BioINSouth

Supporting regional environmental sustainability assessment for the BIO-based sectors to improve INnovation, INdustries and INclusivity in SOUTH Europe

Deliverable 4.6

Toolkit Requirements Analysis

- Cyprus
- Czech Republic
- France
- Greece
- Portugal
- Italy
- Slovenia
- Spain
- Türkyie

Bio-based Industries Consortium

Circular Bio-based Europe Joint Undertaking

Co-funded by the European Union

Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

BioINSouth

Supporting regional environmental sustainability assessment for the BIO-based sectors to improve INnovation, INdustries and INclusivity in SOUTH Europe

Project title	Supporting regional environmental sustainability assessment for the bio-based sectors to improve innovation, industries and inclusivity in South Europe
Project acronym	BioINSouth
Grant agreement ID	101156363
Project start date	01/06/2024
Duration	36 months

D4.6 Toolkit Requirements Analysis	
Due date	M9 – 28.02.2025
Delivery date	27.02.2025
Work Package	WP4
Author(s) responsible	Andrea Cavallaro and Lorenzo Sutton (INNEN)
Contributor(s)	Jessica Frigerio (UNIMIB), Inma Sanchez and Daniel Checa Alias (LEITAT), Pier Francesco Recchi and, Francesco Caracciolo di Torchiarolo (UNINA)
Reviewer(s)	Carla del Cerro and Marina Barquero (CTA), Ieronymos Zoidakis and Constantinos Vorgias (NKUA), Pierluigi Argoneto and Lara Carlet (SPRING)
Version	1.0
Dissemination level	PU

Co-funded by the European Union

Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members. under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

Circular Bio-based Europe Joint Undertaking

Bio-based Industries Consortium

VERSION AND AMENDMENT HISTORY			
Version	Date (DD/MM/YYYY)	Created by/ Amended by	Review of changes
0.1	13/12/2024	Andrea Cavallaro (INNEN)	ToC Setup
0.2	17/01/2025	Jessica Frigerio (UNIMIB)	Contribution to Section 2.1.3 on T4.4
0.3	17/01/2025	Pier Francesco Recchi (UNINA)	Contribution to Section 2.1.2 on T4.3
0.4	17/01/2025	Daniel Checa Alias (LEITAT)	Contribution to Sections 2.1.1 and 2.1.4 respectively on T4.2 and T4.5
0.5	14/02/2025	Andrea Cavallaro / Lorenzo Sutton (INNEN)	Pre-final version for internal partner review
0.6	17/02/2025	Carla del Cerro and Marina Barquero (CTA)	Check – Quality Review
0.7	18/02/2025	Ieronymos Zoidakis and Constantinos Vorgias (NKUA)	Check – Quality Review
0.8	21/02/2025	Andrea Cavallaro (INNEN)	Consolidated Version
0.9	24/02/2025	Pierluigi Argoneto and Lara Carlet (SPRING)	Final Check
1.0	27/02/2025	Andrea Cavallaro (INNEN)	Final version ready for coordinator review and submission

Co-funded by the European Union
Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members. under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.
Circular Bio-based Europe Joint Undertaking
Bio-based Industries Consortium

Contents

Co-funded by the European Union
Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members, under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.
Circular Bio-based Europe Joint Undertaking
Bio-based Industries Consortium

Co-funded by the European Union
Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members, under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

Executive Summary

Deliverable **D4.6 Toolkit Requirements Analysis** outlines the integration of a comprehensive suite of methodologies and tools into a structured and user-friendly digital toolkit. Developed within the framework of prior project activities, this toolkit will be made accessible to stakeholders through the project's official website, with a potential contribution to the European Commission's Knowledge Centre for Bioeconomy. The objective is to provide a systematic, robust, and sustainable resource that enhances the ability of bio-based industries and other stakeholders, including public and private researchers, to assess environmental impacts, integrate circular economy principles, and make informed decisions based on scientific data. In particular, the toolkit aims to provide effective support to the methodologies and tools provided in BioINSouth Work Package 4 which, in turn, provide assessment and monitoring of environmental impacts and circularity of bio-based industries.

The process described in Task 4.6 follows three key phases. First, **Requirements Analysis and Specification** ensures the toolkit meets user expectations. This includes authentication features, data storage and management capabilities, external data access, and output format considerations. Precise environmental parameters, conversion factors, and calculation methods are also defined.

Next, **Data Analysis and Content Enrichment** is conducted in collaboration with key partners leading WP4 tasks related to impact assessment and monitoring systems (LEITAT, UNINA, UNIMIB) to integrate environmental and circularity insights. Informative content is developed to guide bio-based industries in assessing their environmental footprint and improving sustainability practices.

Finally, in the **Development, Testing, Release, and Maintenance** phase of this task generates the first version of BioINSouth Toolkit due at M14 (D4.7 BioINSouth Toolkit), INNEN will develop and deploy the first version of the toolkit, ensuring long-term usability through continuous updates, user feedback integration, and system maintenance. Moreover, the toolkit will evolve throughout the project's duration, adapting to emerging needs, advanced features, and possible requirements, ensuring its effectiveness and long-term impact on the bioeconomy sector.

Co-funded by the European Union

Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members. under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

1 Introduction

The BioINSouth project contributes to the CBE-JU Strategic Research and Innovation Agenda (SRIA) by developing guidelines and tools to improve sustainability and promote circularity of bio-based industries in Mediterranean European regions. This aligns with the CBE-JU's objectives of accelerating innovation, improving market deployment, and ensuring high environmental performance in bio-based industrial systems. The BioINSouth toolkit is being developed as an enabler for the environmental impact assessment and circularity monitoring system developed in WP4 which is designed to contribute to the above strategies as well as being guided by sustainability principles such as SSbD (Safe and sustainable by design).[1]

More specifically, the development of BioINSouth toolkit, follows a structured requirement analysis phase to ensure a seamless user experience and robust technical functionalities. The requirement gathering process is divided into key dimensions: user needs analysis, technical specifications, functional requirements, non-functional requirements, and external integration possibilities.

Deliverable **D4.6 Toolkit Requirements Analysis** is organised as follows:

- Chapter 1: consists of the present introduction
- Chapter 2 describes the requirements gathering methodologies
- Chapter 3 outlines both functional and non-functional requirements
- Chapter 4 provides an initial overview of technical constraints and assumptions
- Chapter5 presents the conclusions about the collected requirements and the proposed development roadmap leading towards the delivery of the BioINSouth Toolkit (D4.7) by M14.

[1] Safe and sustainable by design – European Commission - https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/chemicals-and-advanced-materials/safe-and-sustainable-design_en

Co-funded by the European Union

Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members. under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

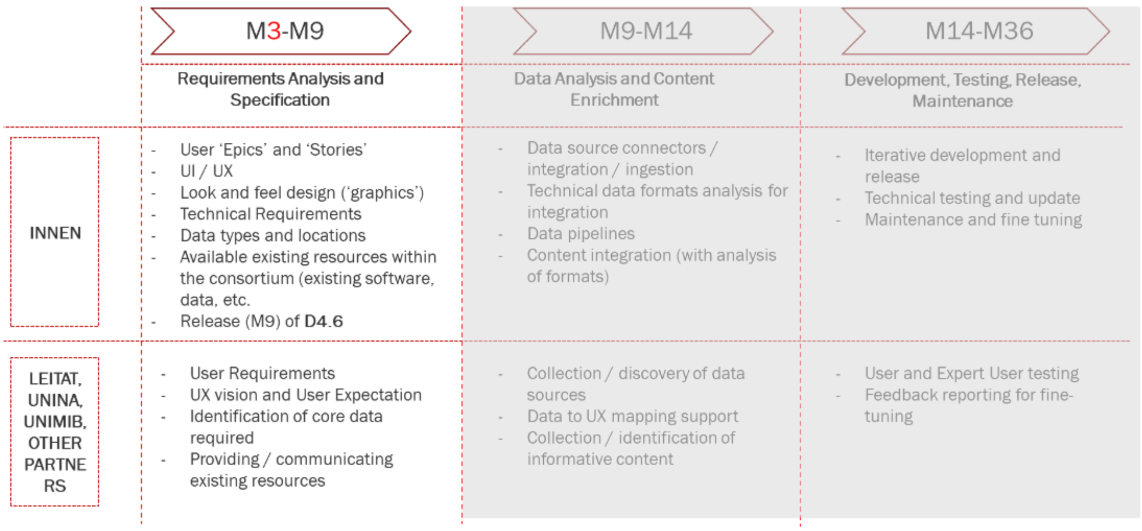
Circular Bio-based Europe Joint Undertaking

Bio-based Industries Consortium

2 Requirements Gathering Methodologies

2.1 Interviews and Questionnaires

A comprehensive analysis of user expectations and functional demands is conducted to tailor the toolkit for various stakeholders involved in the project who represent the core target users of the Toolkit. This process includes engagement with key stakeholders such as researchers, and sustainability experts represented by several project partners. Through structured workshops, interviews and surveys, user expectations regarding usability, data access, and analytical capabilities are documented as follows. An example of the process are the specific workshop meetings with expert BioINSouth partners which have been carried out in the first phase of the project to understand how the methodologies are currently implemented and used: this allowed us to understand on the one hand how to functionally implement/provide these methodologies and related tools within the toolkit and on the other hand to better understand user requirements in using the methodologies. For instance, some tools require a set of inputs which could, for certain users, result 'overwhelming' so the approach to have templated or pre-filled sheets was proposed. This process is- / will be- also an ongoing and continuous process part of the overall Toolkit development plan as also shown in the figure below.



	M3-M9 Requirements Analysis and Specification	M9-M14 Data Analysis and Content Enrichment	M14-M36 Development, Testing, Release, Maintenance
INNEN	- User 'Epics' and 'Stories' - UI / UX - Look and feel design ('graphics') - Technical Requirements - Data types and locations - Available existing resources within the consortium (existing software, data, etc. - Release (M9) of D4.6	- Data source connectors / integration / ingestion - Technical data formats analysis for integration - Data pipelines - Content integration (with analysis of formats)	- Iterative development and release - Technical testing and update - Maintenance and fine tuning
LEITAT, UNINA, UNIMIB, OTHER PARTNE RS	- User Requirements - UX vision and User Expectation - Identification of core data required - Providing / communicating existing resources	- Collection / discovery of data sources - Data to UX mapping support - Collection / identification of informative content	- User and Expert User testing - Feedback reporting for fine-tuning

Figure 1: BioINSouth Toolkit Planning

An initial mapping between leading partners expertise and involved resources (e.g. datasets, existing software platforms, etc.) has been obtained, through a set of online workshops supported by an online questionnaire, with the aim to identifying:

1. <u>Target segment</u>: Regional Hub, Regional public authorities & policymakers, and Bioeconomy experts are the three more voted answers as for Figure 2.

Co-funded by the European Union

Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members, under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

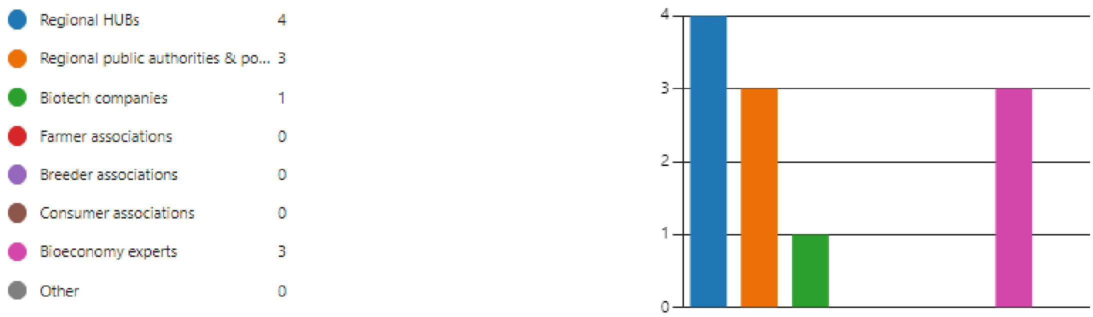


Figure 2: Target segments to be approached also by using BioINSouth Toolkit

2. Recruitment and engagement means: typically, workshops, events, and round tables are the tools used for supporting target segment recruitment and engagement as confirmed by the answers collected and shown in Figure 3

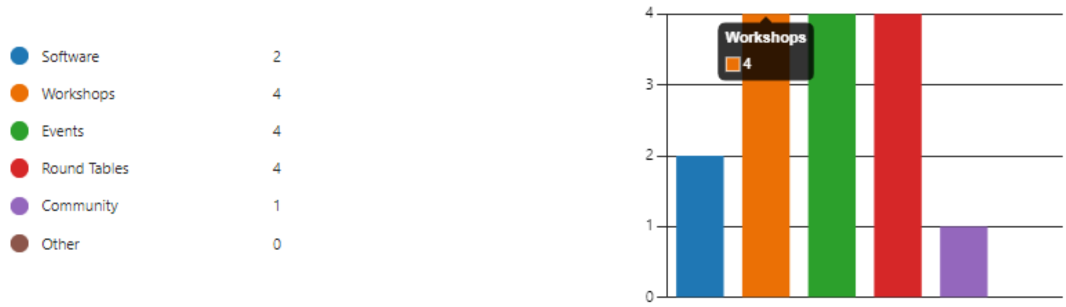


Figure 3: Recruitment and Engagement means

3. Distribution between tools and methodologies: it is significant to highlight that three software tools (Geographic Information System - GIS, calculation, and open dataset) and one methodology Life Cycle Assesment (LCA) for defining circularity indicators (attractive graphical user interface) are planned to be integrated within the BioINSouth toolkit.
4. The most useful features to be integrated within the BioINSouth toolkit: a qualitative graphical output format is the most relevant feature encompassed by user authentication and login, integration and interoperability with external sources of data, and quantitative output formats-

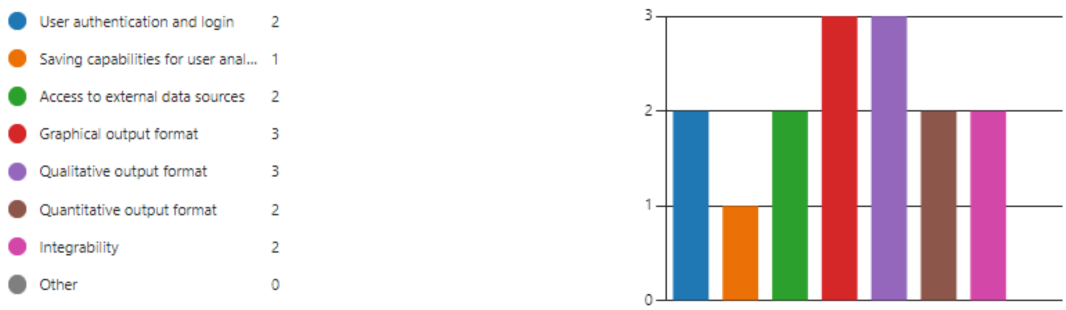


Figure 4: BioINSouth Toolkit preferred features

2.1.1 Input from T4.2 Environmental assessment

Beneficiary Target Segment

The beneficiary target segment for the toolkit will consist of users who are interested in understanding the environmental impacts associated with bioproducts and bioprocesses. These users may include researchers, policymakers, industry professionals who seek actionable insights into the ecological footprint, resource efficiency, and environmental sustainability of biobased technologies. By providing data on environmental impacts, the toolkit will empower these users to make informed decisions, optimize processes, and contribute to the development and adoption of environmentally responsible solutions in the bioproducts and bioprocesses.

Tool/Methodology General Description

The main methodology derived from the Life Cycle Thinking approach is the Life Cycle Assessment (LCA). Life Cycle Assessment (LCA) is a process that assesses the environmental impact of a product over its entire life cycle, thereby increasing the efficiency of resource use and reducing liabilities. It can be used to examine the environmental impact of either a product or the function the product is designed to perform.

The key elements of a LCA are:

1) identifying and quantifying the environmental impacts, such as energy and raw materials consumed, emissions and waste generated.
2) assessing the potential environmental effects of these impacts.
3) evaluating the options available to reduce these environmental impacts.

The study is carried out according to the ISO 14040:2021[2] and ISO 14044:2021[3] Standards. As per the given standards, the study is divided into the following four phases/stages:

a) **Goal and Scope Definition**, in which the purpose for which the study is carried out, the target, the boundaries of the system that will be analysed, the functional unit of reference, etc., are defined.
b) **Life Cycle Inventory (LCI)**, in which the collection of all input and output data of the process being analysed is carried out.
c) **Life Cycle Impact Assessment (LCIA)**, in which results are obtained for all impact categories that are of interest to the study.
d) **Life Cycle Interpretation**, in which the results are summarised and discussed, in accordance with the objective and scope definition, as a basis for conclusions, recommendations and decisions.

Figure 1 shows the relationship between the four stages of the LCA.

[2] https://store.uni.com/en/uni-en-iso-14040-2021
[3] https://store.uni.com/en/uni-en-iso-14044-2021

Co-funded by the European Union

Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members. under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

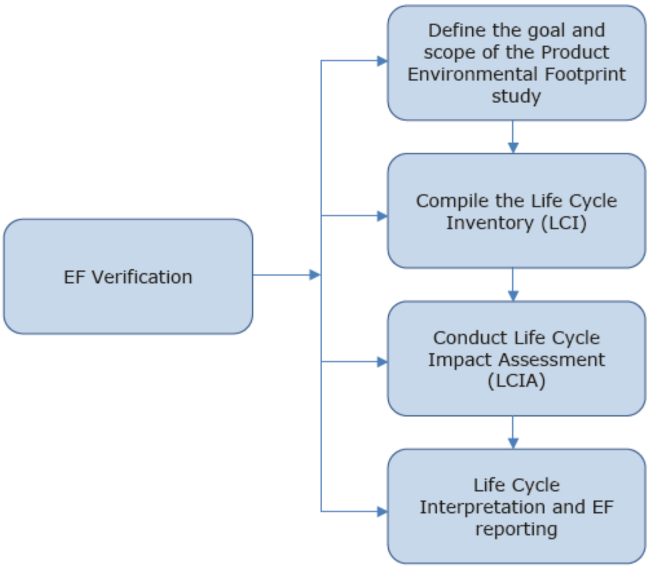


Figure 1. Phases of a Product Environmental Footprint study.

Tool/Methodology Technological Description

The input data for the environmental assessment in the toolkit will be sourced from the BIORADAR project.[4] This project provides detailed and high-quality data on bioproducts and bioprocesses, which serves as a critical foundation for assessing their environmental impacts. The data from BIORADAR is aligned with the input requirements for conducting a Life Cycle Assessment (LCA), ensuring compatibility and consistency with established methodologies.

In an LCA, key input data typically includes resource consumption (e.g., raw materials, energy inputs), process emissions, waste generation, and end-of-life considerations. The BIORADAR project has considered these types of data across different stages of the bioproduct or bioprocess lifecycle, from raw material extraction to usage and disposal. This integration allows the toolkit to deliver robust and reliable environmental assessments, enabling users to evaluate the sustainability of biobased solutions. By adopting BIORADAR's dataset, the toolkit ensures the accuracy and relevance of its assessments while adhering to the data standards required for LCA methodologies.

A wide range of environmental issues is addressed to ensure a comprehensive assessment. The Product Environmental Footprint (PEF) and Organisation Environmental Footprint (OEF) methods aim to achieve this by addressing 16 impact categories. These are periodically updated to reflect the latest scientific knowledge and best practices, also informed by discussions within Commission's expert groups.

Table 1. EF Impact categories

Impact category	Description	Unit	Relevance
Climate Change (CC)	Contribution of greenhouse gases to global warming.	kg CO_2-equivalent	Assesses effects like rising temperatures and sea-level changes.

[4] BIORADAR - Monitoring system of the environmental and social sustainability and circularity of industrial bio-based systems - Grant agreement ID: 101112457 - https://cordis.europa.eu/project/id/101112457https://cordis.europa.eu/project/id/101112457 - https://www.bioradar.org/

Ozone Depletion (ODP)	Impact of substances that deplete the stratospheric ozone layer.	kg CFC-11-equivalent	Protects against increased UV radiation risks (e.g., skin cancer).
Ionizing Radiation (human health) (IR)	Harm to humans from ionizing radiation due to radioactive substances.	kBq U-235-equivalent	Includes impacts from nuclear power and radioactive waste.
Photochemical Ozone Formation (POF)	Formation of ground-level ozone (smog) from pollutants like NO_x and VOCs.	kg NMVOC-equivalent	Affects human respiratory health and ecosystems.
Particulate Matter (PM)	Health effects of fine particles and their precursors (e.g., SO_2, NO_x).	Disease incidence	Links to respiratory and cardiovascular diseases.
Acidification (AC)	Potential for acidifying substances to harm terrestrial and aquatic ecosystems.	mol H^+-equivalent	Impacts soil quality, water bodies, and biodiversity.
Eutrophication (Terrestrial) (TEU)	Nutrient enrichment in terrestrial ecosystems (e.g., nitrogen compounds).	mol N-equivalent	Can lead to loss of biodiversity in sensitive areas.
Eutrophication (Freshwater) (FEU)	Nutrient enrichment (e.g., phosphorus) affecting freshwater ecosystems.	kg P-equivalent	Leads to algal blooms and oxygen depletion in water bodies.
Eutrophication (Marine) (MEU)	Nutrient enrichment (e.g., nitrogen compounds) affecting marine ecosystems.	kg N-equivalent	Causes algal blooms and hypoxic zones in oceans.
Land Use (LU)	Changes in land use affecting soil quality, biodiversity, and carbon storage.	Pt (PDF·m^2·yr)	Examines the transformation and occupation of land.
Water Use (Water Scarcity) (WU)	Impacts of water consumption on water availability in regions with scarcity.	m^3 world-equivalent	Addresses the effects on ecosystems and human needs.
Resource Use (Fossil) (FRD)	Depletion of fossil fuel resources like coal, oil, and natural gas.	MJ	Highlights energy demand and resource scarcity.
Resource Use (Minerals/Metals) (MRD)	Depletion of abiotic resources like metals and rare earth elements.	kg Sb-equivalent	Accounts for resource availability and extraction impacts.
Ecotoxicity (Freshwater) (ECOTOX)	Toxic impacts of chemicals on freshwater ecosystems.	CTUe (Comparative Toxic Unit)	Reflects harm to aquatic life from pollutants.

Co-funded by the European Union
Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members. under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.
Circular Bio-based Europe Joint Undertaking
Bio-based Industries Consortium

Human Toxicity (Cancer) (HTOX_c)	Potential for chemicals to cause cancer in humans.	CTUh (Comparative Toxic Unit)	Examines long-term human health risks.
Human Toxicity (Non-cancer) (HTOX_nc)	Toxic effects of chemicals unrelated to cancer (e.g., organ damage).	CTUh	Includes effects like organ damage and reproductive issues.

The toolkit will graphically display the quantification of environmental impacts of bioproducts and bioprocesses using a set of impact categories (see Table 1). It will also allow end-users to import/export publicly available or licensed data in CSV format. No llicence type needs to be considered for such BioINSouth Toolkit component.

2.1.2 Input from T4.3 Set-up of the Methodology to study the scenarios of growth while estimating impacts on food security Land Use, Land Use Change and Forestry

<u>Beneficiary Target Segment</u>

The output of Task 4.3 is designed to assist policymakers and land-use planners by providing a comprehensive methodology and a suite of tools to evaluate the likely consequences of potential growth scenarios in the regional biobased sector and bioeconomy. The methodology focuses on the potential impacts on Land Use, Land Use Change, and Forestry (LULUCF) and their implications for food security.

A key feature of the proposed methodology is the active involvement of stakeholders in defining scenarios and understanding the consequences of their decision-making processes. This participatory approach ensures the development of informed and effective policies, enhancing both awareness and impact.

<u>Tool/Methodology General Description</u>

The development of the bio-based sector may significantly impact land use and land cover due to the increased demand for biomass and/or the altered utilization of organic by-products. Assessing the impact of bio-based supply chains on LULUCF is therefore essential to achieve sustainability goals. This assessment involves, first, the creation of growth scenarios for the bio-based sector at the regional level and, second, a specific impact analysis based on target indicators.

Building reliable scenarios requires a thorough understanding of the regional context, particularly regarding socioeconomic aspects, recent land-use dynamics, and potential constraints that may influence future land development. A critical element in scenario building is the analysis of land use changes over a reference period within the region of interest. This is achieved using a land-use matrix, where rows and columns represent the same land-use categories, and each entry indicates the proportion of land that has transitioned from one category to another during the reference period. Trends of change derived from this matrix are pivotal for scenario creation, which can be based on linear or non-linear projections. In this case, the analysis will cover a 10-year horizon.

Datasets and information on current and past land-use patterns, along with additional geographic data, will be provided through *Earth Map*,[5] a free Geographic Information System developed by the FAO (at the time this report has been written, it is worth to mention that an agreement between FAO and BioINSouth

[5] http://earthmap.org/

Co-funded by the European Union

Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members, under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

Circular Bio-based Europe Joint Undertaking

Bio-based Industries Consortium

project is under definition). Earth Map enhances accessibility, visualization, and processing of geospatial data, providing critical support for the scenario-building process.

Evaluating the impact of potential future developments requires a comparison between a baseline (or reference) scenario and specific scenarios resulting from defined growth scenarios actions. The baseline scenario may reflect current conditions or a "business-as-usual" (BAU) trajectory. Possible growth scenarios of bio-based supply chain development at regional level will be shaped based on expert opinions gathered through semi-structured interviews and validated through a participatory feedback process involving stakeholders. The structure of the semi-structured interview and guidelines for defining scenarios based on the interview outcomes will form part of the methodology to be provided.

The impact on LULUCF will be assessed by analysing greenhouse gas (GHG) emissions generated or avoided by human activities driven by the bio-based sector. This involves comparing carbon outputs between the business-as-usual scenario and the various bio-based sector growth scenarios. The analysis will utilize the Environmental Externalities Accounting Tool (EX-ACT), a specialized tool developed by the FAO to appraise GHG emissions across the Agriculture, Forestry, and Other Land Use (AFOLU) sectors, as well as livestock, fisheries, and aquaculture. EX-ACT is a land-use-based tool that accounts for major drivers of GHG emissions, including land-use change and land management. Standard carbon stocks for different land-use types in each ecoregion are derived from the Intergovernmental Panel on Climate Change (IPCC) guidelines for national GHG inventories. The methodology will include instructions on how to input data and adapt the tool for bio-based sector-specific scenarios, ensuring relevance and accuracy in the analysis.

Scenarios of land-use change will serve as a foundation for evaluating the impact of bio-based supply chain development on food security. Agricultural production is closely tied to the total cultivated area, farming systems, and cropping patterns. If agricultural productivity remains stable over the next 10 years, total food supply will be estimated by multiplying the cropping area affected by land-use changes by the average regional yields. Yield estimates will be derived from databases such as the EU Farm Sustainability Data Network (FSDN) and the FAO Food and Agriculture Macrodata (FAM). Additionally, data on crop area and composition at the local level will be sourced from Earth Map.

To evaluate food security, regional self-sufficiency ratio will be calculated. This indicator compares the region's food supply with the national food supply, offering insights into the region's ability to meet its own food demands. It also provides possible risks of the region's dependency on external food sources, highlighting vulnerabilities in the event of disruptions to national or global supply chains.

Tool/Methodology Technological Description

EX-ACT[6] is an open license tool developed by the FAO to evaluate the effects of human activities on carbon stocks and GHG emissions, expressed in terms of tCO_2-e. Specifically, the tool performs a carbon balance between a reference situation (normally a business as usual scenario) and a situation where specific actions are implemented in order to reach target goals (e.g. a development program). The difference between carbon stocks and emissions in the two situation makes the carbon balance. Its field of application covers the whole AFOLU sector, livestock, fishery and aquaculture. It can be used to perform ex-ante analysis (as in this case), monitoring and ex-post evaluation. Maximum duration of analysis is 20 years, subdivided into implementation and capitalization phase, respectively representing the period of realization of planned actions and that affected by their effects.

[6] https://www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act/en/

Co-funded by the European Union
Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members. under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.
Circular Bio-based Europe Joint Undertaking
Bio-based Industries Consortium

The FAO provides access to EX-ACT in two formats: an Excel-based applet and an online, web-based application. These formats enhance accessibility and flexibility, allowing users to choose the platform that best suits their needs. In its Excel version, EX-ACT is organized into a system of spreadsheets divided into 10 sections: 1) Description, 2) LUC (Land Use Change), 3) Cropland, 4) Grassland, 5) Management, 6) Inland Wetlands, 7) Coastal Wetlands, 8) Fisheries and Aquaculture, 9) Inputs, and 10) Results. All sections, except for the first and the last, correspond to a specific component of the carbon balance. According to the aim of Task 4.3, some of these sections can be overlooked. Section 1 is dedicated to project description and identification of ecoregion and soil characteristics, which are crucial parameters for correct calculation.

The tool is land use-based, which means that basic information to be provided is the extent of each land use type at the beginning and at the end of analysis reference period, for both BAU and target scenario, expressed in ha. Accessory information may concern management aspects, such as fertilizers or fuel consumption of agriculture and other activities. Carbon stocks and GHG emissions associated to each land use type and management refer to the Tier 1 of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. If much detailed information is available at regional or local scale, it is possible to redefine standard values at the Tier 2, or even Tier 3. The output of data processing are forward land use matrices, value of carbon balance and explanatory tables and graphics.

The latest available version of EX-ACT is 9.4.2, which requires enabling macros for full functionality. As mentioned earlier, an online platform for the software is also available; however, its definitive version is still under development.[7]

As for food security, a specific Excel-based tool will be developed, drawing inspiration from the structure and approach of EX-ACT. This tool will be designed to evaluate the impact of land-use changes on food security by integrating key data such as regional crop yields, land area composition, and land-use change scenarios. The tool will utilize the same land-use change matrix applied in EX-ACT, as defined by the growth scenarios, to ensure a consistent and integrated analysis. This matrix will serve as the foundation for calculating changes in cropping areas and compositions over time. These inputs will then be combined with regional yield data to assess total food production and calculate a range of food security indicators, including: Regional Self-Sufficiency Ratio - An indicator that compares regional food production with national food supply, highlighting the region's ability to meet its own food demands and its dependency on external sources; Land Allocation Efficiency - An indicator that evaluates how efficiently land is utilized to meet food production needs relative to the available area.

Most of input data needed for Task 4.3 analyses can be sourced from Earth Map, a web-based application developed by the FAO which allows free access to Earth Observation (EO) big data, provided by several national and international agencies such as ESA, USGS, WWF and IPCC. The whole geographic information is divided into 18 thematic categories, including climate, soil, biodiversity, land-use and satellite imagery, for a total of more than 100 parameters. Earth Map has a user-friendly graphical interface, and it doesn't require specific expertise in geodata management, nor high computing power. The area of interest can be selected from a drop-down menu listing national and subnational boundaries, or hand drawn by pointing and clicking on a Google Map background. The desired parameter can be visualized and processed for a set of on-the-fly statistics, including map comparison. The outputs of Earth Map querying can be thematic maps, a graphs and tables which can be exported as GeoTIFF, PNG and

[7] The EX-ACT tool – Archived version accessed February 2025: web.archive.org/web/20250213110131/https://www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act/en/

Co-funded by the European Union
Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members, under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.
Circular Bio-based Europe Joint Undertaking
Bio-based Industries Consortium

CSV files. In this case, Earth Map can provide land-use change matrices and information about crop composition of agricultural areas.

2.1.3 Input from T4.4 Set-up of the Methodology to study the biodiversity, and ecosystems integrity

Beneficiary Target Segment

Biodiversity loss is progressing at an alarming and unprecedented pace worldwide, pushing countless species to the brink of extinction. The decline in plants, animals, and microorganisms poses significant risks to food security, sustainable development, and the provision of essential ecosystem services. To address these challenges and align with the Sustainable Development Goals (SDGs) for 2030, Task 4.4 aims to identify monitoring tools and indicators to evaluate the link between bio-based activities and biodiversity integrity. These tools are designed for use by national investment banks, international financial institutions, and policymakers, enabling comprehensive biodiversity assessments of project-level activities in the Agriculture, Forestry, and Land Use sector.

Tool/Methodology General Description

To achieve the objectives of Task 4.4 the B-INTACT tool[8] (designed by the Food and Agriculture Organization of the United Nations (FAO)) was selected. The Biodiversity Integrated Assessment and Computation Tool (B-INTACT) delivers a comprehensive evaluation of project-level biodiversity impacts using both quantitative and qualitative methods, and is designed for the Agriculture, Forestry, and Other Land Use sector.

The quantitative analysis leverages relationships between anthropogenic impacts—such as land use changes, habitat fragmentation, infrastructure development, and human encroachment—and biodiversity loss, measured through the Mean Species Abundance (MSA) metric. The quantitative methodology is based on the Global Biodiversity (GLOBIO). Meanwhile, qualitative assessments address non-quantifiable impacts, providing a holistic understanding of biodiversity effects.

Tool/Methodology Technological Description

The input data include various human pressure indicators (e.g., land use, infrastructure) and ecosystem-related metrics (e.g., Mean Species Abundance (MSA), extinction risk). These data can be obtained using tools like GIS software, the Earthmap platform, and the Ecosystem Service Valuation Database (details to be determined).

The outputs of data processing include information on Mean Species Abundance (MSA), policy indicators, and a qualitative summary of biodiversity impacts.

The main functionality of the tools is to quantify the biodiversity impacts of various investments at both project and policy levels, using globally recognized environmental assessment methodologies using xlsx format for import/export purposes.

The latest available version of B-INTACT requires enabling macros for full functionality. An online platform for B-INTACT software could be made available - under open-source license - by FAO in the coming future (to be monitored by the consortium partners).

[8] https://www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/b-intact/en/

Co-funded by the European Union

Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members. under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

Circular Bio-based Europe Joint Undertaking

Bio-based Industries Consortium

2.1.4 Input from T4.5 Design of a circularity monitoring system for the southern European bioeconomy sector

Beneficiary Target Segment

The beneficiary target segment for the toolkit will consist of users who are interested in understanding the circularity assessment of bioproducts and bioprocesses. These users may include researchers, policymakers, industry professionals who seek actionable insights into the circularity KPIs of biobased technologies. By providing data on circularity indicators, the toolkit will empower these users to make informed decisions, optimize processes, and contribute to the development and adoption of more circular solutions in the bioproducts and bioprocesses.

Tool/Methodology General Description

Circularity monitoring methodology aims to quantify and monitor all the bio-economy actions within the region, to gain insight into the circularity performance of each specific system defined.

The current definition of the methodology will include possible fine tuning of definitions, which might be requested after the feedback of users (HUBS) in the context of WP5. Moreover, due to the clustering activities with other EU projects, such as BIORADAR or ESCIB, a list of indicators validated by industrial stakeholders will be explored as potential KPIs of interest in BioINSouth. A complete description of the methodology will be part of Deliverable 4.1, due in M12.

The fundamental of the circularity monitoring approach is based on the latest published ISO standard, regarding Measuring and assessing circularity performance (ISO 59020:2024). ISO 59000 family of standards is designed to harmonize the understanding of the circular economy and to support the implementation and measurement and it aims at supporting organizations in implementing a transition towards a circular economy.

Tool/Methodology Technological Description

Input data requested for implementing the methodology is structured as follows:

- Definition of system in focus of each region
- Definition of circular goals to be measured
- Measurements of resource inflows (flows through the system boundaries into the system in focus)
    - Reused content
    - Recycled content
    - Renewable content
    - Non-renewable content
- Measurements of resource outflows (resources that flow out of the boundaries of the system in focus)
    - Components and products that are reused
    - Recycled materials derived from outflow
    - Products and materials for renewable recirculation
- Data on outflow data

Output data, corresponding to the calculated core of circularity indicators (KPIs), is summarised in the table below.

INDICATOR CATEGORY	KPI
Resource inflows	Average reused content of an inflow

	Average recycled content of an inflow
	Average renewable content of an inflow
Resources outflows	Per cent actual reused products and components derived from outflows
	Per cent actual recycled products and components derived from outflows
	Per cent actual recirculation of outflow in the biological cycle

The main functionalities rely to the capacity of informing and supporting decision making process to promote the role of HUBs activities towards the circular bioeconomy within the region also by exploiting a user-friendly graphical interface capable of graphically displaying tables of numerical circularity indicators results (e.g. comparison with the circularity goals) while allowing data Import/Export via *.CSV format.

2.1.5 T4.2 to T4-5 Input Summary Representation

To facilitate a more comprehensive evaluation of the provided input, a summary table characterising the assets (tools/methodology) provided as inputs collected in T4.2, T4.3, T4.4, and T4.5 is provided below.

Asset	Target Segments	Tool/Methodology General Description	Tool/Methodology Technological Description
Environmental Assessment (T4.2)	Researchers, policymakers, industry professionals interested in environmental impacts of bioproducts and bioprocesses.	Life Cycle Assessment (LCA) based on Life Cycle Thinking approach. Assesses environmental impacts of products/processes through four stages: Goal & Scope Definition, Life Cycle Inventory (LCI), Life Cycle Impact Assessment (LCIA), and Interpretation. Uses ISO 14040:2021 and ISO 14044:2021.	Uses BIORADAR project data for LCA. Covers 16 Environmental Footprint (EF) impact categories. Allows graphical representation and import/export of data in CSV format.
Growth Scenarios & Food Security (T4.3)	Policymakers and land-use planners evaluating bio-based sector growth scenarios and their impacts on LULUCF and food security.	Assessment of bio-based supply chains' impact on LULUCF. Uses land-use change matrices, scenario modelling, and stakeholder participation. Compares business-as-usual and growth scenarios using FAO EX-ACT tool.	EX-ACT tool (FAO) in Excel/web format for carbon balance and LULUCF impact assessment. Uses Earth Map GIS for geospatial data. Custom Excel tool to assess land-use change impacts on food security.
Biodiversity & Ecosystems Integrity (T4.4)	National investment banks, international financial institutions, and policymakers assessing biodiversity impacts of bio-based activities.	Uses B-INTACT tool (FAO) for quantitative and qualitative biodiversity impact assessment in Agriculture, Forestry, and Land Use. Based on GLOBIO and Mean Species Abundance (MSA) methodology.	B-INTACT tool for biodiversity impact assessment. Uses GIS, Earth Map, and ecosystem service valuation databases. Outputs MSA, policy indicators, and qualitative biodiversity impact summaries.
Circularity Monitoring System (T4.5)	Researchers, policymakers, industry professionals analysing	Circularity monitoring based on ISO 59020:2024. Assesses resource inflows/outflows for circularity KPIs, validated with industrial stakeholders. Supports decision-making in circular bioeconomy.	ISO 59020:2024-based circularity tool. Measures inflows/outflows of reused, recycled, and renewable resources. Graphical results

	circularity KPIs in bioproducts and bioprocesses.		display with CSV data import/export.

3 Functional and Non-Functional Requirements

3.1 Functional Requirements

The BioINSouth toolkit is designed to serve as a **comprehensive digital resource**, integrating a range of methodologies and tools to support stakeholders in sustainability assessments. To achieve its objectives, the toolkit must incorporate a set of well-defined **functional requirements** that govern its behaviour, interactions, and outputs. These requirements ensure that the system meets user expectations while enabling seamless data analysis, reporting, and decision-making. As is typical with any digital toolkit the requirements reported in the following sections are represented by a snapshot at Month 9 of the project and might be updated and/or refined in the future based on user input, technical/technological updates and project strategy. Development of the toolkit will purposefully follow an Agile approach (see also Section 3.3 below), allowing to quickly adapt and update it in case of evolving or reviewed requirements.

3.1.1 User Authentication and Access Control Module

The toolkit must provide a secure authentication system, enabling users to create accounts and log in using credentials or federated authentication (e.g., institutional login or OAuth-based authentication).

Role-based access control (RBAC) will be used to segregate administrative and user functionalities. The following table describes the basic roles involved in the "hook up" process managed by the BioINSouth Toolkit, with the specification if the role interacts directly with the platform or is a participant to the process, exploiting the process' outputs.

Role Name	Description	Process Role	Platform Role
Visitor	BioINSouth end users interested to use and exploit the project toolkit	X	X
Admin	INNEN Personnel dedicated to the configuration of the toolkit	X	X
Service Desk	Service Desk Support by INNEN	X	

3.1.2 Data Management Module

Users must be able to **input data manually** through interactive forms or upload datasets in standard formats (e.g., CSV, JSON, Excel). The system should support **pre-defined templates** to streamline data entry while validating inputs to prevent errors and inconsistencies.

Furthermore, the toolkit must allow connectivity – where/if needed - with **external databases and APIs**, enabling real-time access to updated environmental indicators, conversion factors, and sustainability metrics.

3.1.3 Analysis and Computation Module

A **computational module** will perform data processing, integrating conversion factors, impact indicators, and environmental calculations. The system must support different analysis models, including **quantitative assessments**, **scenario simulations**, and **comparative evaluations** of sustainability practices.

3.1.4 Reporting and Visualization Module

Users should be able to obtain **graphical, qualitative, and quantitative reports** based on their analyses. The system should provide, where possible and appropriate, **dynamic visualizations** such as charts,

Co-funded by the European Union
Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members. under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.
Circular Bio-based Europe Joint Undertaking
Bio-based Industries Consortium

heatmaps, and trend analysis graphs to help users interpret results effectively. Reports should be exportable in **PDF, CSV, and interactive web formats**.

3.2 Non-Functional Requirements

The development of the BioINSouth toolkit requires not only a robust functional framework but also a well-defined set of non-functional requirements that ensure the system's efficiency, usability, security, maintainability, and overall reliability. These non-functional requirements shape the foundation upon which the toolkit operates, guaranteeing a high-quality user experience while maintaining technical strength. This section elaborates on the key non-functional requirements that drive the development and deployment of the toolkit.

3.2.1 Performance and Scalability

One of the fundamental non-functional requirements for the toolkit is its **performance efficiency** and **scalability**. The system must handle multiple simultaneous users and execute calculations involving large datasets in a timely manner.

- **Response Time**: The toolkit should ensure that user queries and computations return results within an acceptable threshold, typically under **3 seconds** for standard operations and under **10 seconds** for complex data analyses. It should be noted that such response time parameter relates to the toolkit itself and not to response time of external tools (e.g. such as the FAO tools reported in section 2).
- **Concurrent Users**: The platform must support **concurrent users access** without degradation in performance.
- **Scalability**: The system should allow for horizontal scaling (i.e., adding more servers or computational resources) in case of increased demand, ensuring long-term sustainability and adaptability.

3.2.2 Usability and Accessibility

An **intuitive and user-friendly experience** is essential to maximize stakeholders' adoption at various expertise levels. The toolkit must follow modern usability principles and be accessible to a broad range of users, including those with limited technical knowledge.

- **User Interface (UI) Simplicity**: The design must be clear, logically structured, and avoid unnecessary complexity, ensuring that even non-technical users can navigate and operate the toolkit with ease.
- **User Experience (UX) Consistency**: A consistent layout, clear visual hierarchy, and a guided workflow should be implemented to minimize the learning curve.

Aspects like **Accessibility Compliance** with **WCAG 2.1 Level AA** accessibility guidelines and **Multi-Language Support** could be considered as "nice to have" feature.

Co-funded by the European Union

Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members. under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

3.2.3 Security and Data Protection

BioINSouth toolkit may not process sensitive user inputs but could access to external data sources, so security must be a top priority. The platform must comply with **GDPR** and other relevant data protection regulations to ensure user privacy and system integrity.[9]

- **User Authentication & Authorization**: A role-based access control (RBAC) system should be implemented, ensuring that users can only access functionalities relevant to their role. Multi-factor authentication (MFA) is considered a "nice to have" feature.
- **Protection Against Cyber Threats**: The system must be resilient to common cybersecurity threats such as **SQL injection**, **cross-site scripting (XSS)**, and **distributed denial-of-service (DDoS) attacks.**

3.2.4 Maintainability and Modifiability

Since the BioINSouth toolkit will undergo continuous revision until M36, a structured approach to maintenance and future upgrades is essential.

- **Modular Architecture**: The system should follow a **modular architecture** to facilitate independent module updates and minimize downtime.
- **Code Maintainability**: Development should adhere to best coding practices, following standards such as solid **principles**, **clean architecture**, and **comprehensive documentation** to ensure long-term maintainability.
- **Continuous Integration/Continuous Deployment (CI/CD)**: Automated testing and deployment pipelines should be implemented to enable seamless updates without service disruption.
- **Extensibility**: The toolkit must be designed with an open-ended architecture to accommodate new functionalities, external data source integrations, and evolving requirements over time.

3.2.5 Reliability and Availability

To ensure uninterrupted access and service reliability, the system must be designed with high availability and fault tolerance.

- **Uptime Guarantee**: The toolkit should maintain an **uptime of 99.9%**, ensuring minimal downtime and service disruptions.
- **Regular Backups**: Automated backups should be scheduled daily to prevent data loss and allow for disaster recovery in the event of a system failure.
- **Error Handling & Logging**: Comprehensive error handling should be implemented, ensuring that users receive informative error messages rather than system crashes. A centralized logging system should record all errors for analysis and troubleshooting.

[9] To this end please also refer to BioINSouth D1.2 DMP — Data Management Plan which details the global approaches, processes and measures to ensure compliance throughout the project.

Co-funded by the European Union

Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members, under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

Circular Bio-based Europe Joint Undertaking

Bio-based Industries Consortium

3.2.6 Interoperability and Integration Capabilities

Given that the toolkit must interact with external systems, databases, and potentially the **European Commission's Knowledge Centre for Bioeconomy**, interoperability is a key requirement.

- **API Support**: The toolkit could provide **RESTful APIs** or **GraphQL endpoints** for seamless data exchange with other systems.
- **Standardized Data Formats:** The platform should support common data formats such as **CSV**, **JSON**, and **XML** to ensure smooth interoperability.
- **Third-Party Service Compatibility**: The toolkit should be designed to integrate with external data sources and analysis tools, including **geospatial data APIs**, **environmental impact databases**, and **bioeconomy-related datasets**.

3.2.7 System Deployment and Hosting Requirements

To ensure a reliable and scalable deployment environment, hosting and infrastructure considerations must be considered.

3.3 Epics and User Stories

To consolidate requirements gathering and supporting a more robust and comprehensive BioINSouth Toolkit development, an Agile approach with **Scenario-based** requirements collection via **Epics** and **User Stories** has been also adopted by INNEN following its consolidated enterprise software development practices. The main Epics are detailed in the following sub-sections.

3.3.1 Epic 0: Common Use for All Users

Stories		
Log-in to the system/toolkit via username/password and 2FA	Access my profile and change data such as: - email/password - name, etc. - 2FA and security options - Application options (e.g. theme if it is available)	Set notification settings for different events based on my profile such as: - I am assigned to a business or project - New updates on KPIs and/or metrics for a I manage / contribute
Reset password or recover account log-in if I lost it or cannot access my account		

3.3.2 Epic 1: User Registration & Authentication

Stories		
Register/subscribe to the system/toolkit	As a stakeholder, I want to create an account and securely log in	I can access personalized features of the toolkit.

Co-funded by the European Union

Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members. under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

Circular Bio-based Europe Joint Undertaking

Bio-based Industries Consortium

Cancel the registration/subscription from the system/toolkit		

3.3.3 Epic 2: Intuitive Dashboard

Stories		
Retrieve key insights via dashboarding	As a user, I want to have a dashboard with an overview of key insights and tools so that I can quickly access the most relevant information	I want to see real-time updates and notifications on the dashboard so that I stay informed about new environmental impact assessments and circular economy insights.

3.3.4 Epic 3: Environmental Impact Assessment

Stories		
Data input & processing	As an industry expert, I want to input data about my bio-based processes so that I can assess their environmental impact.	As a researcher, I want to upload datasets and integrate them with existing models so that I can analyse environmental impact trends.
Impact analysis & reporting	As a stakeholder, I want to generate automated environmental impact reports so that I can understand the sustainability of different production methods	As a policy maker, I want to compare different impact scenarios so that I can make informed regulatory decisions.

3.3.5 Epic 4: Circular Economy Integration

Stories		
Material & Resource Efficiency	As a sustainability expert, I want to analyse material flows and resource efficiency in my production cycle so that I can minimize waste and optimize resource use.	As a business owner, I want to explore alternative bio-based materials so that I can transition towards a circular economy approach.
LCA Tools	As a researcher, I want to use lifecycle assessment (LCA) tools to evaluate the entire lifecycle of a product so that I can assess its overall sustainability.	As a manufacturer, I want to compare different LCA results so that I can choose the most environmentally friendly production method.

3.3.6 Epic 5: Collaboration and Knowledge Sharing

Stories

Co-funded by the European Union

Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members, under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

Community & Expert Forum	As a researcher, I want to participate in forums and discussions so that I can share insights and gain new knowledge.	As a business professional, I want to connect with industry leaders so that I can learn from best practices in sustainability.
Open Data & Case Studies	As a policymaker, I want to access open data and case studies so that I can base my policies on real-world examples.	As a consultant, I want to contribute and share case studies so that I can help others implement effective sustainability strategies.

3.3.7 Epic 6: Admin managing the BioINSouth Toolkit

Stories		
View all businesses, users, and project in the system/toolkit	Manage users: - Add/invite via email - Delete/block - Modify - Bulk add (e.g. email CSV) - Password resets, 2FA, etc.	Assign user roles and permissions e.g. - Visitor - Admin - Service Desk
Assign / manage projects to BioINSouth Toolkit end user		

3.4 Prioritization of Requirements

The MoSCoW prioritization method[10] is a widely used technique for categorizing and managing requirements based on their importance and urgency. This methodology, named after the first letters of its four priority levels—**Must-Have, Should-Have, Could-Have, and Won't-Have**—is particularly useful in project management, software development, and business analysis. By applying MoSCoW, teams can effectively allocate resources, manage stakeholder expectations, and ensure that critical functionalities are delivered on time.

In the context of BioINSouth, we have systematically classified both functional and non-functional requirements based on their impact and necessity. **Must-Have** requirements are critical to the system's functionality and cannot be compromised, such as user authentication, data management, and real-time reporting. **Should-Have** requirements enhance the system's performance and usability but are not mandatory for initial deployment, like external database connectivity and modular architecture. **Could-Have** (or **Nice-to-Have**) requirements, such as multi-language support and multi-factor authentication, provide additional benefits but are not essential for core functionality.

The outcome presented in the table below ensures a structured approach to requirement prioritisation, aligning the project's goals with stakeholder expectations. By distinguishing the must-have functionalities from optional enhancements, the development process remains streamlined, reducing

[10] Dai Clegg and Richard Barker. 1994. *Case Method Fast-Track: A Rad Approach*. Addison-Wesley Longman Publishing Co., Inc., USA.

Co-funded by the European Union
Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members, under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

risks and ensuring a robust, scalable, and user-friendly system. This prioritization framework supports decision-making and ensures a well-balanced allocation of resources throughout the project lifecycle.

	Requirement	Priority	Description
1	User Authentication and Access Control	Must-Have	Secure authentication system with role-based access control (RBAC).
2	Data Management	Must-Have	Users can input and upload datasets in standard formats.
3	External Database Connectivity	Should-Have	Allows real-time access to environmental indicators and conversion factors.
4	Analysis and Computation	Must-Have	Supports different sustainability analysis models.
5	Reporting and Visualization	Must-Have	Users can generate and export graphical reports in multiple formats.
6	Performance & Scalability	Must-Have	Ensures response time under 3 seconds for standard operations.
7	Concurrent User Support	Should-Have	Handles multiple users without performance degradation.
8	Usability & Accessibility	Must-Have	Ensures intuitive UI with accessibility compliance.
9	Security & Data Protection	Must-Have	Implements GDPR compliance and protection .
10	Maintainability & Modifiability	Should-Have	Modular architecture for independent updates.
11	Reliability & Availability	Must-Have	99.9% uptime guarantee with daily backups.
12	Interoperability & Integration	Should-Have	Supports RESTful APIs and standardized data formats.
13	Multi-Language Support	Nice-to-Have	Provides multilingual UI for broader accessibility.
14	Multi-Factor Authentication	Nice-to-Have	Adds an extra layer of security.

Co-funded by the European Union

Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members. under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

4 Technical Constraints and Assumptions

4.1 Hardware and Software Requirements

Based on the user needs analysis, a preliminary BioINSouth Toolkit technical specification document is developed, ensuring alignment with project objectives and technological feasibility. The specifications for such web-based and open-source toolkit cover:

1. **System Architecture:**
    - A scalable (cloud-edge) architecture ensuring high availability and security.
    - Possible implementation of microservices-based backend for modularity and maintainability.
    - A responsive front-end framework for cross-device compatibility.
2. **Data Handling:**
    - Support for structured and unstructured data.
    - Secure storage mechanisms (encryption protocols to be further considered during project implementation).
    - API-driven data access for extensibility.
3. **Analytical Capabilities:**
    - Implementation of data analytics engines for environmental impact calculations.
    - Integration of lifecycle assessment (LCA) methodologies.
    - Support for both qualitative and quantitative output formats.
4. **User Experience (UX) Considerations:**
    - Intuitive user interface with customizable workflows.
    - Interactive tutorials and help sections.
    - Accessible design, adhering to Web Content Accessibility Guidelines (WCAG).
5. **Security and Compliance:**
    - Regular security audits and protection against cyber threats.

4.2 Development, Testing, and Maintenance Strategy

4.2.1 Toolkit Development Approach

The development process follows an agile methodology, ensuring iterative improvements and stakeholder feedback incorporation. The approach consists of:

- **Sprint-Based Development:** Regular iterative cycles for incremental feature deployment.

Co-funded by the European Union

Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members. under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

Circular Bio-based Europe Joint Undertaking

Bio-based Industries Consortium

- **Stakeholder Review:** Periodic feedback sessions to refine functionalities.
- **Version Control:** Utilizing Git repositories for collaborative development and code tracking.
- **Automated Testing:** Implementation of unit, integration, and user acceptance tests to ensure stability.

4.2.2 Testing and Quality Assurance

A robust quality assurance framework is established to validate the toolkit's performance and security:

- **Functional Testing:** Ensures all modules operate as specified.
- **Performance Testing:** Assesses system speed, responsiveness, and scalability under varying loads.
- **Security Testing:** Conducts penetration tests and vulnerability assessments.
- **User Acceptance Testing (UAT):** Engages stakeholders in live environment tests before final deployment.

4.2.3 Deployment and Continuous Maintenance

Upon successful testing, the toolkit is deployed on the project's website, making it accessible to all stakeholders. To ensure long-term usability and adaptability, a comprehensive maintenance plan is established, covering:

- **Regular Updates:** Implementation of feature enhancements based on evolving stakeholder needs.
- **Bug Fixes and Performance Optimization:** Addressing technical issues and refining algorithms.
- **User Support and Documentation:** Providing training materials, FAQs, and user manuals.
- **Security Patching:** Continuous monitoring and security updates to mitigate risks.

4.2.4 Potential Future Enhancements and Project Evolution

The BioINSouth toolkit's architecture allows for future scalability and the incorporation of emerging technological advancements. Potential future developments include:

- **Machine Learning Integration:** Automating pattern recognition and predictive analytics for environmental assessments.
- **Blockchain-Based Data Integrity Mechanisms:** Enhancing transparency and traceability in sustainability reporting.
- **Advanced Interoperability Features:** Facilitating seamless integration with industry-standard sustainability platforms.
- **Extended User Collaboration Features:** Enabling multi-user project workspaces with role-specific functionalities.

Co-funded by the European Union

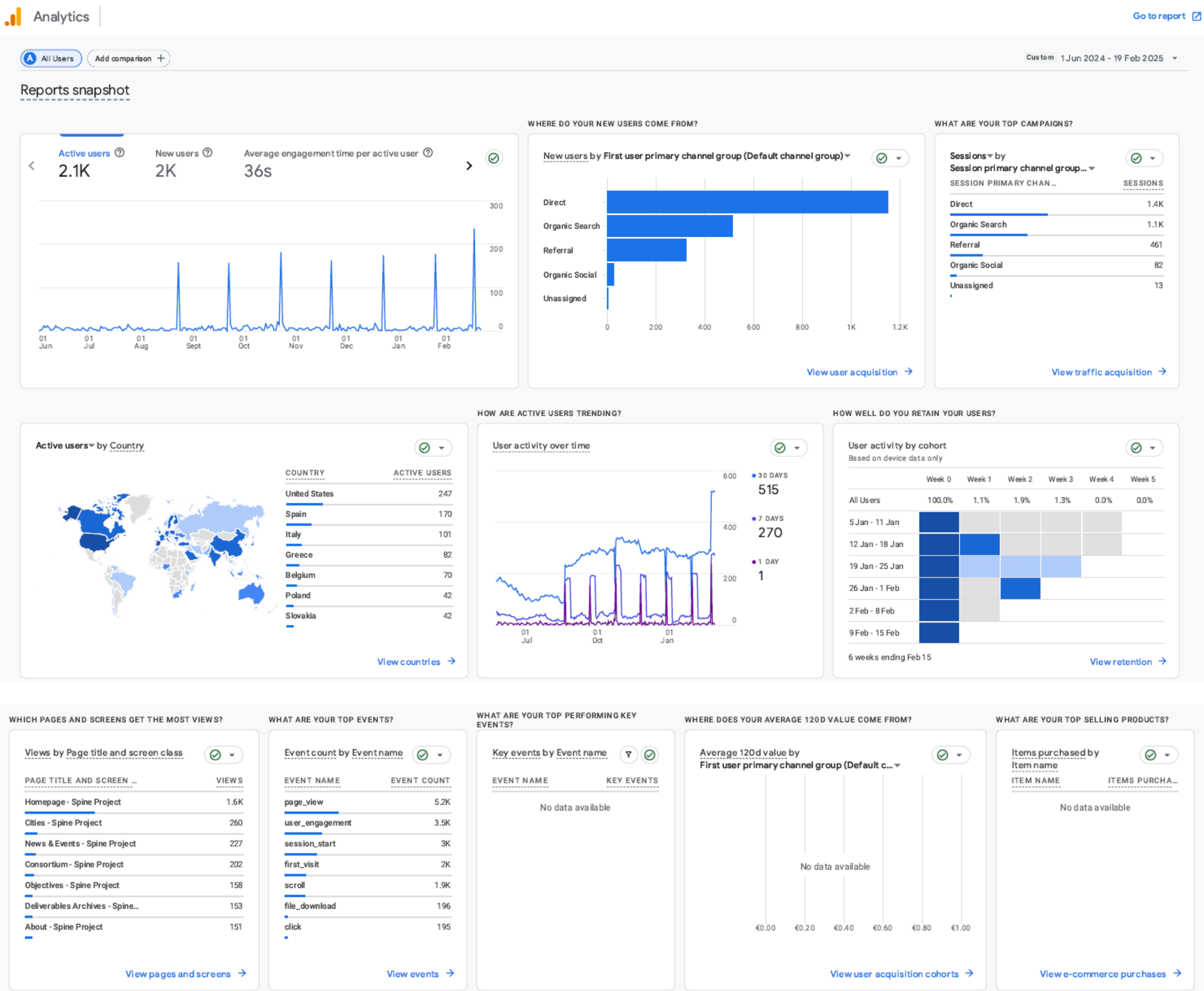
Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members, under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

4.3 BioINSouth Toolkit Analytics

To monitor the level of usage for the web-based BioINSouth Toolkit, **Google Tag Manager (GTM)** and **Google Analytics (GA).** GTM allows to manage and update tracking codes without depending on developers, simplifying the process of tracking clicks, conversions, and user interactions.

Meanwhile, GA is going to be used as primary tool for understanding visitor behaviour, providing insights into user demographics, page views, and engagement. By integrating GTM with GA, INNEN could capture every interaction efficiently.

With these tools, BioINSouth consortium gains a clear picture of BioINSouth Toolkit's performance, making data-driven decisions easier than ever.



Co-funded by the European Union

Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members, under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

5 Conclusions

This deliverable presents a structured roadmap for the development, deployment, and maintenance of a sophisticated and accessible toolkit designed to support bioeconomy stakeholders. Through rigorous requirements gathering, technical analysis, and iterative development, the toolkit will provide a scientifically robust, user-friendly, and scalable solution for environmental sustainability assessment. Its integration into the European Commission's Knowledge Centre for Bioeconomy further enhances its relevance, ensuring long-term impact and accessibility for policymakers, researchers, and industry professionals. The toolkit's evolution will be driven by user feedback, project advancements, and technological innovations, maintaining its effectiveness and adaptability throughout the project's lifecycle.

Co-funded by the European Union

Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members. under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

BioINSouth Info Box

The BioINSouth project aims to support decision-makers to incorporate considerations of ecological limits into their regional bioeconomy strategies and roadmaps relevant to circular bio-based activities. We aim to develop guidelines and digital tools, considering the safe and sustainable by design (SSbD) assessment framework, to support the adoption of innovative methodologies to assess environmental impacts in multiple industrial bio-based systems, increasing regional competitiveness and innovation capacity, and contributing to the EU fair & green transition.

Find out more:

Website: https://www.bioinsouth.eu/
LinkedIn: https://www.linkedin.com/company/104361906/
YouTube: https://www.youtube.com/@BioINSouth
Contact coordinator:
SPRING the Italian Circular Bioeconomy Cluster info@clusterspring.it

Authors: Andrea Cavallaro, Lorenzo Sutton (PNO Innovation Digital), Jessica Frigerio (UNIMIB), Inma Sanchez, Daniel Checa Alias (LEITAT), Pier Francesco Recchi, Francesco Caracciolo di Torchiarolo (UNINA)

Review by: Carla del Cerro Maestre, Marina Barquero (CTA), Ieronymos Zoidakis, Constantinos Vorgias (NKUA), Pierluigi Argoneto, Lara Carlet (SPRING)

This document was published as “D4.6 Toolkit Requirements Analysis”, and as part of the project “BioINSouth: Supporting regional environmental sustainability assessment for the BIO-based sectors to improve INnovation, INdustries and INclusivity in SOUTH Europe” (Grant Agreement No. 101156363), co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

Co-funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members under Grant Agreement No 101156363. Views and opinions expressed are however those of the author(s) only and do not necessarly reflect those of the European Union or the CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.