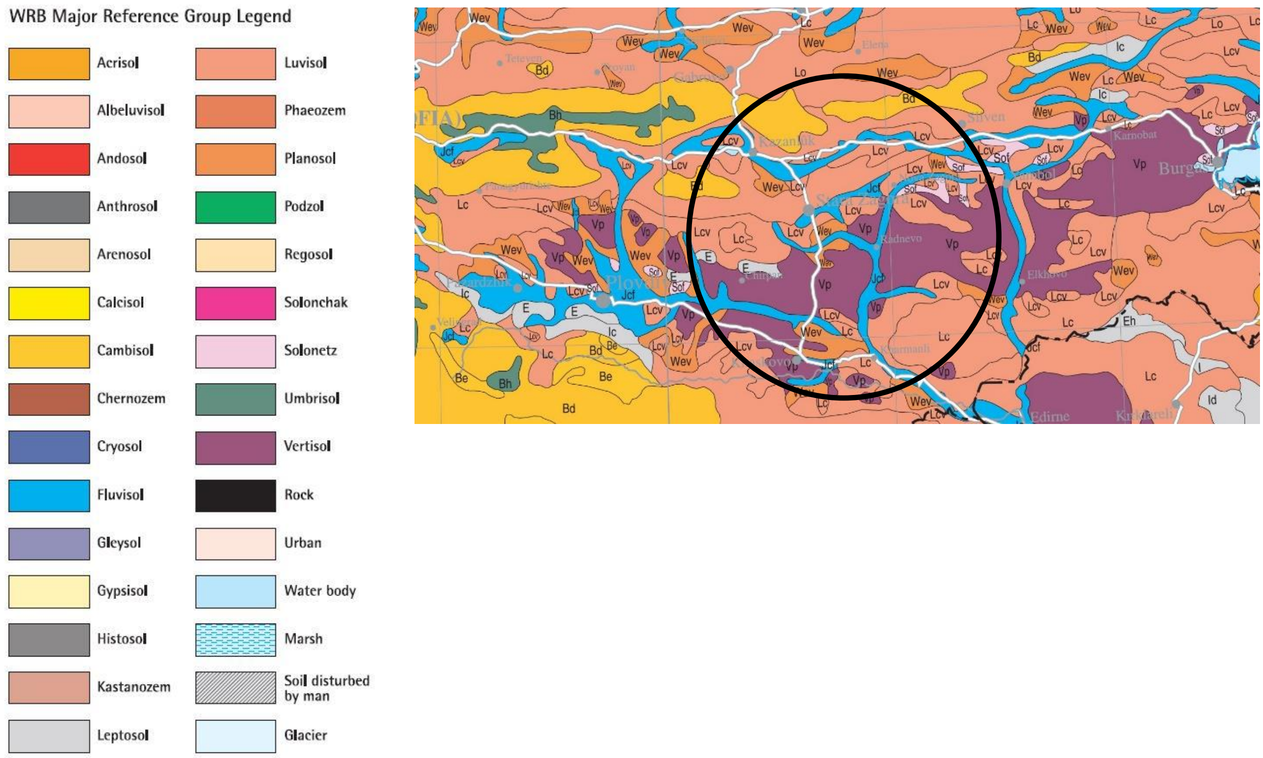
Among the crops that are currently present in the region are for instance rose and lavender for oil production in the Kazanlak valley, as well as medical crops and dried herbs. Moreover, the Chirpan region produces cotton and durum wheat, which deliver the base for the development of the local industries of textiles and pasta, respectably. Furthermore, there are also fruit trees and vineyards in the Stara Zagora Region, which are also fundamental for locally produced high quality consumer (bio-based) products (Anzaldúa et al. 2019).

Regarding the types of practices that are applied in this agricultural production, local land area is being converted to organic production at a quick pace, even though practices remain rather intensive. For instance, the area used for agriculture grew by 25% from 2017 to 2018 – and area used for certified organic crops increased more than 18% (Anzaldúa et al., 2019).

As mentioned before, soils are a crucial component in land management. Regarding the types of soils in particular, the region of Stara Zagora presents predominantly Luvisols and Vertisols, with also some Cambisols towards the northern part of the region and Planosols in the proximity of the Stara Zagora city (see Figure 7).

[3] For the map view see https://land.copernicus.eu/pan-european/corine-land-cover/clc2018?tab=mapview for the legend, see https://www.eea.europa.eu/data-and-maps/figures/corine-land-cover-2006-by-country/legend/image_large

Figure 7: Excerpt of soil map of Europe showing the Stata Zagora region



Source: European Soils Bureau Network, 2005

With respect to the status soil organic content in general, National Programme for Conservation, Sustainable Use and Restoration of Soil Functions (2020-2030) points out that, while the total amount of hummus in Bulgaria is not high, the necessary conditions for hummus formation are favourable in a large part of the country (Bulgarian Ministry of Environment and Water 2020). This is especially the case in the flat and gently undulating areas where the arable land is concentrated, such as the Kazankak valley and the southern plains of the Stara Zagora region, which have relatively large stocks of soil organic matter (SOM) (see Figure 8)

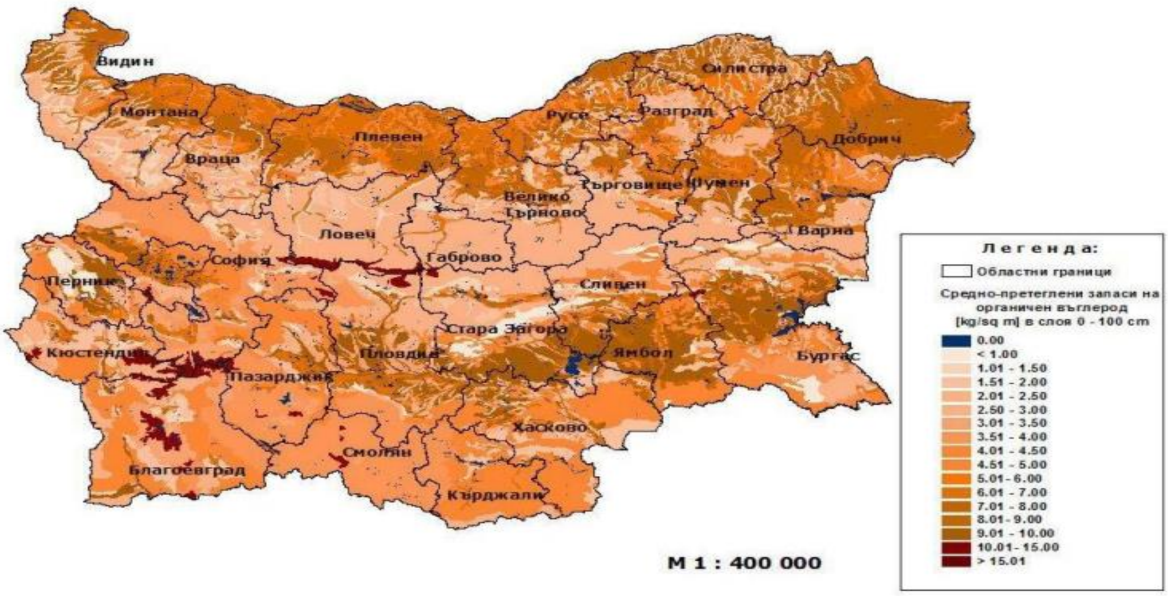
In terms of governance, soils are regulated in Bulgaria at a national level, mainly under the jurisdiction of the Bulgarian Ministry of Environment and Water. According to Trichkova (n.d.), two of the most relevant legislations that deal with soils are:

- The Bulgarian Law of Environment Protection (2002), which considers soils as limited, indispensable and non-renewable natural resources that need to be protected, restored and used in a sustainable way with the aim of protecting their multifunctionality, as well as human health.
- The Soil Protection Act (2007, amended in 2009) which makes concrete provisions on the prevention of destruction and long-term protection of soils and their functions, as well as on the restoration of depleted soil functions.

Other relevant regulations Protection of Agricultural Land Act, Waste Management, Protection against Harmful Effects of Chemical Substances Act, as well as other strategic documents such as the recently adopted National Programme for Conservation, Sustainable Use and Restoration of Soil Functions (2020-2030) and the National Action Program for Sustainable Land Management and Desertification Combat 2014-2020[4].

[4] See Bulgaria in FAO soils portal https://www.fao.org/soils-portal/soilex/country-profiles/details/en/

Figure 8 Map of soil organic matter in kg/m^2 at a depth of 0-100cm at Oblast level



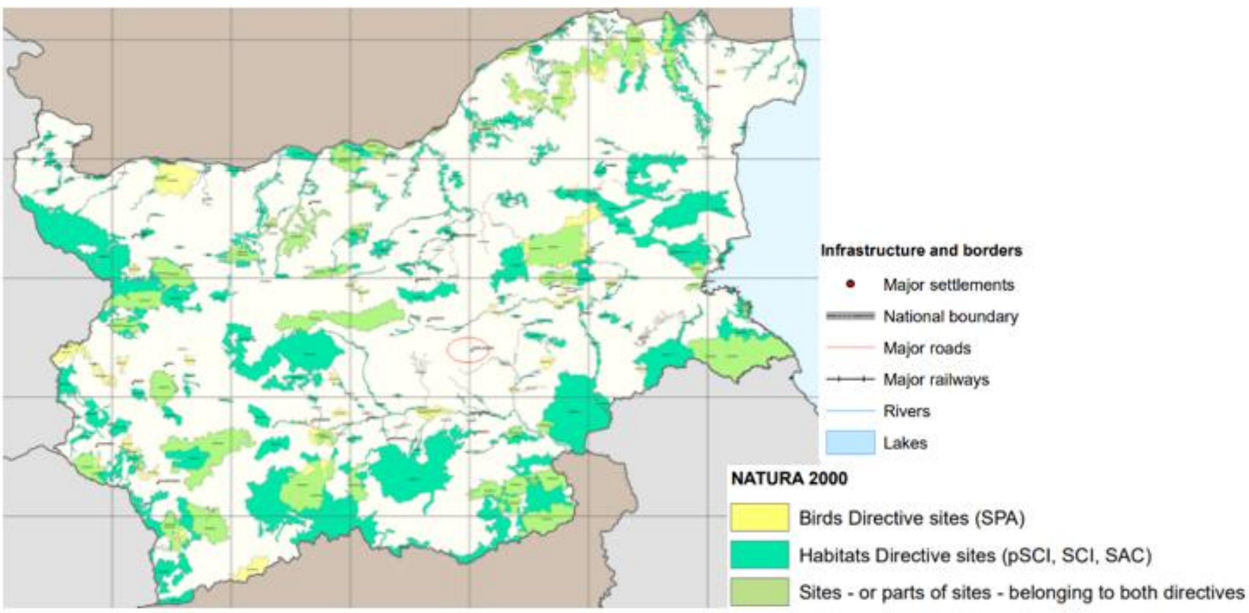
Source: Bulgarian Ministry of Environment and Water, 2020

2.1.3 Biodiversity

According to the Fourth National Report for the Convention on Biological Diversity, Bulgaria is one of Europe's biodiversity hotspots. Within Bulgaria, there are more than 1,300 endemic species, i.e. 5% of the total flora, 8.8% of the total non-insect species and 4.3% of the total insect species (Bulgarian Ministry of the Environment and Energy, 2010).

In terms of protected areas designated under the Habitats Directive and the Birds Directive, more than 30% of the territory of Bulgaria falls within the scope of the Natura 2000 network, with 234 areas for the protection of natural habitats and 120 areas for the protection of wild birds, respectively (Figure 9).

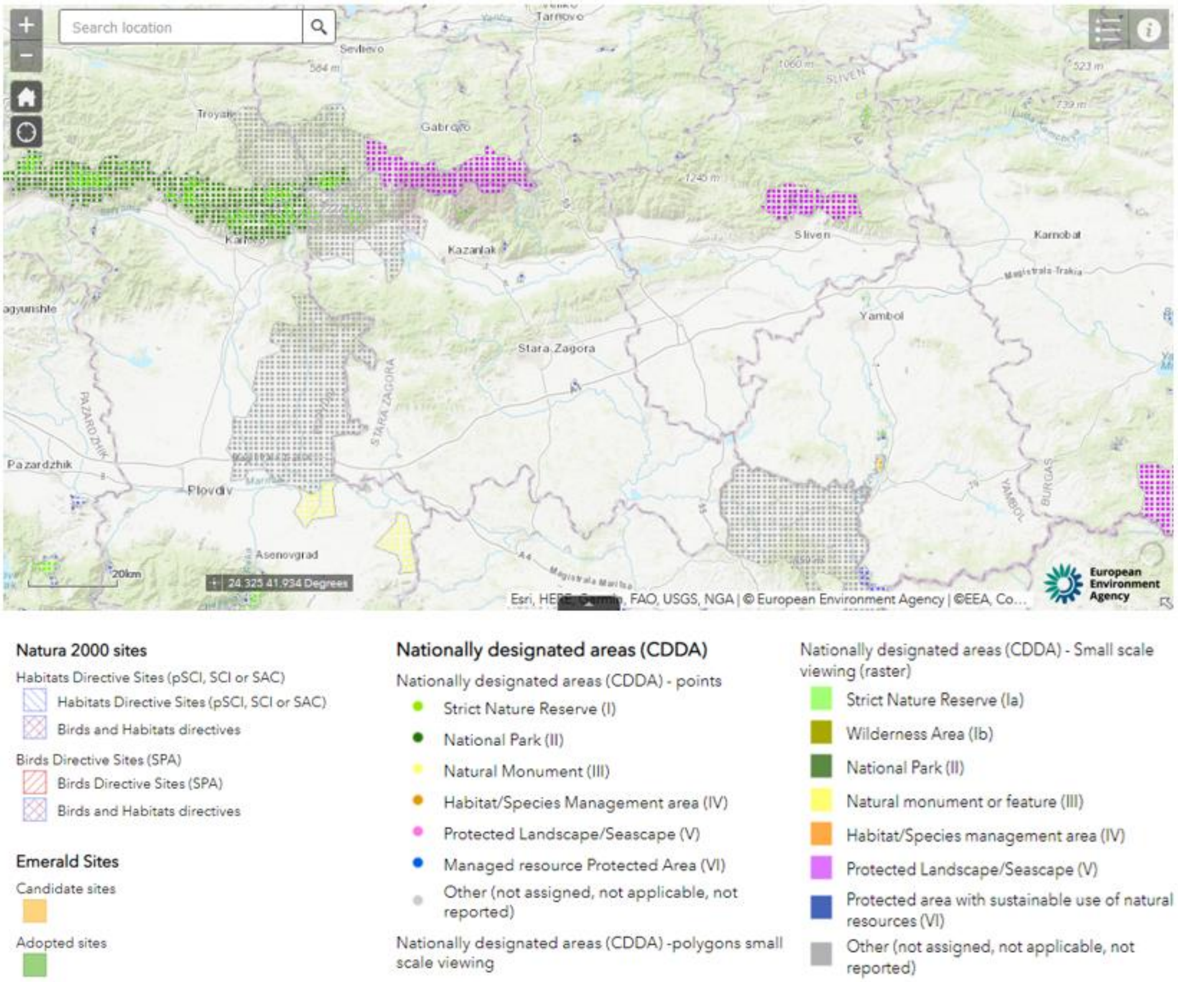
Figure 9 Overview of NATURA 2000 protected sites in Bulgaria



Source: European Commission [5]

As it can be observed in Figure 9, there are also protected areas in the Stara Zagora region, mostly in the north and north-west of the Oblast. These are for instance portions of the Habitats and Birds Directive Sites Tsentralen Balkan bufer (BG0001493 and BG0002128 respectively), inside which the strict nature reserve[6] Kamenshtitza is located, as well as the protected landscape[7] Bulgarka.

Figure 10 Overview of NATURA 2000 and nationally designated areas (CDDA) in Stara Zagora region



Source: EEA[8]

2.1.4 Biomass resources

According to Directive 2001/77/EC biomass is defined as 'the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste'. Biomass resources are renewable and inseparably linked with land and water resources and also influence biodiversity. Biomass resources can be distinguished as actual, i.e. already available, and potential that can be cultivated on marginal, degraded, and contaminated (shallow contamination with certain contaminants)

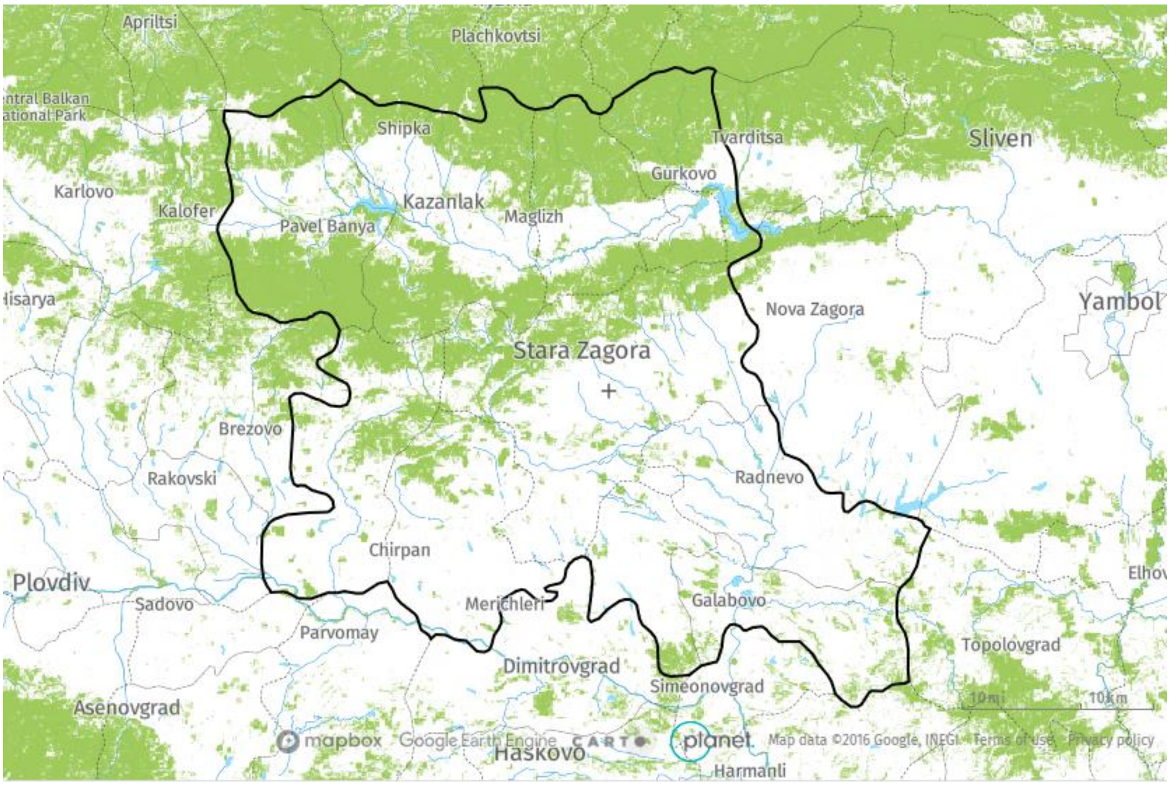
[5] See https://ec.europa.eu/environment/nature/natura2000/db_gis/pdf/BGn2k_0802.pdf
[6] following IUCN category number ! for Nationally Designated Areas (CDDA)
[7] following IUCN category number V for Nationally Designated Areas (CDDA)
[8] See https://www.eea.europa.eu/themes/biodiversity

lands. Actual biomass resources in Stara Zagora can be categorised as forest biomass, biomass from agriculture (including straw of grain crops, by-products of sunflower production, biomass from pruning, and livestock manure), and municipal, industrial organic waste and sewage sludge. Potential biomass resources are perennial herbaceous and woody energy crops that could grow on marginal lands.

The total forested area of the region is 171,285.2 ha (National Statistical Institute of Bulgaria, 2022) (data as of 2011) and includes land under natural or planted stands of trees and brushwood (Kakanakov, Zahariev and Aladjadjiyan 2009). For defining forest, Bulgaria uses the definition in the Bulgarian Forest Act (last amendment 18.12.2015): “Area over 0.1 ha, covered with forest tree species higher than 5 meters and tree crown cover over 10% or with trees which can reach these parameters in natural environment”[9]. Not all forests are used for economic purposes, as there are protected forests, including reserves, national and nature parks and forests for water, soil and buildings protection and erosion control[10].

Forest biomass comes from exploitable forests, where there are no legal, economic or technical restrictions on wood production. This includes natural and planted forests in Stara Zagora, with areas of 158,165.7 ha and 3,370.8 ha correspondingly (data as of 2010 for tree canopy[11] >10%)[12], extending over 31% of the region’s land area (see Figure 11).

Figure 11 Tree cover in Stara Zagora, Bulgaria (2010)



Source: Global Forest Watch[12]

From 2001 to 2021, the Stara Zagora region lost 6.01 thousand ha of tree cover, equivalent to a 3.8% decrease in tree cover since 2000[12]. It should be mentioned that “tree cover loss” is not the same as “deforestation”, and reasons for tree cover loss include change in both natural and planted forest, and

[9] Bulgarian Forestry Act. See: http://www.minfin.bg/upload/38249/Forestry_Act.pdf
[10] Regional Development Strategy of the Stara Zagora for 2014-2020 https://www.strategy.bg/FileHandler.ashx?fileId=6963
[11] Tree canopy is a collection of tree crowns that cover the ground when viewed from above and that can be measured as a percentage of a land area shaded by trees.
[12] Data from Global Forest Watch for “land cover” and “forest cover” in Stara Zagora, Bulgaria. See https://www.globalforestwatch.org/dashboards/country/BGR

are not exclusively human caused, but can be caused by natural factors, including disease, insects, natural disasters. In 2020, total forest area of the region Stara Zagora was 172,272 ha[12].

Table 1 Harvested timber of all types of property in the Stara Zagora region, in m^3 by category of wood[12]

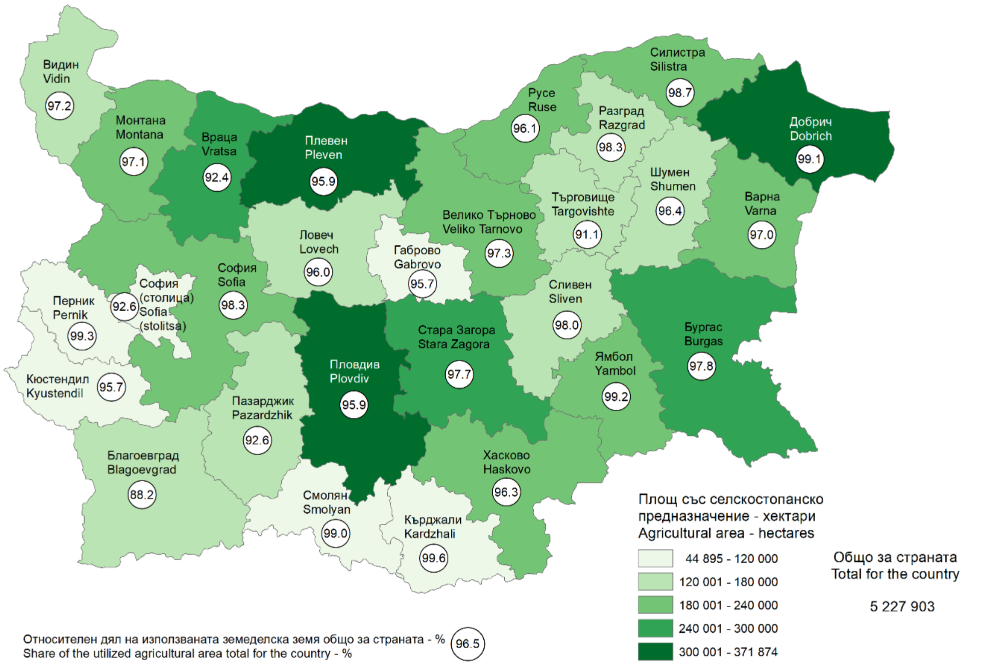
Category	Year					
	2015	***2016***	***2017***	***2018***	***2019***	***2020***
Fellings	312214	319151	354313	336786	312818	253286
Round wood removals	263874	267005	282932	270820	258129	220350
- Fuelwood	189038	198576	194732	183534	180864	147369
- Loppings	693	414	296	401	631	306
- Industrial wood	74143	68015	87904	86885	76634	72675

Source: Own elaboration based on official statistics from the regional authority.

Biomass resources from agriculture include agricultural residues, which are crop residues remaining in fields after harvest (primary residues) and processing residues generated from the harvested portions of crops during food, feed, and fibre production (secondary residues), biomass from pruning, and livestock manure.

The agricultural territory in Stara Zagora is 286 993.7 ha, which accounts for 56% of the agricultural territory of the region. Of this territory, agricultural area (land designated to agriculture) accounts for 281 657 ha, including utilized agricultural area of 275 182 ha (Bulgarian Ministry of Agriculture, Food and Forestry, 2021). The share of the utilized agricultural area from the agricultural area was 97.7% in 2020 (Figure 12). The area of abandoned fields within agricultural area decreased since 2012 from 3.1% (7911 ha) to 2,3% (6475 ha) in 2020. In case these lands are not utilized because of their marginality they could be potentially used for energy crops production (Bulgarian Ministry of Agriculture, Food and Forestry, 2021).

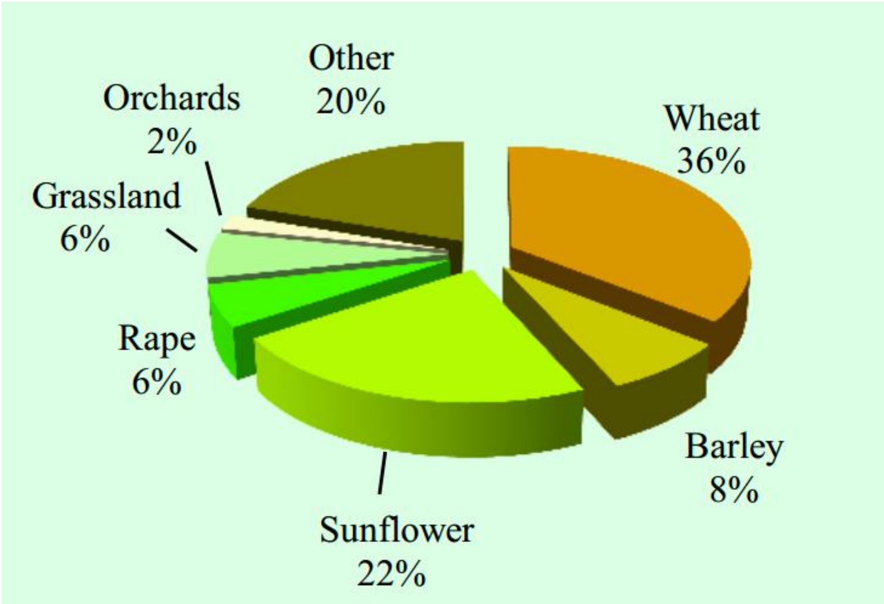
Figure 12 Share of the utilized agricultural area from the agricultural area in 2020



Source: Bulgarian Ministry of Agriculture, Food and Forestry, 2021

Utilized agricultural area is distributed among cereals (incl. wheat, barley), industrial crops (incl. sunflower, rape), permanent crops (incl. fruit orchards and vineyards) and permanent grassland. The latest data on areas occupied by these crops is available from the census of agricultural holdings (Figure 13) conducted in 2010 in Bulgaria (Bulgarian Ministry of Agriculture, Food and Forestry, 2012).

Figure 13 Distribution of Utilized Agricultural Area by crops in 2010



Source: Bulgarian Ministry of Agriculture, Food and Forestry, 2012

The area under permanent crops in the region of Stara Zagora is 4,454.3 ha, of which fruit orchards cover an area of 1,446.2 ha and vineyards - 1,418.8 ha. Pruned biomass waste from intensively grown fruit orchards and vineyards is another source of biomass feedstock in the region (Bulgarian Ministry of Agriculture, Food and Forestry, 2012).

Livestock manure generated at animal farms can be considered as another biomass source that could be used for energy production (biogas, biomethane, heat and power) in the region of Stara Zagora (Bulgarian Ministry of Agriculture, Food and Forestry, 2012).

Table 2 Estimated volume of manure generated at animal farms by livestock types at Stara Zagora region

Livestock type	Farms	Number of heads	Manure per animal, kg/day	Estimated volume of manure, t/year
Cattle	387	26,710	40	389,966
Pigs	12	138,680	3	41,998
Poultry	46	2,799,850	0.04	622,994
Sheep	186	29,878	4	44,817
Goat	75	5022	4	7,533

Source: Own elaboration

As of April 2022 there are no strategies dedicated to bioeconomy at national level in Bulgaria. Among bioeconomy related strategies there is an Integrated National Energy and Climate Plan of the Republic of Bulgaria, 2021-2030[13].

[13] See https://knowledge4policy.ec.europa.eu/bioeconomy/country/bulgaria_en

Biomass utilization for energy is regulated by the following national policies and legislation:

- Law on renewable energy sources (adopted 2011, amended 2015) encourages the development of new technologies with high extend of environmental protection when producing energy from biomass (from forests including);
- Integrated National Energy and Climate Plan of the Republic of Bulgaria, 2021-2030 (foresees introduction of individual devices for burning of biomass with at least 85% effectiveness for households and at least 70% effectiveness for industrial buildings)[14];
- National Action plan for energy development from forest wood biomass 2018-2027 (contains strategic framework with 6 priority areas and concrete actions for increasing the efficiency in utilization of forest biomass as RES);

3 Part C: Rough appraisal of available capacity

3.1 Methodological aspects of the sustainability screening for Stara Zagora

3.1.1 Water data and indicators

To run the appraisal of the capacity of surface and groundwater bodies potentially relevant to the Stara Zagora region, the authors of this report have reviewed the data reported in the 2nd River Basin Management Plan of the East Aegean River Basin District published in 2016 (data from the 3rd rerporting cycle was not yet available on the WISE Database at the time of the analysis). The benefits of tapping on this reporting process is that it includes well-defined indicators like the status of water bodies in the river basin district as well as data on significant pressures and impacts on them. Further, these data are official, largely available, accessible, and updated periodically (every six years). Authorities in charge of developing a regional bioeconomy strategy would generally be expected to have good access to the entity in charge of developing the River Basin Management Plan (i.e. the River Basin Authority), and so could theoretically consult it if necessary.

3.1.1.1 Description of the data / definition of the indicators employed

Data reviewed for this part of the screening included the reported ecological and chemical status of rivers and lakes as well as the quantitative and chemical status of groundwater bodies in the East Aegean RBD. These data give indications on water quality in the river basin according to the five status classes defined in the WFD. These are: High (generally understood as undisturbed), good (with slight disturbance), moderate (with moderate disturbance), poor (with major alterations), and bad (with severe alterations) (EC, 2003). Further, data on significant pressures and significant impacts on the water bodies in the river basin district are used to indicate the burden of specific pressure and impact types on water ecosystems in the region based on the number and percentage of water bodies subject to them. Significant pressures are defined as the pressures that underpin an impact which in turn may be causing the water body to fail to reach at least the good status class (EEA, 2018).

All data described above were accessed on 02.06.2021 from the WISE WFD data viewer (Tableau dashboard) hosted on the European Environment Agency's website.[15]

[14] See https://ec.europa.eu/energy/sites/default/files/documents/bg_final_necp_main_en.pdf
[15] https://www.eea.europa.eu/data-and-maps/dashboards/wise-wfd

Table 3 Indicators used for the water component of the sustainability screening

Category	Indicator Family	Indicator	Spatial level	Unit of measure	Comments/Reference
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[16] Disaggregated data for ecological and chemical status of surface water bodies; quantitative and chemical status of groundwater bodies, per River Basin District
	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[16]
	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[16]

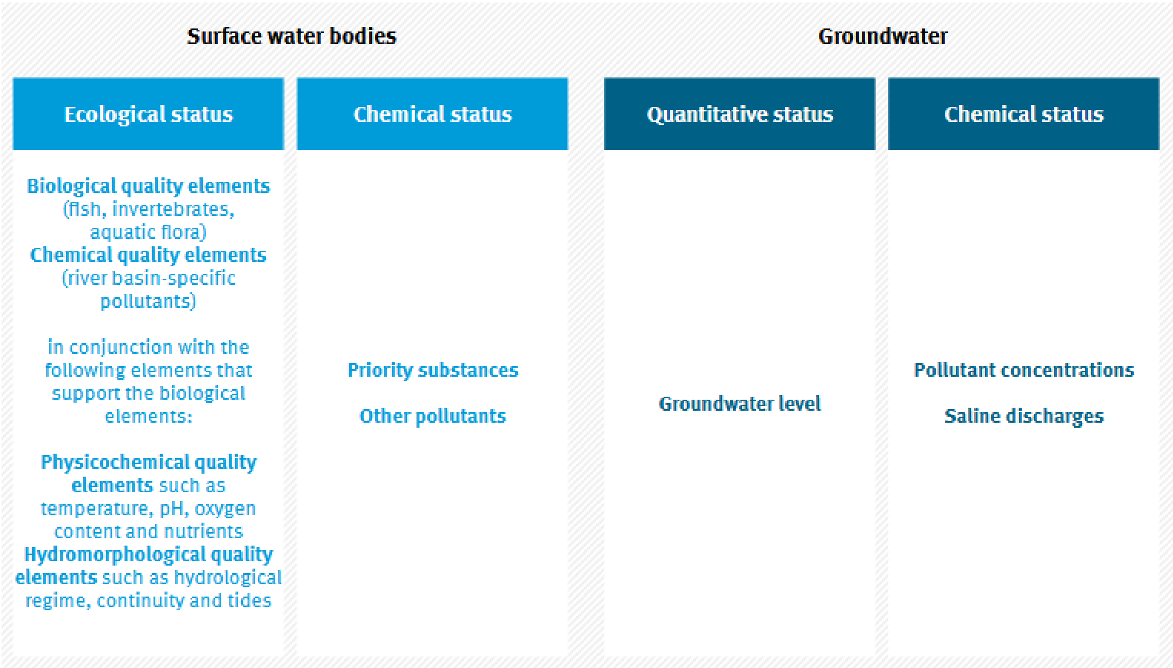
Source: Own elaboration based on the information in the WISE WFD data viewer.

To determine which status class a certain water body falls into, WFD assessments evaluate the *ecological* and *chemical* status of surface waters (i.e. rivers and lakes) and the *quantitative* and *chemical* status of groundwater bodies. Ecological status refers to *"an expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters".* It covers assessments of biological (e.g. presence and diversity of flora and fauna), physico-chemical (e.g. temperature and oxygen content) and hydromorphological criteria (e.g. river continuity) (EC, 2003; BMUB/UBA, 2016). The chemical status of a surface water body is determined by comparing its level of concentration of pollutants against pre-determined environmental quality standards established in the WFD (concretely in Annex IX and Article 16(7)) and in other relevant Community legislation. These standards are set for specific water pollutants and their acceptable concentration levels.

In the case of groundwater bodies, chemical status is determined on the basis of a set of conditions laid out in Annex V of the WFD which cover pollutant concentrations and saline discharges. Additionally, the water body's quantitative status is included in the WFD assessments, defined as "*an expression of the degree to which a body of groundwater is affected by direct and indirect abstractions"*. This gives indication on groundwater volume, a relevant parameter to evaluate hydrological regime (BMUB/UBA, 2016).

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

Figure 14 Overview of surface water body and groundwater status assessment criteria, as per the Water Framework Directive.



Source: BMUB/UBA, 2016.

In the case of surface water bodies, the WFD objective is not only that they reach good status, but that quality does not deteriorate in the future (EC, 2003), which is relevant in the context of drawing up a regional bioeconomy strategy.

3.1.1.2 Methodology applied

The authors of this report have devised an approach to valorise the data from the WFD reporting described in the previous sub-section that allows for an appraisal that is non-resource intensive (based on reliable, publicly available and accessible data) yet capable of providing a rough overview of the state of the region's waters. This is in line with the rationale of this sustainability screening, which aims to enable regions with limited financial resources and/or expertise in the field to consider ecological limits in a structured manner when developing a regional bioeconomy strategy or roadmap. The preferred option for this part of the assessment would have been to supplement the WFD data with a water quantity balance indicator like the Water Exploitation Index plus (WEI+) developed by the EEA and its partners. That indicator compares the total fresh water used in a country per year against the renewable freshwater resources (groundwater and surface water) it has available in the same period. This could have strengthened the water quantity element in the screening. However, the calculation of the WEI+ at regional level is currently not conducted or foreseen by its developers, and it would entail a disproportionately large effort that falls beyond the scope of this task in BE-Rural. For these reasons, the reported data from the WFD process has been employed exclusively within the following methodology.

The overall apportionment of rivers, lakes and groundwater bodies in the East Aegean RBD according to their WFD status classification can be used to set the baseline for the sustainability screening. It provides initial insight on the situation in the demarcation as regards "ensuring access to good quality water in sufficient quantity", "ensuring the good status of all water bodies", "promoting the sustainable use of water based on the long-term protection of available water resources" and "ensuring a balance between abstraction and recharge of groundwater, with the aim of achieving good status of groundwater bodies", all explicit aims of the WFD that are aligned with the consideration of ecological limits. Further, the data on significant impacts and pressures affecting the water bodies in the river basin are useful as they can point towards specific problems (e.g. nutrient pollution) and the types of activities that may be causing them (e.g. discharge of untreated wastewater, agriculture).

As a first step, the approach used for this element of the screening entails calculating what proportion of the total number of surface water bodies located in the RBD is reported as failing to achieve Good Ecological Status/Good Chemical Status or for which conditions are unknown. Similarly for groundwater bodies, the proportion is calculated of those who are reported as failing to achieve Good Chemical Status/Good Quantitative Status or for which conditions are unknown. The resulting ratios are then compared to the respective EU proportions, which are used as (arbitrary) thresholds. According to the latest assessment published by the EEA in 2018, “around 40% of surface waters (rivers, lakes and transitional and coastal waters) are in good ecological status or potential, and only 38% are in good chemical status” (EEA, 2018). Accordingly, “good chemical status has been achieved for 74% of the groundwater area, while 89% of the area achieved good quantitative status” (EEA, 2018). Using these markers, the following step is to rank the current conditions of the region using an ordinal risk rating (high, moderate, low) based on the distance of the result of each indicator to the EU level results. On this basis, the thresholds and ordinal ranking convention suggested by the authors of this report are as shown in Table 4 and Table 5.

Table 4 Proposed thresholds for the water section of the sustainability screening

Water body type	Status category	2018 EU-level assessment results (proportion of water bodies achieving good status)	Proposed thresholds for the sustainability screening		
			High concern	Moderate concern	Low concern
Surface water bodies	Ecological status	~40%	0-40%	41-89%	90-100%
	Chemical Status	38%	0-38%	39-89%	90-100%
Groundwater bodies	Chemical status	74%	0-74%	75-89%	90-100%
	Quantitative status	89%	0-89%	-	90-100%

Source: own elaboration.

Table 5 Ordinal ranking convention for the water section of the sustainability screening

Ordinal ranking for water resources		Chemical status		
		High concern	Moderate concern	Low concern
Ecological or Quantitative status	High concern			
	Moderate concern			

	Low concern			

Source: own elaboration.

This initial appraisal based on the thresholds shown above is then supplemented with a review of the reported data on the types of significant pressures and impacts on surface and groundwater bodies. In this case percentage values are already given, and so this step in the screening simply entails the listing of the reported pressures and impacts and the identification of those which are more frequently reported. From here, the screening team can seek potential correlations between the most reported pressure types and the most reported impact types (e.g. diffuse sources causing nutrient pollution).

The final step in the approach is to draft a note describing the share of water bodies failing to reach good status and formulating preliminary statements on the types of bioeconomy activities that could be considered, those that should be considered with reserve, and those that should be avoided. These initial statements are intended to frame the discussion of the group of stakeholders involved in the development of the regional bioeconomy strategy or roadmap.

3.1.1.3 Data uncertainties

The data resulting from the assessments reported in the RBMP and subsequently in WISE are subject to the limitations of the scientific and methodological approaches used by their authors. For instance, the summary of the 2016-2021 RBMP for the East Aegean RBD makes reference to actions undertaken to improve the accuracy and reliability of the assessment of the conditions of water bodies in the RBD relative to the first cycle reporting. Aspects mentioned include the revision of boundaries of surface water bodies, increased number of monitoring points, and improved analysis of biological quality elements (MOEW, n.d.). It thus must be considered that the official assessments are based on estimates, include assumptions, and will therefore carry a margin of error.

An important limitation bound to the implementation of the sustainability screening is that the WFD data used cover a larger area than that of the Stara Zagora region. Concretely, in addition to Stara Zagora, the RBD encircles three other NUTS3 areas in their entirety (Kardialy, Plovdiv and Haskovo) as well as large proportions of the population of other four districts (Pazardijk, Yambol, Silven and Smolvan) (Vladimirova, 2018). Disaggregated data for the four sub-basins included in the East Aegean RBD (Maritsa, Tundja, Arda and Biala Reka) are not reported in the WISE WFD Data Viewer. Individual reports for each of them have been found in local language on the website of the East Aegean River Basin Authority, albeit for the previous reporting period only.[17] A future iteration of this exercise by the local stakeholders could increase the resolution of the screening of water resources by tapping on these additional information sources if they are made available also for the following cycles of river basin management planning.

Lastly, another issue to consider is the data currently available on WISE is from 2016, while more updated (interim) assessments are already available at the time of writing of this document. These come as part of the 3rd cycle of river basin management planning (2022-2027). While the reports containing this information are accessible on the website of the Bulgarian Ministry of the Environment and Water[18], they are intended for consultation and thus not yet final. Nonetheless, such sources could also be considered by the stakeholders performing the sustainability screening to avoid overlooking any relevant recent developments.

3.1.1.4 Methodological uncertainties

The proposed methodology for the water section used in this application of the sustainability screening is straight-forward and accessible, yet it must be used with care and, where possible, should

[17] See: https://earbd.bg/indexdetails.php?menu_id=364&sys_lang=bg
[18] See: https://www.moew.government.bg/bg/vodi/planove-za-upravlenie/planove-za-upravlenie-na-rechnite-basejni-purb/

incorporate higher resolution data evaluated by thematic experts. As previously mentioned, the thresholds set in this case have been the proportions, at EU-level, of water bodies that fail to achieve good status or for which conditions have been reported as unknown. This has been a pragmatic, yet easy to challenge way of defining a benchmark for the Stara Zagora region. Conditions and context in other European river basin districts may be significantly distinct to those in the Bulgarian region, and thus a more appropriate reference point could be defined in those cases. For this, the authors envision the contributions and guidance from the team of local and foreign experts as briefly described in Chapter 1 of this screening report and in further detail in Section 3.2 of the main deliverable report. Optimally, these thematic experts should know the regional context well and thus be in a good position to guide the setting of such thresholds. Beyond this, the simplicity of the necessary calculations and the fact that the data on significant pressures and impacts are used without further computation and compared in relative terms within the RBD limit the possibility of additional accuracy or uncertainty issues emerging.

3.1.2 Soil data and indicators

3.1.2.1 Description of the data / definition of the indicators employed

The selected indicators for vulnerability to soil depletion are closely interrelated and refer specifically to soil erosion **by water**. These are:

- Estimated mean soil erosion rate (in $t\ ha^{-1}\ a^{-1}$)
- Share (%) of area under severe erosion (>10 $t\ ha^{-1}\ a^{-1}$)

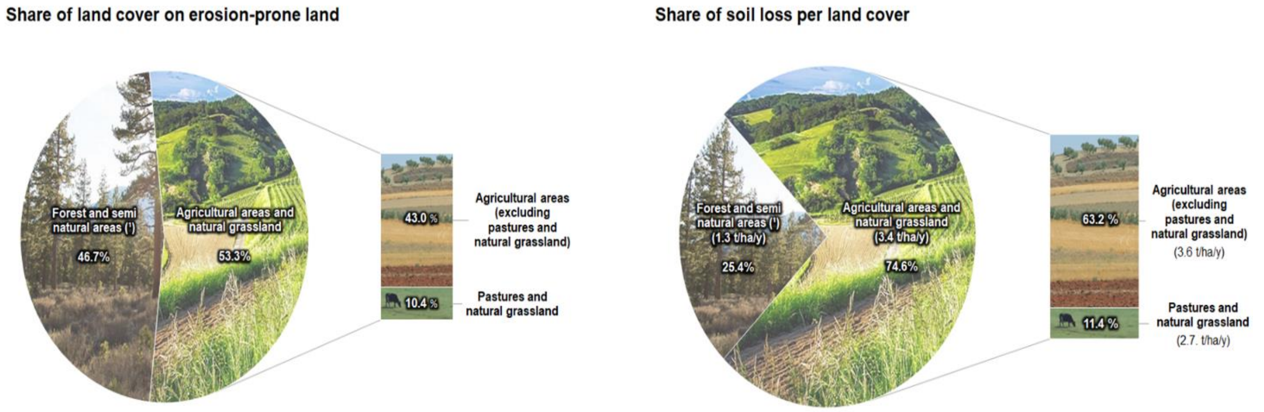
In broad terms, soil erosion describes the process through which land surface (soil or geological material) is worn away (e.g. through physical forces like water or wind) and transported from one point of the earth surface to be deposited somewhere else (Eurostat, 2020). The above-mentioned indicators describe particularly the amount of soil (in t) per unit of land surface (in ha) that is relocated by water per year.

Variations of these indicators can be calculated by considering different combinations of land cover classification groups, such as *all land*[19] and *agricultural land*[20]. As shown in 14, at EU level in 2016, about three quarters of soil loss occurred in agricultural areas and natural grasslands, while the remaining quarter occurred in forests and semi natural areas (Eurostat, 2020). Therefore, since it is the type of land cover that is most vulnerable to erosion, the present sustainability screening will consider in first line the above-mentioned indicators specifically for agricultural areas and natural grasslands. This scope of the indicators is also in line with the two sub-indicators for soil erosion considered by the Joint Research Centre European Soil Data Centre (JRC ESDAC). Moreover, both the *mean erosion rate for agricultural land* and the *share of agricultural area under severe erosion* are part of the EU Common Agriculture Policy (CAP) context indicator 42 (CCI42) for the period 2014-2020.

Nonetheless, there are regions where forests represent a larger proportion of the land cover and forestry related activities are in the focus of interest with regards to the development of the bioeconomy. Therefore, for these particular cases, we recommend using estimated mean soil erosion rate for *all lands*, as this also includes forested areas, adding an additional angle to the screening and making it more suitable for regions which may have a bioeconomy partly or wholly dependent on forestry resources (such as Stara Zagora).

[19] This refers to all potentially erosive-prone land (in simplified terms), specifically to CORINE Land Cover classification groups: Agricultural areas (2), forest and semi natural areas (3) excluding beaches, dunes, sand plains (3.3.1), bare rock (3.3.2), glaciers and perpetual snow (3.3.5). These, as well as other classes, are excluded because they are not subject to soil erosion.
[20] This refers only to agricultural land (agricultural cropland as well as grassland in simplified terms), specifically to CORINE Land Cover classification groups: Agricultural Areas (2) and Natural Grasslands (321)

Figure 15 Share of land cover and soil loss across the EU-27 in 2016[21]



Source: JRC, Eurostat

The data has been extracted from EUROSTAT, specifically the dataset "Estimated soil erosion by water, by erosion level, land cover and NUTS 3 regions (source: JRC) (aei_pr_soiler)". For determining the baseline in the sustainability screening, we have selected the latest available data, i.e. for 2016.

Mean soil erosion rate, which undergirds both selected indicators, is considered useful because it provides a solid baseline to estimate the actual erosion rate in the NUTS 3 regions (Panagos et al., 2015). This indicator is based on the latest Revised Universal Soil Loss Equation of 2015 (RUSLE2015), specifically adapted for the European context (see Panagos et al., 2015), which is a model that takes into account various aspects, including two dynamic factors, namely the cover-management[22] and policy support practices[23] (both related to human activities) (Panagos et al., 2020).

The estimated mean soil erosion rate value obtained through the RUSLE2015 model refers to water erosion only, but it is considered to be the most relevant at least in terms of policy action at EU level, due to the relative predominance of water erosion over other types of erosion. Furthermore, it offers the important advantage of providing a viable estimation for erosion vulnerability at a relatively small geographic scale, i.e. the local or regional level. This can serve as an important tool for monitoring the effect of local and regional policy support strategies of good environmental practices (Panagos et al., 2015, 2020 and Eurostat, 2020). The NUTS3 nomenclature matches the regional scale of "oblast" in Bulgaria, which means that there is readily available data for the Stara Zagora region (NUTS3 code BG344) that can be used directly for the present sustainability screening.

3.1.2.2 Methodology applied

The near-universal indicators available to track soil vulnerability are related to either erosion or the decline in soil organic carbon (SOC)/soil organic matter (SOM) (Karlen & Rice, 2015). However, there are major data gaps regarding to SOC/SOM 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" (by water), which they calculate using the RUSLE2015 model. For our purposes, we have complemented the *mean soil*

[21] Excluding not erosion-prone land (e.g. beaches, dunes, etc.). Forest and natural areas exclude also natural grasslands, which are evaluated together with agricultural areas.
[22] Known as the c-factor, it has a non-arable component, which includes changes in land cover and remote sensing data on vegetation density, as well as an arable component, which includes Eurostat data on crops, cover crops, tillage and plant residues
[23] Known as the p-factor, it reflects the effects of supporting policies in estimating the mean erosion rate by including data reported by member states on Good Agricultural Environmental Conditions (GAEC) according to the CAP, specifically contour farming, as well data from LUCAS Earth observation on stone walls and grass margins

erosion rate indicator, with the *share of agricultural area under severe erosion* in order to gain a comprehensive picture of soil erosion in a region.

Soil erosion is considered generally as a sort of proxy indicator of soil degradation, which in turn is the most relevant component of land degradation at EU level (EC, 2018). However, not all types of bio-based activities have a direct effect on erosion, but rather primary production of biomass. Nonetheless, as these are currently the most widespread bioeconomy activities in rural areas, we will consider their impact on soil degradation, and therefore on soil erosion, to be the most relevant one for this assessment.

The indicators for vulnerability to soil degradation were selected, on one hand, due to the limited number of soil indicators available at the required regional scale (NUTS3). On the other hand, the RUSLE2015 model used for this data also represents the current state-of-the-art methodology for calculating soil erosion. These aspects are crucial, since the choice of indicators needs to be: a) acceptable to experts, b) routinely and widely measured, and c) have a currency with the broader population to achieve global acceptance and impact (Stockmann et al., 2015). In order to carry out the screening of soil vulnerability, a number of datasets need to be accessed. As mentioned above, this data can be accessed via Eurostat.

In terms of processing the erosion data, it is important to consider that the overall erosion rate changes across geographic areas, meaning the vulnerability/risk is not necessarily evenly distributed. In cases where the mean soil erosion rate exceeds the 10 t ha^{-1} a^{-1}, erosion is considered severe and activities that can generate, or are associated with a high erosion impact should be strongly discouraged. Erosion rates between 5 and 10 t ha^{-1} a^{-1} are considered moderate, requiring some attention towards practices that have a high impact on erosion, but with less urgency. However, it is relevant to take a look not only at the mean erosion rate for the area itself, but also at its spatial distribution, which is roughly reflected on the indicator of share of (agricultural) area under severe erosion.

3.1.2.3 Data uncertainties

The data used is produced from an empirical computer model (RUSLE2015) and produces estimates. Hence, there are several uncertainties related to the figures if compared to data collected on the ground. However, the purpose of the model is to generate data for a large spatial scale taken into account human intervention, which is not possible to do only through empirical measurements. That being said, like every model, assumptions have to be made and there is an intrinsic level of uncertainty. Specifically related to the RUSLE methodology, Benavidez et al. (2018) critically reviewed the RUSLE methodology, upon which RUSLE2015 is based, and identified following main limitations:

- its regional applicability to regions that have different climate regimes and land cover conditions than the ones considered (in the original RUSLE for the USA, in RUSLE 2015 for Europe)
- uncertainties associated generally with soil erosion models, such as their inability to capture the complex interactions involved in soil loss, as well as the low availability of long-term reliable data and the lack of validation through observational data of soil erosion, among others.
- issues with input data and validation of results,
- its limited scope, which considers only soil loss through sheet (overland flow) and rill erosion, thus excluding other types of erosion which may be relevant in some areas, e.g. gully erosion and channel erosion, to name a few. Moreover, it also excludes wind erosion.

A further factor of uncertainty in the data is the fact that the RUSLE model is calculated using mean precipitation data over multiple years and a large territorial scale (in this case Europe). Thus, it fails to account the changes in rainfall intensity, which are highly relevant for determining water erosion accurately. This is the case not only considering the seasonality of rainfall, but also its distribution across the continent (Panagos et al., 2020). Another important uncertainty identified by Panagos et al. (2020) is the lack of georeferenced data for annual crops and soil conservation practices in the field at a continental level, which has had to be estimated from statistical data.

Nonetheless, when considered best available estimates, the mean soil erosion values generated through the application of RUSLE2015 model offer a very suitable basis for assessing vulnerability to soil loss in general terms, even if the generated absolute values are to be taken with caution (Benavidez et al., 2018).

3.1.2.4 Methodological uncertainties

Among the most relevant uncertainties regarding the application of the sustainability screening in terms of soil vulnerability are the selection of the threshold against which the severity of erosion is evaluated and the selection of the land cover types that will be considered.

Regarding the threshold of 10 t ha^{-1} a^{-1} for severe erosion, it is important to mention that this was obtained directly from the dataset that was used[24]. However, it is still an arbitrary value which can be adapted. For instance, some sources like Panagos et al. (2015, 2020), who were involved in the generation of the data for the JRC ESDAC, consider severe erosion to be above 11 t ha^{-1} a^{-1}. In this regard, we have also decided to stick to the lower value described in the Eurostat dataset because it is more conservative and, as such, more suitable for an initial (and indicative) sustainability screening like the one we are proposing.

The selection of land cover types presents another area for potential uncertainty. Choosing between "all lands" and "agricultural lands" can have considerable implications for interpreting the data. For example, it is possible that the mean soil erosion rate is 5 t ha^{-1} a^{-1} (moderate erosion) in one land cover type, but lower in the other. This would have an effect on the assessment, which would present any potential concerns about erosion and steps that should be taken. As such, it is important to have solid grounding for the choice of dataset. The ultimate decision whether to consider all lands (including forests) is arbitrary and lays with the group performing the sustainability screening. Particularly when that decision is based on considerations of the economic relevance of forestry related industries in the region rather than on the actual share of the area that is covered with forest (it should be high to justify their inclusion), the values of soil erosion (for all lands) shall be taken with some reservations. This is because these values tend to be lower than the value for agricultural land and can create the impression that vulnerability to erosion is lower than it actually is. However, due to the indicative (and non-exhaustive) nature of the present sustainability screening, this uncertainty is not especially relevant for cases such as Stara Zagora, where both values (for all lands and agricultural land with natural grassland) are low.

3.1.3 Biodiversity data and indicators

Within the European frame of biodiversity monitoring, there are different potential datasets to assess the conditions of biodiversity on EU territory. One central EU data source relates to the Member States' reporting under the Birds and Habitats Directives that is assessed every six years by the EEA. Nonetheless, due to the spatial scale of the reporting, which is based on the biogeographical and marine regions, the meaningful application on this data within a smaller region is limited. Due to these data limitations, using reporting results such as the conservation status or pressure data is considered to be not specific enough for a regional analysis. Data for a specific region, especially on species (which are mostly mobile and not endemically encountered in single regions), this hard to obtain, often not openly available and its availability highly dependent on national efforts and resources, the implementation by local authorities or the active non-governmental engagement (e.g. monitoring by NGOs or citizen science).

To get to know the biodiversity condition in the Stara Zagora region, the authors of this report thus propose a two-fold approach depending on the general type of landscape that is expected to be affected by bioeconomic activities. For *agricultural land*, we propose using the data set from EEA (European Environment Agency) on the loss of High Nature Value Farmland (HNVF) during the year 2006 to 2012[25]. The data was published in 2017 and last modified in 2019. For *forested land*, we propose evaluating their changes, particularly in terms of loss or gain of mixed and broad-leafed dominated forests. For this purpose, we have compared the data on forest type for the years of 2012

[24] See metadata of the used dataset at https://ec.europa.eu/eurostat/cache/metadata/en/aei_pr_soiler_esms.htm

[25] https://www.eea.europa.eu/data-and-maps/figures/loss-of-hnv-farmland-due/datapackageformap_fig_22.xls/at_download/file

and 2018 found on Copernicus Land Monitoring Service[26].The following sections elaborate the definitions of the selected indicators, the methodology applied to assess them and their limitations.

While the proposed indicator for forested land has been tested (see results in section 4.2.5), the indicator for HNVF will only be developed as a theoretical concept in this section.

3.1.3.1 Description of the data / definition of the indicators employed

Understanding how the biodiversity in a region will respond to and/or is affected by bioeconomy activities and their expansion is critical. This issue is particularly pronounced considering the bioeconomy's potential role as a driver of land-use change, which can cause impacts on biodiversity. In order to understand and evaluate the sustainability of biomass production in a region, it is therefore necessary to look at how it affects biodiversity.

Agricultural land

The concept of High Nature Value farmland (HNV farmland) ties together the biodiversity to the continuation of farming on certain types of land and the maintenance of specific farming systems. Typical examples include semi-natural grassland systems, traditional olive, vine and fruit production, Dehesa, Montado and other wood pasture systems and extensive farming in bocage landscapes (Schwaiger et al., 2012). The HNV farmland is an EU indicator of the conservation value of an agricultural area. The definition is as follows:

> *"High Nature Value farmland comprises those areas in Europe where agriculture is a major (usually the dominant) land use and where that agriculture supports or is associated with either a high species and habitat diversity or the presence of species of European conservation concern or both" (Andersen, 2004).*

In the concept of HNV farmland, 3 types of farmlands are included:

- ***Type 1:*** Farmland with a high proportion of semi-natural vegetation, e.g., heath, dehesa or grasslands.
- ***Type 2:*** Farmland with a mosaic of habitats and/or land uses, e.g., dry arable areas and small-scale farms in southern Europe. Small scale features includes open water, ditches, relict grassland, field boundaries and woodland.
- ***Type 3:*** Farmland supporting rare species or a high proportion of European or World populations, e.g., areas of intensively managed wet grassland favoured by migrating geese.

HNV farmland existence is under threat, with one of the main threatening factors being changes in agricultural land usage. While farming practices on better farmland have generally intensified, inferior land has been abandoned or reforested. Traditional, low-intensity farming systems with high environmental value are rare at EU scale (EEA, 2009; Keenleyside et al., 2014).

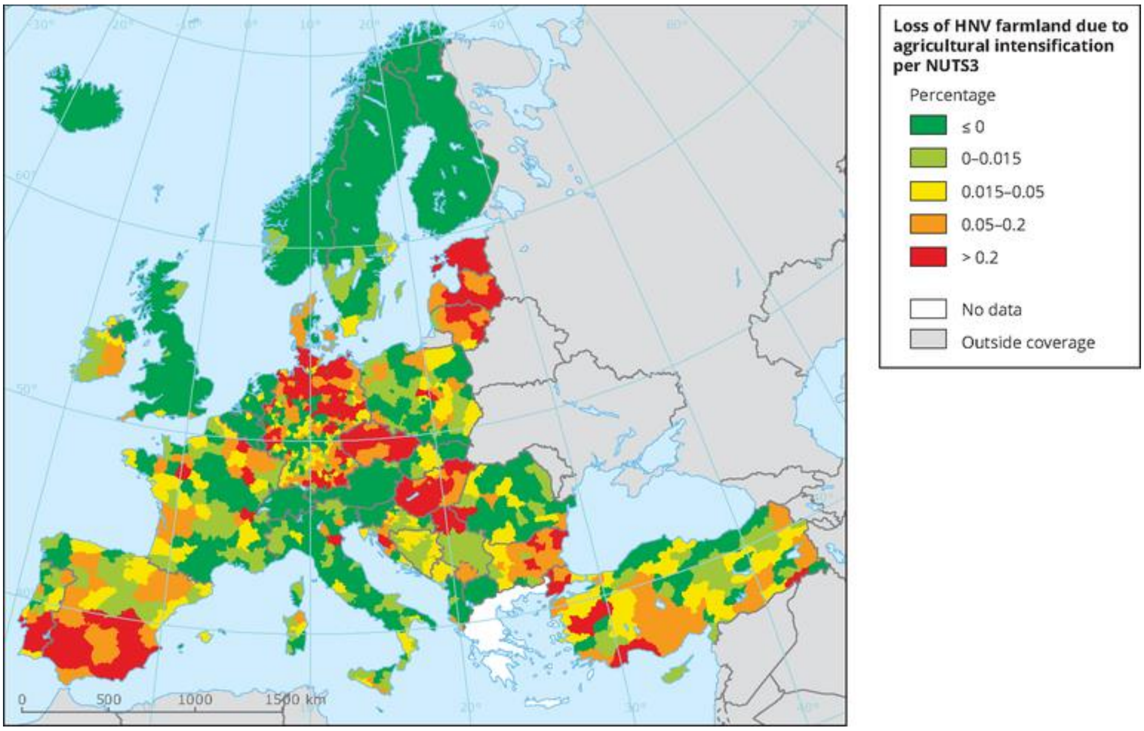
Increased regional biomass production usually comes with intensifying agriculture in a region. Therefore, the risk intensified agriculture might have on the regional biodiversity (in terms of decreased diversity and abundance of species across a hierarchy of trophic levels and spatial scales within Europe) could be assessed with the loss of HNV farmland due to agricultural intensification per NUTS3 region (Emmerson et al., 2016). In short, increased biomass production through intensification of agriculture directly influences the loss of HNV farmland.

In this exercise, we use the loss of HNV farmland by percentage during 2006 and 2012 to track representative loss in biodiversity of agricultural land and thus define a baseline for the assessment of the sustainability changes in Stara Zagora (Figure 15). The map (data set) we used[27] is developed, hosted and maintained by the European Environment Agency, which aims to improve the European map of HNV farmland, depicts the projected distribution and likelihood of HNV farmland loss over the whole European continent, thus for Stara Zagora as well. The threshold we use (see Figure 15) could be summarised into three scales for our exercise. The percentage of the loss of HNV farmland under 0.015% is considered low, between 0.015% to 0.2% is considered moderate and over 0.2% is

[26] https://land.copernicus.eu/pan-european/high-resolution-layers/forests/forest-type-1/status-maps
[27] See: https://www.eea.europa.eu/data-and-maps/figures/loss-of-hnv-farmland-due

considered high. This threshold is defined by the author based on land changes compare to other countries/regions in the map.

Figure 16 Loss of HNV farmland due to agricultural intensification[28] per NUTS3



Source: EEA, 2017.

Forested land

For the present screening, we analyzed the change of forest types across time, measured as the change of dominant leaf types covering the canopy surface. For this purpose, the screening employed the Forest Type dataset published by the EEA Copernicus Land Monitoring Service[26], which is based on high resolution (100m) optical satellite imagery. The dataset has a European wide coverage and is freely available for the years 2012, 2015, and 2018. For each year, the dataset provides a status map in the form of a Tiff-format raster, which indicates the dominant leave type for each pixel, categorizing the landscape in four discrete and collectively exhaustive classes: no forest (pixel value = 0); broadleaf forest (pixel value = 1); coniferous forest (pixel value = 2); and mixed forest (pixel value = 3).

The present screening analyzed the observable changes from 2012 to 2018 for Stara Zagora, using the GISCO statistical unit dataset for NUTS 3 from the year 2021, which is published by Eurostat and freely available as a vector shapefile. Both datasets are projected with the European projection EPSG: 3035. In order to complement the specific spatial data calculated for 2012 – 2018, we have also looked at the trends described on Global Forest Watch Dashboard, which offers data at a regional level that matches the NUTS 3 classification[12].

3.1.3.2 Methodology applied

Agricultural land

[28] The following land cover flows are classified as agricultural intensification: conversions of arable land to permanently irrigated areas; conversions of permanent crops (vineyards, orchards, olive groves) to irrigated and non-irrigated arable land; and conversions of pasture to arable land and permanent crops. The JRC/EEA HNV farmland methodology is currently being revised and an updated time series for the years 2000 to 2018 will be published by the end of 2022.

The HNV farmland indicator is initially defined by a report from EEA (Andersen, 2004). Since then, the recognition of the relation between biodiversity and HNV farmland is used for socioeconomic analysis (Lomba, 2020), landcover change research in Europe (Anderson, 2020) and assessment of policy on biodiversity protection (Schulp, 2016). In all of the above mentioned research, the authors used the dataset of loss of HNV farmland from EEA (Figure 16).

In order to map the loss of HNV agriculture at a 1 km^2 resolution, the CORINE Land Cover (CLC) map is used to pinpoint all agricultural land in Europe and classify it agricultural classes, as well as other classes relevant to HNV farmlands, such as “natural grasslands” and “peat bogs” (Schwaiger et al., 2012). This information is then combined with the most up-to-date spatial data on biodiversity distribution in Europe—specifically, data from the Natura 2000 database, Important Bird Areas, Prime Butterfly Areas, and, when accessible and appropriate, National Biodiversity databases.

Forested land

The applied methodology included a geospatial analysis. The advantage of this approach is the availability of consistent data, allowing assessments over larger areas (e.g. entire regions), while being comparable across time and space. This facilitates local analyses to be contextualized in broader regional trends, which is indispensable for any biodiversity assessment.

The geospatial analysis was performed with Quantum GIS, a freely available open source software for geographic information systems. First, the polygons representing Stara Zagora were used as mask layers to clip the status maps, extracting the extent of the respective NUTS3 region. All values outside the region boundaries were set to NoData values, while zero values contained by the boundaries were kept as zero values. Finally, an outcome raster was produced by multiplying all raster cell values of the baseline year 2012 by ten and subsequently adding the raster cell values of the year 2018. The final outcome raster contains 16 discrete classes indicating different change combinations. These change classes can be analyzed through a unique value report, which calculates the total area covered by each change class.

Table 6 Overview of the changes in forest types considered (own creation)

no forest = “N”; broadleaf forest = “B”; coniferous forest = “C”; “mixed forest” = “M”; direction of change = “→”							
value	change	value	change	value	change	value	change
0	N → N	10	B → N	20	C → N	30	M → N
1	N → B	11	B → B	21	C → B	31	M → B
2	N → C	12	B → C	22	C → C	32	M → C
3	N → M	13	B → M	23	C → M	33	M → M

Source: Own elaboration.

3.1.3.3 Data uncertainties

Agricultural land

In terms of characterization and location, the three categories of HNV farming provide various challenges. To characterize and locate type 1 and type 2 farmland, two complimentary techniques (landcover and farm system typology) are used. The actual species distributions are plotted to locate type 3 agriculture. Except for breeding birds, this is not achievable on an EU and regional scale due to a lack of species data.

Moreover, CLC distinguishes between 44 land-cover classes (LCCs) (Copernicus Land Monitoring Service 2018), a diversity of which can be considered potentially closely related with agricultural land. Moreover,CLCalso has a minimum mappable unit of 25 hectares and a minimum linear element width of 100 meters. Nonethless, CORINE is also regularly updated. For instance, the data set utilized in this exercise (CLC2006) was last updated in 2020. Despite being the best data source for land cover, CORINE has some limitations:

- Because the CORINE classes are either determined by the most dominant land use or categorized as a mix class (because the minimum mapping unit of 25 hectares) it can be difficult to determine whether HNV farming areas are found in a particular class.
- It is important to highlight that forest LCCs are not included in the LCC selection process since CLC does not distinguish between forest and agricultural management systems. This also means that pinpointing the location of various types of grazed forest that could be considered HNV farming is not technically possible.
- Land cover data cannot tell much about the quality of the Nature Value in relation to its potential (unless in extreme cases), because it does not tell anything about management practices.

Forested land

The Copernicus Forest Type dataset is derived from a pan-European assessment, which favors large scale coverage over local accuracy. The limited accuracy reduces the reliability of the data at the local level. Because the imagery has a resolution of 100m, local conditions cannot be assessed below the scale of 1ha, which might hide meaningful detail that would appear at a finer resolution. Furthermore, methods for large scale pan-European assessments are not tailored to account for specific climatic or ecological conditions that are present at the local level, which might result in measurement errors.

The low temporal resolution of the available data is another limiting factor. A change between 2012 and 2018, as it was analyzed here, might not suffice to draw conclusions about meaningful trends or the nature of long-term changes. Moreover, since the latest available data was four years old by the time it was applied here, it might represent outdated information. However, if these datasets become regularly updated, as it has been the case for the last six-year period, the quality of the analysis will increase.

The data based on the CORINE Forest Type dataset that is presented in the following section could not yet been validated.

3.1.3.4 Methodological uncertainties

Agricultural land

It is clear from the three categories of farmlands discussed in the previous section that the term HNV farmland does not refer to priority habitats for rare species or Habitats Directive priority habitats. Some farms with high biodiversity may not be included in this methodology, however this is not a large portion of the EU's HNV agriculture. In any case, this strategy will still have narrower policy objectives centred on threatened species and environments.

The land cover technique used for HNV type 1 (and partly type 2) allows for a close approximation of semi-natural vegetation and, to a lesser extent, low-intensity agriculture mosaics. For HNV type 3, data on the location of cropland that supports rare species or a large proportion of European or global populations is required. Despite the existence of European initiatives aimed at providing harmonised information on landscape typologies and landscape elements, the information contained in these initiatives does not allow for successful mapping of HNV farmland, particularly Type 2, which is defined by mosaics of low intensity agricultural patches and linear elements. Landscape maps, if they exist, are found only at a national level, but could still potentially provide some valuable information to this regard. According to research conducted for the JRC in France and Wallonia (Pointereau et al., 2007), national statistics, when accessible at the NUTS3 level, can be particularly valuable for identifying the share of HNV farming in agricultural areas at the local level. In most cases, landscape data will need to be combined with land use intensity data to provide a reliable indicator of the likelihood of HNV agriculture being present.

In short, the mapping accuracy of (the loss of) the HNV farmland could be improved by:

- Refined definition by including rare species
- Using more regional/small resolution data while mapping

Forested land

Comparing the coverage of dominant leaf types at the canopy surface over time results in a very limited indicator for changing habitats, which does not allow firm conclusions regarding impacts on the local biodiversity. The application of this method requires complementary field work and local knowledge to determine how regional changes in forest types have impact on biodiversity. The Global Forest Watch Dashboard offers some information on certain parameters, but more detailed information about the species composition of the forest in (parts of) the region is still needed. In addition, more information on local forest management practices is needed to derive to substantiated conclusions with regard to local biodiversity impacts. One future option could also include to link the data with protected areas, such as the Natura 2000 area delineations or the European inventory of nationally designated protected areas (CDDA) to derive more information on the de- or afforested areas and their significance for biodiversity (e.g. by looking at different protected area classifications).

Moreover, applying this method does require some extra technical knowledge that may not be readily available within the screening working group. Nonetheless, this is only a minor limitation, since the dataset and the software used are open source, and the calculation methodology relatively straightforward.

3.1.4 Biomass data and indicators

The screening of biomass resources aims to show the theoretical availability of different types of biomass in the region. Data availability at regional level is crucial in selection of biomass indicators for screening.

The screening of biomass potential is performed using the following data sources:

- Datasets of national and regional statistics (National Statistical Institute of Bulgaria 2022)
- Official reports of national authorities and international organisations (Bulgarian Ministry of Agriculture and Forestry[29], FAO)
- Publications of international and national projects (BEE, S2Biom, CELEBio, Bio4Eco, BioStep etc).

3.1.4.1 Description of the data / definition of the indicators employed

Indicators assessed are biomass quantities of the following categories:

- forest biomass (in t a^{-1})

- agricultural biomass (in $t\ a^{-1}$)

- energy crops (in $t\ a^{-1}$)

Forest biomass

Forest biomass includes woody feedstock derived from forests or from processing of timber. Only exploitable forests[30] that are available for wood supply are considered as a source of forest biomass. In order to ensure the sustainable use of forests in the region and minimise the environmental impact

[29] https://www.mzh.government.bg

[30] according to FAO (1999) 'exploitable forest' is a forest and other wooded land on which there are no legal, economic or technical restrictions on wood production. It includes areas where, although there are no such restrictions, harvesting is not currently taking place, for example, areas included in long-term utilization plans or intentions

of wood harvest, the estimation of forest biomass potential considers that the maximum volume of annual fellings should not exceed the net annual increment of woody biomass.

For the screening of the potential of forest biomass the following biomass types are considered:

- stemwood,
- primary forestry residues and
- secondary forestry residues.

Agricultural biomass

Agricultural biomass considered in this screening refers to agricultural residues that include three main classes:

- Primary agricultural residues, like straw of cereals that remain in the fields after harvesting and pruned biomass from orchards and vineyards
- Secondary agricultural residues, like sunflower husks and similar biomass, generated from the processing of the primary crops
- Manure (e.g. from pig, cattle and chicken)

Energy crops

- Perennial herbaceous and woody energy crops that could grow on marginal lands (poplar, willow, miscanthus, etc.).

3.1.4.2 Methodology applied

Forest biomass - stemwood

For the screening of forest biomass theoretical potential in Stara Zagora region a basic resource focused statistical method is applied[31]. The method requires data on net annual increment and wood removals.

*Theoretical stem wood potential = Net annual increment of stem wood (m^3/year) * (1-Harvest losses[32]) - Roundwood removals * (1+ Bark fraction[33])*

As there is no available information of net annual increment for Stara Zagora region (NUTS3 level), but only for the Bulgaria, we assess the net annual increment at the local level by applying net annual increment per hectare to the forest area in the region.

According to Eurostat, forest area and net annual increment in Bulgaria in 2019 amounted 3,879,000 ha and 13,928,000 m^3, respectively. Taking into account average net annual increment per hectare of forest land (3.6 m^3/ha) net annual increment of forests in Stara Zagora amounts 581,531.4 m^3. Applying the equation above, theoretical stemwood potential in Stara Zagora region can be preliminary assessed as 234,273.78 m^3, which is about 105,423.2 t of dry matter[34].

---

31 https://www.researchgate.net/publication/268388401_Harmonization_of_biomass_resource_assessments_Volume_I_Best_Practices_and_Methods_Handbook

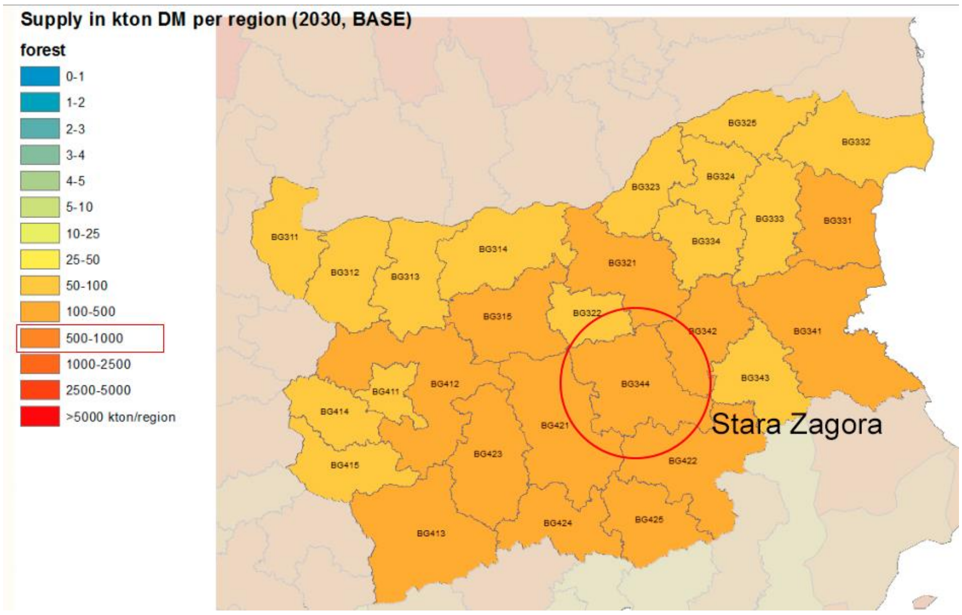
32 For harvest losses default values of 0.08 for coniferous species and 0.10 for broadleaved species are used according to recommendations IPCC2006a.

33 Average bark fraction of 12% (range 4-30%) is reported byFonseca and Task Force Members 2010, https://unece.org/fileadmin/DAM/timber/publications/DP-49.pdf

34 to asses the amount of forest biomass the density of coniferous (850 kg/m3) and deciduous (1000 kg/m3) trees, as well as moisture content in wood at harvest (50%) were considered.

The assessed theoretical potential of forest biomass is in line with the other research performed within S2Biom project (Figure 17), where forest potential have been estimated using the EFISCEN forest resource model[35].

Figure 17 Estimated sustainable potential of forest biomass in Bulgaria per region, thousand ton of dry matter (S2Biom, 2030, Base)[36]



Source: S2Biom, n.d.

Agricultural biomass - primary agricultural residues

For screening of the potential of primary agricultural residues in the region a residue-to-crop ratio is applied to the crops that are cultivated in the region, namely wheat, barley, triticale, sunflower, rape. Estimation of the theoretical amount of residues available depends on a number of factors like the weather and soil conditions, seed type, and others and is therefore difficult to estimate. In order to utilize primary agricultural residues sustainably and protect soil fertility, identified theoretical potential should be further reduced by the amount left in the field. As a result of varying local conditions, the estimates of the amount of residues that may be removed while maintaining soil productivity vary widely. According to Scarlat et al. (2010) applied sustainable removal rate for straw of wheat, barley, rye, triticale and oats is 40%, and for maize stover, rice straw, rapeseed stover and sunflower stalks is 50%.

According to the latest research for Bulgaria (Ivanova et al. 2020) residue-to-crop ratio for these crops are: wheat - 1.00, barley - 0.93, triticale - 0.95, sunflower seed - 2.70 and rape - 1.70 (Table 7)

Table 7 Agricultural biomass potential for the Stara Zagora region

Crop	Harvested production in EU	Harvested production in EU	Theoretical potential (range based on 2020-2021 data) (t)	Theoretical potential (based on

---

35
https://www.s2biom.eu/images/Publications/D1.8_S2Biom_Atlas_of_regional_cost_supply_biomass_potential_Final.pdf
https://www.s2biom.eu/images/Publications/D1.8_S2Biom_Atlas_of_regional_cost_supply_biomass_potential_Final.pdf

36 https://www.s2biom.eu/images/Publications/WP8_Country_Outlook/Final_Roadmaps_March/S2Biom-BULGARIA-biomass-potential-and-policies.pdf

	standard humidity (t)	standard humidity (t)		sustainable removal rate), (t)
	2020	**2021**		
Wheat*	308,136	363,424	308,136 … 363,424	134,312
Barley	41,517	37,967	38,611 … 35,309	14,784
Triticale	3,320	3,789	3,154 … 3,600	1,351
Sunflower	81,604	89,173	220,330.8…240,767.1	115,274

* includes Common wheat and spelt and Durum wheat

Source: Own elaboration based on Ivanova et al., 2020.

Agricultural biomass - pruned biomass from orchards and vineyards

According to Bilandzija et al (2012) amount of biomass obtained from prunings of fruit orchards can vary from 1.2 to 5.8 t/ha and up to 4.2 t/ha for vineyards (research was performed to Croatia which can be considered similar to Bulgaria in terms of nature conditions). Taking into account areas under fruit orchards and vinyards, amount of obtained biomass can be the following:

- pruned biomass from fruit orchards: from 1735.44 t to 8387.96 t annually
- pruned biomass from vineyards: 5958.96 t annually

Agricultural biomass - livestock manure for biogas and biomethane

The potential of biogas production from the digestion of animal manure can be preliminary assessed multiplying the amount of generated manure by the specific biogas yield. Biomethane share in the biogas depends on the biogas composition and the process used for its production and can vary from 45% to 75% by volume[37].

Energy crops

The potential of biomass from energy crops is somewhat theoretical and based on the assumption of abandoned agricultural land availability. Taking into account that agricultural lands are usually abandoned due to marginality (i.e. worse soil quality and nature conditions than required for production of food crops) biomass yields from energy crops can be below general average yields.

3.1.4.3 Data uncertainties

Forest biomass

When accounting for wood biomass - there are statistics only for round timber and most often there is no statistics for woody biomass, including branches, logs and brushwoods, called other wood components, and it is the main resource for use in the bioeconomy.

As there is no available data on net annual increment in Stara Zagora region, a country based indicator of specific net annual increment per hectare was used to assess the theoretical potential of forest biomass resources in the Stara Zagora region.

Zagora region, a country based indicator of specific net annual increment per hectare was used to assess the theoretical potential of forest biomass resources in the Stara Zagora region.

[37] https://www.iea.org/reports/outlook-for-biogas-and-biomethane-prospects-for-organic-growth/an-introduction-to-biogas-and-biomethane

Agricultural biomass

It is extremely difficult to make a realistic assessment of the agricultural biomass potential in a given region, as there is no statistical information on the available residual biomass.

Models are used to determine the biomass of agricultural products, which in practice simplifies the assessment, but they do not include factors such as different varieties, agro-climatic conditions and practices. Another obstacle to determining the existing quantities of biomass is the lack of information about the existing collection practices and technical possibilities for collecting field residues, as well as about the necessary residual mass to meet the criteria for sustainability, e.g. prevention of soil erosion.

In addition, there is a lack of information on how much of the residual biomass is used for farm animal feed, as well as sufficiently accurate information on imports and exports.

3.1.4.4 Methodological uncertainties

The main considered uncertainties of the applied method for forest biomass resources screening that may limit its accuracy are availability and quality of primary statistical data. The method applied doesn't consider constraining factors of biomass availability and can be used only for preliminary screening.

Methodology applied to screening of primary agricultural residues considers the standards crops to residues ratio that can differ depending on crop varieties. Another uncertainty that should be considered is the share of biomass residues that can be taken from the field, which strongly depends on the type of soil and demand in mineral nutrients.

3.2 Rough appraisal of available capacity

The pilot screening of the environmental resources in the Stara Zagora region yielded the following appraisal of available capacity of the regional ecological system. As noted in the previous sections of this chapter, these results may carry considerable uncertainty and in some cases may be limited in scope. Thus, they are intended here merely as an exercise to show what the pilot of the sustainability screening for Stara Zagora was capable of generating. If deemed valuable, members of the OIP Stara Zagora are encouraged to conduct future iterations of this work and expand it to increase its applicability.

Table 8 Rough appraisal of available ecological capacity in the Stara Zagora region

Resources screened		**Ordinal Baseline Rating**	**Appraisal**
Category	**Sub-Category**		
Water	**Surface water bodies**	(red)	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. Further, there is a high proportion of surface water bodies under unknown chemical conditions. 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. Almost half of the lakes in the RBD are affected by unknown impacts.

Resources screened		Ordinal Baseline Rating	Appraisal
Category	**Sub-Category**		
	Groundwater bodies		Almost half of the groundwater bodies in the East Aegean RBD are in poor chemical status. Diffuse sources of pollution are the most recurrent pressures on groundwater bodies in the RBD. Nutrient pollution is the most recurrent impact on groundwater bodies in the RBD.
Land Resources	**-**		With a mean soil erosion rate in all lands of 1.4 t/ha per year in 2016 (latest available data), Stara Zagora is not considered vulnerable to erosion. Erosion in arable lands is 2.1 t/ha per year, which is still well below the European threshold for low erosion level (low < 5 t/ha per year). Only 0.82% of all land in Stara Zagora surpasses the European threshold for severe erosion rate (severe >=10 t/ha per year). In this context, soil erosion does not pose a risk for the sustainability of the bioeconomy in the region.
Biodiversity	**Agricultural land**		Stara Zagora area, NUTS3 number BG344, has a rate of 0.406 regarding losing HNV farmland. This rate is rather high in comparison with other NUTS3 unit in Europe (as only 169 out of 1483 NUTS3 regions have loss rates higher than 0.2%).
	Forested land		Between 2012 and 2018, Stara Zagora experienced a gross forest cover increase of 25.875 ha. The majority of cover losses and gains can be attributed to changing broad-leaf cover, particularly to a change of previously non-forest land to new broadleaf forest cover. During the same period, the region accounted for a relatively small gross forest cover loss of 2.157 ha, resulting in a net forest gain of 23.718 ha. The area of mixed forest cover has increased by a substantial extent over the observed period, explaining more than one third of the gross forest increase.
Biomass	**-**		Screening of biomass resources in Stara Zagora showed that there is a potential of biomass resources from forest and agriculture that can be utilised by applying appropriate practices for collection of a sustainably available biomass. Other parts of potential are of theoretical origin and include biomethane, when produced from animal manure, and energy crops, when grown

Resources screened		Ordinal Baseline Rating	Appraisal
Category	Sub-Category		
			on marginal lands. Conservative assessment shows the availability of at least 105,423.2 t of dry matter of forest biomass. Further detailed assessment may increase this figure by considering a sustainable amount of primary and secondary forest residues.

4 Part D: Potential ecological burden of regionally relevant bioeconomic activities

4.1 Bioeconomic activity selected for the screening

As mentioned in Chapter 1, the regional strategy formulated by the OIP Stara Zagora defines Agriculture and Forestry as priority sectors for the development of the region's bioeconomy. Thus, a sustainability screening for specific economic activities falling within these sectors was considered of relevance by the authors of this report. However, given the limited resources available for this task (not included or budgeted for in the original work plan), as well as its illustrative purpose, activities falling within only one of the sectors have been considered. As no indication or preference for the examination of specific agricultural crops was provided by the members of OIP Stara Zagora, and given the comparably better availability of information, the authors of this report decided to explore Forestry activities.

The following two sections provide some working definitions and a typology of forestry management practices. The rest of this chapter aims to synthesise the results of a literature review on potential impacts of specific forestry activities on water, land, biodiversity and biomass, respectively.

4.2 Overview of forestry, forestry management practices and their potential burden on the resources examined

4.2.1 Definitions

What exactly is understood by *forest* can vary from academic and political context. For instance, the UN Food and Agriculture Association (FAO) defines forests as "land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use." (FAO 2010). In the case of Bulgaria, the Bulgarian Forest Act takes a similar definition, only that it considers already areas of 0.1 ha and above that fulfil these characteristics as forest. For more information on the definition of forests that is applicable in Bulgaria see chapter 2.1.4.

Following the definition by Grebner, Bettinger and Siry (2013), *forestry* can be understood as "the art, science, and business of managing forests to achieve a diverse set of goals that range from timber production to ecosystem services". In line with this understanding, a great proportion of forestry activities are also associated *forest management*, even though they do not overlap completely. Following the FAO (2010) definition, forest management can be understood as "the processes of planning and implementing practices for the stewardship and use of forests and other wooded land aimed at achieving specific environmental, economic, social and /or cultural objectives. It includes management at all scales such as normative, strategic, tactical and operational level management." Therefore, forest management is not exclusively aimed at production of goods and services, but forests can also be managed mainly for conservation purposes.

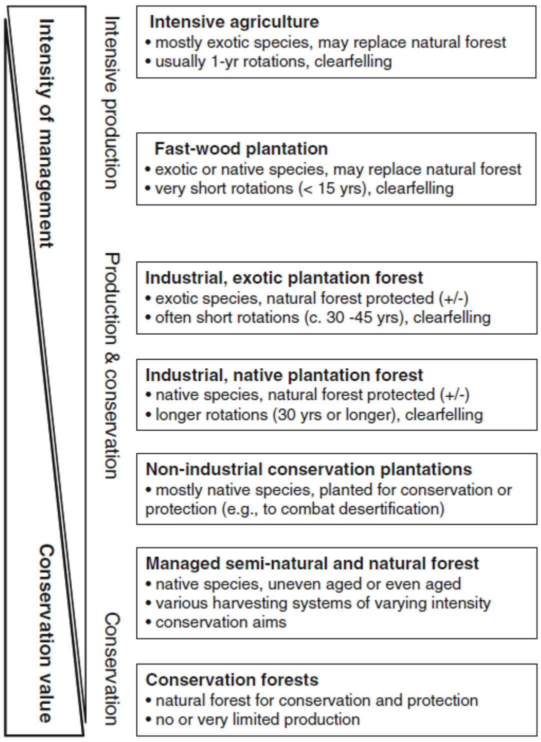
According to the definition of FAO (2010), *forest plantations* consist "[…] either of introduced species (all planted stands), or intensively managed stands of indigenous species, which meet all the following criteria: one or two species at plantation, even age class, regular spacing". Conversely, forests classified as *undisturbed by man* can be described as those "in which the natural forest development cycle persists or was restored and show characteristics of natural tree species composition, natural age structure, deadwood component and natural regeneration and no visible signs of human activity" (FOREST EUROPE 2020).

4.2.2 Overview of Forestry and common management practices

According to Hannah et al. (1995) about 0.2% of the European deciduous forests are in relatively natural conditions. The rest is more or less intensively managed, mostly for the production of timber and energy (Nascimbene et al. 2013). An increasing proportion of these are plantation forests which are established through large scale planting or seeding of trees that are even aged and from the same species (FAO 2010). In Bulgaria, all forests are managed to some extent (Stoeva, Markoff and Zhiyanski 2018). However, according to the State of European Forests 2020, about 18% of Bulgaria's forest fall under the category "undisturbed by man"(one of the largest rates in the whole continent), while about 20% of the total forest area (also one of the largest shares in Europe) is occupied by plantation forests (FOREST EUROPE 2020).

At the operational level, it is possible to differentiate between different management intensities, with (near) natural forest often being characterized by close to minimal management (close-to-zero human intervention). At the opposite end, certain types of commercial forestry, such as fast wood plantations, are characterised by very intense management practices across the entire life cycle of the plantation, from planting/seeding to harvesting and regeneration (Brockerhoff et al. 2008). For a general orientation see the conceptual model of Brockerhoff et al. (2008) in Figure 18.

Figure 18 Conceptual model of the relative conservation value of planted forests relative to conservation forests and agricultural land uses



Source: Brockerhoff et al., 2008.[38]

Regardless of the purpose of the forest management, there is a basic, common set of forestry practices that are employed throughout the world, even if with some differences related to the region and forest type (Grebner, Bettinger and Siry 2013). Many of these practices are related to one of the following (Grebner, Bettinger and Siry 2013):

- the establishment of a forest,
- the maintenance of its health and productivity,
- the control of its composition, e.g. in terms of tree size, species and quality.

The combination, timing and intensity, as well as the resulting environmental impact of these practices vary depending on the goals and objectives that the landowner/manager pursues, and the local conditions (Grebner, Bettinger and Siry, 2013). An overview of the most relevant practices for the purposes of this general sustainability screening of regional bioeconomies can be found on Table 9, which for orientation reasons can be grouped in the following three main categories, according to the stage in the life cycle of the forest[39]:

- Initial stage
- Core stage
- End-stage

[38] As pointed out by the authors of this figure, this is a schematic representation that does not reflect all types of forest plantations, as some of them may serve multiple purposes. Moreover, some forest found in Europe can also be difficult to categorise using this model, as they were established as plantations long time ago, but with the time have become more diverse by natural processes. Under this model, so-called “close-to-nature forests” form part of the category “managed semi-natural and natural forest” (Brockerhoff et al. 2008)

[39] The lifecycle of a forest can be understood as a loop, therefore the end-phase(harvesting) can have an important influence on the sub-sequent initial phase (e.g. regarding the type of forest regeneration and, in the case of artificial regeneration, the species composition chosen)

Table 9 Overview of forestry management practices (own creation based on Grebner, Bettinger and Siry 2013)

Stage	Practice category	Sub-category	Description
Initial stage	Site preparation	/	involves making a site in question suitable for the establishment of a new (in most cases even-aged) forest. This includes methods for removing ground vegetation and debris (manually, mechanically, or aerially) prior to the establishment of a new forest. Some of these practices include burning, chopping, raking, ploughing, bedding and (aerial) application of herbicides
	Forest regeneration	Natural regeneration	Involves the establishment of a new forest from self-sown seed, coppice shoots or root suckers. Coppice shoots are new growth (stems) arising from dormant or adventitious buds near the base or stump of a tree, where the previous tree was cut. Coppicing is considered a natural reforestation process, even though it is also associated with harvesting practices.
		Artificial regeneration	Artificial regeneration involves using seed, seedlings, or rooted cuttings to establish a new forest. Seeding can be performed aerially. Seedlings are very young trees, (1 - 2 years old), that have been either grown from seed in a tree nursery or developed from a rooted cutting of an older plant. Seedlings are planted directly.
		Afforestation	practice of planting trees on land that has not recently been used to grow a crop of trees
Core stage	Early tending	/	practices employed to manipulate the vegetative conditions and therefore influence the character of an even aged forest during its early developmental stages (first decade of the forest). These practices are designed to affect the stocking of plants, and thus competition among plants, with the intent of enhancing the success of the desired tree species. One important example is weeding (suppression of undesirable vegetation growing alongside the desired tree seedlings) by means of herbicides, hand tools (brush knives or axes), or power tools that mow or cut undesired vegetation
	Thinning/pruning	Precommercial thinning	Practices designed to remove trees of the desirable tree species when their stands are too dense at early stages. This involves practices similar to those used in weeding. These are meant to facilitate accelerated diameter growth of the remaining trees, thus maintain desirable tree stocking levels and improve the form and quality of the remaining trees
		Pruning	practice that may be applied early in the life of a forest in order to improve the quality of the wood in the main stem of a tree. It involves limiting the number and size of knots in the bole of a tree in order to facilitate the milling of high-quality boards or due to safety reasons. During the process of

			pruning, the lower branches (both live and dead) of a tree are removed, using pruning ladders and hand or power saws
		Commercial thinning	In a commercial thinning, individual trees are selectively removed to promote the quality and growth of the trees that remain or to salvage trees that may die before the next thinning or before the final harvest occurs. This practice has major overlaps with partial selection harvests (see below)
	Fertilisation	/	Fertilisation aims to increase the productivity of forests, especially since fast-growing forests may require nutrients beyond what is naturally available in the soil. Fertilisers generally include nitrogen, phosphorous, and potassium, as well as a range of other nutrients, and can be applied at the time of planting or later during the forest's lifespan.
	Understory cleaning	/	Involves the removal of forest litter, understory firewood, and most biomaterial from the forest floor. This can take place either within a certain radius of specific trees, or indiscriminately in an entire area.
	Agroforestry	/	An approach to land management combining standard forestry practices with agricultural or livestock production, which aims to increase or optimise production of a certain product in an area. A range of specific practices can fall under this umbrella, including silvopastoral systems (tree growing combined with livestock production), alley cropping, and windbreaks.
End-stage	Harvesting	Clearcut (Final Harvest)	A continuous harvesting operation which removes all trees from an area. Non-merchantable trees may be left standing, if it is thought that they could be removed for future site preparation, while undergrowth may be left in place for the re-establishment of a new forest.
		Group selection Harvest	Aims to encourage natural regeneration of mature live trees trees by opening the canopy of a forest through small harvests to create gaps. Avoids many of the aesthetic concerns of clearcutting, since patches generally range from 0.2 ha to 2-4 ha.
		Seed tree harvest	A seed tree harvest is a type of final harvest practice which leaves scattered *seed trees* standing after the harvest to act as a source of seeds for natural regeneration of new trees.
		Shelterwood harvest	An afforested plantation composed of trees planted to shelter farmland and agricultural crops from the effects of wind and potentially reduce soil erosion, can eventually be harvested to serve as a source of fuelwood or income.

		Partial selection harvest (uneven-aged)	Common in uneven-aged forests, partial harvests or selection harvests involve the periodic removal of individual or groups of mature trees. This allows smaller, younger trees to grow into the openings in the canopy. The selection of trees for removal is often based on maintaining the structure and viability of the forest.
		Partial selective harvests	The removal of trees according to their age, quality, size, or value, with less importance placed on the overall remaining forest character. This practice frequently ignores management goals and the sustainability of yields.
		Salvage or sanitation harvest	Salvage harvest is the removal of trees which are dead/dying or deteriorating and risk soon becoming worthless. Sanitation harvest removes trees which pose a threat to the overall health of the forest, i.e. those which may be affected by insects or disease.

4.2.3 Potential burden on water resources

Given the recurrence of nutrient pollution as an impact on rivers, lakes and groundwater bodies in the RBD where Stara Zagora is located, it seems important to recognize forestry practices which could help to mitigate (or, conversely, exacerbate) such impacts. In their review work, Keenan and van Dijk (2010) examine the relationship between forest management practices and water resources, identifying how certain practices may affect water quality, water quantity, precipitation and flooding. They present cases in which changes in water quality can be associated to specific practices. For instance, the planting of belts of trees as filter strips around point sources of pollution (e.g. urban and industrial wastewater discharges, both substantially problematic for Stara Zagora) can act as intercepts to run-off and nutrients before they reach streams (Ellis et al., 2006 as cited in Keenan and van Dijk, 2010). Similarly, afforestation is generally linked to improved water quality, inter alia through the reduction of salt inputs. Further, the careful selection of tree species to be employed in forestry activities is relevant not only due to differences in water demand, but also due to varying chemical composition that can have implications for water quality. For instance, Augusto et al. (2002) point to several cases illustrating larger concentrations of Nitrogen and Phosphorus in the leaves of hardwood species compared to conifers. Here, considering the balance between the stand's capacity to bind such nutrients more effectively against the potential impact of pollution from their litterfall combined with other nutrient sources present in the basin seems important. Similarly, given the key role played by lychens in nutrient cycling (Pike, 1978 as cited in Nascimbene et al., 2013), harvest practices like partial selection harvesting, which can maintain comparably stable conditions of substrate availability and exposure to sunlight, could help mitigate or control nutrient pollution impacts. Further on this, May et al. (2009) compare plantation forests with agricultural land use and state that the latter's potential nutrient contribution to streams can be considerably higher. However, this would be contingent to the type of agricultural practice implemented. Given the priority given by OIP Stara Zagora to both Agriculture and Forestry in its bioeconomy strategy, it appears relevant to incorporate such considerations and thorough spatial planning into decisions on the location of new agricultural and forestry operations and/or the rescaling of existing ones. In extreme cases, large-scale harvesting operations can cause nutrient enrichment of downstream water bodies (Nisbet & McKay, 2002). Lastly, activities accompanying forestry operations, like the construction and (inadequate) maintenance of roads has previously been associated with impacts on downstream water bodies (e.g. high turbidity levels, siltation, and nutrient pollution) (Nisbet & McKay, 2002). With regards to flooding, the picture is somewhat mixed, and there is no clear evidence as to whether clearing or afforestation have a direct correlation with flooding in river basins. Afforestation is mentioned as affecting regional weather patterns through changes to albedo and evapotranspiration, thus having a potential link to increased rainfall levels (Keenan and van Dijk, 2010). However, afforestation and reforestation are also tied to reduced water availability, specifically reduced streamflow and groundwater inputs. Similarly, areas where there has been extensive clearing often experience increased water availability. These effects, however, will depend on the extent of the catchment that has been planted as well as the spatial configuration of the trees (Keenan and van Dijk, 2010).

4.2.4 Potential burden on land resources

Keenan and van Dijk (2010) also identify certain forest management practices that can have a positive impact on soil resources. Afforestation is mentioned as a possible approach to reducing soil erosion as well as improving soil infiltrability. Furthermore, they note that maximum erosion protection requires the development of a litter layer, understory growth and surface roughness from tree roots. On the other hand, the act of establishing a forest (and harvesting, poor road network design) can shift large amounts of sediment and cause damage to soils that may counteract the positive effects for soil erosion. Finally, as mentioned above, afforestation can lead to reduced salt inputs which is beneficial for soil quality. According to the Bulgarian National Programme for Conservation, Sustainable Use, and Restoration of Soil Functions (2020-2030), soil salinization is an issue for Stara Zagora. Large parts of saline soils are not cultivated due to severely reduced soil fertility. Also, the anthropogenic salinisation in urban areas is increasing (Bulgarian Ministry of the Environment and Water, 2020).

In their general accounts of forestry management practices with focus on the USA, Grebner, Bettinger and Siry (2013) point out that site preparation activities, such as burning, chopping, raking, plowing, and bedding can all lead to soil compaction and the removal of topsoil. Moreover, the application of herbicides can also cause problems related to toxicity in the soil. Further practices can also have negative effects on soil quality. For instance, understory cleaning may cause soil compaction, which can have effects on soil moisture content and other soil features (Grebner, Bettinger and Siry 2013). On the other hand, these authors also refer to the positive effects of precommercial thinning, which generally involves cutting trees and leaving them on the ground, thus enhancing the soil quality (Grebner, Bettinger and Siry 2013).

In a study on the impacts of harvesting activities on soils, tree stands, and regeneration in forests, Picchio et al. (2020) identify how a variety of practices can lead to changes in the physical, chemical and biological properties of forest soil. They note that soil compaction as a result of large-scale harvesting operations (such as clearcutting and the final harvest of shelterwood) can cause reduced soil porosity and water infiltration, leading to increased waterlogging on flat land, and soil runoff and erosion on slopes. The study also points specifically to the negative impacts of harvesting equipment and machinery, which can cause long-term damage to soil health, negatively affecting the productivity of the forest and ecosystem functions (Picchio et al. 2020).

Furthermore, Augusto et al. (2002) have carried out an extensive assessment of the impacts of various tree species found in European forests on soil health and fertility. Though few generalizations can be made, the results also can be applied to the Stara Zagora region. The authors highlight how various tree species can impact, for example, the presence and abundance of soil microflora and fauna. The acidity of the soil is also affected by the species of trees in the overstory, as the acids originate from the atmospheric decomposition of biomass. Additionally, they note that the moisture content of soil tends to be higher around hardwood trees compared to conifers. Hardwood trees also tend to contain more nutrients, meaning that the decomposition of their litterfall (fallen foliage) can lead to more nutrient-rich soils (Augusto et al. 2002). As such, it is beneficial for soil health to consider the diversity of tree species in forests and ensure an adequate mix of conifers and broadleaved trees is given in order to improve the soil properties.

4.2.5 Potential burden on biodiversity

All types of management change some properties of the open land and forest, and it is unrealistic to expect any type of forestry to have no impact on forest biodiversity. Different types of forests with different management systems may result in substantially different biodiversity impacts (Chaudhary et al., 2016).

In terms of the impact of forestry on biodiversity, the literature generally differentiates between the impacts (both positive and negative) of plantation forests in comparison to alternative land uses –such as (semi) natural forests or agricultural land– and the impacts of different degrees of forest management intensity, mostly on species richness (often differentiated by specific groups of organisms) (see e.g. Brockerhof et al. 2007; Paillet et al. 2010; Nascimbene et al. 2013; Irwin et al. 2014).

For instance, regarding the general impacts of plantation forests, Brockerhof et al. (2007) conclude that the conversion of natural forests to plantation forests and the afforestation of natural non-forest land is detrimental for biodiversity. Nonetheless, in landscapes where forests are the natural land cover, afforestation of agricultural land can actually be of great benefit for biodiversity, as it can provide complementary forest habitat for forest species, as well as buffering edge effects, and increasing connectivity between patches of (semi) natural forests. Therefore, in order to determine whether plantation forests are rather damaging or beneficial for biodiversity, it is crucial to gather information on following aspects (Brockerhof et al. 2007):

- the land use preceded the establishment of a plantation (e.g. agriculture of semi-natural forest),
- alternative land uses that would be likely to occur at the given location (e.g. agriculture or urbanization),
- the tree species involved (amount and type: native or introduced), and
- purpose for which a plantation is being managed (only timber/energy production or also some others such as conservation management included?)

Following the general analysis of Brockerhof et al (2008) (based on the case studies of Brazil, Indonesia, New Zealand, UK, China, France and USA), natural forests have indeed a higher habitat value for native forest species than plantation forests. However, the extent of this difference varies depending on the management intensity and the tree species composition of the plantations and how much it varies from the structure of natural forests in the same area. Moreover, the richness of certain species that are specially adapted to the specific conditions of native forest is more severely affected than that of species that are adopted to live in forests but do not require such specific conditions. For the latter, plantation forests can represent a valuable habitat, especially if it substitutes other land uses such as intensive agricultural land. Similar conclusions were found by Irwin et al. (2014) in their comparison of species diversity in semi-natural woodlands versus (tempered) plantation forests in Ireland.

In relation to this, the metanalysis carried out by Paillet et al. (2010) focusing on the impacts of different management practices (in comparison to unmanaged forests) on biodiversity highlighted that:

> "species dependent on forest cover continuity, deadwood, and large trees (bryophytes, lichens, fungi, saproxylic beetles) and carabids were negatively affected by forest management. In contrast, vascular plant species were favored. The response for birds was heterogeneous and probably depended more on factors such as landscape patterns."

Referring specifically species richness of lychens, which are a crucial component in forest food-webs and also play an important role in the forest water and nutrient cycles, Nascimbene et al. (2013) highlight the comparative advantages of partial selection harvesting in comparison to extensive harvesting practices such as the final felling in shelterwood systems. To this respect, they argue that latter practices cause a dramatical change in the ecological conditions lychens require to prosper, e.g. through the reduction of substrate availability and the swift change from low to high sunlight exposure conditions (Nascimbene et al. 2013). According to the results of Paillet et al (2010), which were focused on European temperate forests and are therefore relevant for the Stara Zagora region, the management practice with the highest impact on overall biodiversity was the practice of harvesting through clearcutting followed by a change in the tree species composition (Paillet et al. 2010). On the other hand, the impact of clearcutting itself did not seem to be the most relevant factor, as the species richness in formerly clearcut forests that had not undergone a subsequent change in tree species (either by natural or artificial regeneration processes) did not differ significantly from unmanaged forests (Paillet et al. 2010).

A study by Deal et al. (2013) explores lessons that can be learned from the management of native spruce forests in Alaska with regards to biodiversity and ecosystem services. Although this context is rather different than that of Stara Zagora, some general lessons can be taken away. These authors point towards introducing a mix of broadleaved species in conifer-dominated forests a beneficial forest management approach (Deal et al. 2013). For a variety of ecosystem processes, mixed stands, such as those combining pine and hardwood species, are expected to be less susceptible to pest outbreaks and herbivory, to host higher biodiversity, and to be more resilient to disturbances and changing environmental conditions. As a result, favoring mixed pine hardwood species stands is becoming a more popular technique for improving forest resilience (Gauquelin et al., 2018). This, too, can have benefits for biodiversity, providing a stable ecosystem and source of food for birds, small mammals, and fish. In general, low-impact silviculture systems – i.e. taking a „close to nature“ management approach have a positive impact on biodiversity (Ray et al., 2015).

Regarding the forest type in Stara Zagora, we could observe that changing broadleaf forest cover accounts for the majority of forest cover losses and forest cover gains (see Table 10). Reversely, most of the broadleaf net increase stems from new forest growth on previous non-forest land (about 80%). The majority of lost broadleaf forest cover is replaced by mixed forests, but a significant part is not replaced by any forest, which explains the majority (80%) of forest cover loss in the region. In contrast, the conversion of broadleaf forests to coniferous type forests accounts for a relatively small extent (211 ha).

Table 10 Overview of the results of the screening for biodiversity on forested land

Stara Zagora, changes 2012 - 2018				
no forest = “N”; broadleaf forest = “B”; coniferous forest = “C”; “mixed forest” = “M”; direction of change = “→”				
	Total forest gain: 25.875 ha	**Total broad leaf loss: 5.641 ha**	**Total coni. loss: 7.224 ha**	**Total mixed loss: 6.473 ha**
Total forest loss: 2.157 ha	N --> N	B --> N	C --> N	M --> N
	322.096 ha	1.762 ha	175 ha	220 ha
Total broadleaf gain: 30.016 ha	N --> B	B --> B	C --> B	M --> B
	23.682 ha	135.864 ha	1.243 ha	5.091 ha
Total coni. gain: 2.027 ha	N --> C	B --> C	C --> C	M --> C
	654 ha	**211 ha**	**10.880 ha**	**1.162 ha**
Total mixed gain: 11.013 ha	N --> M	B --> M	C --> M	M --> M
	1.539 ha	**3.668 ha**	**5.806 ha**	**9.216 ha**

Source: Own elaboration.

Changes in coniferous forest cover account for a net decrease of -5.197 ha. Both cover losses and cover gains are the direct result of mixed forest change. The conversion of coniferous forest to forest area, on the other hand, appears to be very low, which might indicate that clear-cutting of coniferous plantations has not been widely practiced in Stara Zagora during the time of analysis. In contrast, the conversion of broadleaf forests to non-forest areas was roughly ten times higher.

The area of mixed forest cover has increased by a substantial extent over the observed period, explaining more than one third of the gross forest increase. Most of the new mixed forest areas replace coniferous forests (53%), followed by broadleaf forests (33%) and non-forest areas (14%). The largest lost mixed forest, however, is replaced by broadleaf forest types.

4.2.6 Potential burden on biomass resources

With regards to biomass, the two important management practices examined by Deal et al. (2013) are also thought to have a positive effect on the structure and function of forests. Partial cutting, or thinning, creates more complex, multi-layered forest canopies, while favoring the growth of individual trees for timber production. Additionally, increasing species diversity through planting of broadleaved trees (e.g. alder, birch) can improve forest structure and function, e.g. through lower tree stocking and stand density. This can lead to reduced uncertainty in timber production, but also biomass and carbon stock levels in the long term. It is worth noting, however, that this can come with a cost of reduced production (Ray et al., 2015). Finally, MacDonald et al. (2009) identify five important management practices for improving forest biomass: retaining trees to older ages, selective thinning, creating gaps between trees, natural regeneration, and increased variation in tree age, size, spacing, and species.

According to Panoutsou & Singh (2016) different biomass feedstocks available in Bulgaria mostly have from low to moderate sustainability risks. High risks for Land use in terms of iLUC can happen in case of growing perennial lignocellulosic crops (energy crops), but this can be avoided by growing such crops on marginal lands.

Production of forest biomass including stemwood from thinnings and final fellings, logging and crown biomass from early thinnings, and logging residues from final fellings represent no risk to land resources use in terms of indirect land use change. At the same time it leads to the following sustainability risks at a moderate level: 1) increased risk of soil erosion; 2) risk to loose soil organic carbon; 3) risk to loose nutrients and risk of reduced soil fertility and soil structure when overharvesting forest residues. Sustainability risk of forest biomass production on Water resources is moderate. It has no effect on the quantity of water resources, but if no removal leads to increased fertilisation the leaching of N to water may increase.

As biomass resources are directly connected with soil, water and influence biodiversity their management should be performed sustainably, considering slopes, soil texture and soil depth. Collection of biomass resources from forests should not increase net annual increment. Annual fellings exceeding the net annual increment can be allowed only to level age-class distribution in areas where overmature stands prevail (Vis and van den Berg, 2010). Sustainable management also should not allow diseased trees to negatively influence the other available biomass within forests, causing diseases and drying up of trees, as well as forest fires.

Collection of agricultural residues can have a negative influence on soil and biodiversity only in case of overharvesting, as this may lead to loss of soil organic carbon and nutrients, as well as have a moderate risk of biodiversity loss. Concerning agricultural biomass it should be mentioned that the total manure potential of animal farms must be managed in order to avoid pollution of soils or waters. The byproducts of manure digestion for biogas production can be used as fertilisers in agricultural practice.

5 Part E: Screening results and recommendations

5.1 Overview

Table 11 Overview of the sustainability screening results for Stara Zagora

Resources screened		Ordinal Baseline Rating	Forestry Management Practices	
Category	**Sub-Category**		**Potentially beneficial to the baseline status**	**Potentially detrimental to the baseline status**
Water	**Surface water bodies**		**Filter strips** around point sources of pollution to capture and transpire part of the pollutant load. **Afforestation** with species that can effectively bind the nutrients that cause the pollution without generating new pressures and impacts (e.g. water scarcity). **Partial selection harvesting** to maintain stable conditions of substrate availability and light exposure, promoting nutrient cycling.	**Reforestation / afforestation** with species of high water demand in areas subject to water abstraction pressures could result in water scarcity problems which could subsequently exacerbate water quality issues. **Large-scale harvesting operations (e.g. clearcutting)** may interrupt nutrient cycling functions and cause nutrient enrichment of downstream water bodies.
	Ground water bodies			
Land Resources	**-**		**Artificial regeneration** with various tree species (mixing hardwood and coniferous species) can increase the abundance of soil microflora and fauna, reduce acidity, as well as improve the moisture and nutrient contents of soils **Afforestation** – particularly in the context of shelter belts for farmland– can potentially reduce soil erosion and increase soil moisture content. It can	**Site preparation** e.g. through raking, plowing, and bedding can all lead to soil compaction and the removal of topsoil, while the application of herbicides can lead to issues of toxicity in the soil **Understory cleaning** may cause soil compaction, which can have negative effects on soil moisture content and other soil features.

			also improve the infiltrability of the soil and can lead to reduced salt inputs, which is beneficial for soil quality **Precommercial thinning** generally involves cutting trees and leaving them on the ground, which can enhance the soil quality	Large-scale harvesting operations (e.g. **clearcut** and final harvest of **shelterwood**) can cause reduced soil porosity and water infiltration, leading to increased waterlogging on flat land, and soil runoff and erosion on slopes
Biodiversity	**Agri-cultural land**		**Artificial regeneration** with various tree species can generate a greater diversity of habitats to the benefit of native species. Moreover, mixed plantations tend to be more resistant and resilient to natural and human disturbances **Afforestation** of (particularly intensive) agricultural land can provide a comparably favourable habitat for forest species increase connectivity between patches of (semi) natural forest The species richness of forests **clearcut** in the past but that did not undergo a change in tree species (**natural or artificial regeneration**) is comparable to unmanaged references **Partial selective harvest** has generally no significant negative impact and is even beneficial for certain species such as lychens.	An **artificial regeneration** that replaces already existing (semi)natural forest with plantation forest has a negative impact on species richness and diversity **clearcutting** causes large and intense disturbances and a subsequent change in the tree species (mainly **artificial regeneration**) can have a strong detrimental effect on species richness
	Forested land			
Biomass	**-**		**Applying a felling-over-increment ratio of 70%** to avoid over-maturing will help to decrease/prevent risks of diseases and forest fires. It may positively influence the net annual increment and increase the biomass potential over time.	**Increasing and staying much below the recommended felling-over-increment ratio of 70%** may decrease the biomass potential over time.

5.2 Recommendations

Surface water bodies: the screening of reported data has shown that the majority of rivers and lakes in the East Aegean Sea RBD fail to achieve the objectives of the EU WFD. This raises concern for new or increased pressures that could arise from the development of new economic activities in the region or the expansion of existing operations. Water abstraction is already one of the main pressures on rivers in the RBD, and under certain conditions, afforestation and reforestation have been associated with reductions in streamflow. Additionally, the onset of climate change should be considered carefully as this could increase the complexity of the challenges faced so far by water managers and other decision-makers. Thus, it is recommended that decisions regarding the expansion of existing forestry activities as well as the establishment of new forestry operations that could take place as part of the region’s bioeconomy strategy are accompanied by diligent spatial planning that expands on the preliminary indications raised by this pilot screening. Given the recurrence of nutrient pollution in the RBD and the known issues with urban and industrial wastewater discharge, forestry practices that could compound these existing impacts or result in significant detrimental changes in the chemical properties of water resources should preferably be avoided or at least be considered with reserve until more information is collected. For instance, practices like partial selection harvesting should be favoured instead of clearcutting and other large-scale harvesting operations that are generally associated to moderate or high nutrient discharges to the environment should. Further information on pressures and impacts on the region's lakes should be collected as part of the bioeconomy strategy development process.

Groundwater bodies: The situation regarding groundwater bodies in the East Aegean Sea RBD is moderately better than for their surface water counterparts. However, while all water bodies in the RBD are reported to be in good quantitative status, one-fourth of the total are affected by chemical pollution and over one-third are affected by nutrient pollution. For this reason, in similarity to the case for surface water bodies, forestry management practices associated to moderate or high nutrient discharges to the environment should be avoided. Given that diffuse sources are reported to be the most important pressure on groundwater bodies in the RBD, it would be relevant to incorporate additional available knowledge on what these diffuse sources are (e.g. existing agricultural or forestry operations, both which have been declared as priority activities for the region) into decision-making associated to the rollout of a bioeconomy strategy for Stara Zagora. Dedicating efforts here to reducing the environmental impact of existing operations while ensuring that new forestry developments are designed to provide environmental benefits in addition to economic and social ones would be a promising way to exploit the region’s potential within a frame of sustainable resource management.

Soil: Our baseline screening has shown that the selected indicator for evaluating the condition of land resources (soil) in Stara Zagora does not exceed the threshold for severe erosion, which thus does not pose a significant risk for the sustainability of the bioeconomy in the region in this regard. Nonetheless, the review of the links between forestry management practices and soil health allows us to provide certain recommendations for Stara Zagora‘s exploitation of forest resources for its bioeconomy.

Firstly, despite there being no immediate threat of soil erosion in the area, afforestation (mainly of agricultural land) is identified as a practice that can reduce this risk, while also improving soil infiltrability (Keen and van Dijk, 2010). However, this must be carried out with specific attention to the damage that can also be caused by shifting sediments in the process. Afforestation practices should also take care to ensure the development of a litter layer, understory growth, and surface roughness to allow for maximum erosion protection. Finally, in Stara Zagora, afforestation could also be beneficial in addressing the existing problems tied to soil salinity.

Forest managers in Stara Zagora should take care to ensure an adequate balance of conifers and hardwood trees in forests, which can have positive impacts on the soil microflora and fauna,the acidity of the soil, as well as its water and nutrient content (Augusto et al., 2002). In forests being exploited for bioeconomy purposes, practitioners should assess soil health, and develop management plans to ensure that reforestation and regeneration includes a regionally suitable mix of tree species.

With regards to harvesting of trees for the bioeconomy, special attention should be given to the practices employed, in order to avoid soil compaction (Picchio et al., 2020). Harvesting equipment and machinery should be carefully selected and used in such a way as to avoid significant damage to soil structure and overall health.

Finally, even though soil salinity and other soil properties related to its health are directly assessed through the selected regionalized indicator of mean soil erosion, they are still a relevant aspect that could be taken into consideration by further iterations of this screening in this and other regions. However, it is a pre-requisite that data at the regional level is available, for which the engagement of a working group becomes crucial.

Biodiversity: Despite the limitations in assessing the vulnerability of forested lands in terms of biodiversity, the fact that overall forests are increasing in Stara Zagora and that this increase mostly involves mixed and broad-leaf forests region could be linked with relatively favorable conditions for biodiversity. In order to maintain biodiversity and reduce the risk of its loss in forested areas in Stara Zagora, it is important to keep tree species diversity in order to create a habitat that is complex enough to host a higher variety of plant, fungi and animal species (Brockerhoff et al. 2008). This is particularly relevant if plantation forests are planned in areas that are currently semi-natural forest. In these cases, the even aged, single species stands would result in a considerable impact on species richness, particularly on forest specialist species. In this case, it would be necessary to evaluate local data on species of concern that may be threatened and live in the area to decide whether proceeding with these changes does not pose a high risk. Due to extensive cover of broad-leafed forest in the mountainous areas of Stara Zagora, it is possible to expect that their biodiversity value is high, and therefore, that rare species are found there. Nonetheless, this would need to be proved with further data. In any case, if plantations are planned, it is recommended to select more than one species, ideally native, but not strictly necessary (Irwin et al. 2014).

With regards harvesting, selective harvesting is the most recommendable practice to maintain a high biodiversity value of forests (Deal et al 2013). This avoids the extensive disturbances that large-scale harvesting operations cause such as clearcutting, which are detrimental for biodiversity for instance in terms of biomass removal (shelter, food source) and changes in light regimes (detrimental for like lychens) (Nascimbene et al. 2013). Moreover, it helps create a mixed-age stand, which is also beneficial for improving biodiversity (Brockerhoff et al. 2008). This type of harvesting is recommended for managing stands of semi-natural forest like the ones that dominate The northern part of Stara Zagora. However, if larger-scale harvesting operations are planned, it is important to bear in mind the previously existing tree species in the area and include these in regeneration activities, as the negative impact of clearcutting on biodiversity are the highest if these are succeeded by a complete change in the species regime (Paillet et al. 2010)

Biomass: As biomass resources are directly connected with soil, water and influence biodiversity the main recommendation for their sustainable management is to improve statistics collection for their monitoring. For sustainable management of forest biomass it is recommended not to consume more than the net annual increment, and to avoid forest stands from over maturing, preventing risks of diseases and forest fires. For sustainable management of agricultural biomass it is recommended to avoid overharvesting, and to collect part (30-40% depending on site conditions) of agricultural residues and avoid their combustion on the fields. Total manure potential of animal farms must be managed in order to avoid pollution of soils or waters. The byproducts of manure digestion for biogas production can be used as fertilisers in agricultural practice. Perennial woody and grass-like energy crops should be considered for marginal and contaminated lands, as they can improve soil fertility (for marginal lands) and decrease contamination (for shallow and low-contaminated lands).

List of references

Agra, H., Schowanek, S., Carmel, Y., Smith, R.K. & Ne'eman, G. (2020) Forest Conservation. Pages 323-366 in: W.J. Sutherland, L.V. Dicks, S.O. Petrovan & R.K. Smith (eds) What Works in Conservation 2020. Open Book Publishers, Cambridge, UK.

Andersen, E., Baldock, D., Bennett, H., Beaufoy, G., Bignal, E., Brouwer, F., Elbersen, B., Eiden, G., Godeschalk, F., Jones, G., McCracken, D.I., Nieuwenhuizen, W., van Eupen, M., Hennekens, S. & Zervas, G., 2003. Developing a high nature value indicator. Report for the European Environment Agency, Copenhagen.

Anderson, E., & Mammides, C. (2020) Changes in land-cover within high nature value farmlands inside and outside Natura 2000 sites in Europe: A preliminary assessment. *Ambio*, *49*(12), 1958-1971.

Anzaldúa, G., Abhold, K., Araujo, A., Chebotarev, A., Cosnita, D., Diaconescu, T., Dimov, L., Duic, N., Iorgulescu, R., Kiresiewa, Z., Lazdina, D., Makovskis, K., Markovska, M., Mihajloska, E., Mytlewski, A., Pauna, C., Pavlova, I., Rakowski, M., Schock, M., Szulecka, O., Tröltzsch, J., Zelljadt, E. (2019). D2.2 The macro-environment surrounding BE-Rural's Open Innovation Platforms. Deliverable D2.2 of the H2020 BE-Rural project. https://be-rural.eu/wp-content/uploads/2019/10/BE-Rural_D2.2_Macro-environment_OIPs.pdf

Augusto, L., Ranger, J., Binkley, D., and Rothe, A. (2002) *Impact of several common tree species of European temperate forests on soil fertility*. Ann. For. Sci. 59 (2002) 233-253. DOI: 10.1051/forest:2002020

Benavidez, R., Jackson, B., Maxwell, D., Norton, K. (2018) A review of the (Revised) Universal Soil Loss Equation ((R)USLE): with a view to increasing its global applicability and improving soil loss estimates. Hydrol. Earth Syst. Sci., 22, 6059–6086. https://doi.org/10.5194/hess-22-6059-2018

BMUB/UBA (2016) Water Framework Directive – The status of German waters 2015. Bonn, Dessau. https://www.gewaesser-bewertung.de/files/wrrl_englische_version_dez_2016.pdf

BIlandzija, N., Voca, N., Kricka, T. (2012) Energy potential of fruit tree pruned biomass in Croatia. SPANISH JOURNAL OF AGRICULTURAL RESEARCH 10(2):292. https://www.researchgate.net/publication/271189331_Energy_potential_of_fruit_tree_pruned_biomass_in_Croatia

Brockerhoff, E.G., Jactel, H., Parrotta, J.A. et al. (2008) Plantation forests and biodiversity: oxymoron or opportunity?. Biodivers Conserv 17, 925–951. https://doi.org/10.1007/s10531-008-9380-x

Bulgarian Ministry of Agriculture, Food and Forestry (2021) Annual Report on the State and Development of Agricultural (Agricultural Report 2021). Sofia. https://www.mzh.government.bg/media/filer_public/2022/01/21/ad_2021_en.pdf

Bulgarian Ministry of Agriculture, Food and Forestry (2012) Census of agricultural holdings in 2010

STARA ZAGORA - main results. Sofia. https://www.mzh.government.bg/media/filer_public/2018/02/21/224-publication-census2010-starazagora.pdf

Bulgarian Ministry of Environment and Water (n.d) *Soils*. https://www.moew.government.bg/en/soils/

Bulgarian Ministry of the Environment and Energy (2005) Report on the National Biodiversity Conservation Plan for 1999-2004 & National Biodiversity Conservation Plan for 2005-2010. Sofia. https://www.cbd.int/doc/world/bg/bg-nbsap-v2-en.pdf

Bulgarian Ministry of the Environment and Energy (2010) Fourth National Report 2005 – 2008, Convention on Biological Diversity.

Bulgarian Ministry of Environment and Water (2020) *National Programme for Conservation, Sustainable Use and Restoration of Soil Functions (2020-2030)*, Sofia

Chaudhary, A., Burivalova, Z., Koh, L. P., & Hellweg, S. (2016). Impact of forest management on species richness: global meta-analysis and economic trade-offs. *Scientific reports*, *6*(1), 1-10.

Copernicus Land Monitoring Service (2018) CORINE Land Cover. https://land.copernicus.eu/pan-european/corine-land-cover

Deal, R.L., Hennon, P., O'Hanlon, R., D'Amore, D. (2013) Lessons from native spruce forests in Alaska: managing Sitka spruce plantations worldwide to benefit biodiversity and ecosystem services. Forestry 2014; 87, 193–208, doi:10.1093/forestry/cpt061

European Commission (2003) Analysis of Pressures and Impacts in the implementation of the Water Framework Directive: Guidance document no 3. Publications Office of the European Union, Luxembourg.

European Commision (2018) CAP specific objectives explained, Brief No. 5 Efficient Soil Management. https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/key_policies/documents/cap-specific-objectives-brief-5-soil_en.pdf

European Environment Agency (2009) Distribution and targeting of the CAP budget from a biodiversity perspective. EEA Technical report No 12/2009. European Environment Agency, Copenhagen. Available at: http://www.eea.europa.eu/publications/distribution-and-targetingof-the-cap-budget-from-a-biodiversity-perspective?&utm_campaign=distributionand-targeting-of-the-cap-budget-from-a-biodiversityperspective&utm_medium=email&utm_source=EEASubscriptio

European Environment Agency (2017) Loss of HNV farmland due to agricultural intensification per NUTS3. https://www.eea.europa.eu/data-and-maps/figures/loss-of-hnv-farmland-due

European Environment Agency (2018) European waters: assessment of status and pressures 2018, EEA Report No 7/2018, European Environment Agency. Available on: https://www.eea.europa.eu/publications/state-of-water

European Environment Agency (2020) State of nature in the EU. Results from reporting under the nature directives 2013-2018. 142 pp.

Ellis, T., Leguédois, S., Hairsine, P. and Tongway, D. (2006) ‘Capture of overland flow by a tree belt on a pastured hillslope in south-eastern Australia’, Australian Journal of Soil Research, vol 44, pp117–125

Emmerson, M., Morales, M. B., Oñate, J. J., Batary, P., Berendse, F., Liira, J., ... & Bengtsson, J. (2016). How agricultural intensification affects biodiversity and ecosystem services. In *Advances in ecological research* (Vol. 55, pp. 43-97). Academic Press.

European Soils Bureau Network (2005) *Soil Atlas of Europe*. European Commision, Luxembourg. https://esdac.jrc.ec.europa.eu/content/soil-atlas-europe

Eurostat (2020) Agri-environmental indicator – soil erosión. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental_indicator_-_soil_erosion#cite_note-7

FAO (2010) Global Forest Resources Assessment 2010 Terms and Definitions. Rome. https://www.fao.org/3/am665e/am665e00.pdf

FOREST EUROPE (2020) State of Europe’s Forests 2020. Ministerial Conference on the Protection of Forests in Europe - FOREST EUROPE, Bratislava.

Gauquelin, T., Michon, G., Joffre, R., Duponnois, R., Génin, D., Fady, B., ... & Baldy, V. (2018). Mediterranean forests, land use and climate change: a social-ecological perspective. *Regional Environmental Change*, *18*(3), 623-636.

Grebner, D., Bettinger, P., Siry, J. (2013) Introduction to Forestry and Natural Resopurces. First Edition. Elservier,UK and USA.

Gómez-González, S., Ochoa-Hueso, R., & Pausas, J. G. (2020). Afforestation falls short as a biodiversity strategy. *Science*, *368*(6498), 1439-1439.

Hannah, L., Carr, J.L., Lankerani, A., 1995. Human disturbance and natural habitat: a biome level analysis of a global data set. Biodivers. Conserv. 4, 128–155.

Irwin, S., Pedley, S.M., Coote, L. et al. (2014) The value of plantation forests for plant, invertebrate and bird diversity and the potential for cross-taxon surrogacy. Biodivers Conserv 23, 697–714. https://doi.org/10.1007/s10531-014-0627-4

Ivanova, B., Shishkova, M., Beluhova-Uznova, R. (2020) Agricultural Biomass Potential in Bulgaria. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 20, Issue 2, 2020. https://www.researchgate.net/publication/344155699_AGRICULTURAL_BIOMASS_POTENTIAL_IN_BULGARIA

Kakanakov, Zahariev and Aladjadjiyan (2009) Current State of Biomass-for-Energy-Potential Assessment in Bulgaria. National Biomass Association of Bulgaria. https://www.researchgate.net/publication/207705394_Current_State_of_Biomass-for-Energy-Potential_Assessment_in_Bulgaria/references

Karlen, D., & Rice, C. (2015). Soil Degradation: Will Humankind Ever Learn? Sustainability, 7(9), 12490–12501. MDPI AG. http://dx.doi.org/10.3390/su70912490

Keenan, R.J. and Van Dijk, A.I.J. (2010) Planted forests and water. In Ecosystem Goods and Services from Plantation Forests. Bauhus J., van der Meer P.J. and Kanninen M. (eds). Earthscan, pp. 77–95.

Keenleyside, C., Beaufoy, G., Tucker, G., & Jones, G. (2014). High Nature Value farming throughout EU-27 and its financial support under the CAP. *Institute for European Environmental Policy, London*, *10*, 91086. Available at: https://ec.europa.eu/environment/agriculture/pdf/High%20Nature%20Value%20farming.pdf

Kiresiewa, Z., Gerdes, H. (2021). D5.3: Regional strategy and roadmap documents. Deliverable of the H2020 BE-Rural project.

Košulič, O., Procházka, J., Tuf, I. H., & Michalko, R. (2021). Intensive site preparation for reforestation wastes multi-trophic biodiversity potential in commercial oak woodlands. *Journal of Environmental Management*, *300*, 113741.

Latawiec, A. E., Crouzeilles, R., Brancalion, P. H., Rodrigues, R. R., Sansevero, J. B., Santos, J. S. D., ... & Strassburg, B. B. (2016). Natural regeneration and biodiversity: a global meta-analysis and implications for spatial planning. *Biotropica*, *48*(6), 844-855.

Lomba, A., Moreira, F., Klimek, S., Jongman, R. H., Sullivan, C., Moran, J., ... & McCracken, D. I. (2020). Back to the future: rethinking socioecological systems underlying high nature value farmlands. *Frontiers in Ecology and the Environment*, *18*(1), 36-42.

Macdonald, E., Gardiner, B., Mason, W. (2009) The effects of transformation of even-aged stands to continuous cover forestry on conifer log quality and wood properties in the UK. Forestry: An International Journal of Forest Research, Volume 83, Issue 1, January 2010, Pages 1–16, https://doi.org/10.1093/forestry/cpp023

May, B. P., Smethurst, C., Carlyle, D., Mendham, Bruce, J. and Baillie, C. (2009) Review of Fertiliser Use in Australian Forestry, Forest & Wood Products, Australia

Moreau, G., Chagnon, C., Achim, A., Caspersen, J., D'Orangeville, L., Sánchez-Pinillos, M., & Thiffault, N. (2022). Opportunities and limitations of thinning to increase resistance and resilience of trees and forests to global change. *Forestry: An International Journal of Forest Research*.

MOEW (Ministry of Environment and Water) (n.d.) Summary of Bulgarian River Basin Management Plans. http://www5.moew.government.bg/?wpfb_dl=17218

National Statistical Institute of Bulgaria (2022) Regions, districts and municipalities in the Republic of Bulgaria 2020, Sofia. https://www.nsi.bg/en/content/19401/%D0%BF%D1%83%D0%B1%D0%BB%D0%B8%D0%BA%D0%B0%D1%86%D0%B8%D1%8F/regions-districts-and-municipalities-republic-bulgaria-2020

Nascimbene, J., Thor, G., Nimis, P.L. (2013) Effects of forest management on epiphytic lichens in temperate deciduous forests of Europe – A review. Forest Ecology and Management, Volume 298, Pages 27-38, https://doi.org/10.1016/j.foreco.2013.03.008.

Nisbet, T.R. and McKay, H. (2002) Sustainable Forestry and the Protection of Water in Great Britain. Forestry Commission, Great Britain.

Oettel, J., & Lapin, K. (2021). Linking forest management and biodiversity indicators to strengthen sustainable forest management in Europe. Ecological Indicators, 122, 107275.

Panagos, P., Ballabio, C., Poesen, J., Lugato, E., Scarpa, S., Montanarella, L., & Borrelli, P. (2020). A Soil Erosion Indicator for Supporting Agricultural, Environmental and Climate Policies in the European Union. Remote Sensing, 12(9), 1365. MDPI AG. Retrieved from http://dx.doi.org/10.3390/rs12091365

Panagos, P., Borrelli, P., Poesen, J, Ballabio, C., Lugato, E., Meusburger, K., Montanarella, L., Alewell, C. (2015) The new assessment of soil loss by water erosion in Europe. Environmental Science & Policy, Volume 54, Pages 438-447. https://doi.org/10.1016/j.envsci.2015.08.012

Panoutsou & Singh (2016) Bulgaria: Roadmap for lignocellulosic biomass and relevant policies for a bio-based economy in 2030), S2Biom project report. https://www.s2biom.eu/images/Publications/WP8_Country_Outlook/Final_Roadmaps_March/S2Biom-BULGARIA-biomass-potential-and-policies.pdf

Paskalev (n.d.) Water Resources Management in Bulgaria. Available on: https://www.oieau.org/eaudoc/system/files/documents/41/207805/207805_doc.pdf

Paillet Y, Bergès L, Hjältén J, Odor P, Avon C, Bernhardt-Römermann M, Bijlsma RJ, De Bruyn L, Fuhr M, Grandin U, Kanka R, Lundin L, Luque S, Magura T, Matesanz S, Mészáros I, Sebastià MT, Schmidt W, Standovár T, Tóthmérész B, Uotila A, Valladares F, Vellak K, Virtanen R. (2010) Biodiversity differences between managed and unmanaged forests: meta-analysis of species richness in Europe. Conserv Biol. 2010 Feb;24(1):101-12. doi: 10.1111/j.1523-1739.2009.01399.x. PMID: 20121845.

Picchio, R., P.S. Mederski & F. Tavankar (2020) How and How Much, Do Harvesting Activities Affect Forest Soil, Regeneration and Stands? Current Forestry Reports

Pike, L.H. (1978) The importance of lichens in mineral cycling. The Bryologist 81, 247–257.

Pointereau, P., Paracchini, M.L., Terres, J.-M., Jiguet, F., Bas, Y., and Biala, K., 2007. Identification of High Nature Value farmland in France through statistical information and farm practice surveys, Report EUR 22786 EN. 62 pp.

Scarlat, N., MArtinov, M., Dallemand, J-F. (2010) Assessment of the availability of agricultural crop residues in the European Union: Potential and limitations for bioenergy use. Waste Management, Volume 30, Issue 10, October 2010, Pages 1889-1897. https://doi.org/10.1016/j.wasman.2010.04.016

Schulp, C. J., Van Teeffelen, A. J., Tucker, G., & Verburg, P. H. (2016). A quantitative assessment of policy options for no net loss of biodiversity and ecosystem services in the European Union. Land Use Policy, 57, 151-163.

Schwaiger, E., Banko, G., Brodsky, L., van Doorn, A. (2012). Updated High Nature Value Farmland in Europe: An estimate of the distribution patterns on the basis of CORINE Land Cover 2006 and biodiversity data. Available at: https://www.eea.europa.eu/data-and-maps/data/high-nature-value-farmland/further-documentation/hnv-farmland-in-europe-2012.pdf/at_download/file

Stockmann, U., Padarian, J., McBratney, A. et al. (2015): Global soil organic carbon assessment. Global Food Secur. 6:9-16.

Stoeva, L., Markoff, I. and Zhiyanski, M. (2018) National Forestry Accounting Plan of Bulgaria, including Forest Reference Levels for the period 2021-2025. Ministry of Environment and Water, Republic of Bulgaria. Sofia. https://www.researchgate.net/publication/330542262

Thorn, S., Bässler, C., Brandl, R., Burton, P. J., Cahall, R., Campbell, J. L., ... & Müller, J. (2018). Impacts of salvage logging on biodiversity: A meta-analysis. Journal of Applied Ecology, 55(1), 279-289.

Tuntova, A. (n.d.) Water Management in Bulgaria. https://www.riob.org/fr/file/270352/download?token=N1eXvvub

Trichkova, T. (n.d.) Soil Protection in Bulgaria. Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences. http://www.unserboden.at/files/dlt2011_17.pdf

Vis, M. & D. van den Berg (2010) Harmonization of biomass resource assessments - Volume I: Best Practices and Methods Handbook. Biomass Energy Europe Deliverable. https://www.researchgate.net/publication/268388401_Harmonization_of_biomass_resource_assessments_Volume_I_Best_Practices_and_Methods_Handbook

Vladimirova (2018) Annex VI. Application of the bottom-up multicriteria methodology in eight European River Basin Districts – The East Aegean RBD. Deliverable to Task A3 of the BLUE 2 project “Study on EU integrated policy assessment for the freshwater and marine environment, on the economic benefits of EU water policy and on the costs of its non- implementation”. Report to DG ENV. Available on: https://ec.europa.eu/environment/blue2_study/pdf/Task%20A3%20Annex%20VI_East_Aegean_RBD_CLEAN.pdf

Water Action Hub (n.d.) Bulgaria Country Overview. UN Global Compact | CEO Water Mandate. Available here: https://wateractionhub.org/geos/country/34/d/bulgaria/#country_overview

WWF (2021) Water Risk Filter: Country Profile for Bulgaria. Available on: https://waterriskfilter.org/explore/countryprofiles#overview/12

Bio-based strategies and roadmaps for enhanced rural and regional development in the EU

BE-Rural Sustainability Screening Report: Vidzeme Region

July 2022

Gerardo Anzaldúa, Ariel Araujo, John Tarpey, Oleksandra Tryboi, Levin Scholl, Rebecca Noebel, Chuan Ma

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818478.

Document information	
Project name:	BE-Rural
Project title:	Bio-based strategies and roadmaps for enhanced rural and regional development in the EU
Project number:	818478
Start date:	1st April 2019
Duration:	40 months

Report:	D5.4: Note on the development of a sustainability screening for regional bioeconomy strategies Annex: BE-Rural Sustainability Screening Report: Vidzeme Region
Work Package:	WP5: Regional strategies & roadmaps
Work Package leader:	ECO
Task:	Subtask 5.3.2: Developing a sustainability screening tool to facilitate the consideration of ecological limits at the regional level.
Task leader:	ECO
Responsible author(s):	Gerardo Anzaldua, Ariel Araujo, John Tarpey, Levin Scholl, Rebecca Noebel (ECO); Oleksandra Tryboi (SECB); Chuan Ma (WIP)
Internal peer review:	Kaspars Liepins (SILAVA / University of Life Sciences and Technologies); Krišjānis Veitners (Vidzeme Planning Region); Kristaps Makovskis, Dagnija Lazdina (SILAVA)
Planned delivery date:	M39
Actual delivery date:	M40
Reporting period:	RP2

Dissemination level of this report		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

ACKNOWLEDGMENT & DISCLAIMER

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818478.

EXECUTIVE SUMMARY

This synthesis report documents the pilot of the BE-Rural sustainability screening as implemented to examine the case of the Vidzeme region in Latvia. The pilot was conducted as part of the BE-Rural project during the first semester of 2022. The main purpose of this task was to generate relevant insights for the further development and implementation of the sustainability screening beyond the project, while providing some initial indications and hopefully inspiration to the members of the Open Innovation Platform (OIP) Vidzeme and Kurzeme on some of the aspects to consider to build environmental sustainability into their bioeconomy strategy. The pilot was carried out by Ecologic Institute and WIP with support from SILAVA, and was reviewed by a representative of the Vidzeme Planning Region.

The report introduces the sequence of steps carried out as part of the pilot and uses these as main structure for the document.

Vidzeme is a highly competitive region for bioeconomic activities, with advantageous climatic conditions, a large share of valuable natural resources and marginal lands with high forestry potential, and a track of dedicated efforts to expand its knowledge base and innovation capabilities. In 2021, as part of the BE-Rural project, the Latvian OIP drafted a bioeconomy strategy which, among others, listed the utilisation of forest and agricultural biomass as priority interests. The examination of the region's situation using BE-Rural's sustainability screening approach is an initial attempt to generate preliminary, yet concrete considerations of ecological limits as part of this process.

The pilot screening, building to the extent possible on openly accessible, regularly updated regional level data (e.g. from the EU Water Framework Directive reporting, European Statistics like the loss of High Nature Value Farmland, Copernicus Earth Observation data on forest cover, and from national and regional statistics on forest and agricultural biomass production), has illustrated some potential concerns regarding the surface water bodies and the biodiversity that the Vidzeme region depends on, while land resources and biomass potential appear to be in low risk of vulnerability, from an environmental sustainability perspective.

Given the limited resources available for this task (not included or budgeted for in the original work plan), as well as its illustrative purpose, the pilot screening focused on one of the priority economic sectors from Vidzeme's bioeconomy strategy: Forestry. On this basis, a literature review on the potential environmental impacts of various forestry management practices was carried out to illustrate the ecological burden that the establishment of new forestry operations or expansion of existing ones could have on the region's ecological systems.

Overlaying and comparing the appraisal of ecosystem and resource capacities with the potential ecological burden of the reviewed forestry activities, the screening team has been able to produce a broad diagnosis and general recommendations that could serve as initial considerations for decision-makers and other stakeholders of Vidzeme's bioeconomy. While limited in its scope and extent, the results of this exercise will hopefully serve as groundwork for open, inclusive and transparent discussions on the sustainability of the region's future development.

Table of contents

Figures

Tables

Abbreviations

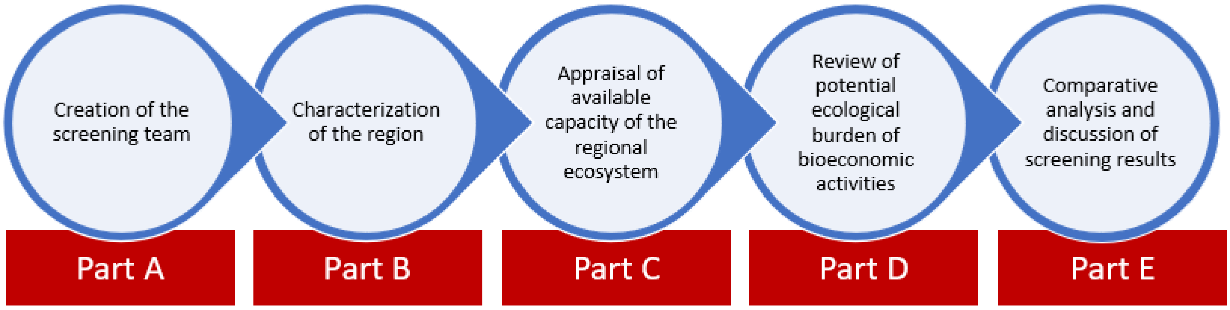
CAP	Common Agricultural Policy
CBD	Convention on Biological Diversity
CORINE Land Cover	Coordination of Information on the Environment, Land Cover
EC	European Commission
EEA	European Environment Agency
EU	European Union
JRC	Joint Research Centre
NUTS	Nomenclature des Unités Territoriales Statistiques
OIP	Open Innovation Platform
PESTEL Analysis	Political, economic, social, technical, environmental and legal analysis
RBA	River Basin Authority
RBD	River Basin District
RBMP	River Basin Management Plan
RES	Renewable Energy Source
SAT	Self-Assessment Tool to promote sustainable chemical production in all regions
WEI+	Water Exploitation Index +
WFD	Water Framework Directive
WISE	Water Information System for Europe

1 Introduction

The BE-Rural sustainability screening has been piloted during the first semester of 2022 to generate relevant insights for its further development and implementation beyond the project.

Figure 1 shows the structure (i.e. the sequence of steps) that has been ideated for the process. With the exception of Part A, all elements therein have been covered at least partly during the pilot, and the outcomes are documented in this screening report for Vidzeme, Latvia. The structure is split into five main parts that are conducted sequentially as follows:

Figure 1 Structure of the BE-Rural sustainability screening



Part A – Creation of the screening team [Not covered in the pilot]

The BE-Rural sustainability screening is targeted to *authorities, policy and decision makers in regions with relatively low financial resources and/or expertise in environmental sustainability* who are interested or already engaged in developing a bioeconomy strategy/roadmap or in improving the environmental sustainability considerations of their existing one. Moreover, the approach aims to bring businesses, universities and civil society representatives on board, for instance through the involvement of clusters or sectoral business associations, research units and civil associations in a joint development of these strategies/roadmaps. To accompany the screening team and provide guidance, the authors' suggestion has been to establish a technical group with local and foreign experts on bioeconomy sustainability.

For piloting the approach within the project, the scientific partners of the consortium who have authored this report have taken over the role of the screening team for the most part. This was due to the lack of capacity and resources left in the project to get OIP members engaged in depth in an additional and elaborate activity (the sustainability screening was not included in the original workplan of the project and no additional resources were made available for its development and piloting). Nevertheless, the report has been reviewed by some of the OIP members, who have kindly contributed their views and provided data.

Part B – Characterisation of the region using the SAT [Partly covered in the pilot and in this document]

Once the screening team has been formed, its first task is to produce a general outline of environmental conditions (climate, land cover, etc.) and run an assessment using the SAT (Self-Assessment Tool to promote sustainable chemical production in all regions)[1] to define biomass availability and bioeconomy potential in the region. For the pilot, the authors used the information collected through the SAT tool in BE-Rural as well as other project results (e.g. the PESTEL analysis[2] documented in Deliverable 2.2) to set the bases of the screening. This was then supplemented with additional information from literary sources. This part of the screening also entails a shortlisting of bioeconomy activities deemed most relevant for the region. Since a screening team could not be formed (as mentioned above), the envisioned participatory process to conduct the shortlisting was not established. Instead, the authors

[1] See: https://ecrn.net/self-assessment-tool-to-promote-sustainable-chemical-production-in-all-regions/
[2] PESTEL stands for political, economic, social, technical, environmental and legal assessment (see Anzaldúa et al. 2019)

resorted to working with a selection of the broad categories of activities that the OIP facilitators have published in their regional strategy and roadmap documents (BE-Rural Deliverable 5.3).

Part C – Rough appraisal of available capacity of the regional ecosystem [Covered in the pilot and in this document]

Using existing indicators and expert opinion from within and beyond the screening team, this part of the screening yields a qualitative (ordinal) categorization of the capacity of the ecological systems in the region to underpin bioeconomy activities. Thus, the key output of Part C is setting a baseline from which the development or update of the regional bioeconomy strategy/roadmap would part.

Part D – Review of the potential ecological burden of regionally relevant bioeconomic activities [Covered in the pilot and in this document]

Based on the outcomes of a literature review conducted for the pilot, this part of the screening provides a synthesis of the potential ecological burden associated with the economic activities selected in Part B. The synthesis also compiles contextual information from the reference studies to ensure transparency as regards comparability issues, and where possible includes information collected on differences between specific management practices in terms of their potential burden on natural resources and ecological systems.

Part E – Overview of screening results and recommendations [Covered in the pilot and in this document]

Based on the results of Parts C and D, the team will overlay and compare the available capacity of the region's ecological system and potential ecological burden of the relevant bioeconomic activities, discuss the results and prepare a synthesis table indicating the natural resources that could be at risk or vulnerability, or, alternatively, could benefit from the adoption of specific management practices. This will be supplemented with recommendations on bioeconomic activities and practices to avoid or incorporate with reserve into the regional bioeconomy strategy/roadmap.

2 Part B: Characterisation of the Vidzeme region

The Vidzeme Planning Region (VPR) lies in the northeast of Latvia and is one of the country's five planning regions[3] and it occupies 30.6% of the entire territory of Latvia, namely 19,770 km^2 (Vidzeme Planning Region, n.d.). Primary sectors (agriculture, forestry, fishery) make up 15.8% of the economic structure of the Vidzeme region. This is the highest percentage of all regions in the country. The sectors with the highest value added in the VPR are manufacturing, agriculture, forestry, woodworking, wholesale and retail industries. The most economically active units (largest number of companies) in the region are forestry, woodworking, agriculture and animal husbandry. Latvia already has a national bioeconomy strategy through 2030, which will facilitate the development of equivalent regional documents (Anzaldúa et al., 2019).

[3] There are five planning regions of Latvia, with Vidzeme, being one of them. The planning regions of Latvia are not administrative territorial divisions, since they are not mentioned in the law that prescribes the administrative territorial divisions of Latvia. However, NUTS 3 typology for Latvia reflects the planning regions. The boundaries of the regions align to the boundaries of the municipalities of Latvia, which have all been updated recently through an Administrative Territorial Reform that came into force in July 2021.

Figure 2 Map of Latvia with the location of the Vidzeme Planning Region[4].

Source: Vidzeme Planning Region, n.d.

Vidzeme has significant biomass potential, including raw material from forests and agricultural residues. Climate change is expected to increase the vegetation period in Latvia, which is currently 180-200 days, by 35-80 days by 2100. This is expected to have a positive impact on tree growth, up to 30% for pine trees, 19% for spruce, and 9% for birch (Anzaldúa et al. 2019).

The region has good road connections with biomass feedstock producers, as well as a skilled technical workforce. Additionally, financing from both public and private bodies is available for the development of bio-based sectors (Anzaldúa et al. 2019).

2.1 Resource availability and management profile

2.1.1 Water resources

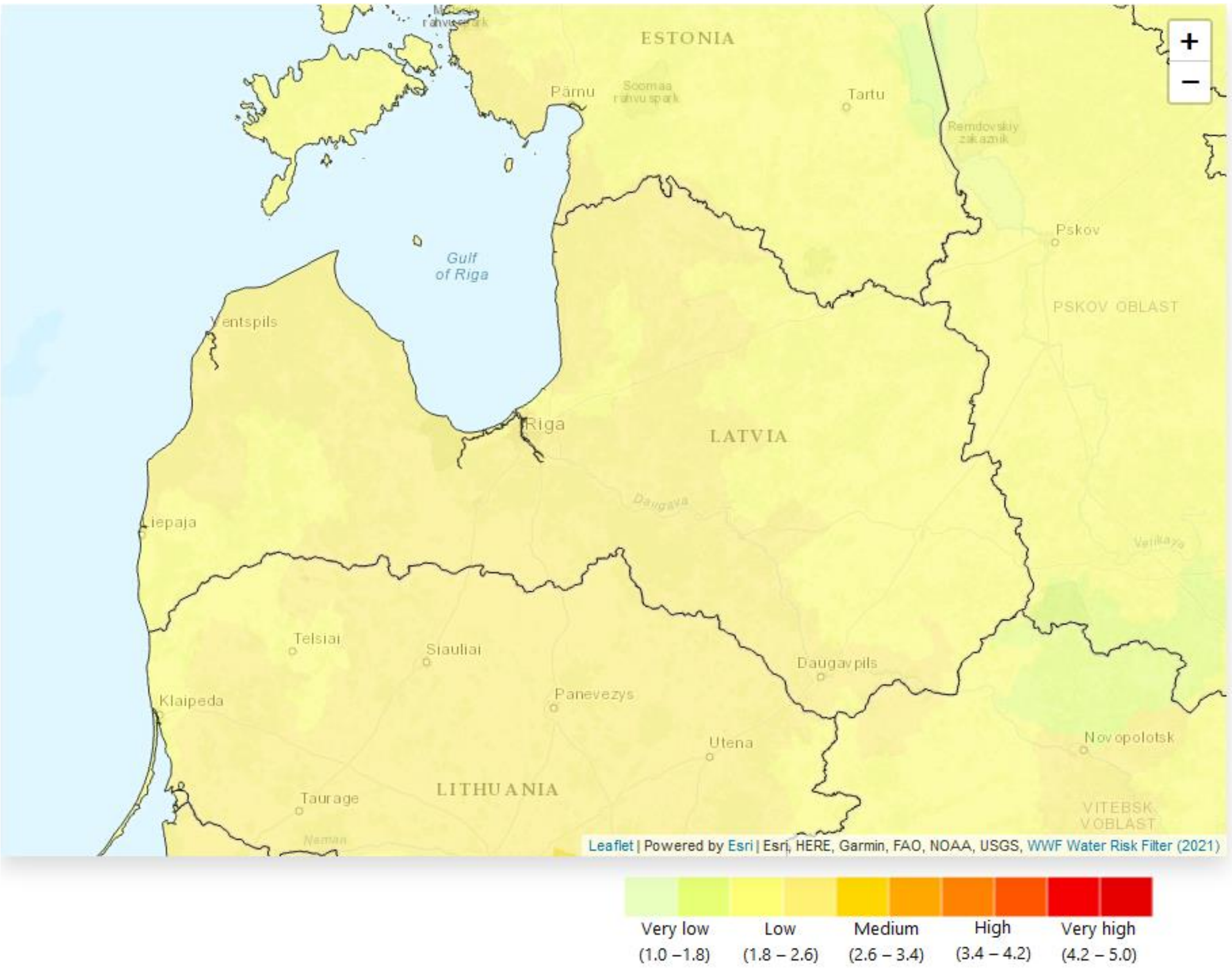
Renewable freshwater resources in Latvia are estimated at 17,000 m^3 per capita per year. Gross freshwater abstraction levels per capita are among the lowest across OECD countries, and projections of future water demand show this is not expected to make water abstraction a key environmental pressure (OECD, 2019). Out of the 107 m^3 per capita that were abstracted in 2017 in the country, around 46% went to public supply, 30% to agriculture, 10% to industry, 8% to services, 6% to mining and 1% to electricity (cooling) (OECD, 2019). According to WWF's Water Risk Filter, the territory of Latvia exhibits an overall low basin risk and ranks just above Slovenia and Estonia on the country comparison (WWF Water Risk Filter, 2021). Conversely, diffuse and point pollution as well as morphological alterations affect water bodies across Latvia (OECD, 2019), leading to water quality issues like eutrophication and degradation of aquatic ecosystems (Water Action Hub, n.d.). These pressures are largely associated with agriculture and forestry (via degradation of ditch networks and expansion of beaver populations[5]) as well as with the transition from a largely centralised management of water supply and wastewater treatment during the Soviet era to one where a large number of water

[4] Map shows the planning region as of July 2021. All data found at NUTS 3 level for Latvia still follows the boundaries set through the previous municipality reform of 1 July 2009, as NUTS typology was last updated in January 2021. Therefore, the data used in this report will not necessarily reflect the current boundaries of the planning region and thus the future NUTS 3 delineation. However, as information for the selected indicators found at NUTS 3 level is expected to be updated, this issue should be resolved in the future. Thus, the currently existing data is considered to be suitable for the illustrative purposes of this concept note.

[5] See: https://interreg-baltic.eu/project/wambaf/

utilities provide these services on behalf of municipalities, many of which were unable to adequately maintain and renovate their water infrastructure (Zaíis and Ernðteins, 2008).

Figure 3 Country profile for Latvia on the WWF Water Risk Filter



Source: WWF Water Risk Filter, 2021.

In Latvia, water management is coordinated at the national and river basin level. With the adoption of the Latvian National Water Management Law in 2002, the country aligned itself with EU water legislation and follows the requirements of the EU Water Framework Directive (WFD). Later on, the National Environmental Policy Plan (2004-2008) and the Water Management Infrastructure Development Programme (2006) set provisions for improving the management of water utilities and for enhancing institutional capacity (Zaíis and Ernðteins, 2008). Latvia's territory is split into four River Basin Districts (RBDs), with most municipalities of the Vidzeme planning region located within the Gauja River Basin District (RBD code: LVGUBA) (see Figure 4**Error! Reference source not found.**).

Figure 4 Location of the four river basin districts in Latvia (Gauja RBD shown in green).

Source: European Commission (n.d.).

The Gauja RBD faces similar challenges as those described above for the entire country. The 2nd River Basin Management Plan (2016) lists diffuse pollution and changes in hydromorphology from agriculture and forestry operations (nutrient run-off and drainage) as well as point pollution from untreated or insufficiently treated wastewater as the main anthropogenic pressures faced by the water bodies in the RBD. More recently, improvements in water quality have been documented and a strategy for the management of wastewater has been elaborated (at the country level)[6].

2.1.2 Land resources management profile

Most of the Vidzeme region (currently 56%) is covered by forest, with an increasing trend in recent years. Agricultural land covers around 34% of the territory. Nonetheless, this proportion has been the subject of several major transformations over the course of the 20th century. For instance, Nikodemus et al (2005) estimate that, in 1935, about 57.3% of the land area of whole Latvia was used for agriculture, while only 26.6% of it was covered by forests. This ratio had already reversed by the year 2000, when agricultural land covered 38.5% and woodland 44.4% of the territory. This rapid change in the land use can be mainly attributed to the land reforms that followed the restoration of Latvian independence from the USSR in 1990. Regarding the situation in Vidzeme, one important factor that derived from this was sharp reduction in use intensity or even the abandonment of the land that resulted from the restauration of land ownership to their original owners before the soviet occupation. This issue has been mostly prominent in the Uplands of the Vidzeme region. This area, characterized by less fertile soils and therefore less suitable for intensive farming, has seen a sharp increase in uncultivated agricultural land in the last decades. This in turn has given way to large extensions of secondary forest as a consequence of the gradual recolonisation of agricultural land by trees and shrubs (Nikodemus et al. 2005).

Generally, the region is characterised by a low building density and a high proportion of natural landscapes with low human impact. Looking at data from the Latvian official statistics portal for forest[7] regeneration, it is possible to observe that the two most widely planted/seeded species of trees in 2020 were spruce and pine, while the most naturally occurring tree species in the Vidzeme region were Birch, Grey Alder and Aspen. However, afforestation with Birch can also be found in the region[8]. On

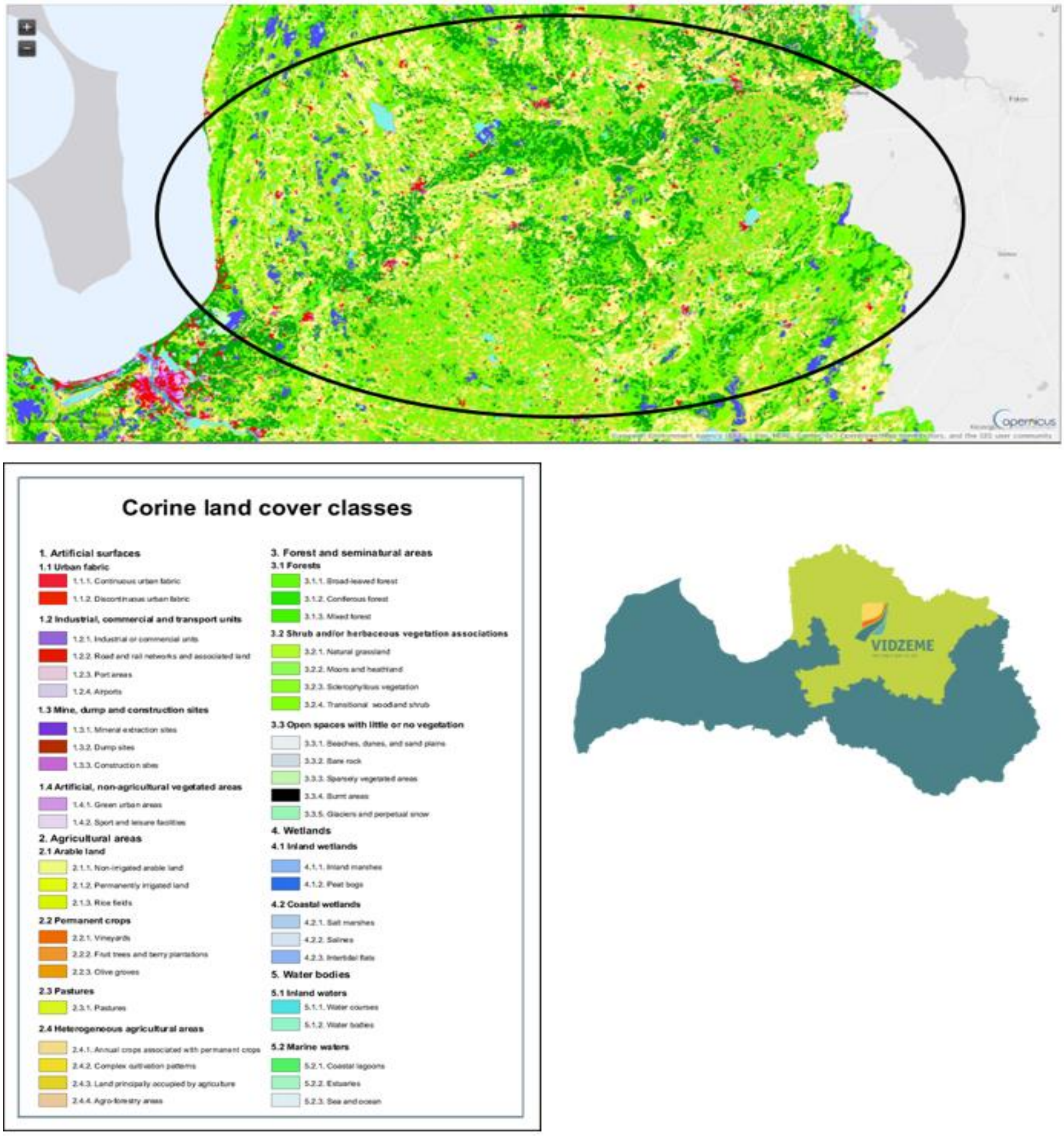
[6] See https://goodwater.lv/aktivitates/punktveida-piesarnojums/
[7] See https://data.stat.gov.lv/pxweb/en/OSP_PUB/START__NOZ__ME__MEP/MEP080/table/tableViewLayout1/
[8] See https://data.stat.gov.lv/pxweb/en/OSP_PUB/START__NOZ__ME__MEP/MEP040/table/tableViewLayout1/

the other hand. the most widespread crops in terms of sown area in the Vidzeme region for 2020 were cereals with 125,190 ha, followed by potatoes with 3,269 ha and then open field vegetables with 1,032 ha[9]. Another important agricultural activity in the region is cattle farming[10], which in the year 2020 accounted for 106,654 animals in total, almost twice as much pigs (58,614) for the same year.

[9] See https://data.stat.gov.lv/pxweb/en/OSP_PUB/START__NOZ__LA__LAG/LAG030/table/tableViewLayout1/

[10] https://data.stat.gov.lv/pxweb/en/OSP_OD/OSP_OD__skait_apsek__dzivnieki__laukskait_20/LSK20-III01.px/table/tableViewLayout1/

Figure 5 CORINE Land Cover Classes (CLC) 2018 for EU-27 with Vidzeme Planning Region (NUTS3 LV008) highlighted[11]



Source: EEA, 2020[12]

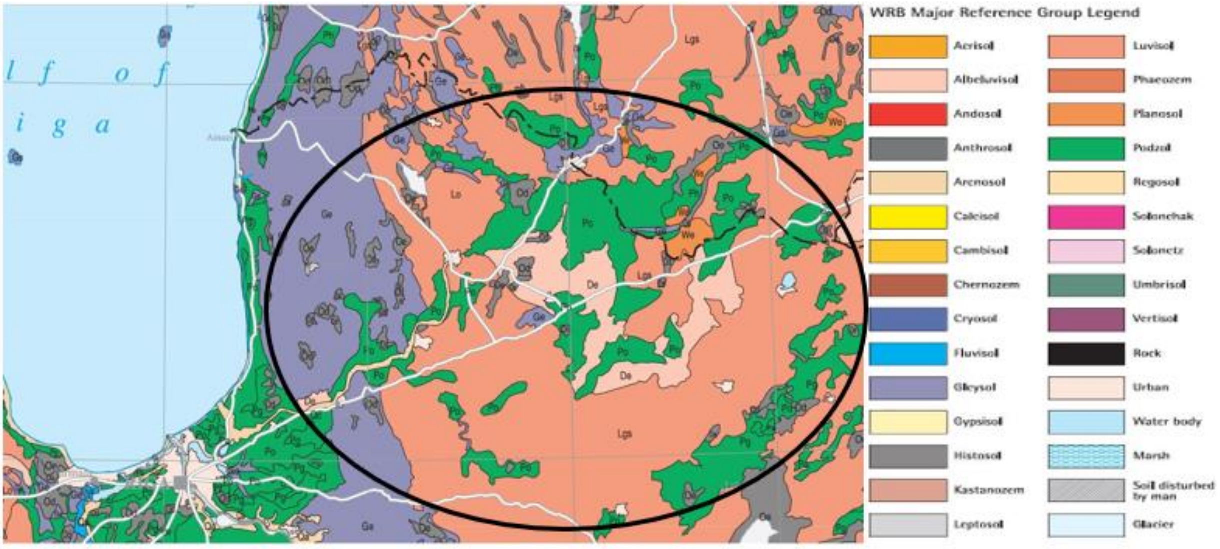
As mentioned before, soils are a crucial component in land management. Regarding the types of soils in particular, the Vidzeme Planning Region presents predominantly Luvisols, with areas with podzols distributed across the territory and also some Albeluvisols towards the central northern part and Histosols at the eastern part of the region (see Figure 6).

---

[11] Due to a process of Administrative Territorial Reform that came into force in July 2021, the limits of Latvia's planning regions and municipalities has changed recently. Therefore, it is technically not possible to delineate exactly the updated limits of Vidzeme in the CLC 2018 map. For illustration purposes, the approximate location of Vidzeme and the current map of the location of Vidzeme in Latvia are presented

[12] For the map view see https://land.copernicus.eu/pan-european/corine-land-cover/clc2018?tab=mapview for the legend, see https://www.eea.europa.eu/data-and-maps/figures/corine-land-cover-2006-by-country/legend/image_large. For the map of Vidzeme, see http://www.vidzeme.lv/en/about_vidzeme

Figure 6 Excerpt of soil map of Europe showing the approximately the Vidzeme Planning Region



Source: European Soil Bureau Network, 2005.

In terms of governance, Planning Regions are responsible for regional sustainable development strategies (long-term regional planning documents that set development priorities and define spatial planning zones)[13]. However, issues related to changes in land use must be addressed in close cooperation between planning regions and municipal governments, which have the main responsibility for local spatial planning (VASAB 2018). Soils in Latvia, on the other hand, are regulated at the national level, under the jurisdiction of the Ministry of Environmental Protection and Regional Development (as well as the Ministry for Agriculture).

The most relevant legislation that deals with soil quality is the Law on Pollution (2001), which includes the "Inventory and registration of contaminated and potentially contaminated areas" (2001) and the "Quality Standards for Soil and Ground" (2005).

Other relevant pieces of legislation include the Land Management Law (2014), the Regulation on Soil and Subsoil Quality Standards (2005), the Law on Amelioration (2010), and regulations on nitrate pollution from agriculture[14]. As soil carbon storage has raised in the policy agenda over recent years, the findings of initiatives like the LIFE GOODWATER IP project[15] are expected to inform regulatory developments in the future.

2.1.3 Biodiversity management profile

Latvia's natural environment is shaped by its location in the western section of the East European plain and on the Baltic Sea's eastern shore. The Baltic Sea's distinctive brackish water habitats and ecosystems, as well as the waters of the Gulf of Riga, contribute considerably to Latvia's biological richness. Around half of Latvia's territory is covered by forests (Convention on Biological diversity, n.d.).

Due to its natural conditions, Latvia sees an advantage in developing its bioeconomy. In Vidzeme region, several strategic documents guiding bioeconomy growth emphasize stakeholder collaboration, knowledge-based bioeconomy, and new governance and business models. The development of

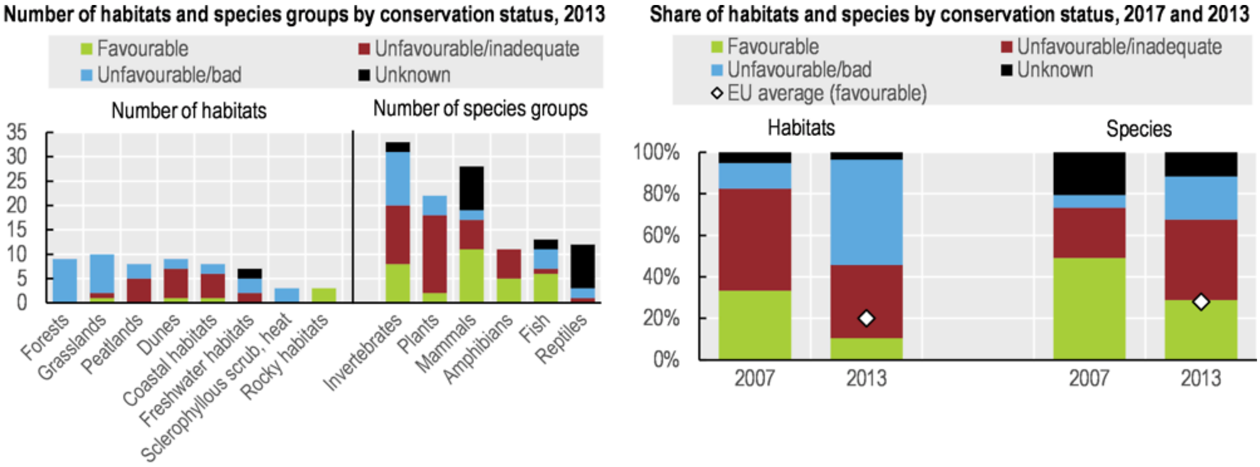
[13] It should be noted that according to the law on development planning, a sustainable development strategy is hierarchically the highest type of planning document. Sustainable development strategies are long-term documents developed both at the national and regional level. These documents contain long-term development priorities and goals and also include the spatial planning part defining zones of development. Despite their name, they are not specifically sustainability-oriented and they are not a policy instrument but used mainly for planning and reference purposes.

[14] See https://www.fao.org/soils-portal/soilex/country-profiles/details/en/?iso3=LVA

[15] See https://goodwater.lv/aktivitates/punktveida-piesarnojums

Vidzeme's bioeconomy is based on preserving and wisely managing natural systems and resources, hence, protecting biodiversity in Vidzeme is crucial (Nordregio 2022).

Figure 7 The conservation status of habitats and species is poor and declining



Source: OECD, 2019

For Latvia as a whole, there is a general negative trend regarding the conservation status of species, as between 2007 and 2013 the share that can be considered as favourable has declined (See Figure 7). There are 22 animal and plant species on the list of specially protected species with exploitation constraints, accounting for 2.6 percent of all known species (MEPRD, 2014). Amphibians and reptiles are the most vulnerable of the threatened species, accounting for 2% of all known species. According to the most recent EU evaluation, the majority of species have an unfavourable status: 39% are unfavourable/inadequate, and 21% are unfavourable/bad. These developments are similar to the EU norms of 42 percent and 18 percent, respectively. Only around a third of species (Figure 7) have a favourable status (OECD, 2019).

To maintain and improve the status of habitats and species in Latvia, many policies were published on EU level, national level and regional level.

In relation to *EU Biodiversity Strategy for 2030* targets, Latvia acts accordingly[16] on:

- *The development of Natura 2000*
- *Maintain and restore ecosystems and their services:*
- *Increase the contribution of agriculture and forestry to maintaining and enhancing biodiversity*
- *Ensure the sustainable use of fisheries resources and ensuring good environmental status of the marine environment*
- *Combat Invasive Alien Species*
- *Help avert global biodiversity loss*

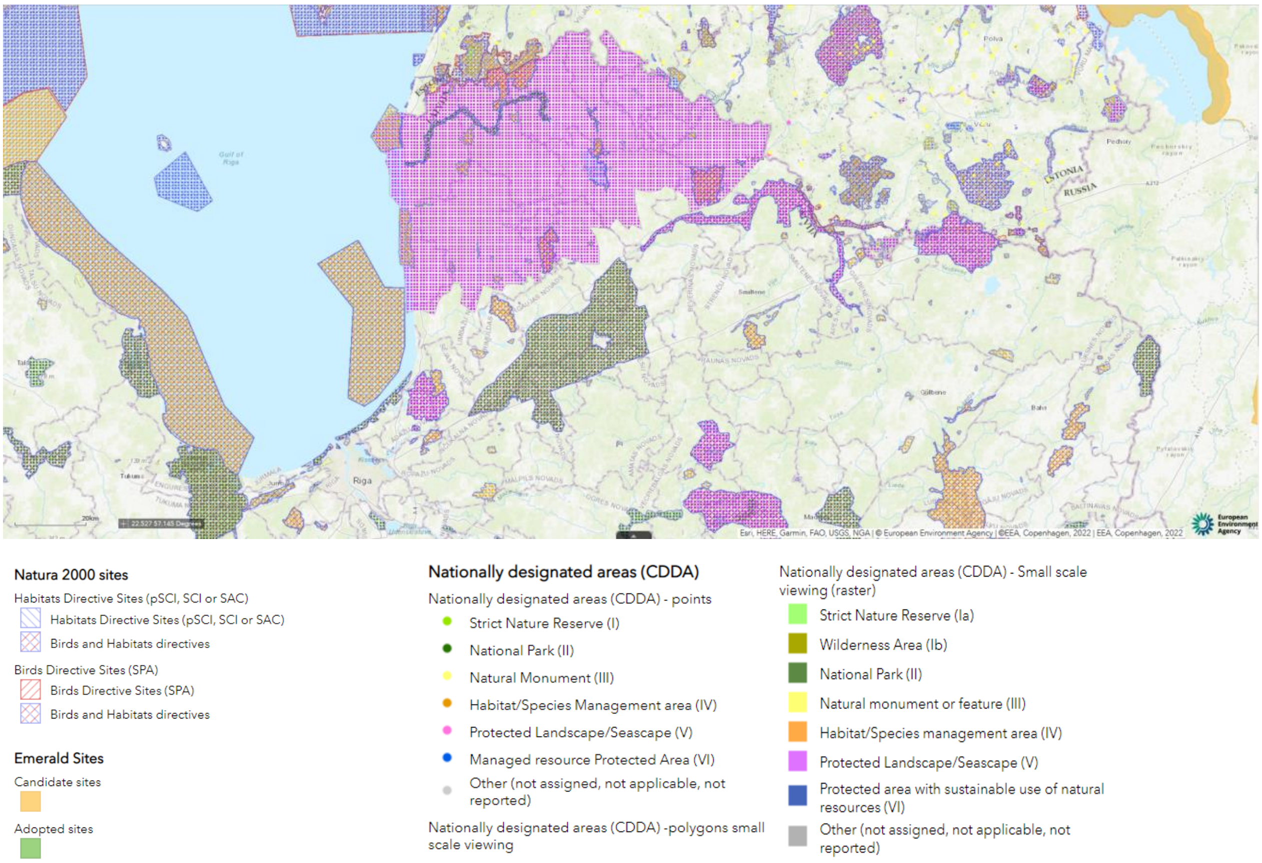
At national level, the *National Biodiversity Programme* includes some objectives that are relevant for the bioeconomy. Some examples are: promoting the conservation of the traditional landscape structures, ensuring sustainable use of natural recourses, promoting sustainable agriculture, protecting natural forest habitats, as well as reducing the rate of fragmentation[17].

The priority in the domain of nature conservation is to put the EU regulations' obligations into practice. Economic pressure and the perception that environmental conservation is primarily a restricting issue are two well-known barriers. It results from a lack of knowledge about the virtues and advantages of biodiversity and from inadequate communication about environmental concerns with policymakers and

[16] https://biodiversity.europa.eu/countries/latvia/eu-biodiversity-strategy
[17] https://biodiversity.europa.eu/countries/latvia/green-infrastructure

the general population. This, in turn, results from a lack of financial and human resources. Another significant barrier is the inadequate consideration of biodiversity issues in sectoral policies and programs; which were often assigned low priority or were treated as merely declaratory matters (MEPRD, 2014). Over the last five years, the situation appears to be improving, with an increased number of areas placed under protection- or special management regimes. New plans for protected species and territories are under development (at the national level)[18].

Figure 8 Significant places for birds in the Vidzeme region



Source: EEA[19]

With regards to the Vidzeme region, there is a public monitoring program created for the project “Biodiversity Protection in the North Vidzeme Biosphere Reserve” (2005-2009), which highlights the importance of stakeholder participation on biodiversity conservation. Residents of the biosphere reserve were asked to fill out surveys about various species, agricultural activities, and the distribution of invasive species on their property or in their vicinity, among other topics. Residents responded in enormous numbers, leading in the collection of a significant amount of useful information[20].

With regards to protected areas, several protected areas are located within the Vidzeme planning region, for instance the birds and habitats directive site Gaujas Nacionālais parks and the protected landscape Gaujas Nacionālais parks (see Figure 8).

2.1.4 Biomass resources management profile

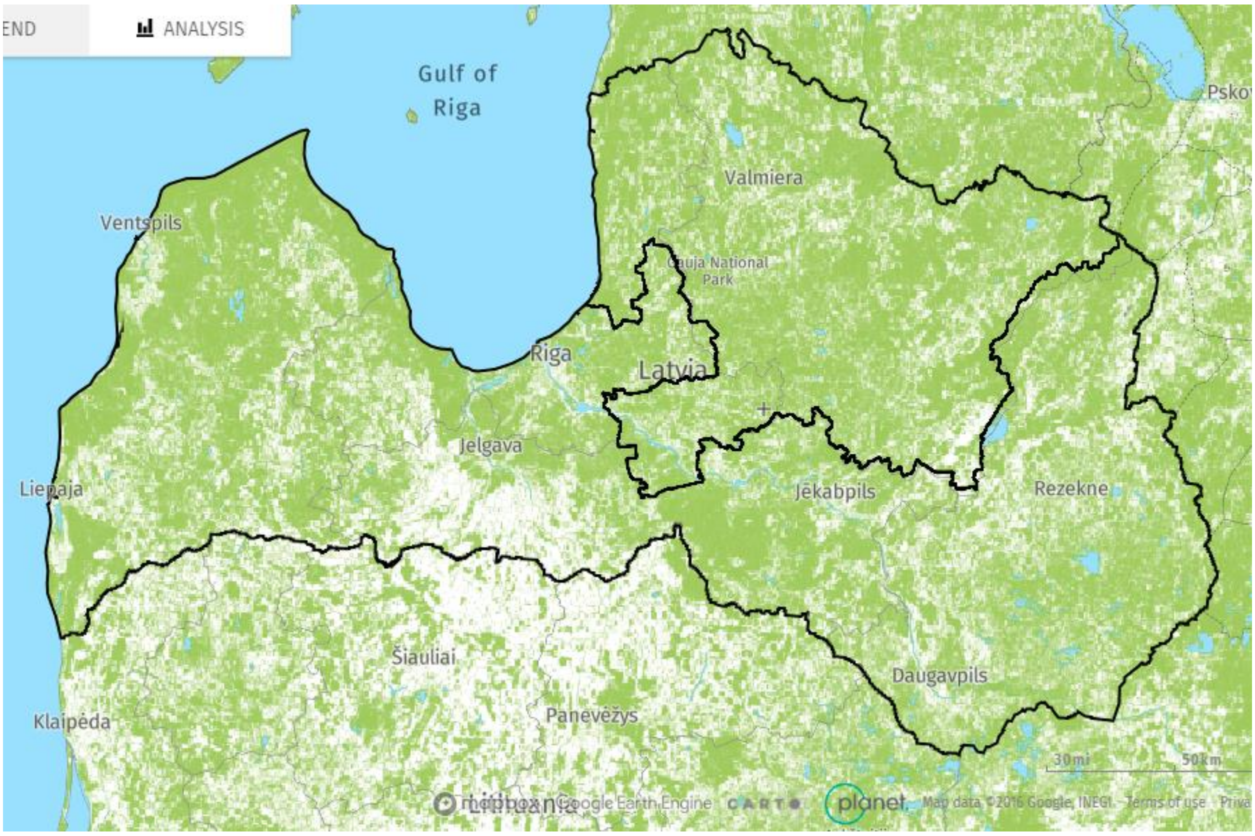
According to Directive 2001/77/EC biomass is defined as 'the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste'. Biomass resources

[18] See https://latvianature.daba.gov.lv/en/
[19] See https://www.eea.europa.eu/themes/biodiversity
[20] https://www.thegef.org/projects-operations/projects/1045

are renewable and inseparably linked with land and water resources and also influence biodiversity. Biomass resources can be distinguished as actual, i.e. already available, and potential that can be cultivated on marginal, degraded, and contaminated (shallow contamination with certain contaminants) lands. Actual biomass resources in Vidzeme region can be categorised as forest biomass, biomass from agriculture (including straw of grain crops, by-products of oil-crops production, biomass from pruning and livestock manure), municipal and industrial organic waste, sewage sludge. Potential biomass resources are perennial herbaceous and woody energy crops that could grow on marginal lands.

The most represented biomass resource in Vidzeme region is forest biomass (Figure 9) (Global Forest Watch, 2010)[21]. Forests cover 54% of the territory of the Vidzeme region that increased to 1,977,000 ha since 01.07.2021 (Vidzeme Planning region, 2021). According to the Latvia Statistical Bureau, forest is "an ecosystem in all stages of its development, dominated by trees, the height of which at the particular location may reach at least five metres and the present or potential tree crown cover accounts for at least 20% of the stand area"[22].

Figure 9 Tree cover in Vidzeme region, Latvia (2010)



Source: Global Forest Watch, 2010[23]

The forest sector in Latvia is under the supervision of the Ministry of Agriculture[24]. According to the State Forest Service[25], forests in Vidzeme region cover 1,072,517[26] ha, which accounts to 92% of the Forest land (1,168,407 ha)[26] that additionally includes "land under the forest infrastructure facilities, as

[21] See also https://forest-energy-atlas.luke.fi/
[22] https://stat.gov.lv/en/metadata/10229-inventoried-forest-areas
[23] Data "Tree cover in Vidzeme, Latvia" for tree canopy >20%. Accessed on 30/05/2022 from www.globalforestwatch.org. Adapted for boundaries after 2021 Administrative Territorial Reform
[24] http://www.zm.gov.lv/
[25] The State Forest Service collects data on Forestry statistics during Forestry Inventory and stores them in the national information system - the State Forest Register
[26] https://data.stat.gov.lv/pxweb/en/OSP_PUB/START__NOZ__ME__MEP/MEP051/table/tableViewLayout1/

well as overflowing clearings, bogs and glades falling within and neighbouring the forest"[27]. Within forests, area of forest stands is 1,019,553 ha[26] (1,019,556.31 ha[28]).

Stock Company "Latvian State Forests"[29], which was established in 1999, manages state-owned forests. The interests of private forest owners are represented by the Latvian Forest Owners' Association[30]. Area of state-owned forests in Vidzeme covers the area of 433,301.23 ha[28]. Other forests (not state-owned) include areas of 586,255.08 ha[28].

Total inventoried forest area with restrictions on forestry activities in Vidzeme planning region (after administrative-territorial reform in 2021) covers 1,072.7 ha, including 46.8 ha where forest activities are prohibited, 67.8 ha - clear fellings prohibited, 6.5 ha - final fellings prohibited, 16.3 ha - final and improvement felling prohibited[31].

Latvia's forestry is considered sustainable, as forests in Latvia are not diminishing and they are not losing their value. Forestry cycle in Latvia takes 70 – 100 years (Figure 10). The most widespread tree species in Latvia are birch, pine and spruce[28].

Figure 10 Forestry cycle in Latvia

Source: Latvia's State Forests[29]

Forest biomass comes predominantly from exploitable forests, where there are no legal, economic, or technical restrictions on wood production. Eight types of cuttings of growing stock are applied in Latvia (Table 1)[32].

Table 1 Types of forest fellings in Latvia

Type	Description

[27] https://stat.gov.lv/en/metadata/10229-inventoried-forest-areas
[28] according to data on Inventoried forest area by main tree species https://data.stat.gov.lv/pxweb/en/OSP_PUB/START__NOZ__ME__MEP/MEP061/table/tableViewLayout1/
[29] https://www.lvm.lv/
[30] www.mezaipasnieki.lv
[31] https://data.stat.gov.lv/pxweb/en/OSP_PUB/START__NOZ__ME__MEP/MEP032/table/tableViewLayout1/
[32] https://stat.gov.lv/en/metadata/8874-information-tree-felling

Main felling	Type of felling for cutting a forest stand at once or repeatedly, taking into account the age of the main felling or reaching a certain diameter of the main felling.
Thinning	Type of felling to improve the composition of the forest stand and the growing conditions of the trees in the remaining forest stand.
Clear felling	Clear felling is a way of performing the main felling. When this felling is performed, the cross-sectional area of the forest stand or a part thereof is reduced to such an extent that, within one year from the beginning of its felling, it becomes smaller than the critical cross-sectional area.
Sanitary felling / Salvage logging	Type of felling to improve the health of the forest by felling trees, damaged by forest diseases, pests, animals or damaged otherwise, windswept or broken trees in a continuous or random manner.
Reconstructive felling	Type of felling for felling a non-productive forest stand in a continuous or random manner.
Landscape felling	Type of felling to ensure the visibility and accessibility of landscape elements.
Deforestation felling	Type of felling in the forest for the implementation of activities due to which the type of land use is changed.
Other felling	Type of felling that is used if the felling is necessary for the establishment and maintenance of forest infrastructure and border tracks, removal of dangerous trees, preservation of natural values.

Source: Latvia Statistical Bureau[32]

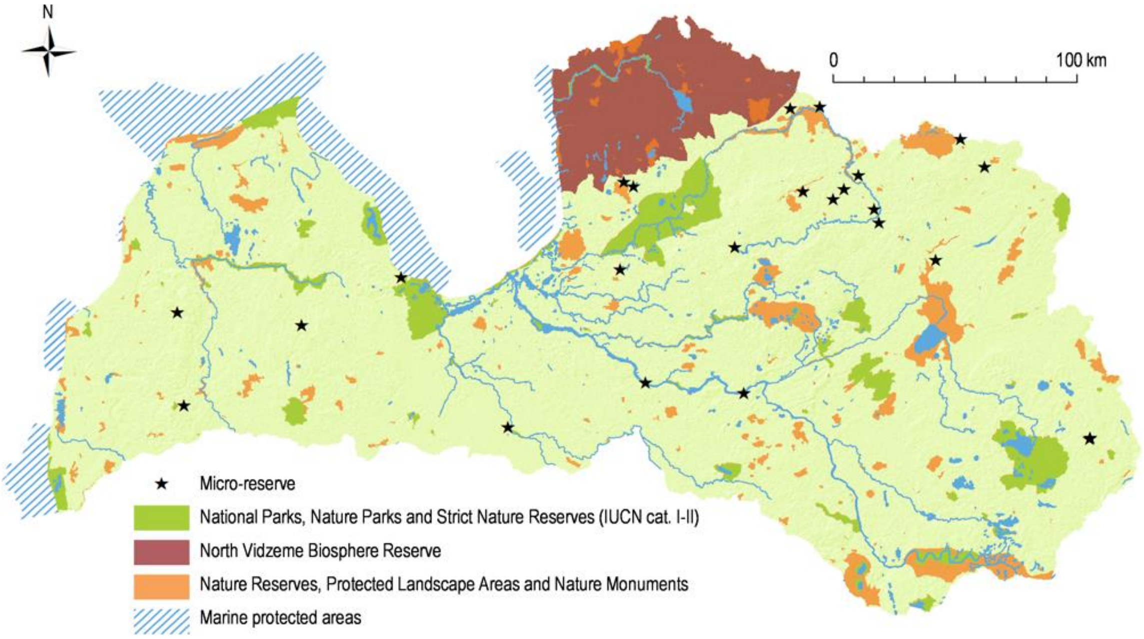
Inventoried standing timber in Vidzeme planning region (by main tree species) amounts 212,271,122 m^3. Total area of fellings in the region covers the area of 40,823 ha, and the volume of the cutting stock (removals) amounts 4,618,782 m^3 [33].

Forestry activities are prohibited in specially protected natural areas, and only sanitary fellings, felling of dangerous trees that endanger human life and health, nearby buildings and infrastructure objects, felling of trees for the performance of forest fire safety measures and some other types are permitted. Specially protected natural areas (Figure 11) are supervised and managed by the Nature Conservation Agency of the Ministry of Environmental Protection and Regional Development and can be monitored through Natural data management system OZOLS[34]. The biggest protected areas on the territory of Vidzeme planning region are:

- North Vidzeme Biosphere Reserve (475,514.16 ha);
- Gauja National Park Area (91,786 ha).

[33] https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__NOZ__ME__MEZ/MEZ011/table/tableViewLayout1/
[34] https://ozols.gov.lv/pub/

Figure 11 Nature reserves and protected areas in Latvia



Source: OECD report Latvia, 2019[35]

Biomass resources from agriculture include agricultural residues, which are crop residues remaining in fields after harvest (primary residues) and processing residues generated from the harvested portions of crops during food, feed, and fibre production (secondary residues), biomass from pruning, and livestock manure.

Agricultural area in Vidzeme region covers 441,222 ha, including utilized agricultural area – 423,772 ha. Unutilized agricultural land covers 17,450 ha[36] and can be partly used for growing perennial woody or grass-like energy crops. Additionally, within Utilized Agricultural area there are 18,565.7 ha of meadows and pastures no longer used for production purposes that could potentially be used for growing perennial woody or grass-like energy crops. Sown area under crops covers 227,199 ha, 95% of arable land and 54% of utilized agricultural area in the Vidzeme region.

Utilized agricultural area is distributed among cereals (incl. wheat, barley, rye, oats), industrial crops (incl. rapeseed), fodder crops, and meadows and pastures (Figure 12). Area of permanent crops (incl. fruit orchards 778 ha) is less than 1% (1,497 ha) of the total Utilized agricultural area[37].

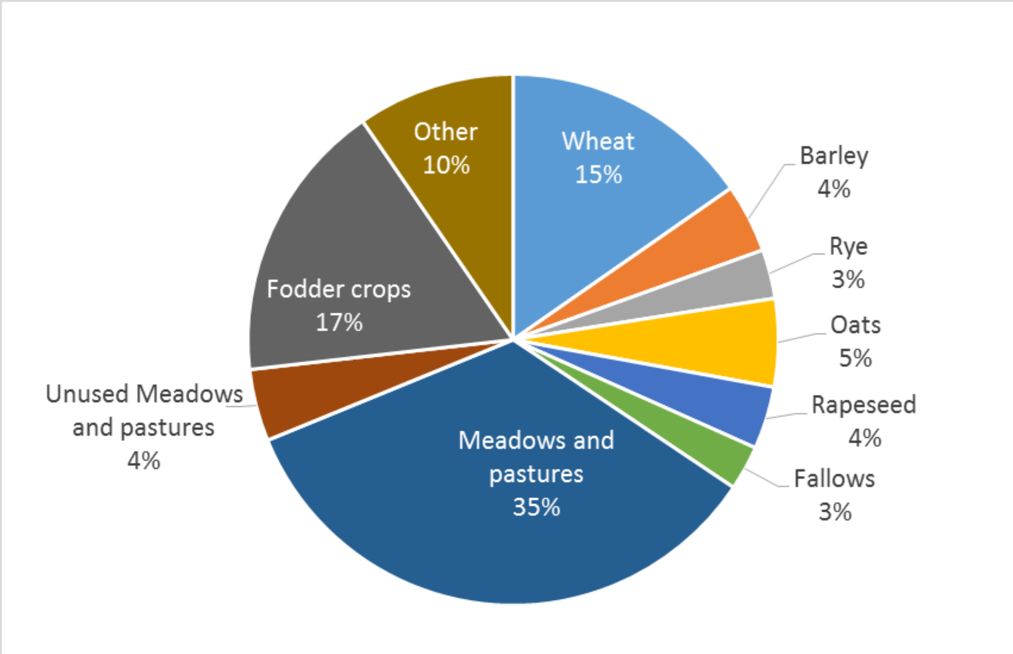
Sown areas of main crops in 2020 covered an area of 135,684.6 ha (Table 2)

[35] OECD report Latvia 2019, https://www.oecd-ilibrary.org/sites/9c1ffde5-en/images/images/2cb03cdd/media/image53.png

[36] According to description of the Central Statistical Bureau of Latvia Unutilised agricultural land includes former arable land, meadows, pastures, perennial crops, which due to the high moisture, unsuitable relief, social or economic reasons are not used, as well as, land laying waste.

[37] https://data.stat.gov.lv/pxweb/en/OSP_OD/OSP_OD__skait_apsek__zeme__laukskait_20/LSK20-II01_01.px/table/tableViewLayout1/

Figure 12 Distribution of Utilized Agricultural Area, 2020



Source: Central Statistical Bureau of Latvia[38]

Table 2 Sown area and harvested production of main crops in Vidzeme in 2020

Crop	Sown area, ha	Harvested production (in EU standard humidity), t
Wheat	64,978.5	307,614
Oats	22,747	67,243
Barley	17,729.3	61,664
Rye	12,647.2	56,928
Rapeseed	16,109.8	50,396
Triticale	1,472.8	6,735

Source: Central Statistical Bureau of Latvia[39]

Livestock manure generated at animal farms can be considered as another biomass source that could be used for energy production (biogas, biomethane, heat & power) in the Vidzeme planning region. According to Straume (2012) biogas potential of Vidzeme region (in boundaries before the Administrative Territorial Reform of 2021) amounts 304 million m^3 of biogas per year. The assessed potential was calculated for biogas produced from domestic animal (cattle, pigs and chicken) manure, as well as the unused agricultural available land (AAL) area, the wastewater treatment of biological

[38] Own calculation based on statistical data from https://data.stat.gov.lv/pxweb/en/OSP_OD/OSP_OD__skait_apsek__zeme__laukskait_20/LSK20-II09.px/table/tableViewLayout1/ and https://data.stat.gov.lv/pxweb/en/OSP_OD/OSP_OD__skait_apsek__zeme__laukskait_20/LSK20-II01_01.px/table/tableViewLayout1/

[39] https://data.stat.gov.lv/pxweb/en/OSP_OD/OSP_OD__skait_apsek__zeme__laukskait_20/LSK20-II09.px/table/tableViewLayout1/

plants of the largest cities, the largest landfills of solid household waste in the region and food processing industry waste[40].

Table 3 Number of livestock and poultry in Vidzeme region in 2015-2021

Livestock type	2015	2016	2017	2018	2019	2020	2021
Cattle	101,968	101,581	101,417	100,648	102,104	103,680	103,178
of which dairy cows	37,794	36,120	35,521	34,552	33,434	33,101	32,225
Pigs	49,841	53,941	58,310	54,559	57,505	57,258	56,283
Sheep	29,688	31,139	33,519	32,469	30,408	26,523	25,962
Poultry	82,000	81,000	224,000	212,000	231,000	338,000	456,000

Source: Central Statistical Bureau of Latvia [41]

Table 4 Annual volume of manure generated at animal farms by livestock types at Vidzeme planning region

Livestock type	Number of heads	Manure per animal, kg/day	Estimated volume of manure, t/year
Cattle (dairy cows)	32,225	40	470,485
Pigs	56,283	4	82,173
Sheep	25,962	4	37,905
Poultry	456,000	0.1	16,644

Source: Central Statistical Bureau of Latvia, own assessment[42]

Biomass utilization, including for energy and bioeconomy is regulated by the following national policies and legislation:

- National Energy and Climate Plan of Latvia 2021-2030[43][44];
- Law on Forests[45];
- Law on Agriculture and Rural Development[46];
- Latvian Bioeconomy Strategy 2030[47].

40 https://www.researchgate.net/publication/256120656_THE_INVESTIGATION_OF_BIOGAS_POTENTIAL_IN_THE_VIDZEME_REGION
41 https://data.stat.gov.lv/pxweb/en/OSP_PUB/START__NOZ__LA__LAL/LAL100/table/tableViewLayout1/
42 conservative estimation, based on open data from literature
43 https://likumi.lv/ta/id/312423-par-latvijas-nacionalo-energetikas-un-klimata-planu-20212030-gadam
44 https://ec.europa.eu/energy/sites/ener/files/documents/ec_courtesy_translation_lv_necp.pdf
45 https://likumi.lv/ta/en/en/id/2825
46 https://likumi.lv/doc.php?id=87480
47 https://www.zm.gov.lv/en/lauksaimnieciba/statiskas-lapas/bioeconomy?nid=2652#jump

3 Part C: Rough appraisal of available capacity

3.1 Methodological aspects of the sustainability screening for Vidzeme

3.1.1 Water data and indicators

To run the appraisal of the capacity of surface and groundwater bodies potentially relevant to the Vidzeme region, the authors of this report have reviewed the data reported in the 2nd River Basin Management Plan of the Gauja River Basin District published in 2016 (data from the 3rd reporting cycle was not yet available on the WISE Database at the time of the analysis). The benefits of tapping on this reporting process is that it includes well-defined indicators like the status of water bodies in the river basin district as well as data on significant pressures and impacts on them. Further, these data are official, largely available, accessible, and updated periodically (every six years). Authorities in charge of developing a regional bioeconomy strategy would generally be expected to have good access to the entity in charge of developing the River Basin Management Plan (i.e. the River Basin Authority), and so could theoretically consult it if necessary.

3.1.1.1 Description of the data / definition of the indicators employed

Data reviewed for this part of the screening included the reported ecological and chemical status of rivers and lakes as well as the quantitative and chemical status of groundwater bodies in the Gauja RBD. These data give indications on water quality in the river basin according to the five status classes defined in the WFD. These are: High (generally understood as undisturbed), good (with slight disturbance), moderate (with moderate disturbance), poor (with major alterations), and bad (with severe alterations) (EC, 2003). Further, data on significant pressures and significant impacts on the water bodies in the river basin district are used to indicate the burden of specific pressure and impact types on water ecosystems in the region based on the number and percentage of water bodies subject to them. Significant pressures are defined as the pressures that underpin an impact which in turn may be causing the water body to fail to reach at least the good status class (EEA, 2018).

All data described above were last accessed on 12.05.2022 from the WISE WFD data viewer (Tableau dashboard) hosted on the European Environment Agency's website.[48]

Table 5: Indicators used for the water component of the sustainability screening

Category	Indicator Family	Indicator	Spatial level	Unit of measure	Comments/Reference
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[49] Disaggregated data for ecological and chemical status of surface water bodies; quantitative and chemical status of groundwater bodies, per River Basin District
	Burden on water bodies	Significant pressures on water bodies	River Basin District	No. and % of water bodies under significant	WISE WFD Data Viewer[7]

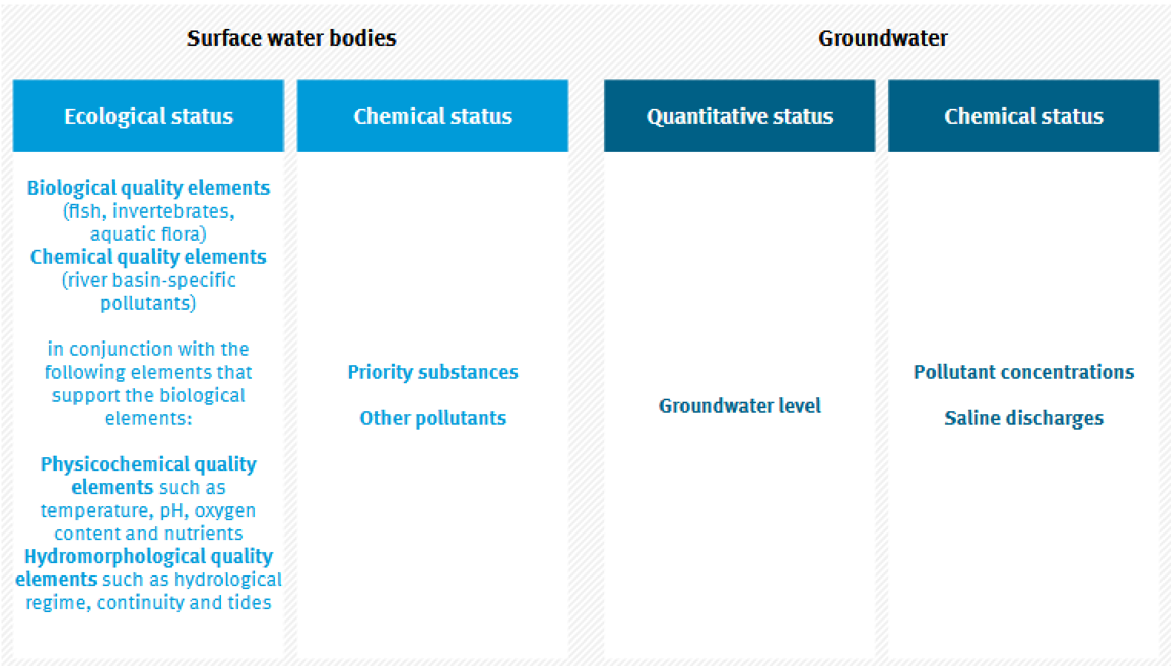
[48] https://www.eea.europa.eu/data-and-maps/dashboards/wise-wfd
[49] WISE WFD Data Viewer (https://www.eea.europa.eu/data-and-maps/dashboards/wise-wfd)

				pressures per pressure type	
	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]

Source: Own elaboration based on the information in the WISE WFD data viewer.

To determine which status class a certain water body falls into, WFD assessments evaluate the *ecological* and *chemical* status of surface waters (i.e. rivers and lakes) and the *quantitative* and *chemical* status of groundwater bodies. Ecological status refers to *"an expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters".* It covers assessments of biological (e.g. presence and diversity of flora and fauna), physico-chemical (e.g. temperature and oxygen content) and hydromorphological criteria (e.g. river continuity) (EC, 2003; BMUB/UBA, 2016). The chemical status of a surface water body is determined by comparing its level of concentration of pollutants against pre-determined environmental quality standards established in the WFD (concretely in Annex IX and Article 16(7)) and in other relevant Community legislation. These standards are set for specific water pollutants and their acceptable concentration levels.
In the case of groundwater bodies, chemical status is determined on the basis of a set of conditions laid out in Annex V of the WFD which cover pollutant concentrations and saline discharges. Additionally, the water body's quantitative status is included in the WFD assessments, defined as "*an expression of the degree to which a body of groundwater is affected by direct and indirect abstractions*". This gives indication on groundwater volume, a relevant parameter to evaluate hydrological regime (BMUB/UBA, 2016).

Figure 13: Overview of surface water body and groundwater status assessment criteria, as per the Water Framework Directive.



Source: BMUB/UBA, 2016.

In the case of surface water bodies, the WFD objective is not only that they reach good status, but that quality does not deteriorate in the future (EC, 2003), which is relevant in the context of drawing up a regional bioeconomy strategy.

3.1.1.2 Methodology applied

The authors of this report have devised an approach to valorise the data from the WFD reporting described in the previous sub-section that allows for an appraisal that is non-resource intensive (based on reliable, publicly available and accessible data) yet capable of providing a rough overview of the state of the region's waters. This is in line with the rationale of this sustainability screening, which aims to enable regions with limited financial resources and/or expertise in the field to consider ecological limits in a structured manner when developing a regional bioeconomy strategy or roadmap. The preferred option for this part of the assessment would have been to supplement the WFD data with a water quantity balance indicator like the Water Exploitation Index plus (WEI+) developed by the EEA and its partners. That indicator compares the total fresh water used in a country per year against the renewable freshwater resources (groundwater and surface water) it has available in the same period. This could have strengthened the water quantity element in the screening. However, the calculation of the WEI+ at regional level is currently not conducted or foreseen by its developers, and it would entail a disproportionately large effort that falls beyond the scope of this task in BE-Rural. For these reasons, the reported data from the WFD process has been employed exclusively within the following methodology.

The overall apportionment of rivers, lakes and groundwater bodies in the East Aegean RBD according to their WFD status classification can be used to set the baseline for the sustainability screening. It provides initial insight on the situation in the demarcation as regards "ensuring access to good quality water in sufficient quantity", "ensuring the good status of all water bodies", "promoting the sustainable use of water based on the long-term protection of available water resources" and "ensuring a balance between abstraction and recharge of groundwater, with the aim of achieving good status of groundwater bodies", all explicit aims of the WFD that are aligned with the consideration of ecological limits. Further, the data on significant impacts and pressures affecting the water bodies in the river basin are useful as they can point towards specific problems (e.g. nutrient pollution) and the types of activities that may be causing them (e.g. discharge of untreated wastewater, agriculture).

As a first step, the approach used for this element of the screening entails calculating what proportion of the total number of surface water bodies located in the RBD is reported as failing to achieve Good Ecological Status/Good Chemical Status or for which conditions are unknown. Similarly for groundwater bodies, the proportion is calculated of those who are reported as failing to achieve Good Chemical Status/Good Quantitative Status or for which conditions are unknown. The resulting ratios are then compared to the respective EU proportions, which are used as (arbitrary) thresholds. According to the latest assessment published by the EEA in 2018, "around 40% of surface waters (rivers, lakes and transitional and coastal waters) are in good ecological status or potential, and only 38% are in good chemical status" (EEA, 2018). Accordingly, "good chemical status has been achieved for 74% of the groundwater area, while 89% of the area achieved good quantitative status" (EEA, 2018). Using these markers, the following step is to rank the current conditions of the region using an ordinal risk rating (high, moderate, low) based on the distance of the result of each indicator to the EU level results. On this basis, the thresholds and ordinal ranking convention suggested by the authors of this report are as shown in Table 6 and Table 7.

Table 6 Proposed thresholds for the water section of the sustainability screening

Water body type	Status category	2018 EU-level assessment results (proportion of water bodies achieving good status)	Proposed thresholds for the sustainability screening		
			High concern	Moderate concern	Low concern
Surface water bodies	Ecological status	~40%	0-40%	41-89%	90-100%
	Chemical Status	38%	0-38%	39-89%	90-100%

Groundwater bodies	Chemical status	74%	0-74%	75-89%	90-100%
	Quantitative status	89%	0-89%	-	90-100%

Source: own elaboration.

Table 7 Ordinal ranking convention for the water section of the sustainability screening

Ordinal ranking for water resources		Chemical status		
		High concern	Moderate concern	Low concern
Ecological or Quantitative status	High concern			
	Moderate concern			
	Low concern			

Source: own elaboration.

This initial appraisal based on the thresholds shown above is then supplemented with a review of the reported data on the types of significant pressures and impacts on surface and groundwater bodies. In this case percentage values are already given, and so this step in the screening simply entails the listing of the reported pressures and impacts and the identification of those which are more frequently reported. From here, the screening team can seek potential correlations between the most reported pressure types and the most reported impact types (e.g. diffuse sources causing nutrient pollution).

The final step in the approach is to draft a note describing the share of water bodies failing to reach good status and formulating preliminary statements on the types of bioeconomy activities that could be considered, those that should be considered with reserve, and those that should be avoided. These initial statements are intended to frame the discussion of the group of stakeholders involved in the development of the regional bioeconomy strategy or roadmap.

3.1.1.3 Data uncertainties

The data resulting from the assessments reported in the RBMP and subsequently in WISE are subject to the limitations of the scientific and methodological approaches used by their authors. It thus must be considered that the official assessments are based on estimates, include assumptions, and will therefore carry a margin of error.

An important limitation bound to the implementation of the sustainability screening is that the geographical coverage of the WFD data used does not coincide fully with the territorial boundaries of the Vidzeme region.

Lastly, another issue to consider is the data currently available on WISE is from 2016, while more updated (interim) assessments are already available at the time of writing of this document.

3.1.1.4 Methodological uncertainties

The proposed methodology for the water section used in this application of the sustainability screening is straight-forward and accessible, yet it must be used with care and, where possible, should incorporate higher resolution data evaluated by thematic experts. As previously mentioned, the thresholds set in this case have been the proportions, at EU-level, of water bodies that fail to achieve good status or for which conditions have been reported as unknown. This has been a pragmatic, yet easy to challenge way of defining a benchmark for the Vidzeme region. Conditions and context in other European river basin districts may be significantly distinct to those in the Latvian region, and thus a more appropriate reference point could be defined in those cases. For this, the authors envision the contributions and guidance from the team of local and foreign experts as briefly described in Chapter 1 of this screening report and in further detail in Section 3.2 of the main deliverable report. Optimally, these thematic experts should know the regional context well and thus be in a good position to guide the setting of such thresholds. Beyond this, the simplicity of the necessary calculations and the fact that the data on significant pressures and impacts are used without further computation and compared in relative terms within the RBD limit the possibility of additional accuracy or uncertainty issues emerging.

3.1.2 Soil data and indicators

3.1.2.1 Description of the data / definition of the indicators employed

The selected indicators for vulnerability to soil depletion are closely interrelated and refer specifically to soil erosion **by water**. These are:

- Estimated mean soil erosion rate (in $t\ ha^{-1}\ a^{-1}$)
- Share (%) of area under severe erosion (>10 $t\ ha^{-1}\ a^{-1}$)

In broad terms, soil erosion describes the process through which land surface (soil or geological material) is worn away (e.g. through physical forces like water or wind) and transported from one point of the earth surface to be deposited somewhere else (Eurostat 2020). The above mentioned indicators describe particularly the amount of soil (in t) per unit of land surface (in ha) that is relocated by water per year.

Variations of these indicators can be calculated by considering different combinations of land cover classification groups, such as *all land*[50] and *agricultural land*[51]. As shown in Figure 14, at EU level in 2016, about three quarters of soil loss occurred in agricultural areas and natural grasslands, while the remaining quarter occurred in forests and semi natural areas (Eurostat 2020). Therefore, since it is the type of land cover that is most vulnerable to erosion, the present sustainability screening will consider in first line the above mentioned indicators specifically for agricultural areas and natural grasslands. This scope of the indicators is also in line with the two sub-indicators for soil erosion considered by the Joint Research Centre European Soil Data Centre (JRC ESDAC). Moreover, both the *mean erosion rate for agricultural land* and the *share of agricultural area under severe erosion* are part of the EU Common Agriculture Policy (CAP) context indicator 42 (CCI42) for the period 2014-2020.

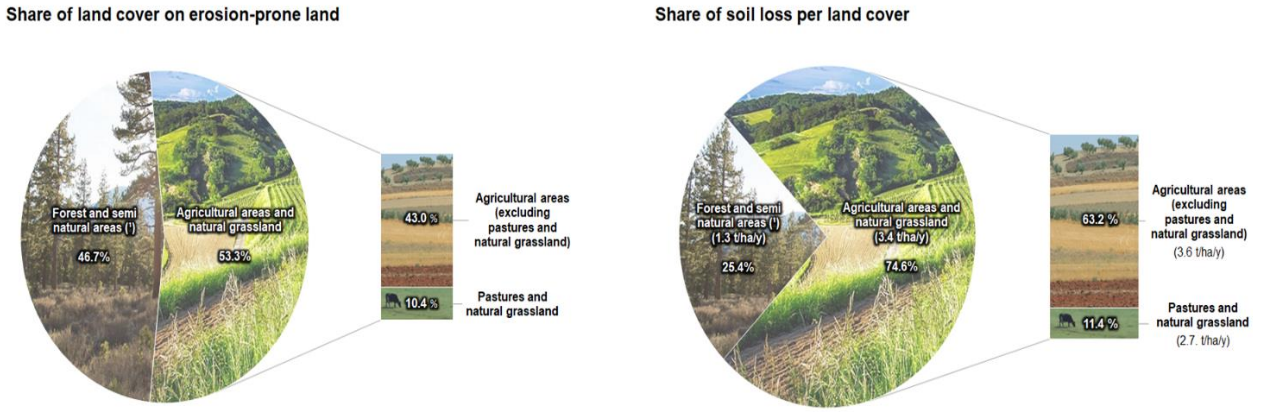
Nonetheless, there are regions where forests represent a larger proportion of the land cover and forestry related activities are in the focus of interest with regards to the development of the bioeconomy. Therefore, for these particular cases, we recommend using estimated mean soil erosion rate for *all lands*, as this also includes forested areas, adding an additional angle to the screening and making it more suitable for regions which may have a bioeconomy partly or wholly dependent on forestry resources (such as Vidzeme).

---

[50] This refers to all potentially erosive-prone land (in simplified terms), specifically to CORINE Land Cover classification groups: Agricultural areas (2), forest and semi natural areas (3) excluding beaches, dunes, sand plains (3.3.1), bare rock (3.3.2), glaciers and perpetual snow (3.3.5). These, as well as other classes, are excluded because they are not subject to soil erosion.

[51] This refers only to agricultural land (agricultural cropland as well as grassland in simplified terms), specifically to CORINE Land Cover classification groups: Agricultural Areas (2) and Natural Grasslands (321)

Figure 14 Share of land cover and soil loss across the EU-27 in 2016[52]



Source: Eurostat, 2020

The data has been extracted from EUROSTAT, specifically the dataset "Estimated soil erosion by water, by erosion level, land cover and NUTS 3 regions (source: JRC) (aei_pr_soiler)". For determining the baseline in the sustainability screening, we have selected the latest available data, i.e. for 2016.

Mean soil erosion rate, which undergirds both selected indicators, is considered useful because it provides a solid baseline to estimate the actual erosion rate in the NUTS 3 regions (Panagos et al. 2015). This indicator is based on the latest Revised Universal Soil Loss Equation of 2015 (RUSLE2015), specifically adapted for the European context (see Panagos et al. 2015), which is a model that takes into account various aspects, including two dynamic factors, namely the cover-management[53] and policy support practices[54] (both related to human activities) (Panagos et al. 2020).

The estimated mean soil erosion rate value obtained through the RUSLE2015 model refers to water erosion only, but it is considered to be the most relevant at least in terms of policy action at EU level, due to the relative predominance of water erosion over other types of erosion. Furthermore, it offers the important advantage of providing a viable estimation for erosion vulnerability at a relatively small geographic scale, i.e. the local or regional level. This can serve as an important tool for monitoring the effect of local and regional policy support strategies of good environmental practices (Panagos et al 2015, 2020 and Eurostat 2020). The NUTS 3 nomenclature matches the scale of the planning regions of Latvia[55], which means that there is readily available data for the Vidzeme region (NUTS 3 code LV008) that can be used directly for the present sustainability screening. Nonethless, it is important to point out the latest update in the limits of the planning regions, which came into force in July 2021 after the Administrative Territorial reform of Latvia, is currently still not reflected in the latest NUTS (valid from January 1, 2021). However, future updates of data at NUTS 3 level are expected to consider these new boundaries.

---

[52] Excluding not erosion-prone land (e.g. beaches, dunes, etc.). Forest and natural areas exclude also natural grasslands, which are evaluated together with agricultural areas.

[53] Known as the c-factor, it has an non-arable component, which includes changes in land cover and remote sensing data on vegetation density, as well as an arable component, which includes Eurostat data on crops, cover crops, tillage and plant residues

[54] Known as the p-factor, it reflects the effects of supporting policies in estimating the mean erosion rate by including data reported by member states on Good Agricultural Environmental Conditions (GAEC) according to the CAP, specifically contour farming, as well data from LUCAS Earth observation on stone walls and grass margins

[55] There are six planning regions of Latvia, with Vidzeme being one of them. The boundaries of the regions align to the boundaries of the municipalities of Latvia following the municipality reform of 1 July 2009. The planning regions of Latvia are not administrative territorial divisions, since they are not mentioned in the law that prescribes the administrative territorial divisions of Latvia.

3.1.2.2 Methodology applied

The near-universal indicators available to track soil vulnerability are related to either erosion or the decline in soil organic carbon (SOC)/soil organic matter (SOM) (Karlen & Rice, 2015). However, there are major data gaps regarding to SOC/SOM 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" (by water), which they calculate using the RUSLE2015 model. For our purposes, we have complemented the *mean soil erosion rate* indicator, with the *share of agricultural area under severe erosion* in order to gain a comprehensive picture of soil erosion in a region.

Soil erosion is considered generally as a sort of proxy indicator of soil degradation, which in turn is the most relevant component of land degradation at EU level (EC 2018)[56]. However, not all type of bio-based activities have a direct effect on erosion, but rather primary production of biomass. Nonetheless, as these are currently the most widespread bioeconomy activities in rural areas, we will consider their impact on soil degradation, and therefore on soil erosion, to be the most relevant one for this assessment.

The indicators for vulnerability to soil degradation were selected, on one hand, due to the limited number of soil indicators available at the required regional scale (NUTS3). On the other hand, the RUSLE2015 model used for this data also represents the current state-of-the-art methodology for calculating soil erosion. These aspects are crucial, since the choice of indicators needs to be: a) acceptable to experts, b) routinely and widely measured, and c) have a currency with the broader population to achieve global acceptance and impact (Stockmann et al., 2015). In order to carry out the screening of soil vulnerability, a number of datasets need to be accessed. As mentioned above, this data can be accessed via Eurostat.

In terms of processing the erosion data, it is important to consider that the overall erosion rate changes across geographic areas, meaning the vulnerability/risk is not necessarily evenly distributed. In cases where the mean soil erosion rate exceeds the 10 t ha^{-1} a^{-1}, erosion is considered severe and activities that can generate, or are associated with a high erosion impact should be strongly discouraged. Erosion rates between 5 and 10 t ha^{-1} a^{-1} are considered moderate, requiring some attention towards practices that have a high impact on erosion, but with less urgency. However, it is relevant to take a look not only at the mean erosion rate for the area itself, but also at its spatial distribution, which is roughly reflected on the indicator of share of (agricultural) area under severe erosion.

3.1.2.3 Data uncertainties

The data used is produced from an empirical computer model (RUSLE2015) and produces estimates. Hence, there are several uncertainties related to the figures if compared to data collected on the ground. However, the purpose of the model is to generate data for a large spatial scale taken into account human intervention, which is not possible to do only through empirical measurements. That being said, like every model, assumptions have to be made and there is an intrinsic level of uncertainty. Specifically related to the RUSLE methodology, Benavidez et al. (2018)[57] critically reviewed the RUSLE methodology, upon which RUSLE2015 is based, and identified following main limitations:

- its regional applicability to regions that have different climate regimes and land cover conditions than the ones considered (in the original RUSLE for the USA, in RUSLE 2015 for Europe)
- uncertainties associated generally with soil erosion models, such as their inability to capture the complex interactions involved in soil loss, as well as the low availability of long-term reliable data and the lack of validation through observational data of soil erosion, among others.
- issues with input data and validation of results,

[56] https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/key_policies/documents/cap-specific-objectives-brief-5-soil_en.pdf
[57] https://hess.copernicus.org/articles/22/6059/2018/

- its limited scope, which considers only soil loss through sheet (overland flow) and rill erosion, thus excluding other types of erosion which may be relevant in some areas, e.g. gully erosion and channel erosion, to name a few. Moreover, it also excludes wind erosion.

A further factor of uncertainty in the data is the fact that the RUSLE model is calculated using mean precipitation data over multiple years and a large territorial scale (in this case Europe). Thus, it fails to account the changes in rainfall intensity, which are highly relevant for determining water erosion accurately. This is the case not only considering the seasonality of rainfall, but also its distribution across the continent. (Panagos et al. 2020). Another important uncertainty identified by Panagos et al. (2020) is the lack of georeferenced data for annual crops and soil conservation practices in the field at a continental level, which has had to be estimated from statistical data.

Nonetheless, when considered best available estimates, the mean soil erosion values generated through the application of RUSLE2015 model offer a very suitable basis for assessing vulnerability to soil loss in general terms, even if the generated absolute values are to be taken with caution (Benavidez et al. 2018).

3.1.2.4 Methodological uncertainties

Among the most relevant uncertainties regarding the application of the sustainability screening in terms of soil vulnerability are the selection of the threshold against which the severity of erosion is evaluated and the selection of the land cover types that will be considered.

Regarding the threshold of 10 t ha^{-1} a^{-1} for severe erosion, it is important to mention that this was obtained directly from the dataset that was used[58]. However, it is still an arbitrary value which can be adapted. For instance, some sources like Panagos et al. (2015, 2020), who were involved in the generation of the data for the JRC ESDAC, consider severe erosion to be above 11 t ha^{-1} a^{-1}. In this regard, we have also decided to stick to the lower value described in the Eurostat dataset because it is more conservative and, as such, more suitable for an initial (and indicative) sustainability screening like the one we are proposing.

The selection of land cover types presents another area for potential uncertainty. Choosing between “all lands” and “agricultural lands” can have considerable implications for interpreting the data. For example, it is possible that the mean soil erosion rate is 5 t ha^{-1} a^{-1} (moderate erosion) in one land cover type, but lower in the other. This would have an effect on the assessment, which would present any potential concerns about erosion and steps that should be taken. As such, it is important to have solid grounding for the choice of dataset. The ultimate decision whether to consider all lands (including forests) is arbitrary and lays with the group performing the sustainability screening. Particularly when that decision is based on considerations of the economic relevance of forestry related industries in the region rather than on the actual share of the area that is covered with forest (it should be high to justify their inclusion), the values of soil erosion (for all lands) shall be taken with some reservations. This is because these values tend to be lower than the value for agricultural land and can create the impression that vulnerability to erosion is lower than it actually is. However, due to the indicative (and non-exhaustive) nature of the present sustainability screening, this uncertainty is not especially relevant for cases such as Vidzeme, where both values (for all lands and agricultural land with natural grassland) are low.

3.1.3 Biodiversity data and indicators

Within the European frame of biodiversity monitoring, there are different potential datasets to assess the conditions of biodiversity on EU territory. One central EU data source relates to the Member States’ reporting under the Birds and Habitats Directives that is assessed every six years by the EEA. Nonetheless, due to the spatial scale of the reporting, which is based on the biogeographical and marine regions, the meaningful application on this data within a smaller region is limited. Due to these data limitations, using reporting results such as the conservation status or pressure data is considered to be not specific enough for a regional analysis. Data for a specific region, especially on species

[58] See metadata of the used dataset at https://ec.europa.eu/eurostat/cache/metadata/en/aei_pr_soiler_esms.htm

(which are mostly mobile and not endemically encountered in single regions), this hard to obtain, often not openly available and its availability highly dependent on national efforts and resources, the implementation by local authorities or the active non-governmental engagement (e.g. monitoring by NGOs or citizen science).

To get to know the biodiversity condition in the Vidzeme region, the authors of this report thus propose a two-fold approach depending on the general type of landscape that is expected to be affected by bioeconomic activities. For *agricultural land*, we propose using the data set from EEA (European Environment Agency) on the loss of High Nature Value Farmland (HNVF) during the year 2006 to 2012[59]. The data was published in 2017 and last modified in 2019. For *forested land*, we propose evaluating their changes, particularly in terms of loss or gain of mixed and broad-leafed dominated forests. For this purpose, we have compared the data on forest type for the years of 2012 and 2018 found on Copernicus Land Monitoring Service[60].The following sections elaborate the definitions of the selected indicators, the methodology applied to assess them and their limitations.

While the proposed indicator for forested land has been tested (see results in section 4.2.5), the indicator for HNVF will only be developed as a theoretical concept in this section.

3.1.3.1 Description of the data / definition of the indicators employed

Understanding how the biodiversity in a region will respond to and/or is affected by bioeconomy activities and their expansion is critical. This issue is particularly pronounced considering the bioeconomy's potential role as a driver of land-use change, which can cause impacts on biodiversity. In order to understand and evaluate the sustainability of biomass production in a region, it is therefore necessary to look at how it affects biodiversity.

Agricultural land

The concept of High Nature Value farmland (HNV farmland) ties together the biodiversity to the continuation of farming on certain types of land and the maintenance of specific farming systems. Typical examples include semi-natural grassland systems, traditional olive, vine and fruit production, Dehesa, Montado and other wood pasture systems and extensive farming in bocage landscapes (Schwaiger et al., 2012).

The HNV farmland is an EU indicator of the conservation value of an agricultural area. The definition is as follows:

> *“High Nature Value farmland comprises those areas in Europe where agriculture is a major (usually the dominant) land use and where that agriculture supports or is associated with either a high species and habitat diversity or the presence of species of European conservation concern or both” (Andersen. 2004)*

In the concept of HNV farmland, 3 types of farmlands are included:

- ***Type 1:*** Farmland with a high proportion of semi-natural vegetation, e.g., heath, dehesa or grasslands.
- ***Type 2:*** Farmland with a mosaic of habitats and/or land uses, e.g., dry arable areas and small-scale farms in southern Europe. Small scale features includes open water, ditches, relict grassland, field boundaries and woodland.
- ***Type 3:*** Farmland supporting rare species or a high proportion of European or World populations, e.g., areas of intensively managed wet grassland favoured by migrating geese.

HNV farmland existence is under threat, with one of the main threatening factors being changes in agricultural land usage. While farming practices on better farmland have generally intensified, inferior land has been abandoned or reforested. Traditional, low-intensity farming systems with high environmental value are rare at EU scale (EEA, 2009a; Keenleyside et al., 2014).

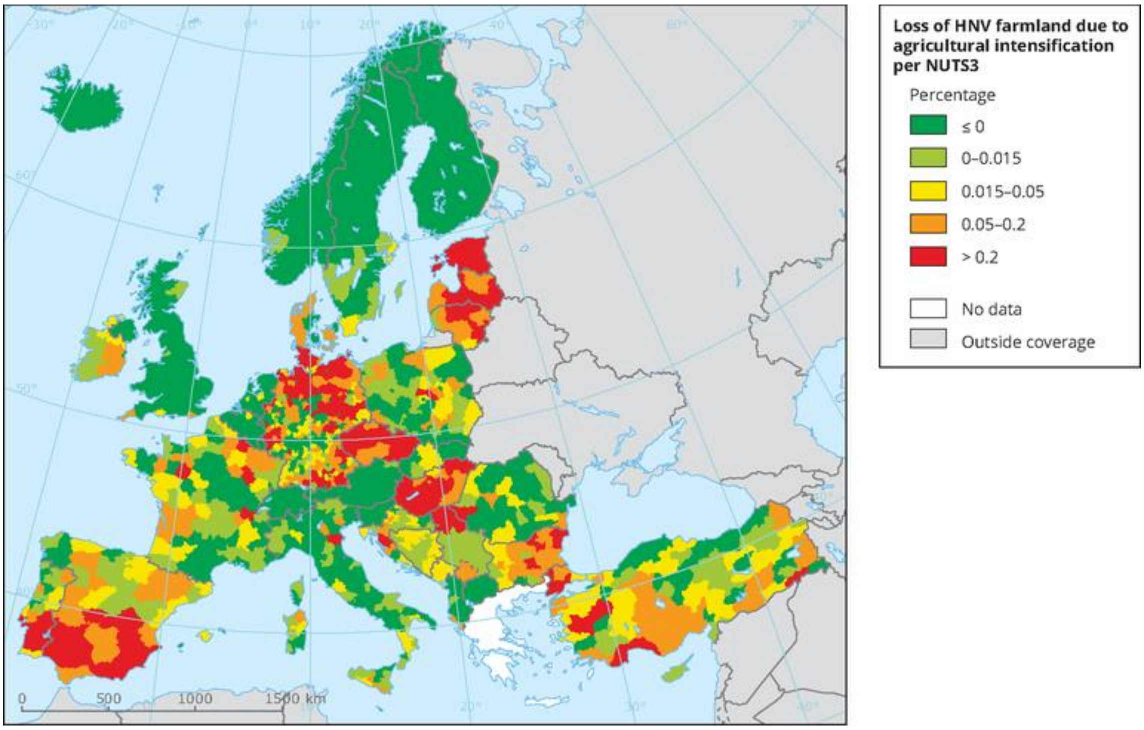
---

[59] https://www.eea.europa.eu/data-and-maps/figures/loss-of-hnv-farmland-due/datapackageformap_fig_22.xls/at_download/file
[60] https://land.copernicus.eu/pan-european/high-resolution-layers/forests/forest-type-1/status-maps

Increased regional biomass production usually comes with intensifying agriculture in a region. Therefore, the risk (decreased biodiversity and the abundance of species across a hierarchy of trophic levels and spatial scales within Europe) intensified agriculture might have on the regional biodiversity could be assessed with the loss of HNV farmland due to agricultural intensification per NUTS3 (Emmerson et al., 2016). In short, increased biomass production through intensification of agriculture directly influences the loss of HNV farmland.

In this exercise, we use the loss of HNV farmland by percentage during 2006 and 2012 to track representative loss in biodiversity and thus define a baseline for the assessment of the sustainability changes in Vidzeme (Figure 15). The map (data set) we used[61] is developed, hosted and maintained by the European Environment Agency, which aims to improve the European map of HNV farmland, depicts the projected distribution and likelihood of HNV farmland loss over the whole European continent, thus for Vidzeme as well. The threshold we use (see Figure 15) could be summarised into three scales for our exercise. The percentage of the loss of HNV farmland under 0.015% is considered low, between 0.015% to 0.2% is considered moderate and over 0.2% is considered high. This threshold is defined by the author based on land changes compare to other countries/regions in the map.

Figure 15: Loss of HNV farmland due to agricultural intensification per NUTS3



Source: EEA, 2017.

Forested land

For the present screening, we analyzed the change of forest types across time, measured as the change of dominant leaf types covering the canopy surface. For this purpose, the screening employed the Forest Type dataset published by the EEA Copernicus Land Monitoring Service**[60]**, which is based on high resolution (100m) optical satellite imagery. The dataset has a European wide coverage and is freely available for the years 2012, 2015, and 2018. For each year, the dataset provides a status map in the form of a Tiff-format raster, which indicates the dominant leave type for each pixel, categorizing the landscape in four discrete and collectively exhaustive classes: no forest (pixel value = 0); broadleaf forest (pixel value = 1); coniferous forest (pixel value = 2); and mixed forest (pixel value = 3).

The present screening analyzed the observable changes from 2012 to 2018 for Vidzeme, using the GISCO statistical unit dataset for NUTS 3 from the year 2021, which is published by Eurostat and freely

[61] See: https://www.eea.europa.eu/data-and-maps/figures/loss-of-hnv-farmland-due

available as a vector shapefile. Both datasets are projected with the European projection EPSG: 3035. In order to complement the specific spatial data calculated for 2012 – 2018, we have also looked at the trends described on Global Forest Watch Dashboard, which offers data at a regional level that matches the NUTS 3 classification.

3.1.3.2 Methodology applied

The HNV farmland indicator is initially defined by a report from EEA (Andersen, 2004). Since then, the recognition of the relation between biodiversity and HNV farmland is used for socioeconomic analysis (Lomba, 2020), landcover change research in Europe (Anderson & Mammides, 2020) and assessment of policy on biodiversity protection (Schulp et al., 2016). In most of the research, they used the dataset of HNV farmland from EEA as they defined the concept and mapped Europe's loss of HNV farmland (Figure 15).

The following is a summary of the methodology used to map the loss of HNV agriculture at a 1 km^2 resolution: Researchers originally used the CORINE Land Cover (CLC) map to pinpoint all agricultural land in Europe. The CLC map is a European-wide initiative that maps land cover in 39 European nations every six years. The most recent HNV farm-lands map is based on the 2006 CLC map to locate agricultural classes, plus other classes relevant to HNV farmlands, such as "natural grasslands" and "peat bogs" (Schwaiger et al., 2012) Then, utilizing the most up-to-date spatial data on biodiversity distribution in Europe—specifically, data from the Natura 2000 database, Important Bird Areas, Prime Butterfly Areas, and, when accessible and appropriate, National Biodiversity databases.

Forested land

The applied methodology included a geospatial analysis. The advantage of this approach is the availability of consistent data, allowing assessments over larger areas (e.g. entire regions), while being comparable across time and space. This facilitates local analyses to be contextualized in broader regional trends, which is indispensable for any biodiversity assessment.

The geospatial analysis was performed with Quantum GIS, a freely available open source software for geographic information systems. First, the polygons representing Vidzeme were used as mask layers to clip the status maps, extracting the extent of the respective NUTS3 region. All values outside the region boundaries were set to NoData values, while zero values contained by the boundaries were kept as zero values. Finally, an outcome raster was produced by multiplying all raster cell values of the baseline year 2012 by ten and subsequently adding the raster cell values of the year 2018. The final outcome raster contains 16 discrete classes indicating different change combinations. These change classes can be analyzed through a unique value report, which calculates the total area covered by each change class.

Table 8 Overview of the changes in forest types considered

no forest = "N"; broadleaf forest = "B"; coniferous forest = "C"; "mixed forest" = "M"; direction of change = "→"							
value	change	value	change	value	change	value	change
0	N → N	10	B → N	20	C → N	30	M → N
1	N → B	11	B → B	21	C → B	31	M → B
2	N → C	12	B → C	22	C → C	32	M → C
3	N → M	13	B → M	23	C → M	33	M → M

Source: Own elaboration.

3.1.3.3 Data uncertainties

In terms of characterization and location, the three categories of HNV farming provide various challenges. To characterize and locate type 1 and type 2 farmland, two complimentary techniques (landcover and farm system typology) are used. The actual species distributions are plotted to locate Type 3 agriculture. Except for breeding birds, this is not achievable on an EU scale due to a lack of species data.

Moreover, CLC distinguishes between 44 land-cover classes (LCCs) (Copernicus Land Monitoring Service 2018), a diversity of which can be considered potentially closely related with agricultural land. Moreover,CLCalso has a minimum mappable unit of 25 hectares and a minimum linear element width of 100 meters. Nonethless, CORINE is also regularly updated. For instance, the data set utilized in this exercise (CLC2006) was last updated in 2020. Despite being the best data source for land cover, CORINE has some limitations:

- Because the CORINE classes are either determined by the most dominant land use or categorized as a mix class (because the minimum mapping unit of 25 hectares) it can be difficult to determine whether HNV farming areas are found in a particular class.
- It is important to highlight that forest LCCs are not included in the LCC selection process since CLC does not distinguish between forest and agricultural management systems. This also means that pinpointing the location of various types of grazed forest that could be considered HNV farming is not technically possible.
- Land cover data cannot tell much about the quality of the Nature Value in relation to its potential (unless in extreme cases), because it does not tell anything about management practices.

Forested land

The Copernicus Forest Type dataset is derived from a pan-European assessment, which favors large scale coverage over local accuracy. The limited accuracy reduces the reliability of the data at the local level. Because the imagery has a resolution of 100m, local conditions cannot be assessed below the scale of 1ha, which might hide meaningful detail that would appear at a finer resolution. Furthermore, methods for large scale pan-European assessments are not tailored to account for specific climatic or ecological conditions that are present at the local level, which might result in measurement errors.

The low temporal resolution of the available data is another limiting factor. A change between 2012 and 2018, as it was analyzed here, might not suffice to draw conclusions about meaningful trends or the nature of long-term changes. Moreover, since the latest available data was four years old by the time it was applied here, it might represent outdated information. However, if these datasets become regularly updated, as it has been the case for the last six year period, the quality of the analysis will increase.

The data based on the CORIINE Forest Type dataset that is presented in the following section could not yet been validated.

3.1.3.4 Methodological uncertainties

It is clear from the three categories of farmlands discussed in the previous section that the term HNV farmland does not refer to priority habitats for rare species or Habitats Directive priority habitats. Some farms with high biodiversity may not be included in this methodology, however this is not a large portion of the EU's HNV agriculture. In any case, this strategy will still have narrower policy objectives centred on threatened species and environments.

The land cover technique used for HNV type 1 (and partly type 2) allows for a close approximation of semi-natural vegetation and, to a lesser extent, low-intensity agriculture mosaics. For HNV type 3, data on the location of cropland that supports rare species or a large proportion of European or global populations is required. Despite the existence of European initiatives aimed at providing harmonised information on landscape typologies and landscape elements, the information contained in these initiatives does not allow for successful mapping of HNV farmland, particularly Type 2, which is defined by mosaics of low intensity agricultural patches and linear elements. Landscape maps, if they exist, are found only at a national level, but could still potentially provide some valuable information to this regard. According to research conducted for the JRC in France and Wallonia (Pointereau et al., 2007), national statistics, when accessible at the NUTS3 level, can be particularly valuable for identifying the share of HNV farming in agricultural areas at the local level. In most cases, landscape data will need to be combined with land use intensity data to provide a reliable indicator of the likelihood of HNV agriculture being present.

In short, the mapping accuracy of (the loss of) the HNV farmland could be improved by:

- Refined definition by including rare species
- Using more regional/small resolution data while mapping

Forested land

Comparing the coverage of dominant leaf types at the canopy surface over time results in a very limited indicator for changing habitats, which does not allow firm conclusions regarding impacts on the local biodiversity. The application of this method requires complementary field work and local knowledge to determine how regional changes in forest types have impact on biodiversity. The Global Forest Watch Dashboard offers some information on certain parameters, but more detailed information about the species composition of the forest in (parts of) the region is still needed. In addition, more information on local forest management practices is needed to derive to substantiated conclusions with regard to local biodiversity impacts. One future option could also include to link the data with protected areas, such as the Natura 2000 area delineations or the European inventory of nationally designated protected areas (CDDA) to derive more information on the de- or afforested areas and their significance for biodiversity (e.g. by looking at different protected area classifications).

Moreover, applying this method does require some extra technical knowledge that may not be readily available within the screening working group. Nonetheless, this is only a minor limitation, since the dataset and the software used are open source, and the calculation methodology relatively straightforward.

3.1.4 Biomass data and indicators

The screening of biomass resources aims to show the theoretical availability of different types of biomass in the region. Data availability at regional level is crucial in selection of biomass indicators for screening.

The screening of biomass potential is performed using the following data sources:

- Datasets of national and regional statistics (Latvia Statistical Bureau)
- Official reports of national authorities and international organisations Latvian Ministry of Agriculture, FAO)
- Publications of international and national projects (BioEast, BIO4ECO, RDI2CLUB etc).
- EU and National Strategic documents (EUBSR, etc).

3.1.4.1 Description of the data / definition of the indicators employed

Indicators assessed are biomass quantities of the following categories:

- forest biomass (in t a^{-1})

- agricultural biomass (in t a^{-1})

- energy crops (in t a^{-1})

Forest biomass

Forest biomass includes woody feedstock derived from forests or from processing of timber. Only exploitable forests that are available for wood supply are considered as a source of forest biomass. In order to ensure the sustainable use of forests in the region and minimise the environmental impact of wood harvest, the estimation of forest biomass potential considers that the maximum volume of annual fellings should not exceed the net annual increment of woody biomass.

For the screening of the potential of forest biomass the following biomass types are considered:

- stemwood,
- primary forestry residues and
- secondary forestry residues.

Agricultural biomass

Agricultural biomass considered in this screening refers to agricultural residues that include three main classes:

- Primary agricultural residues, like straw of cereals that remain in the fields after harvesting
- Manure (e.g. from pig, cattle and chicken)

Energy crops

Perennial herbaceous and woody energy crops that could grow on marginal lands (poplar, willow, miscanthus etc).

3.1.4.2 Methodology applied

For the screening of forest biomass theoretical potential in the Vidzeme region a basic resource focused statistical method is applied[62]. The method requires data on net annual increment and wood removals.

*Theoretical stem wood potential = Net annual increment of stem wood (m^3/year) * (1-Harvest losses[63]) - Roundwood removals * (1+ Bark fraction[64])*

As there is no available information of net annual increment for Vidzeme region (NUT3 level), but only for the Latvia, we will assess the net annual increment at the local level by applying net annual increment per hectare to the forest area in the region.

According to Eurostat forest area and net annual increment in Latvia in 2019 amounted 3,406,920 ha and 20,919,140 m^3 correspondingly. Taking into account average net annual increment per hectare of forest land (6.14 m^3/ha) net annual increment of forests in Vidzeme amounts 6,253,469.04 m3. Applying the equation above, theoretical stem wood potential in Vidzeme region can be preliminary assessed as 455,086.3 m^3, which is about 204,788.8 t of dry matter[65].

The assessed theoretical potential of forest biomass is in line with the other research performed within S2Biom project (Figure 16), where forest potential have been estimated using the EFISCEN forest resource model[66].

62 https://www.researchgate.net/publication/268388401_Harmonization_of_biomass_resource_assessments_Volume_I_Best_Practices_and_Methods_Handbook

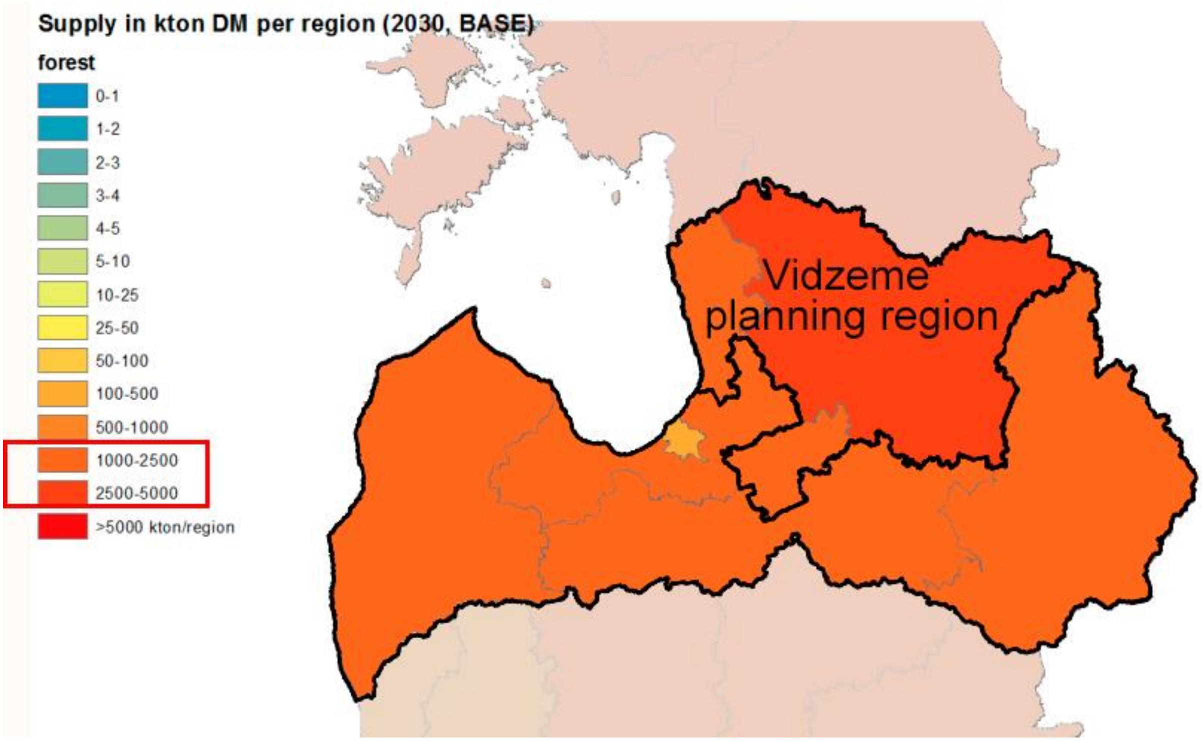
63 For harvest losses default values of 0.08 for coniferous species and 0.10 for broadleaved species are used according to recommendations IPCC2006a.

64 Average bark fraction of 12% (range 4-30%) is reported by Fonseca and Task Force Members 2010, https://unece.org/fileadmin/DAM/timber/publications/DP-49.pdf

65 to asses the amount of forest biomass the density of coniferous (850 kg/m^3) and deciduous (1000 kg/m^3) trees, as well as moisture content in wood at harvest (50%) were considered

66 https://www.s2biom.eu/images/Publications/D1.8_S2Biom_Atlas_of_regional_cost_supply_biomass_potential_Final.pdf

Figure 16 Estimated sustainable potential of forest biomass in Latvia per region, thousand ton of dry matter (S2Biom, 2030, Base)



Source: S2Biom, 2016[67]

Agricultural biomass - primary agricultural residues

For screening of the potential of primary agricultural residues in the region a residue-to-crop ratio is applied to the crops that are cultivated in the region, namely wheat, barley, triticale, sunflower, rape. Estimation of the theoretical amount of residues available depends on a number of factors like the weather and soil conditions, seed type, and others and is therefore difficult to estimate. In order to utilize primary agricultural residues sustainably and protect soil fertility, identified theoretical potential should be further reduced by the amount left in the field. As a result of varying local conditions, the estimates of the amount of residues that may be removed while maintaining soil productivity vary widely. According to Scarlat et al. (2010)[68] applied sustainable removal rate for straw of wheat, barley, rye, triticale and oats is 40%, and for maize stover, rice straw, rapeseed stover and sunflower stalks is 50%.

Residue-to-crop ratio describes the relationship between the biomass that grows as the main product and the residue and varies depending on the type of crop and plant variety, and influenced by climate and soil conditions and management practices (tillage, density of planting, fertilisation, etc.) (Iqbal et al, 2016)[69]. The residue-to-crop ratio for different crops are: wheat – 0.8…1.6, rye – 0.9…1.6, barley – 0.8…1.3, oats – 0.9…1.4, rapeseed – 1.4…2.0. Based on the chosen residue-to-crop ratio and sustainable removal rate theoretical potential of agricultural residues of the main crops in the VIdzeme planning region was assessed (Table 9).

---

[67] https://www.s2biom.eu/images/Publications/WP8_Country_Outlook/Final_Roadmaps_March/S2Biom-LATVIA-biomass-potential-and-policies.pdf Adapted for boundaries after 2021 Administrative Territorial Reform.

[68] https://doi.org/10.1016/j.wasman.2010.04.016

[69] https://ec.europa.eu/energy/sites/ener/files/documents/Ecofys%20-%20Final_%20report_%20EC_max%20yield%20biomass%20residues%2020151214.pdf

Table 9 Agricultural biomass potential for Vidzeme planning region, 2020

Crop	Harvested production (in EU standard humidity), t	Residue-to-crop ratio	Theoretical potential, t	Sustainable removal rate, %	Theoretical potential (based on sustainable removal rate), t
Wheat	307,614	1	307,614	40	123,046
Oats	67,243	1	67,243	40	26,897
Barley	61,664	0.95	58,581	40	23,432
Rye	56,928	1	56,928	40	22,771
Rapeseed	50,396	1.7	85,673	50	42,837
Triticale	6,735	0.95	6,398	40	2,559

Source: own estimation based on Iqbal et al, 2016[69]

Agricultural biomass - livestock manure for biogas and biomethane

The potential of biogas production from the digestion of animal manure can be preliminary assessed multiplying the amount of generated manure by the specific biogas yield. Biomethane share in the biogas depends on the biogas composition and the process used for its production and can vary from 45% to 75% by volume.

Energy crops

The potential of biomass from energy crops is somewhat theoretical and based on the assumption of abandoned agricultural land availability. Taking into account that agricultural lands are usually abandoned due to marginality (i.e. worse soil quality and nature conditions than required for production of food crops) biomass yields from energy crops can be below general average yields.

According to Makovskis & Lazdina (2015)[70] about 90,000 ha of agricultural lands in Vidzeme region are of poor quality (25 quality units out of maximum 100, while 38 is a minimum fertility level for agricultural land in order to ensure commercially viable farming). Growing energy crops on these land at conservative yield of 6 t/ha (dry matter) can provide annually about 630,000 t of biomass.

3.1.4.3 Data uncertainties

Forest biomass

As there is no available data on net annual increment in the Vidzeme region, a country-based indicator of specific net annual increment per hectare was used to assess the theoretical potential of forest biomass resources in the region.

Agricultural biomass

Data on the sown area of agricultural crops from the online database of the Latvia Statistical Bureau and from the publication “Agriculture of Latvia” for the same period (2020) do not match. The data from the online database was used for this report to assess the theoretical potential of agricultural residues.

70 https://www.researchgate.net/publication/296679126_POTENTIAL_AREAS_OF_LOW_PRODUCTIVITY_AGRICULTURE_LANDS_FOR_SRC_ENERGY_WOOD_PRODUCTION_IN_VIDZEME_REGION

3.1.4.4 Methodological uncertainties

The main considered uncertainties of the applied method for forest biomass resources screening that may limit its accuracy are the availability and quality of primary statistical data. The method applied doesn't consider constraining factors of biomass availability and can be used only for preliminary screening.

The methodology applied to screening primary agricultural residues considers the standard crops-to-residues ratios that can differ depending on crop varieties. Another uncertainty we should consider is the share of biomass residues that we can take from the field, which strongly depends on the soil type and demand for mineral nutrients.

3.2 Appraisal of available capacity

The pilot screening of the environmental resources in the Vidzeme planning region yielded the following appraisal of available capacity of the regional ecosystem. As noted in the previous sections of this chapter, these results may carry considerable uncertainty and in some cases may be limited in scope. Thus, they are intended here merely as an exercise to show what the pilot of the sustainability screening for Vidzeme was capable of generating. If deemed valuable, members of the Latvian OIP are encouraged to conduct future iterations of this work and expand it to increase its applicability.

Table 10 Rough appraisal of available ecological capacity in the Vidzeme region

Resources screened		**Ordinal Baseline Status**	**Appraisal**
Category	**Sub-Category**		
Water	**Surface water bodies**		Only over one third (35%) of the rivers and lakes within the Gauja RBD are in Good Ecological Status or higher. Even more concerning is the proportion of rivers and lakes achieving Good Chemical Status, which is only 12% of the total. Significant pressures on rivers are quite varied, with point sources of pollution being the most recurrent ones, followed closely by diffuse sources of pollution, changes in hydromorphology and unknown anthropogenic pressures. The latter two are also important pressures on lakes in the RBD, but diffuse sources are substantially more recurrent for this water body type. As regards significant impacts, both rivers and lakes in the Gauja RBD are affected most often by nutrient pollution, while habitat alterations due to morphological changes are also relevant for both water body types.
	Groundwater bodies		All five groundwater bodies within the Gauja RBD are reported to be in Good Quantitative and Good Chemical Status. Only one of the five is under pressure from point sources (contaminated sites or abandoned industrial sites), but the impact associated to this pressure has not been specified in the WFD reporting.

Land Resources	-		With a mean soil erosion rate in all lands of 0.3 t/ha per year in 2016 (latest available data), Vidzeme is not considered vulnerable to erosion. Erosion in agricultural areas and natural grasslands lands is 0.7 t/ha per year, which is still well below the European threshold for low erosion level (low < 5 t/ha per year). Only 0.01% of all lands in Vidzeme surpass the European threshold for severe erosion rate (severe >=10 t/ha per year). In this context, soil erosion does not pose a risk for the sustainability of the bioeconomy in the region.
Biodiversity	**Agricultural land**		Vidzeme area, NUTS3 number LV008, has a rate of 0.136 regarding losing HNV farmland. This rate is moderate in comparison with other NUTS3 unit in Europe.
	Forested land		Between 2012 and 2018, Vidzeme experienced a gross forest cover loss of 84.930 ha, roughly 60% of which derived from the conversion of broadleaf forests to non-forest areas. Elsewhere, however, the net forest gain accounted for 132.862 ha during the same time period with similar ratios of forest types, Changing broadleaf forest covers account for the majority of forest cover losses and forest cover gains. Most of the 105.991 ha net increase in broadleaf canopy cover stems from new forest growth on previous non-forest land. Moreover, the conversion of 72.410 ha of broadleaf forests to mixed forests accounts for the largest share (80%) of conversions from one forest type to another. The area of mixed forest cover has increased by the largest extent.
Biomass	-		Screening of biomass resources in Vidzeme region showed that there is a potential of biomass resources from forest and agriculture that can be utilised by applying appropriate practices for collection of a sustainably available biomass. Other parts of potential are of theoretical origin and include biomethane, when produced from animal manure, and energy crops, when grown on marginal lands. Conservative assessment shows the availability of at least 204,788.8 t of dry matter of forest biomass. Further detailed assessment may increase this figure by considering a sustainable amount of primary and secondary forest residues.

4 Part D: Potential ecological burden of regionally relevant bioeconomic activities

4.1 Bioeconomic activity selected for the screening

As mentioned in Chapter 1, the regional strategy formulated by the Latvian OIP defines Forestry and Agriculture as priority sectors for the development of the region's bioeconomy. Thus, a sustainability screening for specific economic activities falling within these sectors was considered of relevance by the authors of this report. However, given the limited resources available for this task (not included or budgeted for in the original work plan), as well as its illustrative purpose, activities falling within only one of the sectors have been considered. Given the comparably better availability of information on impacts of forestry practices, the authors of this report decided to explore that sector for the screening.

The following two sections provide some working definitions and a typology of forestry management practices. The rest of this chapter aims to synthesise the results of a literature review on potential impacts of specific forestry activities on water, land, biodiversity and biomass, respectively.

4.2 Overview of forestry, forestry management practices and their potential burden on the resources examined

4.2.1 Definitions

What exactly is understood by *forest* can vary from academic and political context. For instance, the UN Food and Agriculture Association (FAO) defines forests as "land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use." (FAO 2006). In the case of Latvia, the Law on Forest of 2000 takes a slightly different definition, which does not consider a minimum area (in ha)[71]

> *"an ecosystem in all stages of its development where the major producer of organic mass is trees the height of which at the particular location may reach at least five metres and the present or potential projection of the crown of which is at least 20 per cent of the area covered by the forest stand"*

Following the definition by Grebner, Bettinger and Siry (2013), *forestry* can be understood as "the art, science, and business of managing forests to achieve a diverse set of goals that range from timber production to ecosystem services". In line with this understanding, a great proportion of forestry activities are also associated *forest management*, even though they do not overlap completely. Following the FAO (2006) definition, forest management can be understood as "the processes of planning and implementing practices for the stewardship and use of forests and other wooded land aimed at achieving specific environmental, economic, social and /or cultural objectives. It includes management at all scales such as normative, strategic, tactical and operational level management." Therefore, forest management is not exclusively aimed at production of goods and services, but forests can also be managed mainly for conservation purposes.

According to the definition of FAO (2006), *forest plantations* consist "[…] either of introduced species (all planted stands), or intensively managed stands of indigenous species, which meet all the following criteria: one or two species at plantation, even age class, regular spacing". Conversely, forests classified as *undisturbed by man* can be described as those "in which the natural forest development cycle persists or was restored and show characteristics of natural tree species composition, natural

[71] See https://likumi.lv/ta/en/en/id/2825

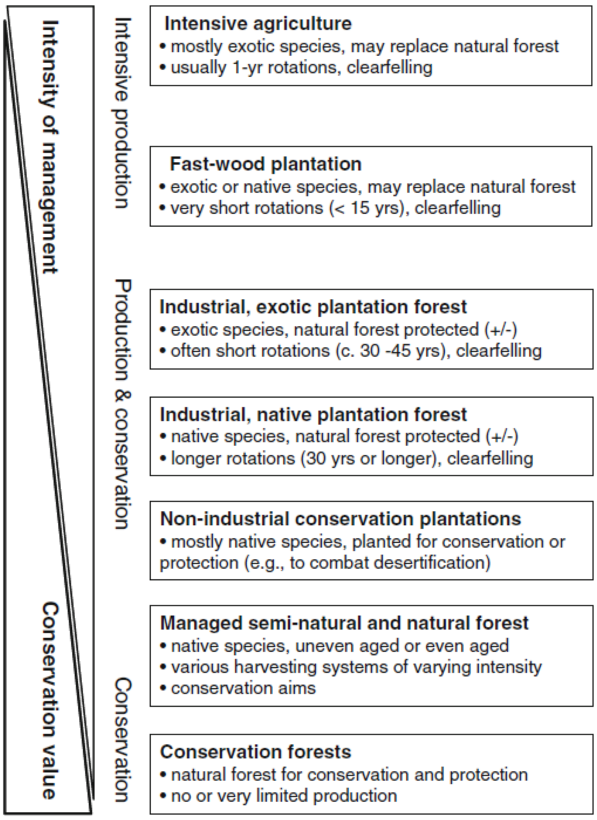
age structure, deadwood component and natural regeneration and no visible signs of human activity" (FOREST EUROPE 2020).

4.2.2 Overview of Forestry and common management practices

According to Hannah et al. (1995) about 0.2% of the European deciduous forests are in relatively natural conditions. The rest is more or less intensively managed, mostly for the production of timber and energy (Nascimbene et al. 2013). An increasing proportion of these are plantation forests which are established through large scale planting or seeding of trees that are even aged and from the same species (FAO 2006). In Latvia, the vast majority of forests can be considered semi-natural and more than 90 % of the entire forest area originated by natural regeneration and natural expansion (FOREST EUROPE 2020)[72].

At the operational level, it is possible to differentiate between different management intensities, with (near) natural forest often being characterized by close to minimal management (close-to-zero human intervention). At the opposite end, certain types of commercial forestry, such as fast wood plantations, are characterised by very intense management practices across the entire life cycle of the plantation, from planting/seeding to harvesting and regeneration (Brockerhoff et al. 2008). For a general orientation see the conceptual model of Brockerhoff et al. (2008) in Figure 17.

Figure 17 Conceptual model of the relative conservation value of planted forests relative to conservation forests and agricultural land uses



Source: (Brockerhoff et al. 2008)[73]

---

[72] https://foresteurope.org/wp-content/uploads/2016/08/SoEF_2020.pdf

[73] As pointed out by the authors of this figure, this is a schematic representation that does not reflect all types of forest plantations, as some of them may serve multiple purposes. Moreover, some forest found in Europe can also be difficult to categorise using this model, as they were established as plantations long time ago, but with the time have become more diverse by natural processes. Under this model, so-called "close-to-nature forests" form part of the category "managed semi-natural and natural forest" (Brockerhoff et al. 2008)

Regardless of the purpose of the forest management, there is a basic, common set of forestry practices that are employed throughout the world, even if with some differences related to the region and forest type (Grebner, Bettinger and Siry 2013). Many of these practices are related to one of the following (Grebner, Bettinger and Siry 2013):

- the establishment of a forest,
- the maintenance of its health and productivity,
- the control of its composition, e.g. in terms of tree size, species and quality.

The combination, timing and intensity, as well as the resulting environmental impact of these practices vary depending on the goals and objectives that the landowner/manager pursues, and the local conditions (Grebner, Bettinger and Siry, 2013). An overview of the most relevant practices for the purposes of this general sustainability screening of regional bioeconomies can be found on Table 11, which for orientation reasons can be grouped in the following three main categories, according to the stage in the life cycle of the forest[74]:

- Initial stage
- Core stage
- End-stage

[74] The lifecycle of a forest can be understood as a loop, therefore the end-phase(harvesting) can have an important influence on the sub-sequent initial phase (e.g. regarding the type of forest regeneration and, in the case of artificial regeneration, the species composition chosen)

Table 11 Overview of forestry management practices (based on Grebner, Bettinger and Siry 2013)

Stage	Practice category	Sub-category	Description
Initial stage	Site preparation	/	involves making a site in question suitable for the establishment of a new (in most cases even-aged) forest. This includes methods for removing ground vegetation and debris (manually, mechanically, or aerially) prior to the establishment of a new forest. Some of these practices include burning, chopping, raking, ploughing, bedding and (aerial) application of herbicides
	Forest regeneration	Natural regeneration	Involves the establishment of a new forest from self-sown seed, coppice shoots or root suckers. Coppice shoots are new growth (stems) arising from dormant or adventitious buds near the base or stump of a tree, where the previous tree was cut. Coppicing is considered a natural reforestation process, even though it is also associated with harvesting practices.
		Artificial regeneration	Artificial regeneration involves using seed, seedlings, or rooted cuttings to establish a new forest. Seeding can be performed aerially. Seedlings are very young trees, (1 - 2 years old), that have been either grown from seed in a tree nursery or developed from a rooted cutting of an older plant. Seedlings are planted directly.
		Afforestation	practice of planting trees on land that has not recently been used to grow a crop of trees
Core stage	Early tending	/	practices employed to manipulate the vegetative conditions and therefore influence the character of an even aged forest during its early developmental stages (first decade of the forest). These practices are designed to affect the stocking of plants, and thus competition among plants, with the intent of enhancing the success of the desired tree species. One important example is weeding (suppression of undesirable vegetation growing alongside the desired tree seedlings) by means of herbicides, hand tools (brush knives or axes), or power tools that mow or cut undesired vegetation
	Thinning/pruning	Precommercial thinning	Practices designed to remove trees of the desirable tree species when their stands are too dense at early stages. This involves practices similar to those used in weeding. These are meant to facilitate accelerated diameter growth of the remaining trees, thus maintain desirable tree stocking levels and improve the form and quality of the remaining trees
		Pruning	practice that may be applied early in the life of a forest in order to improve the quality of the wood in the main stem of a tree. It involves limiting the number and size of knots in the bole of a tree in order to facilitate the milling of high-quality boards or due to safety reasons. During the process of

			pruning, the lower branches (both live and dead) of a tree are removed, using pruning ladders and hand or power saws
		Commercial thinning	In a commercial thinning, individual trees are selectively removed to promote the quality and growth of the trees that remain or to salvage trees that may die before the next thinning or before the final harvest occurs. This practice has major overlaps with partial selection harvests (see below)
	Fertilisation	/	Fertilisation aims to increase the productivity of forests, especially since fast-growing forests may require nutrients beyond what is naturally available in the soil. Fertilisers generally include nitrogen, phosphorous, and potassium, as well as a range of other nutrients, and can be applied at the time of planting or later during the forest's lifespan.
	Understory cleaning	/	Involves the removal of forest litter, understory firewood, and most biomaterial from the forest floor. This can take place either within a certain radius of specific trees, or indiscriminately in an entire area.
	Agroforestry	/	An approach to land management combining standard forestry practices with agricultural or livestock production, which aims to increase or optimise production of a certain product in an area. A range of specific practices can fall under this umbrella, including silvopastoral systems (tree growing combined with livestock production), alley cropping, and windbreaks.
End-stage	Harvesting	Clearcut (Final Harvest)	A continuous harvesting operation which removes all trees from an area. Non-merchantable trees may be left standing, if it is thought that they could be removed for future site preparation, while undergrowth may be left in place for the re-establishment of a new forest.
		Group selection Harvest	Aims to encourage natural regeneration of mature live trees trees by opening the canopy of a forest through small harvests to create gaps. Avoids many of the aesthetic concerns of clearcutting, since patches generally range from 0.2 ha to 2-4 ha.
		Seed tree harvest	A seed tree harvest is a type of final harvest practice which leaves scattered *seed trees* standing after the harvest to act as a source of seeds for natural regeneration of new trees.
		Shelterwood harvest	An afforested plantation composed of trees planted to shelter farmland and agricultural crops from the effects of wind and potentially reduce soil erosion, can eventually be harvested to serve as a source of fuelwood or income.

		Partial selection harvest (uneven-aged)	Common in uneven-aged forests, partial harvests or selection harvests involve the periodic removal of individual or groups of mature trees. This allows smaller, younger trees to grow into the openings in the canopy. The selection of trees for removal is often based on maintaining the structure and viability of the forest.
		Partial selective harvests	The removal of trees according to their age, quality, size, or value, with less importance placed on the overall remaining forest character. This practice frequently ignores management goals and the sustainability of yields.
		Salvage or sanitation harvest	Salvage harvest is the removal of trees which are dead/dying or deteriorating and risk soon becoming worthless. Sanitation harvest removes trees which pose a threat to the overall health of the forest, i.e. those which may be affected by insects or disease.

4.2.3 Potential burden on water resources

Given the recurrence of nutrient pollution and habitat alterations due to morphological changes as the main impacts on rivers and lakes in the Gauja RBD, it appears relevant to identify forestry management practices that could mitigate (or, conversely, exacerbate) them. Point sources of pollution affect 11 (out of 46) rivers and 4 (out of 35) lakes in the basin, while diffuse sources affect 10 rivers and 15 lakes. Both of these pollution source types are potentially linked to the reported nutrient pollution. The authors of this report have reviewed literature that documents how forestry in general as well as specific management practices may affect water quality. In the case of point sources of pollution, the planting of belts of trees as filter strips around these effluent points (e.g. untreated urban wastewater discharges) can act as intercepts to run-off and nutrients before they reach streams (Ellis et al., 2006 as cited in Keenan and van Dijk, 2010). As regards diffuse sources, Nisbet & McKay (2002) state that forestry can help reduce diffuse pollution in surface waters. Concretely, they refer to forestry activities using low amounts of pesticides compared to more intensive land uses like agriculture. While pesticide use and fertilisation is currently not common practice in Latvia, it may still be relevant to consider such issues as the Vidzeme region develops new sites and marginal lands for forestry in the future. May et al. (2009) share a similar view when they compare plantation forests with agricultural land use and state that the latter's potential nutrient contribution to streams can be considerably higher. Similarly, Keenan and van Dijk (2010) state that afforestation is generally linked to improved water quality, inter alia through the reduction of salt inputs. On the other hand, in some cases forestry can also be a source of diffuse pollution (EEA, 2020). In extreme cases, large-scale harvesting operations can cause nutrient enrichment of downstream water bodies (Nisbet & McKay, 2002). Operations like clearcutting can disrupt nutrient cycling processes inter alia through the step changes in substrate availability and exposure to sunlight (Pike, 1978 as cited in Nascimbene et al., 2013). And under certain conditions, reforestation with some tree species could also result in nutrient pollution, as pointed by Augusto et al. (2002), who refer to several cases illustrating larger concentrations of Nitrogen and Phosphorus in the leaves of hardwood species compared to conifers. Here, considering the balance between the stand's capacity to bind such nutrients more effectively against the potential impact of pollution from their litterfall combined with other nutrient sources present in the basin seems important. Lastly, activities accompanying forestry operations, like the construction and (inadequate) maintenance of roads has previously been associated with impacts on downstream water bodies (e.g. high turbidity levels, siltation, and nutrient pollution) (Nisbet & McKay, 2002). Given that forestry is already a significant economic activity in Vidzeme, and the intention to further promote it via the Latvian Bioeconomy Strategy as well as the regional one drafted by the Latvian OIP in BE-Rural, it appears relevant to incorporate the general considerations mentioned here and, more importantly, the more specific and locally relevant knowledge on forestry and its impacts that Latvian institutions already possess.

4.2.4 Potential burden on land resources

Keenan and van Dijk (2010) also identify certain forest management practices that can have a positive impact on soil resources. Afforestation is mentioned as a possible approach to reducing soil erosion as well as improving soil infiltrability. Furthermore, they note that maximum erosion protection requires the development of a litter layer, understory growth and surface roughness from tree roots. On the other hand, the act of establishing a forest (and harvesting, poor road network design) can shift large amounts of sediment and cause damage to soils that may counteract the positive effects for soil erosion. Finally, as mentioned above, afforestation can lead to reduced salt inputs which is beneficial for soil quality.

In their general accounts of forestry management practices with focus on the USA, Grebner, Bettinger and Siry (2013) point out that site preparation activities, such as burning, chopping, raking, plowing, and bedding can all lead to soil compaction and the removal of topsoil. Moreover, the application of herbicides can also cause problems related to toxicity in the soil. Further practices can also have negative effects on soil quality. For instance, understory cleaning may cause soil compaction, which can have effects on soil moisture content and other soil features (Grebner, Bettinger and Siry 2013). On the other hand, these authors also refer to the positive effects of precommercial thinning, which generally involves cutting trees and leaving them on the ground, thus enhancing the soil quality (Grebner, Bettinger and Siry 2013).

In a study on the impacts of harvesting activities on soils, tree stands, and regeneration in forests, Picchio et al. (2020) identify how a variety of practices can lead to changes in the physical, chemical and biological properties of forest soil. They note that soil compaction as a result of large-scale harvesting operations (such as clearcutting and the final harvest of shelterwood) can cause reduced soil porosity and water infiltration, leading to increased waterlogging on flat land, and soil runoff and erosion on slopes. The study also points specifically to the negative impacts of harvesting equipment and machinery, which can cause long-term damage to soil health, negatively affecting the productivity of the forest and ecosystem functions (Picchio et al. 2020).

Furthermore, Augusto et al. (2002) have carried out an extensive assessment of the impacts of various tree species found in European forests on soil health and fertility. Though few generalizations can be made, the results also can be applied to the Vidzeme planning region. The authors highlight how various tree species can impact, for example, the presence and abundance of soil microflora and fauna. The acidity of the soil is also affected by the species of trees in the overstory, as the acids originate from the atmospheric decomposition of biomass. Additionally, they note that the moisture content of soil tends to be higher around hardwood trees compared to conifers. Hardwood trees also tend to contain more nutrients, meaning that the decomposition of their litterfall (fallen foliage) can lead to more nutrient-rich soils (Augusto et al. 2002). As such, it is beneficial for soil health to consider the diversity of tree species in forests and ensure an adequate mix of conifers and broadleaved trees is given in order to improve the soil properties.

4.2.5 Potential burden on Biodiversity

All types of management change some properties of the open land and forest, and it is unrealistic to expect any type of forestry to have no impact on forest biodiversity. Different types of forests with different management systems may result in substantially different biodiversity impacts (Chaudhary et al., 2016).

In terms of the impact of forestry on biodiversity, the literature generally differentiates between the impacts (both positive and negative) of plantation forests in comparison to alternative land uses –such as (semi) natural forests or agricultural land– and the impacts of different degrees of forest management intensity, mostly on species richness (often differentiated by specific groups of organisms) (see e.g. Brockerhof et al. 2007; Paillet et al. 2010; Nascimbene et al. 2013; Irwin et al. 2014).

For instance, regarding the general impacts of plantation forests, Brockerhof et al. (2007) conclude that the conversion of natural forests to plantation forests and the afforestation of natural non-forest land is detrimental for biodiversity. Nonetheless, in landscapes where forests are the natural land cover, afforestation of agricultural land can actually be of great benefit for biodiversity, as it can provide complementary forest habitat for forest species, as well as buffering edge effects, and increasing connectivity between patches of (semi) natural forests. Therefore, in order to determine whether plantation forests are rather damaging or beneficial for biodiversity, it is crucial to gather information on following aspects (Brockerhof et al. 2007):

- the land use preceded the establishment of a plantation (e.g. agriculture of semi-natural forest),
- alternative land uses that would be likely to occur at the given location (e.g. agriculture or urbanization),
- the tree species involved (amount and type: native or introduced), and
- purpose for which a plantation is being managed (only timber/energy production or also some others such as conservation management included?)

Following the general analysis of Brockerhof et al (2008) (based on the case studies of Brazil, Indonesia, New Zealand, UK, China, France and USA), natural forests have indeed a higher habitat value for native forest species than plantation forests. However, the extent of this difference varies depending on the management intensity and the tree species composition of the plantations and how much it varies from the structure of natural forests in the same area. Moreover, the richness of certain species that are specially adapted to the specific conditions of native forest is more severely affected than that of species that are adopted to live in forests but do not require such specific conditions. For the latter, plantation forests can represent a valuable habitat, especially if it substitutes other land uses such as intensive agricultural land. Similar conclusions were found by Irwin et al. (2014) in their comparison of species diversity in semi-natural woodlands versus (tempered) plantation forests in Ireland.

In relation to this, the metanalysis carried out by Paillet et al. (2010) focusing on the impacts of different management practices (in comparison to unmanaged forests) on biodiversity highlighted that:

> "species dependent on forest cover continuity, deadwood, and large trees (bryophytes, lichens, fungi, saproxylic beetles) and carabids were negatively affected by forest management. In contrast, vascular plant species were favored. The response for birds was heterogeneous and probably depended more on factors such as landscape patterns."

Referring specifically species richness of lychens, which are a crucial component in forest food-webs and also play an important role in the forest water and nutrient cycles, Nascimbene et al. (2013) highlight the comparative advantages of partial selection harvesting in comparison to extensive harvesting practices such as the final felling in shelterwood systems. To this respect, they argue that latter practices cause a dramatical change in the ecological conditions lychens require to prosper, e.g. through the reduction of substrate availability and the swift change from low to high sunlight exposure conditions (Nascimbene et al. 2013). According to the results of Paillet et al (2010), which were focused on European temperate forests and are therefore relevant for the Vidzeme region, the management practice with the highest impact on overall biodiversity was the practice of harvesting through clearcutting followed by a change in the tree species composition (Paillet et al. 2010). On the other hand, the impact of clearcutting itself did not seem to be the most relevant factor, as the species richness in formerly clearcut forests that had not undergone a subsequent change in tree species (either by natural or artificial regeneration processes) did not differ significantly from unmanaged forests (Paillet et al. 2010).

A study by Deal et al. (2013) explores lessons that can be learned from the management of native spruce forests in Alaska with regards to biodiversity and ecosystem services. Although this context offers only limited similarities with the boreal forests of Vidzeme, some general lessons can be taken away. These authors point towards introducing a mix of broadleaved species in conifer-dominated forests a beneficial forest management approach (Deal et al. 2013). For a variety of ecosystem processes, mixed stands, such as those combining pine and hardwood species, are expected to be less susceptible to pest outbreaks and herbivory, to host higher biodiversity, and to be more resilient to disturbances and changing environmental conditions. As a result, favoring mixed pine hardwood species stands is becoming a more popular technique for improving forest resilience (Gauquelin et al., 2018). This, too, can have benefits for biodiversity, providing a stable ecosystem and source of food for birds, small mammals, and fish. In general, low-impact silviculture systems – i.e. taking a „close to nature" management approach have a positive impact on biodiversity (Ray et al., 2015).

Regarding the forest type in Vidzeme, we could observe that Vidzeme experienced a gross forest cover loss of 84.930 ha, of which roughly 60% is accounted for by the conversion of broadleaf forests to non-forest areas, while the loss of coniferous- and mixed forests equally explain the remainder. Elsewhere, however, forest cover increased by the total size of 132.862 ha during the same time period. This increase appears to follow a similar ratio of forest types as the ratio that composes forest losses and results in an overall net forest gain of 23.718 ha.

Consequently, changing broadleaf forest covers account for the majority of forest cover losses and forest cover gains. Most of the 105.991 ha net increase in broadleaf canopy cover stems from new forest growth on previous non-forest land. Moreover, the conversion of 72.410 ha of broadleaf forests to mixed forests accounts for the largest share (80%) of conversions from one forest type to another. Conversions between broadleaf and coniferous forest types, on the other hand, happen to a much smaller extent. While the conversion of coniferous forests to broadleaf forests accounts for 1.595 ha, the reverse totals 7.709 ha.

Coniferous forest cover has also increased, though to a lesser extent (75.032 ha). This increase is mostly related to the conversion of mixed forests to coniferous forests (46.965 ha), followed by new coniferous growth of previous non-forest land (20.358 ha). Coniferous forest is mostly replaced by either non-forest areas, which could indicate clear-cuttings, or by mixed forests.

Table 12 Overview of the results of the screening for biodiversity on forested land

Vidzeme, changes 2012 – 2018				
no forest = “N”; broadleaf forest = “B”; coniferous forest = “C”; “mixed forest” = “M”; direction of change = “→”				
	Total forest gain: 132.862 ha	**Total broad leaf loss: 131.587 ha**	**Total coni. loss: 75.032**	**Total mixed loss: 77332**
	N --> N	B --> N	C --> N	M --> N
Total forest loss: 84.930 ha	548.775 ha	51.468 ha	16.713 ha	16.749 ha
	N --> B	B --> B	C --> B	M --> B
Total broadleaf gain: 105.991 ha	**90.778 ha**	**272.816 ha**	**1.595 ha**	**13.618 ha**
	N --> C	B --> C	C --> C	M --> C
Total coni. gain: 75.032 ha	**20.358 ha**	**7.709 ha**	**243.829 ha**	**46.965 ha**
	N --> M	B --> M	C --> M	M --> M
Total mixed gain: 111.887 ha	**21.726 ha**	**72.410 ha**	**17.751 ha**	**83.168 ha**

Source: Own elaboration.

Compared to the other forest types, the area of mixed forest cover has increased by the largest extent. Of this change, most is explained by the expansion of mixed forest at the expense of broadleaf forest (65%). The loss of mixed forest, on the other side, is to 60% explained by its replacement with coniferous forest cover. These results could imply a sequence of forest type conversions, in which coniferous cover replaces mixed forest, which subsequently replaces broadleaf forest cover. This could also be due to an ecological edge effect, in which the fragmentation of forest types increases the area of mixed forests.

4.2.6 Potential burden on biomass resources

With regards to biomass, the two important management practices examined by Deal et al. (2013) are also thought to have a positive effect on the structure and function of forests. Partial cutting, or thinning, creates more complex, multi-layered forest canopies, while favoring the growth of individual trees for timber production. Additionally, increasing species diversity through planting of broadleaved trees (e.g. alder, birch) can improve forests‘ structure and function, e.g. through lower tree stocking and stand density. This can lead to reduced uncertainty in timber production, but also biomass and carbon stock levels in the long term. It is worth noting, however, that this can come with a cost of reduced production (Ray et al., 2015). Finally, MacDonald et al. (2009) identify five important management practices for improving forest biomass: retaining trees to older ages, selective thinning, creating gaps between trees, natural regeneration, and increased variation in tree age, size, spacing, and species.

According to Panoutsou & Singh (2016) different biomass feedstocks available in Latvia mostly have from low to moderate sustainability risks. High risks for Land use in terms of iLUC can happen in case of growing perennial lignocellulosic crops (energy crops), but this can be avoided by growing such crops on marginal lands. Production of forest biomass including stemwood from thinnings and final fellings, logging and crown biomass from early thinnings, and logging residues from final fellings represent no risk to land resources use in terms of indirect land use change. At the same time it leads to the following sustainability risks at a moderate level: 1) increased risk of soil erosion; 2) risk to loose soil organic carbon; 3) risk to loose nutrients and risk of reduced soil fertility and soil structure when overharvesting forest residues. Sustainability risk of forest biomass production on Water resources is moderate. It has no effect on the quantity of water resources, but without removal leads to increased fertilisation and the leaching of N to water may increase.

As biomass resources are directly connected with soil, water and influence biodiversity their management should be performed sustainably, considering slopes, soil texture and soil depth. Collection of biomass resources from forests should not increase net annual increment. Annual fellings exceeding the net annual increment can be allowed only to level age-class distribution in areas where overmature stands prevail (Vis and van den Berg, 2010). Sustainable management also should not allow diseased trees to negatively influence the other available biomass within forests, causing diseases and drying up of trees, as well as forest fires.

Collection of agricultural residues can have a negative influence on soil and biodiversity only in case of overharvesting, as this may lead to loss of soil organic carbon and nutrients, as well as have a moderate risk of biodiversity loss. Concerning agricultural biomass it should be mentioned that the total manure potential of animal farms must be managed in order to avoid pollution of soils or waters. The byproducts of manure digestion for biogas production can be used as fertilisers in agricultural practice.

5 Part E: Screening results and recommendations

5.1 Overview

Table 13 Overview of the sustainability screening results for Vidzeme

<table>
<tr><th colspan="2">Resources screened</th><th>Ordinal Baseline Rating</th><th colspan="2">Forestry Management Practices</th></tr>
<tr><th>Category</th><th>Sub-Category</th><th></th><th>Potentially beneficial to the baseline status</th><th>Potentially detrimental to the baseline status</th></tr>
<tr><td rowspan="2">Water</td><td>Surface water bodies</td><td></td><td rowspan="2">Thinning of- and measures to promote mixed stands in riparian zones, combined with establishment of Rural Sustainable Drainage Systems (RSuDS).

Buffer and filter strips around point sources of pollution to capture and transpire part of the pollutant load.

Partial selection harvesting to maintain stable conditions of substrate availability and light exposure, promoting nutrient cycling.</td><td rowspan="2">While currently not common practice in Latvia, fertilisation to increase forest productivity can result in excess nutrients reaching downstream water bodies. As new sites and marginal lands are developed in the future, adopting this practice could result in further deterioration of surface water bodies in the RBD, and eventually cause groundwater bodies to lose their currently Good Chemical status.

Large-scale harvesting operations (e.g. clearcutting) may interrupt nutrient cycling functions and cause nutrient enrichment of downstream water bodies.</td></tr>
<tr><td>Ground water bodies</td><td></td></tr>
<tr><td>Land Resources</td><td>-</td><td></td><td>Artificial regeneration with various tree species (mixing hardwood and coniferous species) can increase the abundance of soil microflora and fauna, reduce acidity, as well as improve the moisture and nutrient contents of soils</td><td>Site preparation e.g. through raking, plowing, and bedding can all lead to soil compaction and the removal of topsoil, while the application of herbicides can lead to issues of toxicity in the soil</td></tr>
</table>

			Afforestation – particularly in the context of shelter belts for farmland– can potentially reduce soil erosion and increase soil moisture content. It can also improve the infiltrability of the soil and can lead to reduced salt inputs, which is beneficial for soil quality **Precommercial thinning** generally involves cutting trees and leaving them on the ground, which can enhance the soil quality	**Understory cleaning** may cause soil compaction, which can have negative effects on soil moisture content and other soil features. Large-scale harvesting operations (e.g. **clearcut** and final harvest of **shelterwood**) can cause reduced soil porosity and water infiltration, leading to increased waterlogging on flat land, and soil runoff and erosion on slopes
Biodiversity	**Agricult-ural Land**		**Artificial regeneration** with various tree species can generate a greater diversity of habitats to the benefit of native species. Moreover, mixed plantations tend to be more resistant and resilient to natural and human disturbances **Afforestation** of (particularly intensive) agricultural land can provide a comparably favourable habitat for forest species increase connectivity between patches of (semi) natural forest The species richness of forests **clearcut** in the past but that did not undergo a change in tree species (**natural or artificial regeneration**) is comparable to unmanaged references **Partial selective harvest** has generally no significant negative impact and is even beneficial for certain species such as lychens.	An **artificial regeneration** that replaces already existing (semi)natural forest with plantation forest has a negative impact on species richness and diversity **clearcutting** causes large and intense disturbances and a subsequent change in the tree species (mainly **artificial regeneration**) can have a strong detrimental effect on species richness
	Forested Land			
Biomass	**-**		**Applying a felling-over-increment ratio of 70%** to avoid over-maturing will help to decrease/prevent risks of diseases and forest fires. It may positively influence the net annual increment and increase the biomass potential over time.	**Increasing and staying much below the recommended felling-over-increment ratio of 70%** may decrease the biomass potential over time.

5.2 Recommendations

Surface water bodies: As shown in Chapter 3, the review of the WFD reporting data showed that a large number of the surface water bodies located in the Gauja RBD are failing to achieve good status, with recurrent problems of nutrient pollution potentially linked to both point and diffuse sources. Hydromorphology pressures and habitat alterations due to morphological changes are also affecting an important proportion of rivers and lakes in the basin. This raises concern about new or increased pressures that could arise from the development of new economic activities in the region or the expansion of existing operations. In this light, and based on the literature reviewed for this screening, forestry practices that could compound these existing impacts or result in significant detrimental changes in the chemical properties of water resources and the hydromorphology of surface water bodies should preferably be avoided or at least be considered with reserve. Forest thinning and measures promoting the development of mixed stands in riparian zones could help reduce nutrient inputs from diffuse sources (LIFE GOODWATER IP, 2020). The establishment of Rural Sustainable Drainage Systems (RSuDS) like trenches, buffers and retention ponds could also prove beneficial. Practices like partial selection harvesting should be favoured against clearcutting and other large-scale harvesting operations that are generally associated to moderate or high nutrient discharges to the environment as well as disruptions to natural nutrient cycling processes. To exploit synergies and support coherence between the WFD and the multi-level bioeconomy policies affecting Vidzeme, further information on anthropogenic pressures and impacts on the RBD's rivers and lakes that have so far been reported as unknown should be collected as part of the bioeconomy strategy development process of the region.

Groundwater bodies: the screening has shown that the five groundwater bodies in the Gauja RBD are in good status, with four of them experiencing no significant anthropogenic pressures or impacts. To a certain extent, this could be interpreted as a representation of available capacity in this specific part of the system to support bioeconomic activities. Nonetheless, it should be pointed that the objective of the WFD is not only that water bodies reach good status, but that quality does not deteriorate in the future. In this regard, it is important to consider the interdependence of surface and groundwater bodies as a whole hydrological system, and how under climate change conditions the current balance could shift. The main recommendation is thus to take account of the potential effects of new forestry operations and the expansion of existing ones on the integrated hydrological system and the terrestrial ecosystems that depend on them.

Soil: Our baseline assessment has shown that the selected indicator for assessing the condition of land resources (soil) in Vidzeme planning region does not exceed the threshold for severe erosion, which thus does not pose a significant risk for the sustainability of the bioeconomy in the region. Nonetheless, the review of the links between forestry management practices and soil health allows us to provide certain recommendations for Vidzeme‘s exploitation of forest resources for its bioeconomy.

Firstly, despite there being no immediate threat of soil erosion in the area, afforestation (mainly of agricultural land) is identified as a practice that can reduce this risk, while also improving soil infiltrability (Keen and van Dijk, 2010). However, this must be carried out with specific attention to the damage that can also be caused by shifting sediments in the process. Afforestation practices should also take care to ensure the development of a litter layer, understory growth, and surface roughness to allow for maximum erosion protection.

Forest managers in Vidzeme should take care to ensure an adequate balance of confiers and hardwood trees in forests, which can have positive impacts on the soil microflora and fauna,the acidity of the soil, as well as its water and nutrient content (Augusto et al., 2002). In forests being exploited for bioeconomy purposes, practitioners should assess soil health, and develop management plans to would ensure that reforestation and regeneration includes a suitable mix of trees species.

With regards to harvesting of trees for the bioeconomy, special attention should be given to the practices employed, in order to avoid soil compaction (Picchio et al., 2020). Harvesting equipment and machinery should be carefully selected and used in such a way as to avoid significant damage to soil structure and overall health.

Finally, even though soil salinity and other soil properties related to its health are directly assessed through the selected regionalized indicator of mean soil erosion, they are still relevant aspects that could be taken into consideration by further screenings in other regions. However, it is a pre-requisite that data at the regional level is available, for which the engagement of a working group becomes crucial.

Biodiversity: Despite the limitations in assessing the vulnerability of forested lands in terms of biodiversity, the fact that overall forest cover is increasing in Vidzeme and that this increase mostly involves mixed forests could indicate relatively favorable conditions for biodiversity. Nonetheless, the decrease in broad-leafed forests can potentially also point to a negative trend, as broad-leafed forests tend to have a high biodiversity value. That said, it should be considered that Vidzeme lies in a boreal zone where the main tree species are coniferous and where not all sites are suitable for broad-leafed species. These developments should be closely monitor in the future while developing bioeconomy strategies in the region. In order to maintain biodiversity and reduce the risk of its loss in forested areas in Vidzeme, it is important to keep tree species diversity in order to create a habitat that is complex enough to host a higher variety of plant, fungi and animal species (Brockerhoff et al. 2008). This is particularly relevant if plantation forests are planned in areas that are currently semi-natural forest. In these cases, the even aged, single species stands would result in a considerable impact on species richness, particularly on forest specialist species. In this case, it would be necessary to evaluate local data on species of concern that may be threatened and live in the area to decide whether proceeding with these changes does not pose a high risk. Due to extensive cover of broad-leafed and mixed forest in Vidzeme, it is possible to expect that their biodiversity value is high, and therefore, that rare species are found there. The fact that several protected areas are located in the region offers an additional argument for this. Nonetheless, this would need to be proved with further data. In any case, if plantations are planned, it is recommended to select more than one species, ideally native, but not strictly necessary (Irwin et al. 2014).

With regards harvesting, selective harvesting is the most recommendable practice to maintain a high biodiversity value of forests (Deal et al 2013). This avoids the extensive disturbances that large-scale harvesting operations cause such as clearcutting, which are detrimental for biodiversity for instance in terms of biomass removal (shelter, food source) and changes in light regimes (detrimental for like lychens) (Nascimbene et al. 2013). Moreover, it helps create a mixed-age stand, which is also beneficial for improving biodiversity (Brockerhoff et al. 2008). This type of harvesting is recommended for managing stands of semi-natural forest. However, if larger-scale harvesting operations are planned, it is important to bear in mind the previously existing tree species in the area and include these in regeneration activities, as the negative impact of clearcutting on biodiversity are the highest if these are succeeded by a complete change in the species regime (Paillet et al. 2010)

Biomass: As biomass resources are directly connected with soil, water and influence biodiversity the main recommendation for their sustainable management is to improve statistics collection for their monitoring. For sustainable management of forest biomass it is recommended not to consume more than the net annual increment, and to avoid forest stands from over maturing, preventing risks of diseases and forest fires. For sustainable management of agricultural biomass it is recommended to avoid overharvesting, and to collect part (30-40% depending on site conditions) of agricultural residues and avoid their combustion on the fields. Total manure potential of animal farms must be managed in order to avoid pollution of soils or waters. The byproducts of manure digestion for biogas production can be used as fertilisers in agricultural practice. Perennial woody and grass-like energy crops should be considered for marginal and contaminated lands, as they can improve soil fertility (for marginal lands) and decrease contamination (for shallow and low-contaminated lands).

List of references

Ābele, L., Priedāja-Klepere, L., & Vītola, I. (2016). State of the Art of Vidzeme Planning Region. https://projects2014-2020.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1500884694.pdf

Agra, H., Schowanek, S., Carmel, Y., Smith, R.K. & Ne'eman, G. (2020) Forest Conservation. Pages 323-366 in: W.J. Sutherland, L.V. Dicks, S.O. Petrovan & R.K. Smith (eds) What Works in Conservation 2020. Open Book Publishers, Cambridge, UK.

Andersen, E., Baldock, D., Bennett, H., Beaufoy, G., Bignal, E., Brouwer, F., Elbersen, B., Eiden, G., Godeschalk, F., Jones, G., McCracken, D.I., Nieuwenhuizen, W., van Eupen, M., Hennekens, S. & Zervas, G., 2003. Developing a high nature value indicator. Report for the European Environment Agency, Copenhagen.

Anderson, E., & Mammides, C. (2020) Changes in land-cover within high nature value farmlands inside and outside Natura 2000 sites in Europe: A preliminary assessment. *Ambio*, *49*(12), 1958-1971.

Anzaldúa, G., Abhold, K., Araujo, A., Chebotarev, A., Cosnita, D., Diaconescu, T., Dimov, L., Duic, N., Iorgulescu, R., Kiresiewa, Z., Lazdina, D., Makovskis, K., Markovska, M., Mihajloska, E., Mytlewski, A., Pauna, C., Pavlova, I., Rakowski, M., Schock, M., Szulecka, O., Tröltzsch, J., Zelljadt, E. (2019). D2.2 The macro-environment surrounding BE-Rural's Open Innovation Platforms. Deliverable D2.2 of the H2020 BE-Rural project. https://be-rural.eu/wp-content/uploads/2019/10/BE-Rural_D2.2_Macro-environment_OIPs.pdf

Augusto, L., Ranger, J., Binkley, D., and Rothe, A. (2002) *Impact of several common tree species of European temperate forests on soil fertility*. Ann. For. Sci. 59 (2002) 233-253. DOI: 10.1051/forest:2002020

Benavidez, R., Jackson, B., Maxwell, D., Norton, K. (2018) A review of the (Revised) Universal Soil Loss Equation ((R)USLE): with a view to increasing its global applicability and improving soil loss estimates. Hydrol. Earth Syst. Sci., 22, 6059–6086. https://doi.org/10.5194/hess-22-6059-2018

BMUB/UBA (2016) Water Framework Directive – The status of German waters 2015. Bonn, Dessau. https://www.gewaesser-bewertung.de/files/wrrl_englische_version_dez_2016.pdf

BIlandzija, N., Voca, N., Kricka, T. (2012) Energy potential of fruit tree pruned biomass in Croatia. SPANISH JOURNAL OF AGRICULTURAL RESEARCH 10(2):292. https://www.researchgate.net/publication/271189331_Energy_potential_of_fruit_tree_pruned_biomass_in_Croatia

Brockerhoff, E.G., Jactel, H., Parrotta, J.A. et al. (2008) Plantation forests and biodiversity: oxymoron or opportunity?. Biodivers Conserv 17, 925–951. https://doi.org/10.1007/s10531-008-9380-x

Chaudhary, A., Burivalova, Z., Koh, L. P., & Hellweg, S. (2016). Impact of forest management on species richness: global meta-analysis and economic trade-offs. *Scientific reports*, *6*(1), 1-10.

Convention on Biological Diversity (n.d.) Latvia – Main Details. https://www.cbd.int/countries/profile/?country=lv

Copernicus Land Monitoring Service (2018) CORINE Land Cover. https://land.copernicus.eu/pan-european/corine-land-cover

Deal, R.L., Hennon, P., O'Hanlon, R., D'Amore, D. (2013) Lessons from native spruce forests in Alaska: managing Sitka spruce plantations worldwide to benefit biodiversity and ecosystem services. Forestry 2014; 87, 193–208, doi:10.1093/forestry/cpt061

European Commission (n.d.) Implementation of River Basin Management Plans – Latvia. https://ec.europa.eu/environment/water/participation/map_mc/countries/latvia_en.htm

European Commission. (n.d.). Biodiversity strategy for 2030. Retrieved July 1, 2022, from https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en

European Commission (2003) Analysis of Pressures and Impacts in the implementation of the Water Framework Directive: Guidance document no 3. Publications Office of the European Union, Luxembourg.

European Commision (2017), *The EU Environmental Implementation Review Country Report: Latvia*, European Commission, Brussels, http://ec.europa.eu/environment/eir/country-reports/index2_en.htm.

European Commision (2018) CAP specific objectives explained, Brief No. 5 Efficient Soil Management. https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/key_policies/documents/cap-specific-objectives-brief-5-soil_en.pdf

European Commission & European Environment Agency (n.d.) EU Biodiversity strategy. Biodiversity Information System for Europe. Retrieved July 1, 2022, from https://biodiversity.europa.eu/countries/latvia/eu-biodiversity-strategy

European Commission & European Environment Agency (n.d.) Green infrastructure. Biodiversity Information System for Europe. Retrieved July 1, 2022, from https://biodiversity.europa.eu/countries/latvia/green-infrastructure

European Environment Agency (2009). Distribution and targeting of the CAP budget from a biodiversity perspective. EEA Technical report No 12/2009. European Environment Agency, Copenhagen. Available at: http://www.eea.europa.eu/publications/distribution-and-targetingof-the-cap-budget-from-a-biodiversity-perspective?&utm_campaign=distributionand-targeting-of-the-cap-budget-from-a-biodiversityperspective&utm_medium=email&utm_source=EEASubscriptio

European Environment Agency (2017) Loss of HNV farmland due to agricultural intensification per NUTS3. https://www.eea.europa.eu/data-and-maps/figures/loss-of-hnv-farmland-due

European Environment Agency (2018) European waters: assessment of status and pressures 2018, EEA Report No 7/2018, European Environment Agency. Available on: https://www.eea.europa.eu/publications/state-of-water

European Environmental Agency (2019) High nature value (HNV) farmland. Retrieved July 1, 2022, from https://www.eea.europa.eu/data-and-maps/data/high-nature-value-farmland-1

European Environment Agency (2020a) Water pollution. Diffuse sources. https://www.eea.europa.eu/archived/archived-content-water-topic/water-pollution/diffuse-sources

European Environment Agency (2020b). State of nature in the EU. Results from reporting under the nature directives 2013-2018. 142 pp.

Ellis, T., Leguédois, S., Hairsine, P. and Tongway, D. (2006) ‘Capture of overland flow by a tree belt on a pastured hillslope in south-eastern Australia’, Australian Journal of Soil Research, vol 44, pp117–125

Emmerson, M., Morales, M. B., Oñate, J. J., Batary, P., Berendse, F., Liira, J., ... & Bengtsson, J. (2016). How agricultural intensification affects biodiversity and ecosystem services. In *Advances in ecological research* (Vol. 55, pp. 43-97). Academic Press.

European Soils Bureau Network (2005) *Soil Atlas of Europe*. European Commision, Luxembourg. https://esdac.jrc.ec.europa.eu/content/soil-atlas-europe

Eurostat (2020) Agri-environmental indicator – soil erosión. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental_indicator_-_soil_erosion#cite_note-7

FAO (2010) Global Forest Resources Assessment 2010 Terms and Definitions. Rome. https://www.fao.org/3/am665e/am665e00.pdf

FOREST EUROPE (2020) State of Europe’s Forests 2020. Ministerial Conference on the Protection of Forests in Europe - FOREST EUROPE, Bratislava.

Gauquelin, T., Michon, G., Joffre, R., Duponnois, R., Génin, D., Fady, B., ... & Baldy, V. (2018). Mediterranean forests, land use and climate change: a social-ecological perspective. *Regional Environmental Change*, *18*(3), 623-636.

Global Environment Facility. (n.d.). Biodiversity Protection in North Vidzeme Biosphere Reserve. Retrieved July 1, 2022, from https://www.thegef.org/projects-operations/projects/1045

Grebner, D., Bettinger, P., Siry, J. (2013) Introduction to Forestry and Natural Resopurces. First Edition. Elservier,UK and USA.

Gómez-González, S., Ochoa-Hueso, R., & Pausas, J. G. (2020). Afforestation falls short as a biodiversity strategy. *Science*, *368*(6498), 1439-1439.

Hannah, L., Carr, J.L., Lankerani, A., 1995. Human disturbance and natural habitat: a biome level analysis of a global data set. Biodivers. Conserv. 4, 128–155.

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., ... & Townshend, J. (2013). High-resolution global maps of 21st-century forest cover change. science, 342(6160), 850-853.

Iqbal Ya., Lewandowski I., Weinreich A., Wippel B., Pforte B., Haidai O., Tryboi O., Spottle M., Peters D. (2016). Maximising the yield of biomass from residues of agricultural crops and biomass from forestry, Final report, https://ec.europa.eu/energy/sites/ener/files/documents/Ecofys%20-%20Final_%20report_%20EC_max%20yield%20biomass%20residues%2020151214.pdf

Irwin, S., Pedley, S.M., Coote, L. et al. (2014) The value of plantation forests for plant, invertebrate and bird diversity and the potential for cross-taxon surrogacy. Biodivers Conserv 23, 697–714. https://doi.org/10.1007/s10531-014-0627-4

Karlen, D., & Rice, C. (2015). Soil Degradation: Will Humankind Ever Learn? Sustainability, 7(9), 12490–12501. MDPI AG. http://dx.doi.org/10.3390/su70912490

Keenan, R.J. and Van Dijk, A.I.J. (2010) Planted forests and water. In Ecosystem Goods and Services from Plantation Forests. Bauhus J., van der Meer P.J. and Kanninen M. (eds). Earthscan, pp. 77–95.

Keenleyside, C., Beaufoy, G., Tucker, G., & Jones, G. (2014). High Nature Value farming throughout EU-27 and its financial support under the CAP. *Institute for European Environmental Policy, London*, *10*, 91086. Available at: https://ec.europa.eu/environment/agriculture/pdf/High%20Nature%20Value%20farming.pdf

Kiresiewa, Z., Gerdes, H. (2021). D5.3: Regional strategy and roadmap documents. Deliverable of the H2020 BE-Rural project.

Košulič, O., Procházka, J., Tuf, I. H., & Michalko, R. (2021). Intensive site preparation for reforestation wastes multi-trophic biodiversity potential in commercial oak woodlands. *Journal of Environmental Management*, *300*, 113741.

Latawiec, A. E., Crouzeilles, R., Brancalion, P. H., Rodrigues, R. R., Sansevero, J. B., Santos, J. S. D., ... & Strassburg, B. B. (2016). Natural regeneration and biodiversity: a global meta-analysis and implications for spatial planning. *Biotropica*, *48*(6), 844-855.

LIFE GOODWATER IP (2020) Diffuse pollution: Preparatory activities for reducing pollution with nutrients from agriculture and forestlands. https://goodwater.lv/en/activities/diffuse-polution/

Lomba, A., Moreira, F., Klimek, S., Jongman, R. H., Sullivan, C., Moran, J., ... & McCracken, D. I. (2020). Back to the future: rethinking socioecological systems underlying high nature value farmlands. *Frontiers in Ecology and the Environment*, *18*(1), 36-42.

Macdonald, E., Gardiner, B., Mason, W. (2009) The effects of transformation of even-aged stands to continuous cover forestry on conifer log quality and wood properties in the UK. Forestry: An International Journal of Forest Research, Volume 83, Issue 1, January 2010, Pages 1–16, https://doi.org/10.1093/forestry/cpp023

Makovskis, Kristaps & Lazdina, Dagnija (2015) Potential areas of low productivity agriculture lands for SRC energy wood production in Vidzeme Region. Research for Rural Development 2015.

May, B. P., Smethurst, C., Carlyle, D., Mendham, Bruce, J. and Baillie, C. (2009) Review of Fertiliser Use in Australian Forestry, Forest & Wood Products, Australia

Ministry of Environment and Climate Affairs. (2014). 5th National Report to the Convention on Biological Diversity (CBD).

MEPRD - Ministry of Environmental Protection and Regional Development of the Republic of Latvia (2014) 5th National Report to the Convention On Biological Diversity Latvia 2014. https://www.cbd.int/doc/world/lv/lv-nr-05-en.pdf

Moreau, G., Chagnon, C., Achim, A., Caspersen, J., D'Orangeville, L., Sánchez-Pinillos, M., & Thiffault, N. (2022). Opportunities and limitations of thinning to increase resistance and resilience of trees and forests to global change. *Forestry: An International Journal of Forest Research*.

Nascimbene, J., Thor, G., Nimis, P.L. (2013) Effects of forest management on epiphytic lichens in temperate deciduous forests of Europe – A review. Forest Ecology and Management, Volume 298, Pages 27-38, https://doi.org/10.1016/j.foreco.2013.03.008.

Nikodemus, O., Bell, S., Grīnea, I., Liepiņša, I. (2005) The impact of economic, social and political factors on the landscape structure of the Vidzeme Uplands in Latvia. Landscape and Urban Planning Volume 70, Issues 1–2, 15 January 2005, Pages 57-67. https://doi.org/10.1016/j.landurbplan.2003.10.005

Nisbet, T.R. and McKay, H. (2002) Sustainable Forestry and the Protection of Water in Great Britain. Forestry Commission, Great Britain.

Nordregio (2022) Latvia: towards a knowledge-driven bioeconomy Integration of digital solutions to the food sector in Vidzeme. https://storymaps.arcgis.com/stories/59da7a4af92346f19de4a0631f3b8c9e

Nyström, H., Giacometti, A., & Ražaitytė, V. (n.d.). Vidzeme's bioeconomy visions. Retrieved July 1, 2022, from https://storymaps.arcgis.com/stories/59da7a4af92346f19de4a0631f3b8c9e

OECD (2019), OECD Environmental Performance Reviews: Latvia 2019, OECD Environmental Performance Reviews, OECD Publishing, Paris, https://doi.org/10.1787/2cb03cdd-en.

Oettel, J., & Lapin, K. (2021). Linking forest management and biodiversity indicators to strengthen sustainable forest management in Europe. Ecological Indicators, 122, 107275.

Panagos, P., Ballabio, C., Poesen, J., Lugato, E., Scarpa, S., Montanarella, L., & Borrelli, P. (2020). A Soil Erosion Indicator for Supporting Agricultural, Environmental and Climate Policies in the European Union. Remote Sensing, 12(9), 1365. MDPI AG. http://dx.doi.org/10.3390/rs12091365

Panagos, P., Borrelli, P., Poesen, J, Ballabio, C., Lugato, E., Meusburger, K., Montanarella, L., Alewell, C. (2015) The new assessment of soil loss by water erosion in Europe. Environmental Science & Policy, Volume 54, Pages 438-447. https://doi.org/10.1016/j.envsci.2015.08.012

Paillet Y, Bergès L, Hjältén J, Odor P, Avon C, Bernhardt-Römermann M, Bijlsma RJ, De Bruyn L, Fuhr M, Grandin U, Kanka R, Lundin L, Luque S, Magura T, Matesanz S, Mészáros I, Sebastià MT, Schmidt W, Standovár T, Tóthmérész B, Uotila A, Valladares F, Vellak K, Virtanen R. (2010) Biodiversity differences between managed and unmanaged forests: meta-analysis of species richness in Europe. Conserv Biol. 2010 Feb;24(1):101-12. doi: 10.1111/j.1523-1739.2009.01399.x. PMID: 20121845.

Picchio, R., P.S. Mederski & F. Tavankar (2020) How and How Much, Do Harvesting Activities Affect Forest Soil, Regeneration and Stands? Current Forestry Reports

Pike, L.H. (1978) The importance of lichens in mineral cycling. The Bryologist 81, 247–257.

Pointereau, P., Paracchini, M.L., Terres, J.-M., Jiguet, F., Bas, Y., and Biala, K., 2007. Identification of High Nature Value farmland in France through statistical information and farm practice surveys, Report EUR 22786 EN. 62 pp.

Scarlat, N., MArtinov, M., Dallemand, J-F. (2010) Assessment of the availability of agricultural crop residues in the European Union: Potential and limitations for bioenergy use. Waste Management, Volume 30, Issue 10, October 2010, Pages 1889-1897. https://doi.org/10.1016/j.wasman.2010.04.016

Schulp, C. J., Van Teeffelen, A. J., Tucker, G., & Verburg, P. H. (2016). A quantitative assessment of policy options for no net loss of biodiversity and ecosystem services in the European Union. Land Use Policy, 57, 151-163.

Schwaiger, E., Banko, G., Brodsky, L., van Doorn, A. (2012). Updated High Nature Value Farmland in Europe: An estimate of the distribution patterns on the basis of CORINE Land Cover 2006 and biodiversity data. Available at: https://www.eea.europa.eu/data-and-maps/data/high-nature-value-farmland/further-documentation/hnv-farmland-in-europe-2012.pdf/at_download/file

Stockmann, U., Padarian, J., McBratney, A. et al. (2015): Global soil organic carbon assessment. Global Food Secur. 6:9-16.

Straume, Indulis (2013) The investigation of biogas potential in the Vidzeme Region.

Thorn, S., Bässler, C., Brandl, R., Burton, P. J., Cahall, R., Campbell, J. L., ... & Müller, J. (2018). Impacts of salvage logging on biodiversity: A meta-analysis. Journal of Applied Ecology, 55(1), 279-289.

VASAB- Vision and Strategies Around the Baltic Sea (2018) Country Fiche on Terrestrial Spatial Planning. https://vasab.org/wp-content/uploads/2018/06/Latvia_Country_Fiche_Spatial_Planning_May2018.pdf

Vidzeme Planning Region (n.d.) About Vidzeme Planning Region. http://www.vidzeme.lv/en/about_vidzeme

Vis, M. & D. van den Berg (2010) Harmonization of biomass resource assessments - Volume I: Best Practices and Methods Handbook. Biomass Energy Europe Deliverable.

https://www.researchgate.net/publication/268388401_Harmonization_of_biomass_resource_assessments_Volume_I_Best_Practices_and_Methods_Handbook

Water Action Hub (n.d.) Latvia Country Overview. UN Global Compact | CEO Water Mandate. Available here: https://wateractionhub.org/geos/country/121/d/latvia/

WWF (2021) Water Risk Filter: Country Profile for Latvia. Available on: https://waterriskfilter.org/explore/countryprofiles#overview/12

Zaíis, G. and Ernðteins, R. (2008) Premise of optimal water management in Latvia. Proceedings of the Latvian Academy of Sciences, Section B, Vol. 62 (2008), No. ½ (654/655), pp. 55–62. DOI: 10.2478/v10046-008-0005-2