Farm to fork, Communities Development and Climate Action
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INNOAQUA

PROJECT

Document Title:

D5.1. Socio-economic assessments of INNOAQUA's innovations

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Table of Contents

List of Acronyms

Abbreviation / Acronym	Description
D	Deliverable
EC	European Commission
EPD	Environmental Product declaration
EPS	Expanded Polystyrene
EU	European Union
IMTA	Integrated Multitrophic Aquaculture
KPI	Key performance indicator
LCA	Life Cycle Assessment
LCC	Life Cycle Cost Assessment
LCSA	Life Cycle Sustainability Assessment
M	Month
MS	Milestone
PCR	Product Category Rules
RAS	Recirculating Aquaculture Systems
SLCA	Social Life Cycle Assessment
SDG	Sustainable Development Goal
T	Task
UNEP	United Nations Environment Programme
WP	Work package

List of Tables

List of Figures

Executive Summary

This document, Deliverable 5.1 (D5.1), is the first release at month 18 of the results of Task 5.2 of the INNOAQUA project and describes the approach to be followed within Task 5.2 for the socio-economic impacts assessment of INNOAQUA's innovations throughout the project.

The deliverable begins with detailing the close relationship and interaction between WP5 and WP2, WP3 and WP4. Since the data needed to perform the socio-economic impact assessments are related to raw materials, waste, energy consumption, and system configurations, it will be collected from INNOAQUA value chain processes during: a) technology demonstration and industrialization; b) procedures to obtain extracts from microalgae, macroalgae and fish processing waste, and; c) characterization of ingredients and products formulation.

Subsequently, the deliverable defines the scope of the socio-economic impacts assessments, differentiating the assessment at 2 levels:

- Socio-economic impacts at the project level, and
- Socio-economic impacts at the final seafood products and ingredients level.

Further on, the deliverable describes the methodology to carry out the socio-economic impacts assessment throughout the project. The methodology consists of three phases:

- **Phase 1: Analysis of needs and expectations from stakeholders.** In this phase, identification of stakeholders is carried out, followed by an analysis of stakeholders' needs and expectations related to sustainability and circularity assessments.
- **Phase 2: Socio-economic impact assessment.** Assessment of the socio-economic impacts will be done at two levels:
    - Socio-economic impacts at the project level, and
    - Socio-economic impacts at the final seafood products and ingredients level.

      A value stream mapping of all the processes developed within the project is carried out. The mapping will be needed to assess life cycle costs and social impact of ingredients and products.

- **Phase 3: Alignment to international policies.** At this step, the process for the analysis of the project's contribution to most relevant sustainability-related international policies (such as SDGs, Green Deal and Farm to Fork (F2F) Strategy, and EU Resilience Dashboards) is described.

Since most of the tasks needed to collect data for these assessments are under development, the results of the implementation of the methodology will be compiled and presented in the updated versions of this deliverable i.e., in the Deliverable 5.5 (to be released in M30), and in the Deliverable 5.6 - the final report on socio-economic assessments of INNOAQUA's innovations (to be released in M48).

1. Introduction

The INNOAQUA project – Innovative approaches for an integrated use of algae in sustainable aquaculture practices and high-value food applications – aims to pave the path towards the upcoming sustainable and diversified EU in-land aquaculture industry by leaning on the demonstration and mainstreaming of innovative algae-based foods and solutions, using ecology, circularity and digitalization approaches.

When global food systems are challenged by expected population growth, resource impoverishment and other environmental constraints, seafood was identified as a vital source of food and a key component of a healthy diet. Decades of unsustainable overfishing practices have been depleting aquatic ecosystems. Currently, because nearly one-fifth of all animal protein consumed by humans comes from seafood (FAO, see reference [1]), aquaculture has gained traction over wild fisheries. To ensure the future viability of the aquaculture sector and to unlock its potential to provide food with a lower carbon footprint (as stated in the Farm to Fork (F2F) Strategy of the European Green Deal, see reference [2]), it is imperative to improve current technologies and management strategies, incorporating circular economy principles, optimising resources, reducing the operational costs, and minimising the environmental footprint. In this sense, algae (both microalgae and seaweed) have much potential, both for improving the sustainability of the production processes and as a direct food source to increase the seafood offer to consumers.

Within this context, INNOAQUA proposes an ambitious and efficient R&I workplan to develop and mainstream several solutions for the aquaculture industry involving the use of algae. Relying on a multidisciplinary consortium of renowned research centres, associations and companies with high industrial presence (11 companies) it is:

(i) Demonstrating the feasibility and benefits of multi-trophic in-land cultivation management practices (i.e. RAS and IMTA) enhanced by the use of the latest digital technologies.

(ii) Contributing to the improvement of the sustainability and competitiveness of already-established value chains through the implementation of circular economy principles to minimise waste production in cultivation and processing facilities.

(iii) Extracting high-added value ingredients from algae biomass and fish by-products to be used in the formulation of innovative seafood products, focusing from the beginning on social innovation approaches aimed at improving their societal acceptance and market penetration.

All this, enhanced by a robust outreaching strategy aimed at fostering knowledge transfer through an active engagement of relevant European and international actors, ultimately helping to maximize the project's scope and impact.

1.1. Purpose of the document

One of the goals of the INNOAQUA project is to demonstrate its contribution to the improvement of the sustainability and competitiveness of already-established value chains through the implementation of circular economy principles to minimise waste production in cultivation and processing facilities. To achieve this, it is fundamental to evaluate the sustainability and circularity performance of the products and ingredients to be developed within the project.

WP5 main goal is to evaluate the sustainability performance (environmental, economic and social), circularity, and to perform regulatory and safety assessments of the proposed technologies, innovations and products developed within the project.

In this context, Task 5.2 goal is to carry out the assessment of the socio-economic impacts at two different levels, aiming to assess a) social and economic impacts resulting from INNOAQUA innovations and developments as a project and b) social and economic impacts from the ingredients and products to be developed within the project, where:

- the economic assessment will be developed following the Life Cycle Cost (LCC) assessment technique, considering all the costs throughout the life cycle of the ingredients and products.

- the social impact assessment (SLCA) will be performed according to recognised references, such as the Guidelines for Social Life Cycle Assessment of Products and Organizations (see reference [4]).

Results from economic (LCC) and social (SLCA) impact assessments of the life cycle of the products and ingredients will be an input to Task 5.3 for the sustainability - circularity assessment of the ingredients and products developed within the INNOAQUA project. The results will also be reported and updated throughout the project in deliverables D5.1 (M18), D5.5 (M30) and D5.6 (M48), assuming that the development of the ingredients and products is progressing as originally planned.

1.2. Structure of the document

This document is divided into 5 sections:

This section (i.e., **Section 1**) serves as an introduction to the project and WP5, a description of the purpose of the document and a map of interactions of WP5 activities and deliverables with WP2, WP3 and WP4 work packages.

Section 2 summarises the state-of-the-art review of regulations, standards, methodologies and tools related to sustainability – circularity assessment of food ingredients and products.

Section 3 defines the scope of the socio-economic impacts assessment both at a) the project level and at b) the ingredients and products level.

Section 4 describes the methodology for the assessment of socio-economic impacts. It includes the analysis of stakeholder needs and expectations related to sustainability and circularity and the analysis of alignment and contribution of the project to most relevant international policies related to sustainability.

Finally, **Section 5** will present the results obtained from the application of the methodology described in Section 4 in updated versions of this deliverable (D5.5 and D5.6).

1.3. Relation to other project deliverables

Task 5.1 of the project defined the goal and scope for the socio-economic impacts and sustainability – circularity assessments of the ingredients and products to be developed within INNOAQUA project, to be performed within Work Package 5 activities Task 5.2 and Task 5.3.

The goal of the assessments was defined as:

- Task 5.2 will carry out the assessment of the socio-economic impacts of the products and ingredients to be developed within the project, developing a LCC and a SLCA of ingredients and products
- Task 5.3 will carry out a sustainability - circularity assessment of the products and ingredients to be developed within INNOAQUA project, developing an LCA of ingredients and products and then combining economic, social and environmental impacts assessments to carry out sustainability – circularity assessment of ingredients and products.

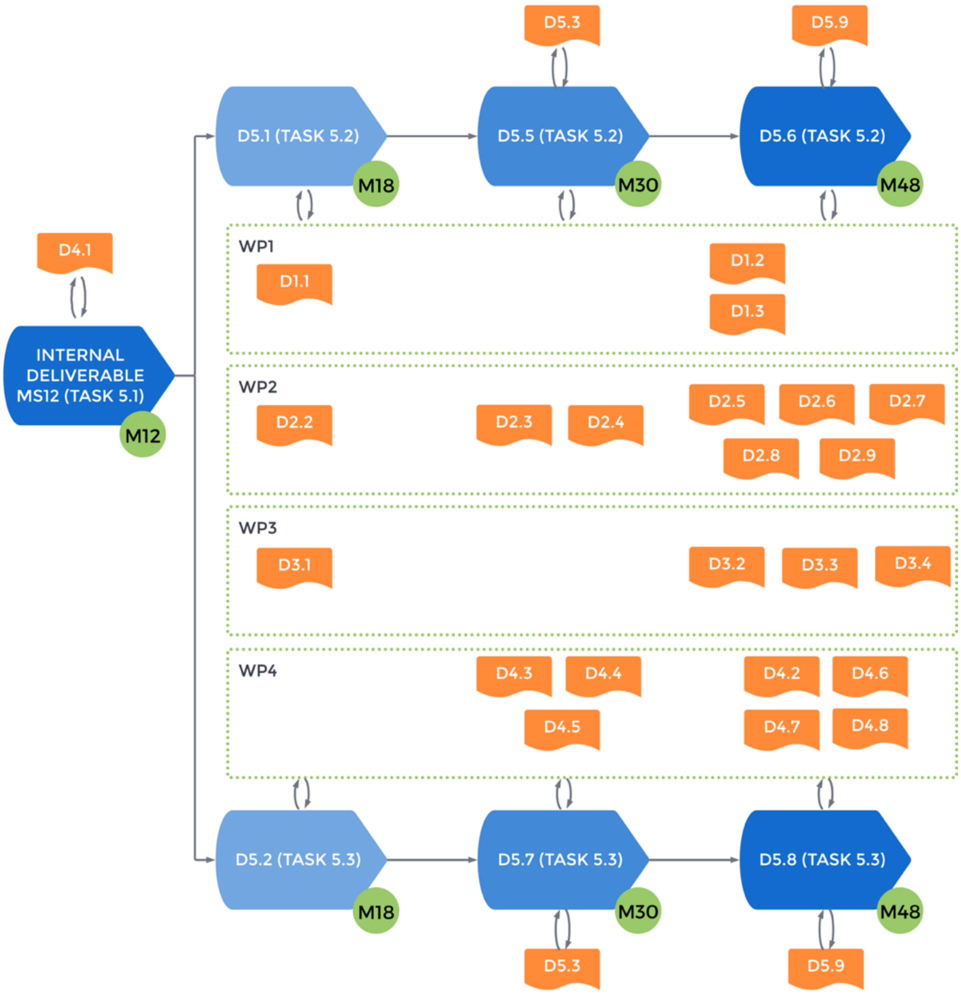
As a result of state-of-the-art review performed and following main references and most relevant projects related to INNOAQUA, goal of socio-economic impact assessments will be expanded, as described in Section 1.1, to:

- Socio-economic impacts at a project level on the different project stakeholders
- Socio-economic impacts at ingredients and products level

The scope of the socio-economic impacts and sustainability-circularity assessments was adjusted according to D4.1, where the ingredients and products to be developed have been identified and the number of prototypes at the kitchen stage have been defined. Scope of life-cycle assessments at ingredients and products level is described in Section 3.2.

Tasks T5.2 and T5.3 are planned to produce two deliverables in M18 (D5.1 and D5.2) and update them in M30 (D5.5, D5.7) and again in M48 (D5.6, D5.8). The scheduling of deliverables is aligned with the progress on WP2, WP3 and WP4. Legal analysis to be performed within T5.4 (reported in D5.3 and updated in D5.9 with the development of the different products) will be considered to reflect the latest legislation trends, standards and industry recommendations for the socio-economic and sustainability – circularity assessments.

Figure 1 shows the overview of relations of WP5 activities and deliverables to other INNOAQUA deliverables throughout the development of the project (from M1 to M48).



D1.1. From Product To Market Co-Creation: methodological guidelines.
D1.2. Co-creation & increased acceptance of innovative seafoods: testing the FPTM C-C
D1.3. From Product To Market Co Creation: methodological guidelines - lessons learned
D2.2. Integration salmon and microalgae cultivation in a coupled RAS-IMTA system
D2.3. Integration sole and seaweed cultivation in a coupled RAS-IMTA system
D2.4. Digital solutions for aquaculture production systems
D2.5. Sludge valorisation procedures for integrated aquaculture production systems
D2.6. Integration salmon and microalgae cultivation in a coupled RAS-IMTA system (update)
D2.7. Integration salmon and microalgae cultivation in a coupled RAS-IMTA system (final update)
D2.8. Integration sole and seaweed cultivation in a coupled RAS-IMTA system (update)
D2.9. Digital solutions for aquaculture production systems (update)
D3.1. Characterisation results of algae biomass and fish/seafood processing waste
D3.2. Procedure for the obtention of extracts from microalgae biomass in a cascading approach
D3.3. Procedure for the obtention of extracts from seaweed biomass in a cascading approach
D3.4.Report on production of bioactive extracts from fish processing waste.
D4.1. Initial report on product prototypes specifications
D4.2. Report on ingredient products technical properties, stability, safety and potential improvements.
D4.3. Report on preliminary seafood product formulation
D4.4. Report on characterisation of algae-based ingredients for packaging
D4.5. Updated report on product prototypes specifications
D4.6. Final report on product prototypes specifications
D4.7. Final report on seafood production formulation
D4.8. Final report on algae based ingredients for packaging
D5.3. Report on the legal analysis
D5.9. Updated report on the legal analysis

Figure 1. Relation of WP5 activities and deliverables to other INNOAQUA deliverables

T5.2 and T5.3 have a close relationship with WP1 regarding the identification of stakeholders and the compilation of their needs and expectations.

Related to WP2 activities, T5.2 and T5.3 will collect all the data needed related to raw materials, species, system configuration, etc. to perform the assessments resulting from the development of the demo sites in D2.2, D2.3, D2.5, D2.6, D2.7 and D2.8. Identification of relevant KPIs from sustainability and circularity perspectives to be carried out within T5.2 and T5.3 on the kitchen development stage will be provided for the development of digital solutions to increase biomass production (D2.4, D2.9).

In relation to WP3 activities, the characterization results of algae biomass and fish/seafood processing waste (D3.1) and the procedures for the obtention of extracts from microalgae, seaweed biomass and fish processing waste (D3.2, D3.3 and D3.4) will be fundamental input for the development of T5.2 and T5.3 all along the project.

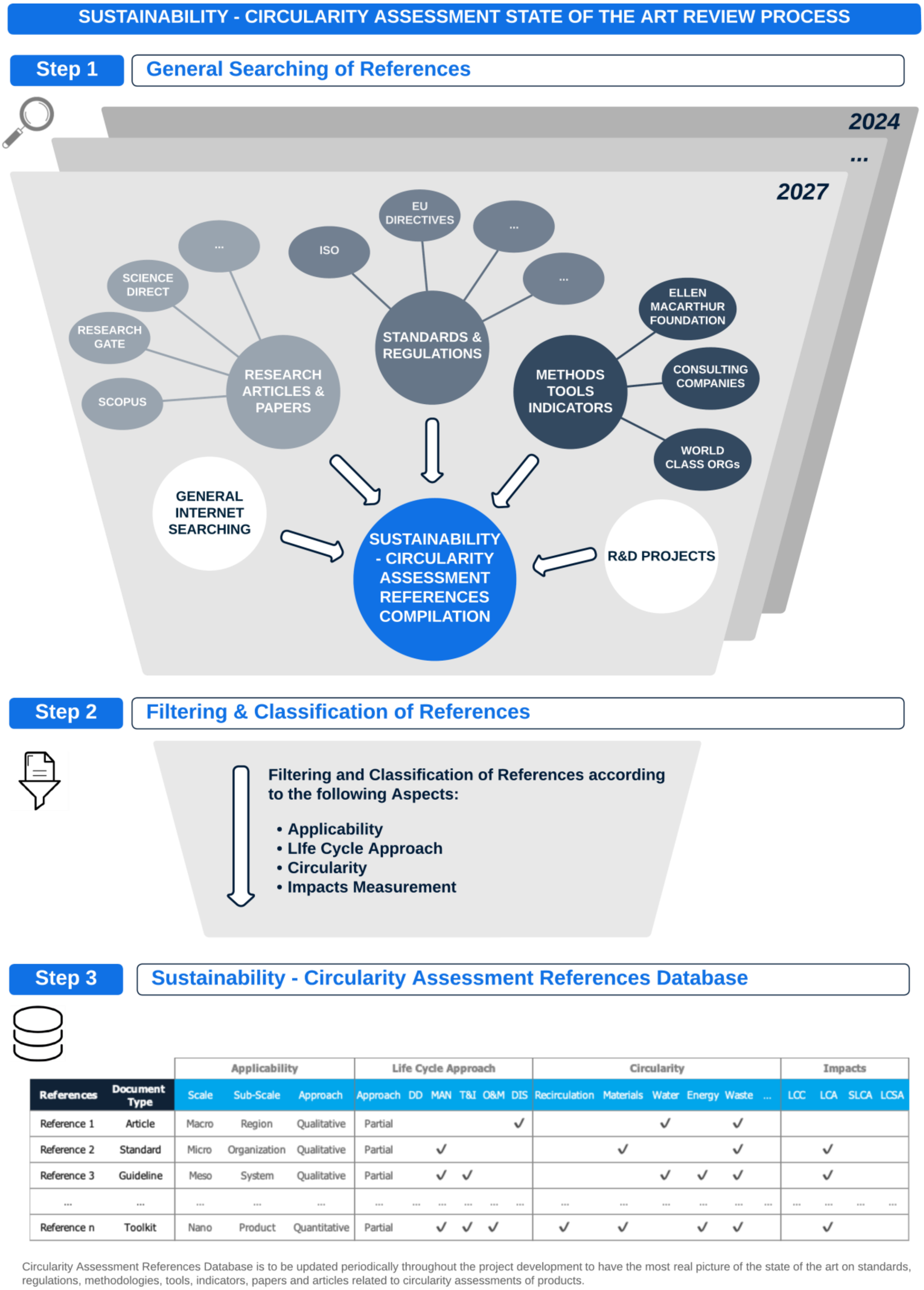
Finally, related to WP4, results from the activities to define the ingredients and products (D4.1, D4.5 and D4.6) the ingredients' technical properties (D4.2), seafood products formulation (D4.3, D4.7) and ingredients for packaging (D4.4, D4.8), will be also a key input for the development of T5.2 and T5.3 throughout the project.

Results from economic (LCC) and social impact (SLCA) assessments of the life cycle of ingredients and products to be obtained from Task 5.2 (and reported in deliverable D5.1) at ingredient and product levels will be an input to Task 5.3 (and deliverable D5.2) for the sustainability - circularity assessment of the ingredients and products developed within INNOAQUA project. It is described more in detail within section 4.2.

2. State-of-the-art review

To ensure that the sustainability and circularity assessments to be conducted in T5.2 and T5.3 are aligned with the latest developments, a comprehensive state-of-the-art review process will be carried out all along the project. This process will regularly evaluate regulations, standards, methodologies, and tools related to the sustainability and circularity assessment of food ingredients and products throughout the project's duration.

See the process overview in the following figure.



		Applicability			Life Cycle Approach						Circularity						Impacts			
References	Document Type	Scale	Sub-Scale	Approach	Approach	DD	MAN	T&I	O&M	DIS	Recirculation	Materials	Water	Energy	Waste	...	LCC	LCA	SLCA	LCSA
Reference 1	Article	Macro	Region	Qualitative	Partial					✓			✓		✓					
Reference 2	Standard	Micro	Organization	Qualitative	Partial		✓					✓			✓			✓		
Reference 3	Guideline	Meso	System	Qualitative	Partial		✓	✓					✓	✓	✓			✓		
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Reference n	Toolkit	Nano	Product	Quantitative	Partial		✓	✓	✓		✓	✓		✓	✓			✓		

Figure 2. Overview of sustainability - circularity assessment state of the art review process

Step 1: General Searching of References

The aim of step 1 is to do a general searching of references related to perform circularity and sustainability assessments of different scopes, such as products, components, etc. Searching is focused on the following sources:

- General internet searching

  Initially, the general searching has been done through the keyword "circular economy" in combination with "assessment", "methodology", "indicator" and "tool".

  As a starting point, the related documents and fundamental references derived from the circular economy plans and the European Green Deal from European Commission will be analyzed.

- Research articles and papers

  A general literature review of research articles and papers with the same combination of keywords described above has been conducted using mainly academic literature databases, such as:

  - Scopus database, from Elsevier (reference [5])
  - Researchgate (reference [6])
  - ScienceDirect (reference [7])
  - Web of science (reference [8])
  - Wiley online library (reference [9])

- Standards and regulations

  As the transition towards the Circular Economy is progressing, standards and regulation are being developed to guide and help implementing its principles in countries, regions and organizations. So, a specific search has been conducted, mainly focused on international and national standardization, certification and regulation bodies, such as ISO, EN, AFNOR, AENOR, BSI and UL.

- Guidelines, methodologies and tools

  A particular searching for specific methodologies, tools and indicators related to the implementation of circular economy has been done on worldwide circular economy reference organizations, such as Ellen Macarthur Foundation, specialized top consulting companies and world class organizations working and promoting sustainability.

- <u>R&D Projects</u>

  The most relevant R&D projects related to the development of novel food and algae based products are analyzed in terms of the sustainability and circularity approach.

Step 2: Filtering & Classification of References

Aim of this step is to review, filter and classify all the references collected from the different information sources according to the following aspects:

- Applicability
- Life Cycle Approach
- Impacts Measurement
- Circularity

These aspects have been defined to evaluate the different Sustainability - Circularity Assessment references found.

Step 3: Sustainability - Circularity Assessment References Database

At this step, all the references found are listed and organized in the Sustainability - Circularity Assessment References Database, which gives a practical overview of their applicability to INNOAQUA project, giving advantages and drawbacks and extracting the main concepts to be applicable to perform the socio-economic and sustainability – circularity assessments to be conducted in Task 5.2 and Task 5.3.

Since there are a lot of initiatives running and a lot of researching about circular economy implementation, General Searching of References (Step1) will be repeated all along the INNOAQUA project development (from 2024 to 2027, as showed in Figure 2).

A state-of-the-art review tool (reference [10]) has been developed and will be updated periodically throughout the project. It will monitor the regulations, standards, methodologies and tools related to sustainability – circularity assessment of food ingredients and products in general and INNOAQUA project related ingredients and products in particular.

See an overview of the contents of the state-of-the-art tool in the following figure.

INNOAQUA	**SUSTAINABILITY - CIRCULARITY ASSESSMENT STATE OF THE ART REVIEW**	Version:	Draft
		Date:	19/5/2024
		Developed by:	Sustainn

1 Sustainability - Circularity Assessment References

It contains the most relevant references related to circularity assessment of regions, organizations, products, services, etc. References are sorted out in different categories, such as regulations, standards, guidelines & methodologies and reports, articles and papers.

2 Environmental Impacts Substitute Products References

It contains the most relevant references of environmental impacts (carbon footprint, EPD, LCA) of product and ingredients that INNOAQUA Project is aiming to substitute

3 Standards summary

It compiles the most relevant standards related to circularity assessment of products with a brief identification of the main aspects potentially applicable to INNOAQUA Project.

4 Guidelines & methodologies summary

It compiles the most relevant guidelines and methodologies related to circularity assessment of products with a brief identification of the main aspects potentially applicable to INNOAQUA Project.

5 Reports, articles and papers summary

It compiles the most relevant reports, articles and papers related to circularity assessment of products with a brief identification of the main aspects potentially applicable to INNOAQUA Project.

Figure 3. Index of contents of Sustainability - Circularity Assessment State-of-the-art Review Tool

Main conclusions extracted from state of the art review analysis conducted until now are:

- No methodology or reference developed ad hoc has been found at this moment to carry out a sustainability - circularity assessment of algae-based products and applications. However, a lot of relevant aspects can be used to develop an specific methodology and tools to perform it combining circularity and sustainability assessments, considering LCC, LCA and SLCA approaches.
- No specific regulations have been developed yet to perform circularity assessment of products.
- Regarding life cycle approach, most of the methodologies, tools, metrics and indicators are considering some particular phases of the life cycle of a product or service, but very few are considering the full life cycle.
- A remarkable effort is being done around the world to develop standards, guidelines and methodologies to assess circularity of territories, cities, organizations, products and components. Remarkably, ISO 59000 series on circular economy have been released to help measure circularity of organizations and products. Regarding standards, guidelines, methodologies, tools, reports, articles and papers, main conclusions are:

- The 3 dimensions of sustainable development (economical, environmental and social) are to be considered to analyze circularity and sustainability, according to some standards (XP X30-901) and methodologies (LCSA approach from Orienting project). Environmental impact, cost impact and social impact can be measured and developed through LCA, LCC and SLCA indicators.
- LCSA (Life Cycle Sustainability Assessment) is increasingly accepted as an assessment method to support decision making on sustainability of alternative solutions of a product.
- LCSA approach is taken as the basis for the development of a methodology to assess sustainability of a product combining environmental LCA, social LCA and life cycle costing (LCSA = LCA + S-LCA + LCC) and integrating circularity assessment.

- A key insight from the review of the related R& D projects is that socio-economic impacts assessment should be conducted not only at the products or technologies level, but also at the project level, evaluating the social and economic impacts of the project development on various stakeholders.

3. Scope of the socio-economic impacts assessment

Following the main references and most relevant projects related to INNOAQUA, and aiming to assess social and economic benefits and impacts resulting from INNOAQUA innovations and developments as a project and social and economic benefits from the specific ingredients and products to be developed within the project, Task 5.2 goal is to carry out the assessment of the socio-economic impacts at two different levels:

- Socio-economic impacts at a project level on the different project stakeholders, and
- Socio-economic impacts at ingredients and products level.

The detailed scope for both levels is outlined in the following chapters.

3.1. Project level

Project Approach – From Technology to Market

INNOAQUA project is focused on the technology development, demonstration and mainstreaming of the ingredients, products and packaging solutions, described in Section 3.2.

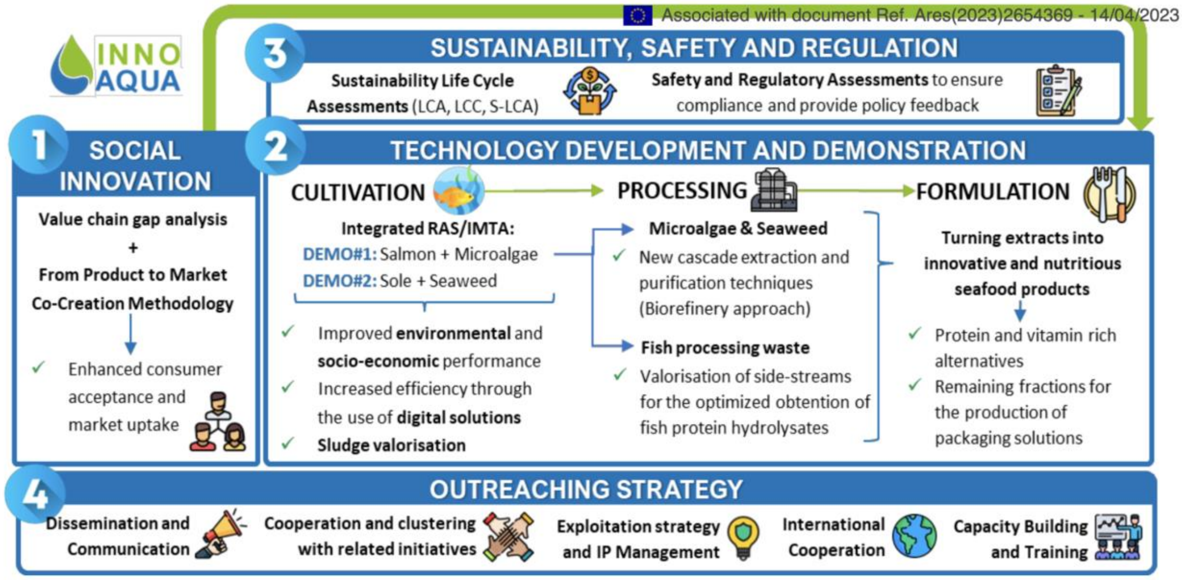


Figure 4. INNOAQUA project overall concept

Two different phases related to the maturity of the validated and demonstrated technologies should be distinguished:

- technology development validation for the integrated cultivation of algae at two demo sites, development of the cascade extraction processes at laboratory scale and formulation of the seafood products and packaging solutions at kitchen scale, and
- industrialization of the ingredients, products and packaging solutions.

Commercialization and serial production of the ingredients and products is outside the scope of the project.

INNOAQUA Processes Value Chain

One of the goals of the INNOAQUA project is to demonstrate processing methods to obtain to obtain algae-based ingredients and fish protein hydrolysates, to be formulated into innovative seafood products and packaging solutions. These components possess numerous benefits for high-added-value food applications widely sought after in the current market, especially as low-carbon protein-rich alternative sources. Thus, to achieve this goal, INNOAQUA partners expect to extract high-added value ingredients from algae biomass, as well as from fish by-products, to later use them in the formulation of different innovative seafood products and packaging solutions. This process will be a multi-stage chain, starting from the algae and fish by-products biomass, and ending with the different seafood and packaging products (see Figure 5). The whole chain will be subsequently upscaled, starting with laboratory/kitchen tests and ending with the industrial production of the final food products. Some of them will be packed inside trays developed within the process.

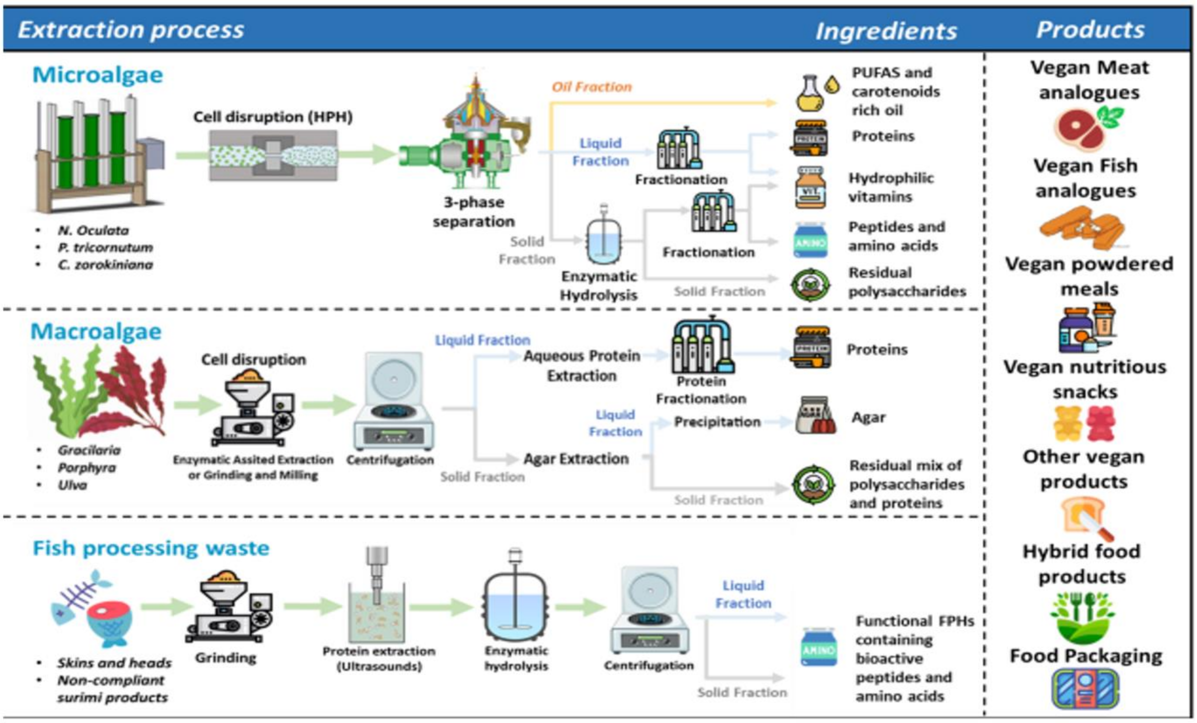


Figure 5. Overview of the INNOAQUA project multi-stage process

Scope of Socio-Economic Impacts Assessments at Project Level

The assessment of socio-economic impacts at the project level will focus then on the entire INNOAQUA processes value chain. This analysis will involve understanding the needs and expectations of stakeholders regarding the social and economic benefits and drawbacks associated with the development and outcomes of the project.

Therefore, socio-economic impacts assessment at a project level will take into account:

- From technology to market approach, considering all the project development phases and subsequent commercialization of ingredients and products, since there will be different stakeholders that could affect the project or be impacted by the project;
- Impacts derived from the entire INNOAQUA value chain, considering all the phases starting from as cultivation, extraction and ending with the different seafood and packaging products.

3.2. Ingredients and products level

Ingredients and Products to be developed

Resulting from the proposed INNOAQUA processes value chain, a list of seafood ingredients and products and packaging solutions to develop has been approved within WP4 and described in D4.1 (reference [20]).

Products were allocated into the following product categories: vegan meat analogues, vegan fish analogues, vegan powdered meals, vegan snacks, other vegan products, hybrid products and packaging solutions. The technology development process was approved for a total of 21 prototypes until the kitchen-scale stage, while at least 14 of them (12 seafood products and 2 packaging solutions) will be finally industrialized.

Table 1 shows the approved list of product prototypes, their product category and the assigned partner in charge of the development.

Table 1. Approved list of the seafood and packaging prototypes to be produced

Product Prototypes		
Product category	**Product**	**Producer**
Vegan meat analogues	Vegan Sausages	VIVA MARIS
	Vegan Nuggets	LEITAT
Vegan fish analogues	Vegan Surimi	PESCANOVA
	Vegan fillets	PESCANOVA
	Vegan burgers	PESCANOVA
	Vegan battered/breaded fish portions	PESCANOVA
Vegan powdered meals	Shakes	ALGEMY
	Breakfast bowls	ALGEMY
	Soups	ALGEMY
Vegan snacks	Cookies	ALGEMY
	Gummy bears	ALGEMY/LEITAT
	Energy bars	ALGEMY
	Energy balls	ALGEMY
Other vegan products	Vegan Shots	VIVA MARIS
	Bread spreads	VIVA MARIS
Hybrid products	Fish & algae fillets	PESCANOVA
	Hybrid sausages	VIVA MARIS
	Hybrid nuggets	LEITAT
	Hybrid bread spreads	VIVA MARIS
Biodegradable packaging	Lidding films	ERANOVA
	Trays	ERANOVA

For the formulation of each of the seafood prototypes (T4.3) and packaging solutions (T4.4), one or more than one ingredient obtained from algae (microalgae or macroalgae) produced as part of WP2 or fish by-products will be used. These ingredients will be produced as part of WP3 after being subjected to different cascade extraction protocols and characterized in T4.2. A total of 5 different ingredients obtained from 3 different species of microalgae will be produced, as well as 3 different ingredients obtained from 3 different species of seaweed, and 1 ingredient obtained from a fish by-product (either non-compliant surimi sticks or fish skins and heads from salmon).

Finally, microalgae and macroalgae residual fraction will be used to obtain plastic resin.

Table 2 shows the list of ingredients to be obtained.

Table 2. Approved list of the different ingredients to be produced

Ingredients		
Biomass of origin	**Ingredient**	**Partner in charge**
Microalgae (NORCE): - *Chlorella sorokinina* - *Phaeodactylum trycornutum* - *Nannochloropsis oculata*	Microalgae protein	ALGEMY
	Microalgae PUFA's and carotenoids rich oil	ALGEMY
	Microalgae hydrophilic vitamins	ALGEMY
	Microalgae peptides and AA's	ALGEMY/LEITAT
	Microalgae residual fraction	ALGEMY/LEITAT
Macroalgae (A4F): - *Ulva* - *Porphyra* - *Gracilaria*	Macroalgae Proteins	A4F
	Macroalgae Agar	A4F
	Macroalgae Residual fraction	A4F
Fish waste: -Fish skins and heads from salmon (VIKINGAQUA) -Non-compliant surimi sticks (PESCANOVA)	Functional Fish protein Hydrolysates (FPHs)	LEITAT
Microalgae and macroalgae residual fraction	Plastic resin	ERANOVA

Life Cycle Approach

According to the existing international standards (ISO 14040, reference [3]; ISO14067, reference [11]), Product Environmental Footprint Category Rules (PEFCR) used for the Environmental Product Declarations (EPDs), a life cycle approach should be followed to carry out environmental impacts assessment and carbon footprint quantification of products. So, all the life cycle phases of a product should be considered, starting from the conception and development of a product, manufacturing, transportation and installation, operation and maintenance (or consumption) and disposal. The same approach should be followed to perform LCC (life cycle costing) assessment of products, according to IEC 61300-3-3 standard (reference [12]), considering all the costs throughout the life cycle of the products, and to analyze the social impact of products (SLCA), as identified in recognized methodologies (such as UNEP Guidelines for Social Life Cycle Assessment of Products). Moreover, the sustainability performance of the products and ingredients will be assessed in Task 5.3 following the LCSA (Life Cycle Sustainability Assessment) approach according to the latest state-of-the-art references and developments (i.e.: ORIENTING Project, reference [13]). Circularity assessment of products will complement sustainability assessment following the ISO59000 series with a life cycle approach.

Scope of Socio-Economic Impacts Assessments at Ingredients and Products Level

Considering all the aspects described previously, such as:

- INNOAQUA project approach “From technology to market”
- INNOAQUA project cascade extraction process,
- ingredients and products to be developed within the project, and
- life cycle approach.

Scope of the socio-economic impacts assessment at ingredients and products level is showed in the following figure and explained below.

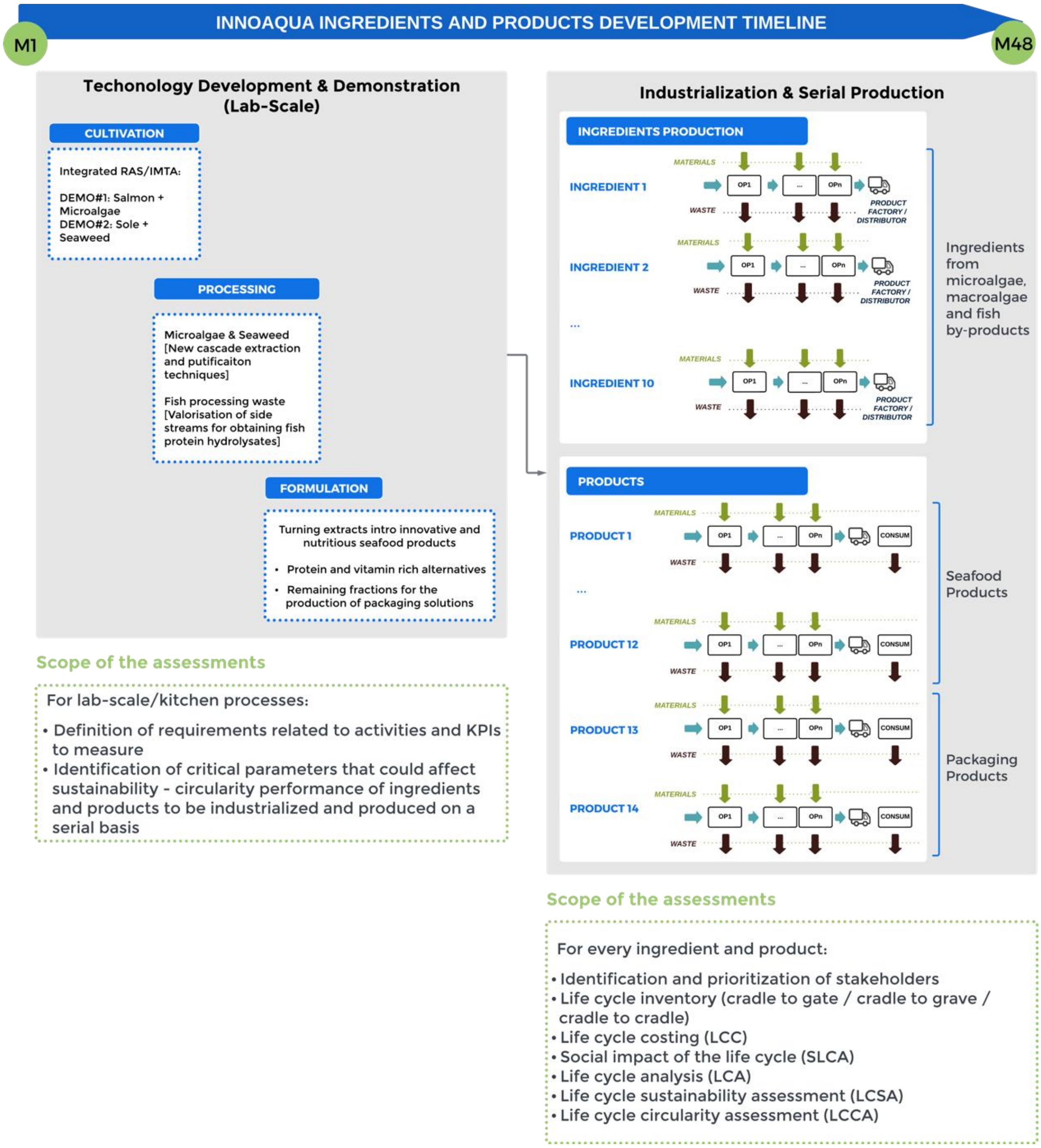


Figure 6. Scope overview of socio-economic impacts assessment and sustainability – circularity assessment of ingredients and products

Within the **industrialization and serial production phase**, socio-economic impact assessment will be focused on the life cycle of 10 ingredients and at least 14 products identified in WP4.

4. Methodology for the socio-economic impacts assessment

Aim of the methodology is to guide assessing social and economic impacts of the INNOAQUA project innovations and developments, both at project level and at ingredients and products level.

The methodology for assessing the socio-economic impacts of the INNOAQUA project innovations contains 3 different phases:

- **Phase 1: Analysis of stakeholders' needs and expectations.** In this phase, identification and prioritization of stakeholders is initially performed. Analysis of needs and expectations related to sustainability and circularity assessments will be collected and analysed.
- **Phase 2: Socio-economic impact assessment.** Assessment of the socio-economic impacts will be done at 2 different levels:
    - Socio-economic impacts at a project level;
    - Socio-economic impacts at products and ingredients level.

      A value stream mapping of all the processes developed within the project, needed to assess life cycle costing and social impact of ingredients and products, is carried out.

      As indicated in Figure 7, results from social impact assessment and cost assessment throughout products and ingredients life cycle will be an input for the life cycle sustainability and circularity assessment, to be performed within Task 5.3 and reported in Deliverable 5.2.
- **Phase 3: Alignment to international policies.** At this step, the process for the analysis of the project contribution to most relevant sustainability-related international policies (incl. SDGs, Green Deal and Farm to Fork (F2F) Strategy, EU Resilience Dashboards) is described.

Figure 7 shows an overview of the methodology, phases and main activities to carry out.

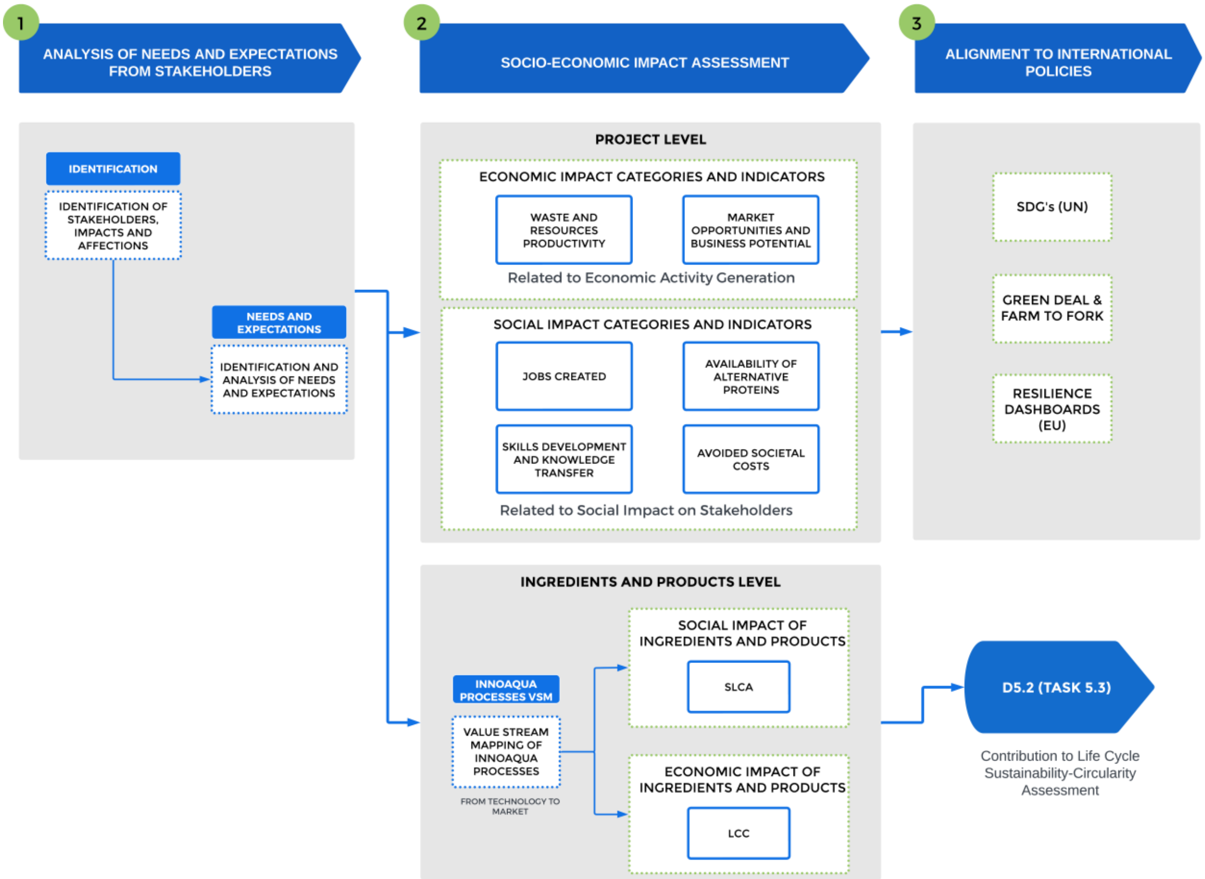


Figure 7. Overview of methodology for the socio-economic impacts assessment

These phases and activities are described in detail in the next sections.

4.1. Stakeholders' analysis

Aim of this phase is to analyze the needs and expectations of the different stakeholders of INNOAQUA project related to social and economic impacts, as well as to sustainability and circularity issues.

4.1.1. Identification of stakeholders

A first identification of the main external stakeholders has been carried within INNOAQUA Deliverable D1.1 (see reference [14]).

Table 3 shows the stakeholders involved in the development, production, distribution, and consumption of innovative seafood products.

Table 3. INNOAQUA key stakeholders

Stakeholder	Description
Seafood Producers/Aquaculturists	Those involved in fishery management, aquaculture, and harvesting of seafood, including fishermen, aquaculture farmers, and seafood suppliers.
Food Manufacturers and Processors	Companies involved in processing, packaging, and manufacturing seafood products, applying innovative techniques to create value-added products.
Regulatory Bodies and Government Agencies	Entities responsible for setting food safety standards, regulations, and policies that impact the development and distribution of seafood products.
Retailers and Distributors	Supermarkets, grocery stores, wholesalers, and distributors involved in selling and distributing innovative seafood products to consumers.
Consumers	Those who purchase and consume seafood products, influencing demand and preferences for innovative products through their choices.
Restaurants and Food Service Providers	Chefs, restaurants, catering services, and foodservice establishments that incorporate innovative seafood dishes into their menus, often driving consumer trends.
Investors and Financial Institutions	Individuals or organizations providing funding, support, or investments for research, development, or commercialization of innovative seafood products.
Environmental and Conservation Groups	Organizations advocating for sustainable fishing practices, responsible aquaculture, and the conservation of marine ecosystems, influencing the direction of innovation towards sustainability.
Supply Chain Partners	Logistics companies, transportation providers, and other intermediaries involved in the efficient movement of seafood products from producers to consumers, impacting distribution and availability.
Scientific Community & Academia	Food scientists and researchers, all experts and individuals conducting research on seafood products, exploring new technologies, ingredients, and processes to create innovative seafood offerings. Innovators who are looking for the knowledge transfer, teaching facilitators and adapters of academic curricula.

4.1.2. Analysis of needs and expectations from stakeholders

In the coming months, needs and expectations of the INNOAQUA key stakeholders related to sustainability and circularity issues will be identified and analysed in order to define the key messages and indicators that the INNOAQUA project should report on concerning its social and economic impacts.

For the specific case of consumers, WP5 will work in close collaboration with WP1 in order to know if consumers could demand any specific information or indicators regarding sustainability and circularity. WP1 is working on the social acceptance of algae-based products to understand how consumer perceptions and social norms influence the consumption of innovative seafood products. In T1.3 empirical data collection will be carried out to gather information about stakeholder perceptions and preferences.

4.2. Socio - economic impact assessment

4.2.1. Project level

According to the organization of tasks and deliverables within the project, the assessment of sustainability impacts at the project level is organized into two distinct tasks as follows:

- Task 5.2 will evaluate the social and economic dimensions of sustainability.
- Task 5.3 will assess the environmental dimension of sustainability.

Quantification of the indicators values, both for economic and social impacts, will be performed in the next months and reported in the updated version of this deliverable (Deliverable 5.5), to be released in month 30 (M30).

4.2.1.1. Economic impacts assessment

As shown in Figure 7, the economic impact at a project level will be evaluated in the following economic impact categories:

- Waste and resources productivity
- Market opportunities and business potential

4.2.1.1.1. Waste and resources productivity

Aligned with EU Taxonomy objectives 3 and 4[1] (see reference [21]), this impact category will evaluate the economic impact of the project derived from:

- Water productivity and recirculation, and
- Zero waste approach, covering minimization of waste generated, waste recirculation and value generated from the use of waste and by-products

The indicators related to water and the zero-waste approach will be converted into economic productivity indicators, estimating the amount of economic production (in euros) or the added value generated by them. Accounting will consider the project development phases and potential impacts that ingredients and products developed within the project could generate once they are eventually commercialized.

4.2.1.1.2. Market opportunities and business potential

This impact category will evaluate the economic impact of the project related to:

- Market Share Potential: Estimation of the portion of the market that the innovation could realistically capture and contribution to target market growth.
- Revenue Potential: Forecasted revenue from the innovations developed within the project over a specified time period.
- Customer Segmentation and Reach: Identifies the customer segments that will benefit most from the innovation, with an emphasis on demographics, geographic regions, and purchasing behaviour.
- Reduced manufacturing costs and increased resource efficiency to produce proteins and functional ingredients, compared to conventional alternatives already on the market.

[1] Objectives of EU Taxonomy:
Objective 3: Sustainable use and protection of water and marine resources
Objective 4: Transition to a circular economy

4.2.1.1. Social impacts assessment

As shown in Figure 7, the social impact at a project level will be evaluated in the following economic impact categories:

- Jobs created,
- Availability of alternative proteins,
- Skill development and knowledge transfer,
- Avoided societal costs.

4.2.1.1.1. Job creation

This impact category will evaluate the social impact of the project related to:

- Estimation of jobs to be created by the project (permanent, R+D, direct, indirect) and the potential jobs to be generated because of the commercialization of ingredients and products and exploitation of key exploitable results. A particularization could be done for activities related to circular economy business models (recycling, upcycling, resource recovery, etc).

4.2.1.1.2. Availability of alternative proteins

This impact category will evaluate the social impact related to the contribution of the project to improve the availability of alternative proteins.

4.2.1.1.3. Skills development and knowledge transfer

This impact category will assess the social effects of the project concerning knowledge transfer and skill development in the field of algae-based ingredients and products. Issues such as training hours, reaching-out, or educational support and materials developed will be identified.

4.2.1.1.4. Avoided societal costs

This impact category will evaluate the avoided societal costs provoked by the project and the potential commercialization of ingredients and products developed within the project, in comparison with conventional alternative products already in the market.

Avoided societal costs can be defined as the avoided losses and expenses, direct and indirect, present and future, borne by the public, ecosystems and future generations due to the reduction of the environmental impacts (mainly carbon footprint).

4.2.2. Ingredients and products level

The aim of this part of the socio-economic impact assessment is to provide evidence of the economic and social benefits and costs of the products and ingredients to be developed within INNOAQUA. Based on the system boundaries established in internal deliverable resulting from Task 5.1 (reference [19]):

- the economic assessment will be developed following the Life Cycle Cost assessment technique (LCC), considering all the costs throughout the life cycle of the products and technologies.
- the social impact assessment (SLCA) will be performed according to recognised references, such as the UNEP Guidelines for Social Life Cycle Assessment of Products and Organizations. Based on the defined framework in T5.1, consistent data will be collected and impacts on human rights, working conditions, governability, health and safety, employment, etc. will be assessed to provide a more comprehensive perspective of the potential benefits and drawbacks of INNOAQUA innovations.

A value stream mapping of all the processes to be developed within the project, which will be needed to assess life cycle costing and social impact of ingredients and products.

4.2.2.1. Value stream mapping

4.2.2.1.1. The value stream mapping concept

As a previous step to the socio-economic impact assessment and subsequent circularity-sustainability assessment of the ingredients and products, all the operations throughout their life cycle are to be mapped. The common life cycle phases to consider, according to ISO 14040 (reference [3]) and IEC 60300-3-3 (reference [12]) are:

Figure 8. Typical life cycle phases of a product

Within each phase, all operations must be mapped to the maximum detail possible, identifying the inputs and outputs in each operation (environmental aspects), showed as arrows in "Operation i" in Figure 9, such as:

- Inputs
    - Consumption of resources (water, energy)
    - Consumption of raw materials
    - Consumption of auxiliary materials
- Outputs
    - Waste, considering its different types (hazardous and non-hazardous waste, scraps, wastewater, etc)
    - Emissions, considering emissions to air as the environmental aspect, if generated (for example in a chimney)

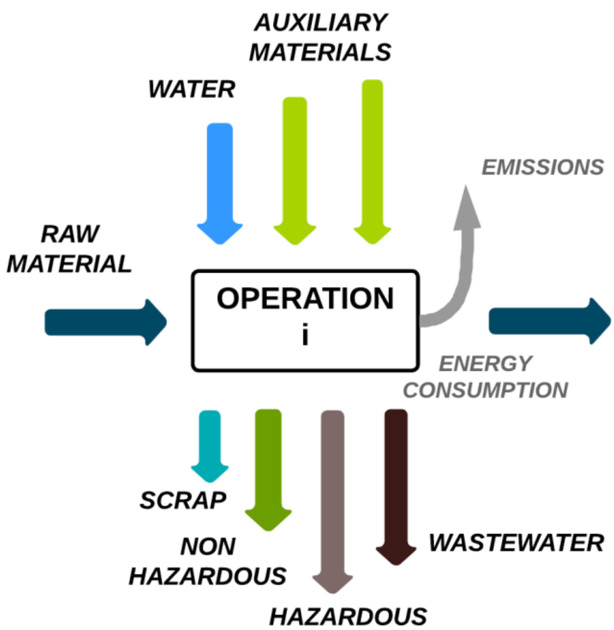


Figure 9. Operation i scheme with common inputs and outputs

The following figures show the representation of the value stream of a food ingredient, a product and a product including its packaging.

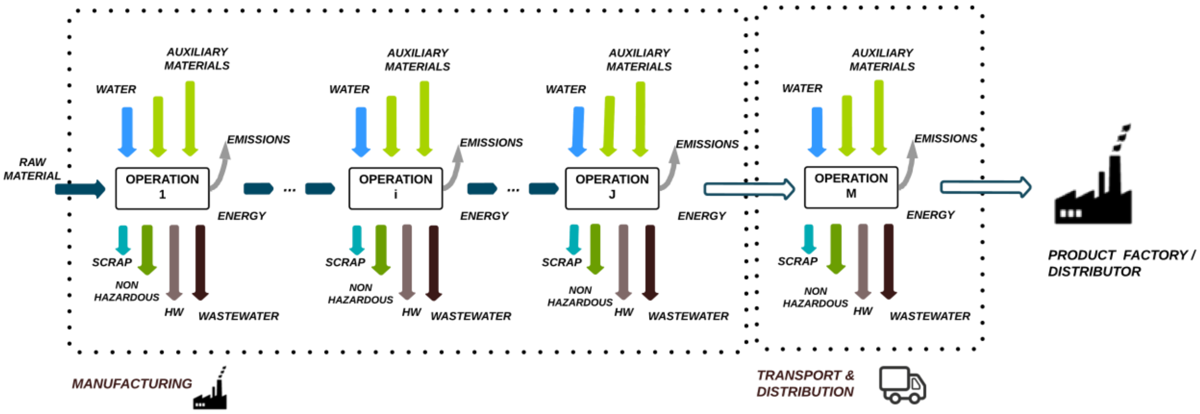


Figure 10. Scheme of phases and activities of a life cycle of a food ingredient

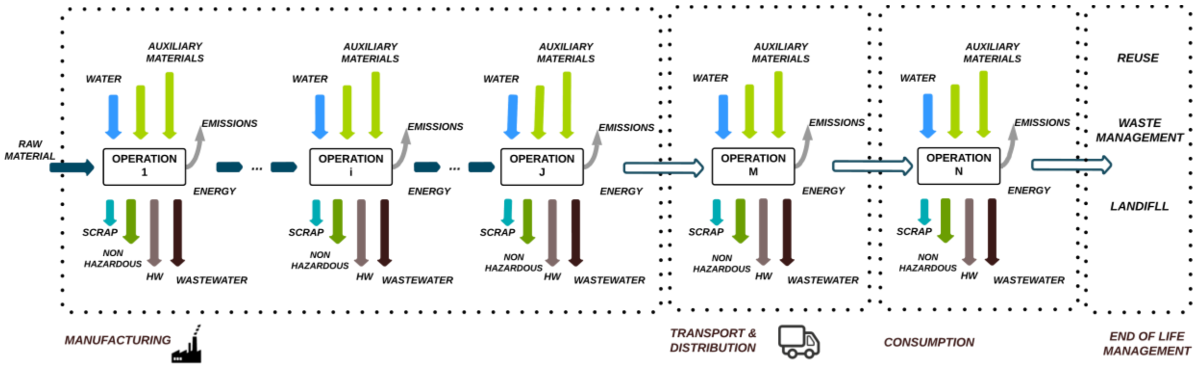


Figure 11. Scheme of phases and activities of a life cycle of a food product

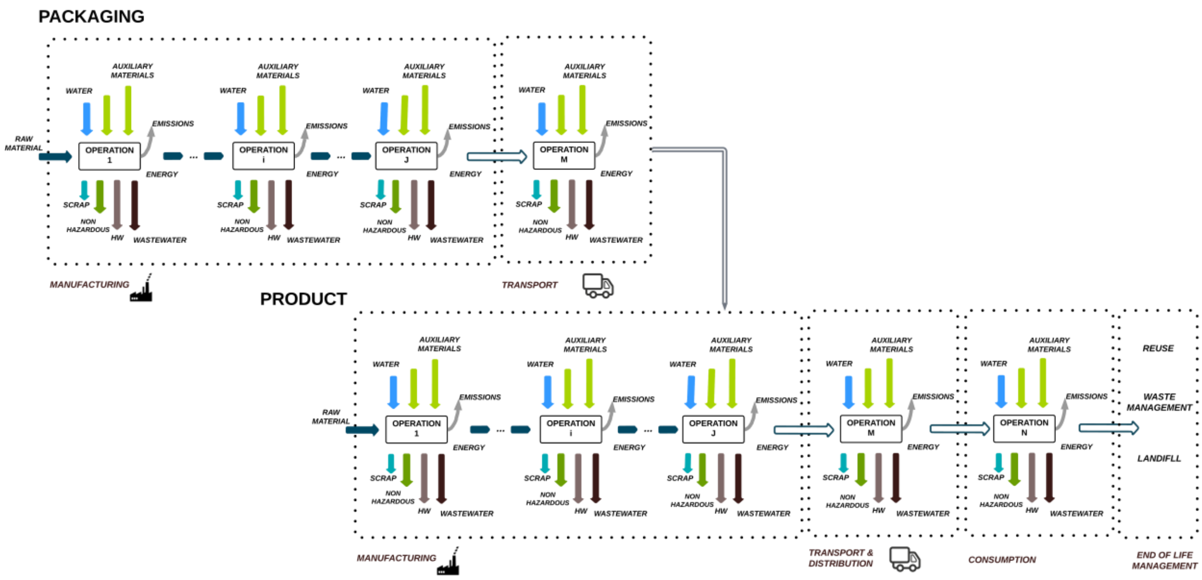


Figure 12. Scheme of phases and activities of a life cycle of a food product including packaging

4.2.2.1.2. Scenarios to be considered

On top of that, it will be key to consider the different scenarios that can occur throughout the ingredients and products' life cycles, because of:

- Supply chain alternatives, depending on the alternative suppliers that manufacturers of ingredients and products could develop for raw materials, substances or ingredients.
- Distribution, consumption and end-of-life alternatives, depending on the different distribution and end-of-life paths (mainly on packaging). Different distribution flows could be carried out from the manufacturing shop, the different users downstream (1st user level, 2nd user level), the waste management and recycling systems.

Identification of different scenarios will be fundamental to know the hot spots and critical parameters from sustainability and circularity perspectives, to be able to make sensitivity analyses against them and to identify risks and opportunities related to adapt the solution (material, product, waste management system, recycling process) to the upcoming trends coming from the market, sector, customer requirements or legislation changes.

As an example, next picture shows a representation of 2 different scenarios that could happen within the distribution, consumption and end-of-life management phases of an EPS fish box (source: Oceanwise project, see reference [15]).

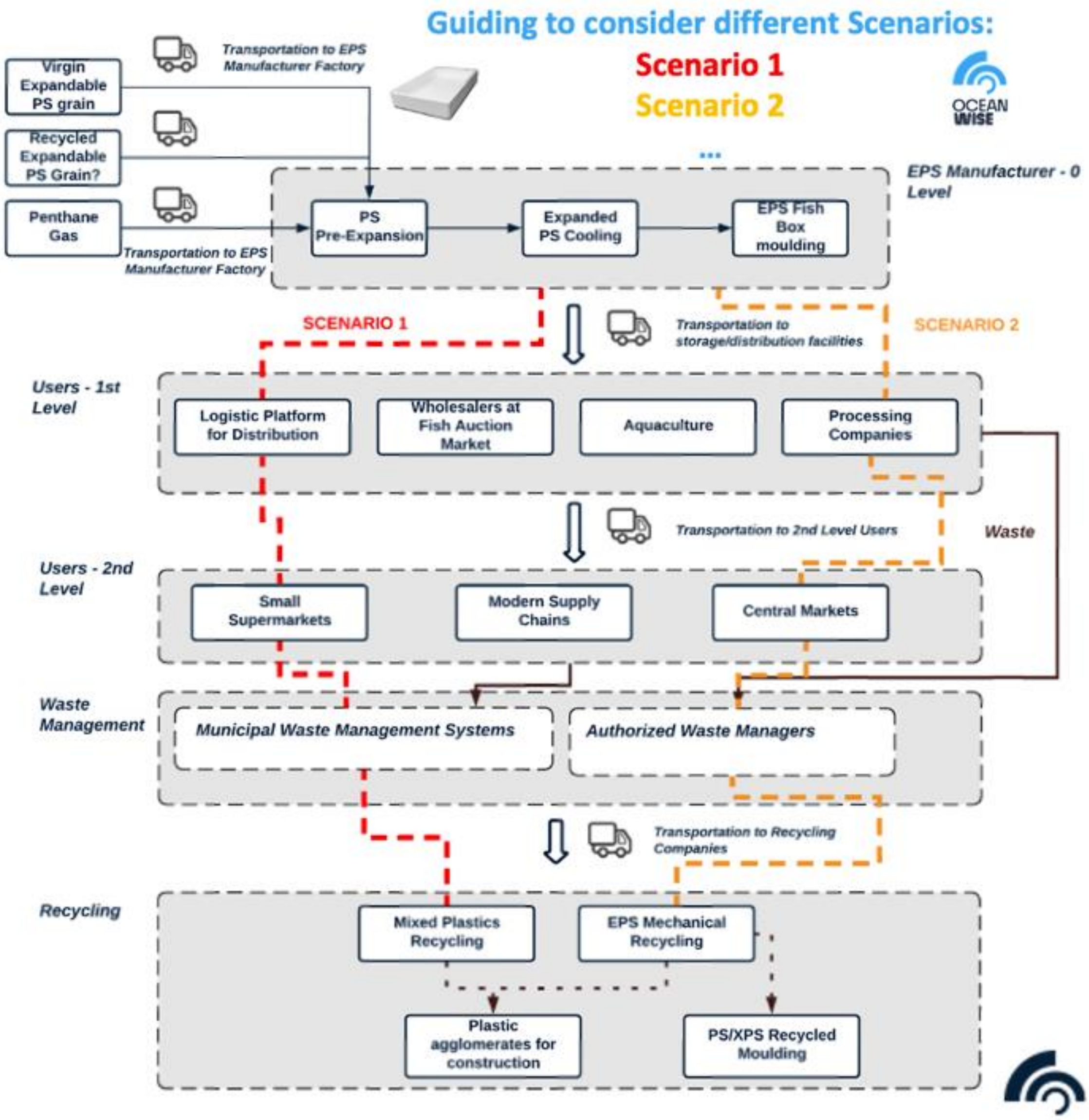


Figure 13. Overview of different potential scenarios identified on an EPS fish box

Therefore, the most representative scenarios combining alternatives upstream and downstream will be considered for any ingredient and product to be assessed within the industrialization and serial production phase. See in Figure 14 and Figure 15 a schematic representation of different scenarios that should be analyzed for ingredients and products.

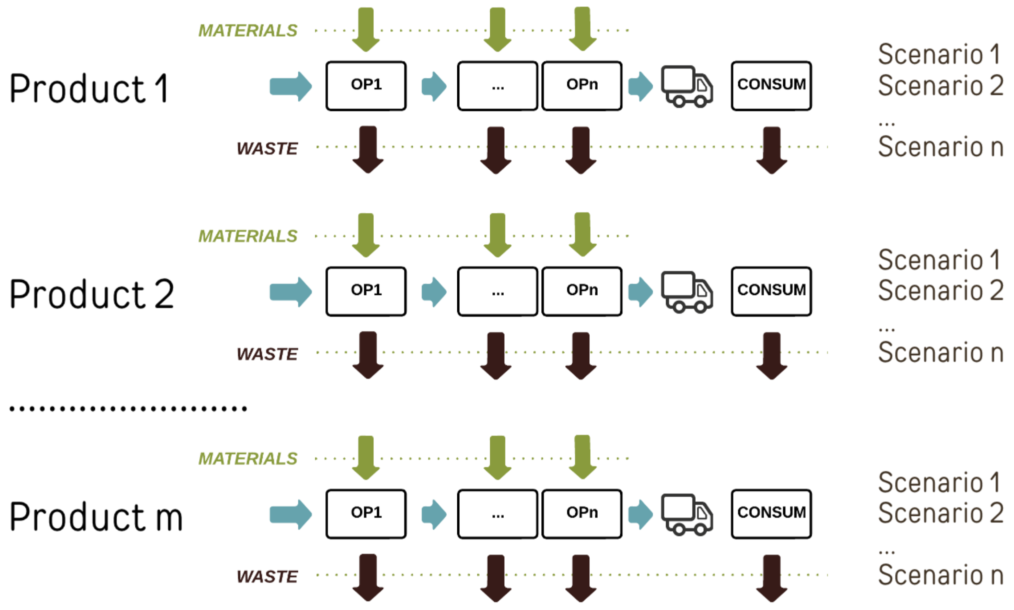


Figure 14. Schematic representation of different scenarios to analyse for every product

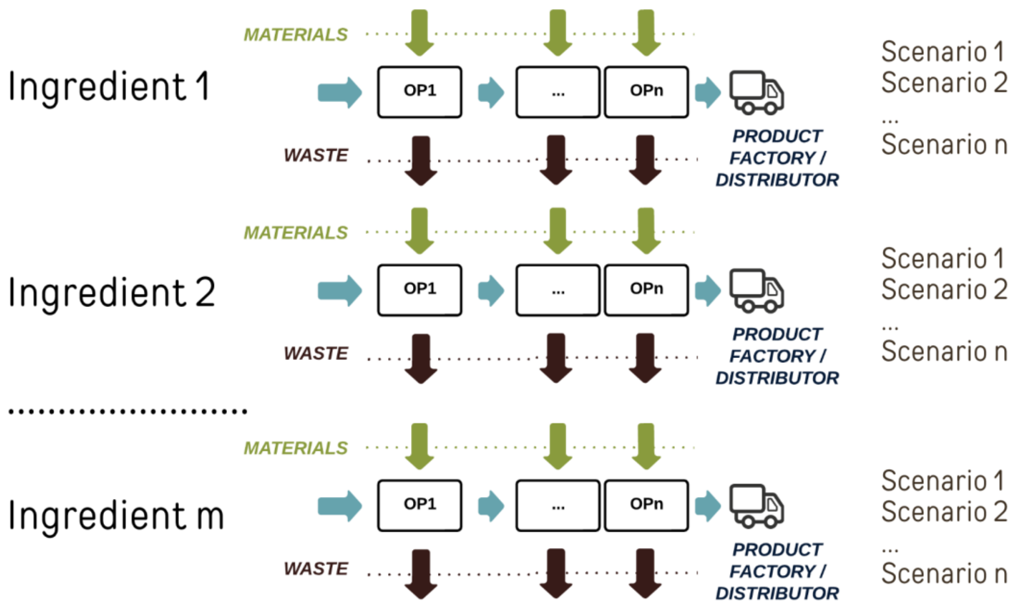


Figure 15. Schematic representation of different scenarios to analyse for every ingredient

In the most relevant scenarios, after mapping operations and identifying inputs and outputs, values will be assigned to each input and output in their respective units.

Before assigning values, the unit of the product has to be clearly defined and measurable. As described in ISO14040, life cycle assessments are structured around a functional unit or declared unit[2]. This functional unit defines what is studied and the quantification of the identified functions (performance characteristics) of the product.

Functional unit definition depends on the type or category of products. Specific Product Category Rules (PCR)[3] are available for different product categories, which define the corresponding functional unit or declared unit to use. The corresponding and applicable PCRs for the ingredients, food and packaging products will be selected for the assessments within the project.

As an example, PCR applicable for Fish and Fish Products (PCR 2021:05, reference [16]) according to *The Internation EPD System* establishes that "the declared unit shall be defined as 1 kg of edible product plus its packaging".

For the case study of a packaging application, and according to NPCR023 (Packaging products and services, see reference [17]) from the Norwegian EPD Foundation, the functional unit for cradle-to-grave analysis for a single and multiple use packaging product is defined as "one delivery of one unit of packaging for a defined good or group of goods". According to PCR 2019:2013 (see reference [18]) from The International EPD System, the functional unit is 1 packaging unit.

To map the whole life cycle, all the inputs and outputs values should be calculated/estimated per the functional/declared unit defined for all the operations, as described above. It is recommended to use value stream mapping tools, which help to map all the operations and identify inputs, outputs and assign the corresponding values to raw materials, auxiliary materials and resources consumed, as well as generated waste.

Additionally, considering that full industrialization of products and ingredients will depend on the priorities of developers and manufacturers and that it is possible that the manufacturing

[2] As per ISO14040, the primary purpose of a functional unit is to provide a reference to which the inputs and outputs are related. This reference is necessary to ensure comparability of LCA results. Comparability of LCA results is particularly critical when different systems are being assessed, to ensure that such comparisons are made on a common basis.

[3] Product Declaration) for a specific product category (https://www.environdec.com/product-category-rules-pcr/the-pcr)

processes could not be fully developed and optimized at the end of the project, we will face data gaps (e.g., about costs, consumption of materials and resources, generation of waste, etc). Estimations of social, economic and environmental impacts will be carried out to perform the socio-economic impacts and sustainability - circularity assessments.

4.2.2.1.3. Value Stream Mapping of INNOAQUA processes

Therefore, a fundamental step before carrying out an evaluation of socio-economic impacts at the level of ingredients and products is to map all the processes and their operations in the INNOAQUA project. The following figure shows an overview of INNOAQUA processes.

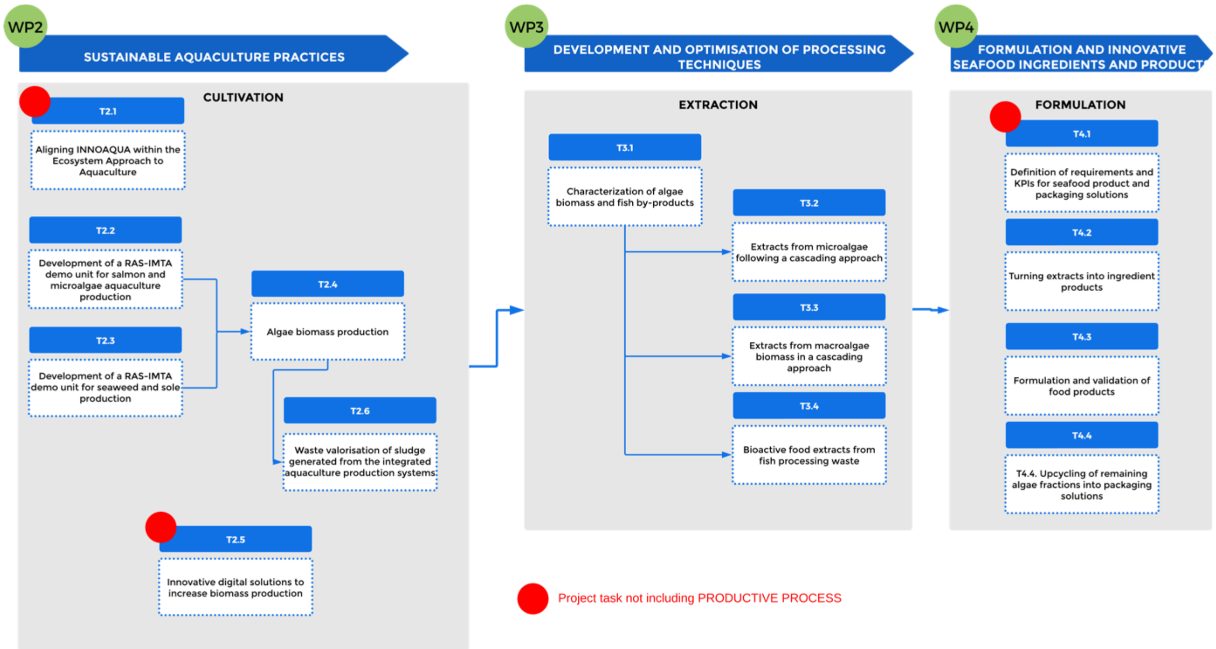


Figure 16. Overview of INNOAQUA processes

As indicated in Figure 16, there are some activities within the project that are not productive process[4]. These are marked with ● "Project task not including productive process".

As the INNOAQUA Project is focused on the technology development and demonstration and mainstreaming of the ingredients, seafood products and packaging solutions, with the

[4] A "productive process" means a process related to the cultivation, extraction and formulation of ingredients and products.

subsequent scale-up to industrialization (from technology to market approach), socio-economic impact assessments at ingredients and products level should cover all these phases. Therefore, value stream mapping of INNOAQUA processes will be carried out for:

- Lab-scale and kitchen tests,
- Pre-ingredients scale,
- Scale up into industrialization.

Goal of mapping these phases in detail is to identify critical parameters related to social and economic impacts that might affect the commercialization and serial production of the ingredients and products.

WP5 is working in close collaboration with the rest of the project partners in mapping each of the project's processes showed in the previous figure. Considering that many of the tasks are under development and some of them have not yet started, processes that have been mapped already are presented next.

Value Stream Mapping of WP2 Processes

The following figures show the mapping of the processes developed to date that are carried out in the different activities of WP2:

- T2.2 Development of a RAS-IMTA demo unit for salmon and microalgae aquaculture production

T2.2 Development of a RAS-IMTA demo unit for salmon and microalgae aquaculture production (M1-M42)

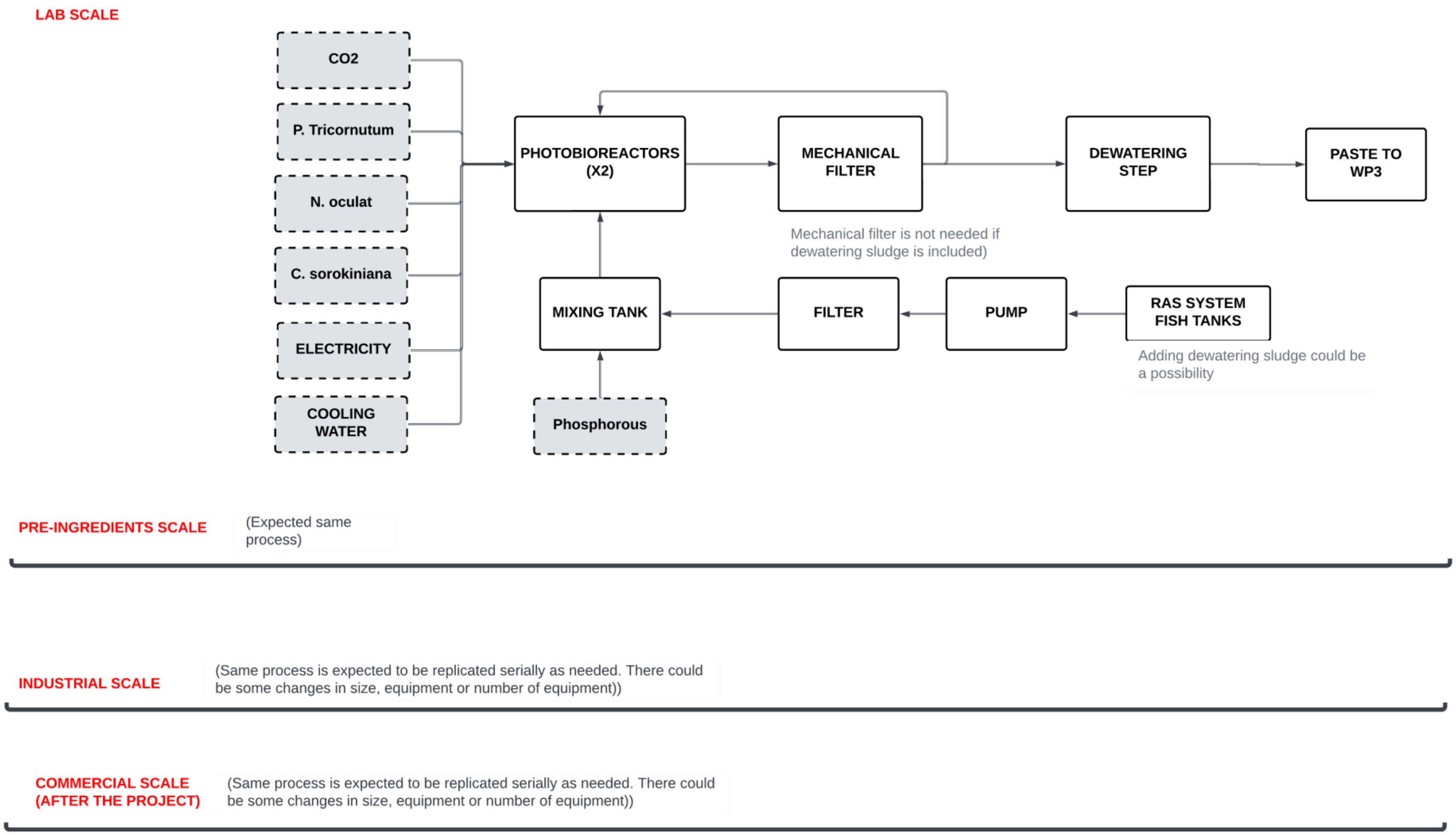


Figure 17. VSM Task 2.2. Development of a RAS-IMTA demo unit for salmon and microalgae aquaculture production

The value stream maps corresponding to the following activities are under development:

- T2.3 Development of a RAS-IMTA demo unit for seaweed and sole production
- T2.4 Algae biomass production
- T2.6 Waste valorisation of sludge generated from the integrated aquaculture production systems

Value Stream Mapping of WP3 Processes

The following figures show the mapping of the processes developed to date that are carried out in the different activities of WP3:

- T3.2 Extracts from microalgae following a cascading approach
- T3.4 Bioactive food extracts from fish processing waste

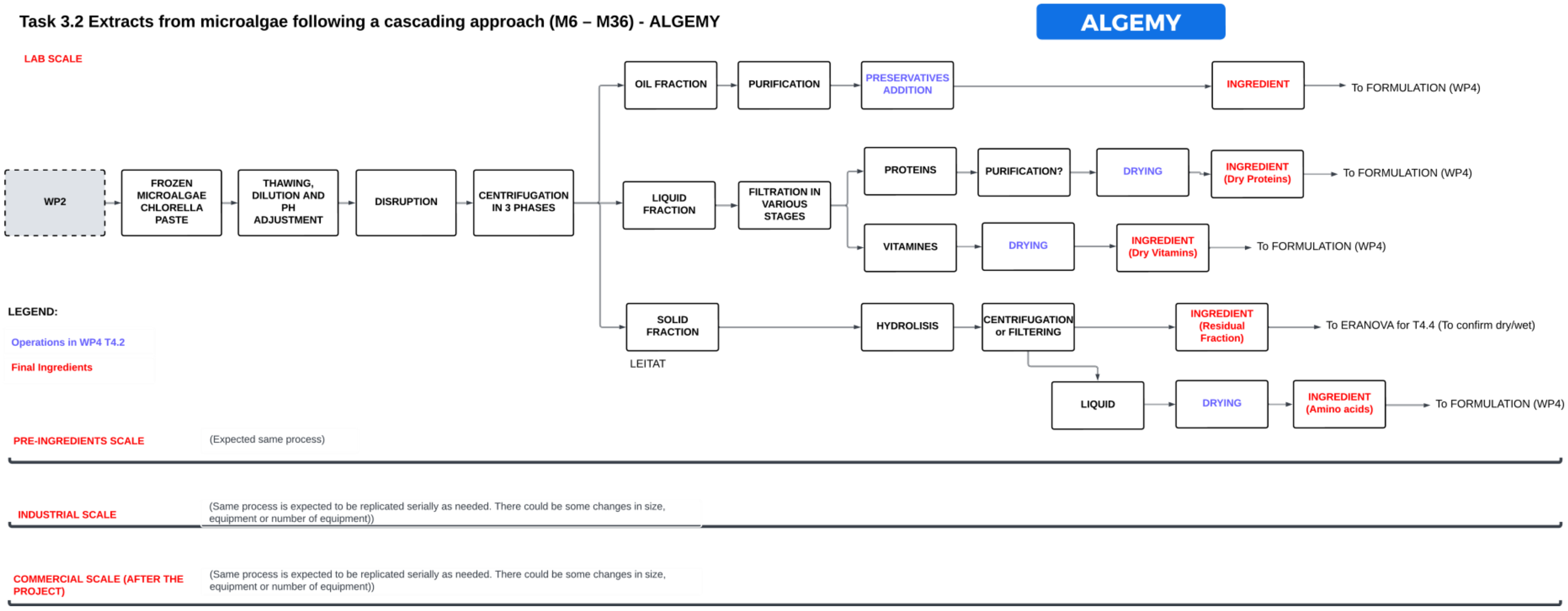


Figure 18. VSM Task 3.2. Extracts from microalgae following a cascading approach

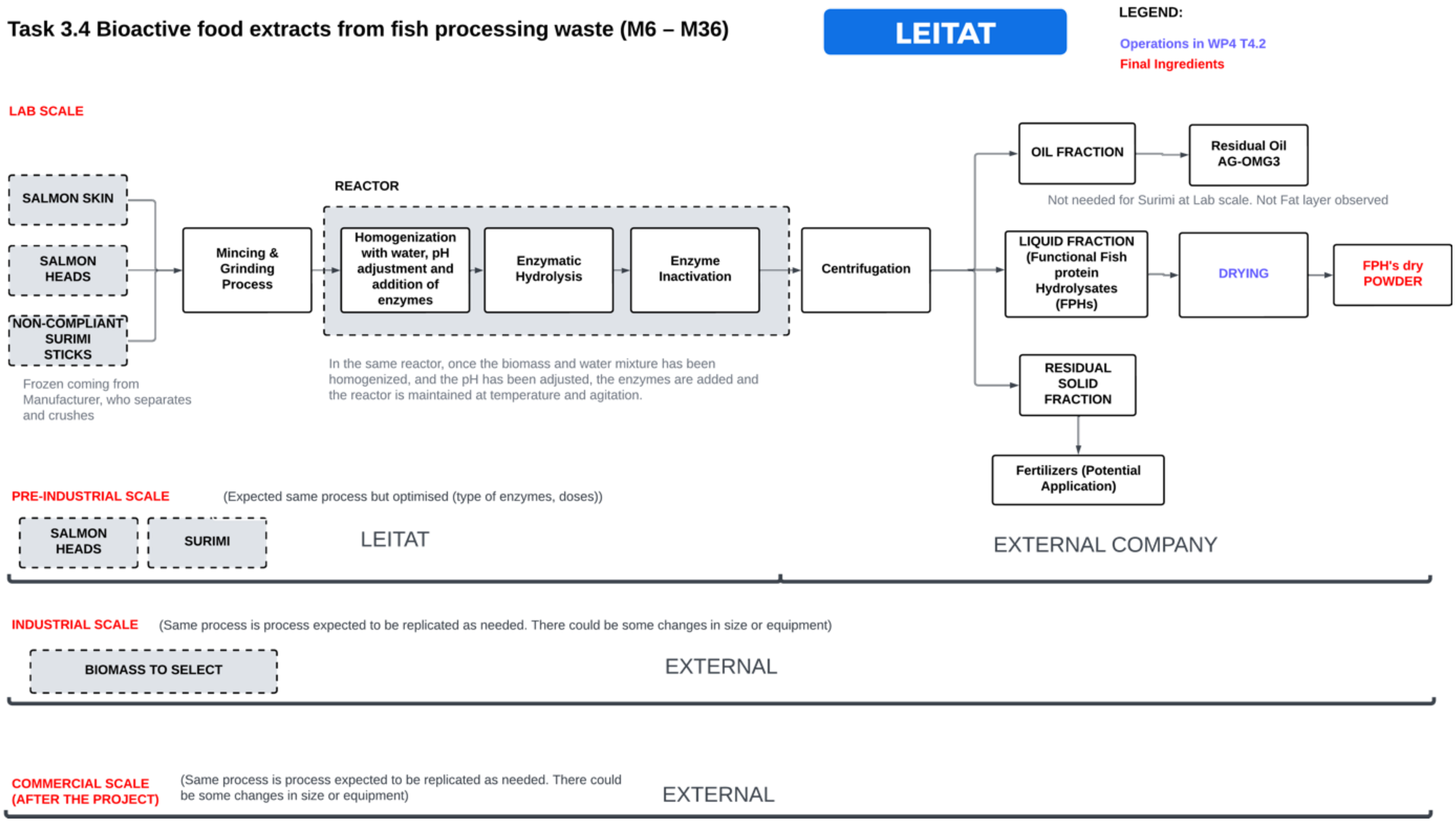


Figure 19. VSM Task 3.4. Bioactive food extracts from fish processing waste

The value stream maps corresponding to the following activities will be generated in the coming months:

- T3.1 Characterization of algae biomass and fish by-products
- T3.3 Extracts from macroalgae biomass in a cascading approach

Value Stream Mapping of WP4 Processes

As the following WP4 activities are developed in the next months, the different operations maps will be generated:

- T4.2 Turning extracts into ingredient products, which has mostly already been included in Figure 18 and Figure 19
- T4.3. Formulation and validation of food products
- T4.4. Upcycling of remaining algae fractions into packaging solutions

Next steps

Once all the processes are mapped and the different operations are identified, the next step will be to identify and quantify inputs and outputs, such as:

- Consumption of raw materials and substances,
- Consumption of resources (water, energy),
- Generation of different type of waste.

Next, we will identify the critical parameters related primarily to the life cycle costs of both ingredients and seafood products during the lab scale, pre-ingredients, and scale-up phases. The objective is to analyze the potential impact of these critical parameters and their variability on the commercialization of ingredients and products. This analysis will help producers define requirements for serial production processes (see deliverable D4.1, reference [20]) and mitigate the risks that may arise during commercialization and serial production.

Complete value stream maps containing identification and quantification of inputs and outputs will be presented and developed in updated versions of this deliverable, which are Deliverable 5.5, to be released in month 30 (M30), and final report on socio-economic assessments of INNOAQUA's innovations in Deliverable 5.6, to be released at the end of the project (M48).

4.2.2.1. Economic assessment – life cycle cost assessment

Life Cycle Cost is defined as the cumulative cost of product/service throughout the life cycle. As described in reference [12], Life Cycle Cost (LCC) Analysis is the technique implemented to assess sustainability of the life cycle of a product on the economic domain.

The primary objective of life cycle costing is to provide input to decision making in any or all phases of a product's life cycle. An important objective in the preparation of LCC models is to identify costs that may have a major impact on the LCC or may be of special interest for that specific application. This technique could be used, as proposed herein, as a measurement of life cycle costs of existing solutions and for the estimation of costs on new solutions all along the life cycle.

Assessing the life cycle cost guides also researchers for the development of alternative materials or products to make decisions at the early design and development phases and have a perspective of the critical parameters related to costs on the different phases of the life cycle of the product.

International Standard IEC 60300-3-3 (see reference [12]) is an application guide to carry out life cycle costing of a product, defining a clear scope of the different life cycle phases in terms of costs, as follows.

- **Concept and Definition (CD).** Concept and definition costs are attributed to various activities conducted to ensure the feasibility of the product under consideration, such as market research, preparation of a requirement specification of the product or product concept and design analysis.
- **Design and Development (DD).** Design and development costs are attributed to meeting the product requirements specification and providing proof of compliance, including activities such as:
    - design engineering, including reliability, maintainability and environmental protection activities,
    - prototype fabrication,

- testing and evaluation,
- producibility engineering and planning,
- vendor selection, and
- demonstration and validation

In this methodology, CD and DD phases are combined together into the phase Design & Development (as showed in Figure 20), aiming to evaluate if concept, definition, design and development phases of a product are addressed.

- **Manufacturing (MAN).** Manufacturing costs refer to making the necessary number of copies of the product or providing the specified service on a continuous basis, including transportation to distributors or final user. Main activities include:
  - construction of facilities,
  - supply chain development and acquisition of bill of materials,
  - fabrication (labour, materials),
  - testing of manufacturing processes,
  - production management and engineering,
  - facility maintenance,
  - quality control and inspection,
  - packaging, storage, shipping and transportation.
- **Installation (INS).** It refers to all costs related to the assembly on site, installation, check-out and commissioning of product at the final destination. Main activities included are:
  - testing of installation processes,
  - assembly, installation and checkout,
  - commissioning,
  - quality control and inspection.
- **Operation and Maintenance (O&M).** Refers to the costs attributed to all the activities related to operation, maintenance (predictive, preventive and corrective) and supply support of products throughout the expected life of the system/product.

- **Disposal (DIS)**. Costs incurred throughout all activities related to decommissioning and disposal of older versions of the products, including system shutdown, disassembly and removal, recycling or safe disposal.

First step is to estimate unitary costs for the different inputs and outputs (resources, raw materials, waste generated, …) for every phase and operation of life cycle of the product identified in the Value Stream Mapping. These unitary costs will be prorated to the functional unit defined. Figure 20 shows a scheme of unitary costs (Ci) for the typical cost batches.

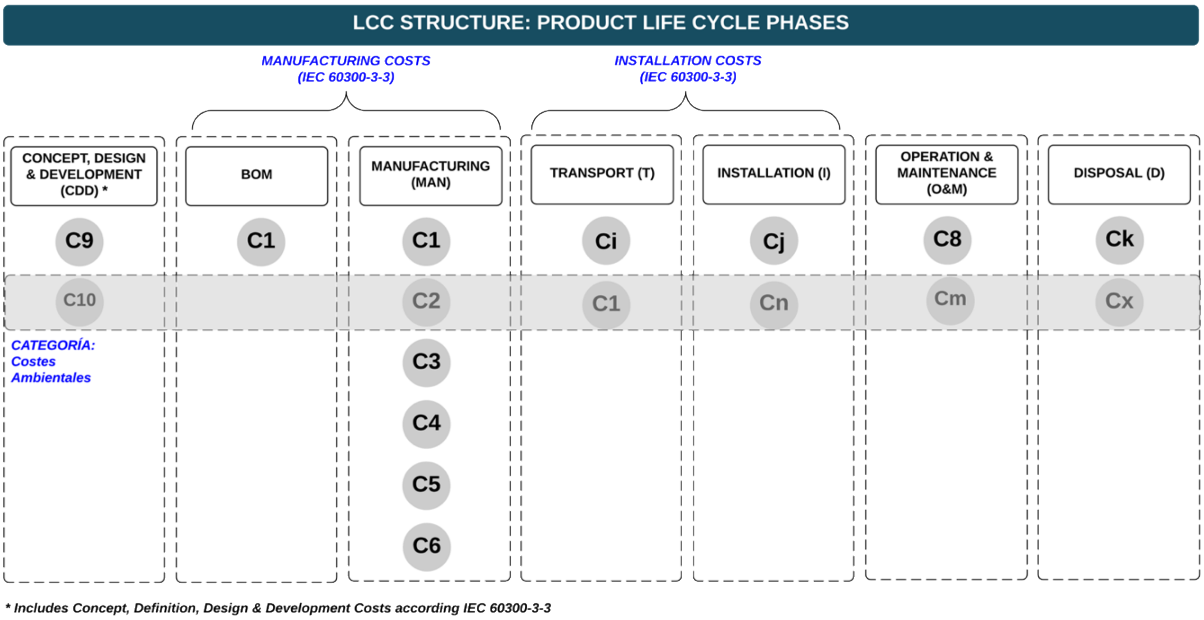


Figure 20. LCC structure with typical costs batches

To calculate or estimate unitary costs prorated to the functional unit, different type of costs should be taken into consideration:

- <u>Recurring cost (REC):</u> "usual" cost incurred repeatedly or for each unit produced or unit of service (cost of machining a part). These recurrent costs could be incurred with different periodicity, such as per unit, monthly, annually, etc
- <u>Non-recurring cost (NREC):</u> unusual cost, which is unlikely to be repeated in the normal course of business or the life of the product (engineering hours, initial training, investment costs, etc.). Sometimes called "extraordinary" cost.

As a result, we are able to have a clear view of the distribution of costs of the different life cycle phases and most relevant batches (material costs, consumption of resources like water and anergy, manufacturing, transport, end of life, etc), and even for every operation. See example in Figure 21.

Product Alternative	Design & Development	Bill of Materials	Manufacturing (MAN)	Transport & Installation	Operation & Maintenance	End of Life
Product 1	1,09	3,67	0,37	0,45	0,12	0,01

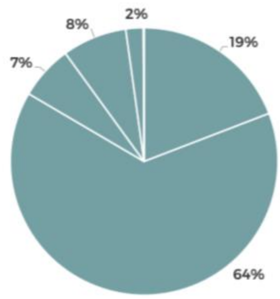


Figure 21. Distribution of costs by phase of the life cycle (product example)

Additionally, if we consider uncertainty and variability of most relevant costs, we could have the perspective of variability of costs per batches and phases, as showed in the following figure, which will be useful for sensitivity analysis against critical parameters.

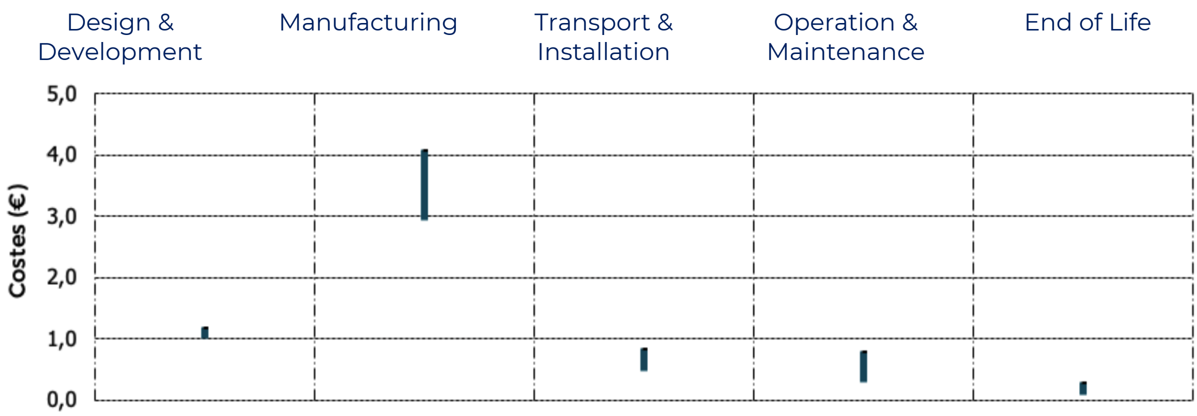


Figure 22. Variability of costs per life cycle phase (product example)

4.2.2.2. Social impact assessment

Social Life Cycle Assessment (SLCA) refers to the evaluation of positive and negative effects of products with social and socioeconomic impact throughout their life cycle, identifying impact categories or key issues for social analysis and relevant stakeholders to consider, such as workers, the local community, consumers, society in general and other participants of the value chain. SLCA can be quantitative, semi-quantitative or qualitative and complements LCA and LCC with the evaluation of the life cycle on the social domain of sustainability. Since there is relatively little experience applying this assessment to a product life cycle, it will not be detailed here.

Some references to carry out the SLCA are:

- the UNEP revised guidelines for the assessment of the social life cycle of products and organizations (UNEP, 2020)
- the methodological sheets for the sub-categories in the assessment of the social life cycle (S-LCA) (UNEP, 2021)
- Social Life Cycle Metrics for Chemical Products. WBCSD. 2016
- Other recognized methodologies (GRI, etc)

Next table shows an example of stakeholders and impact categories according to UNEP guidelines.

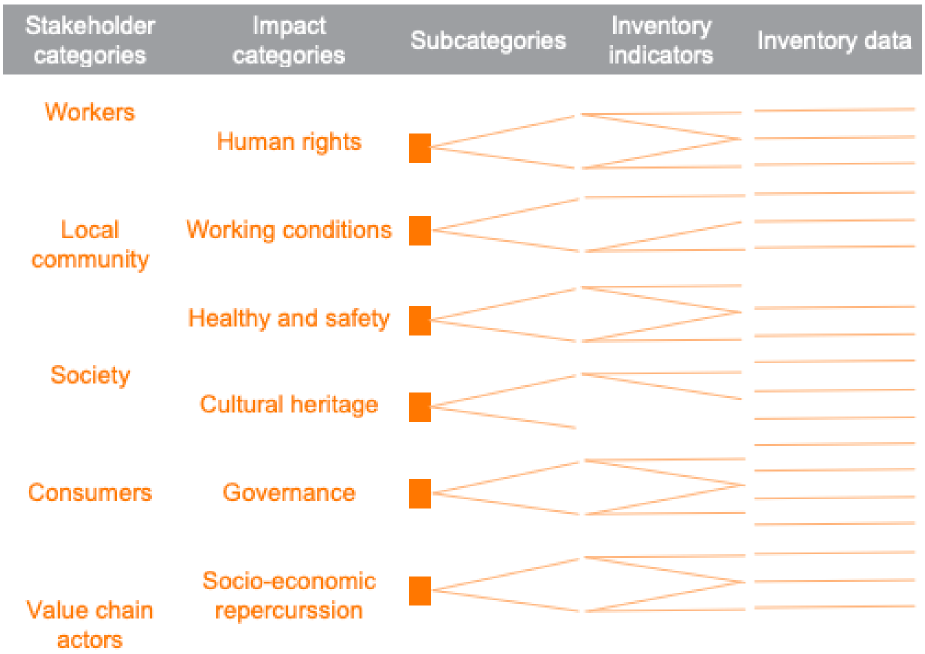


Figure 23. Example of stakeholders and impact categories according to UNEP guidelines

4.3. Alignment with and contribution to international policies

Aim of this part is to analyse and estimate the contribution of INNOAQUA's socio-economic impacts to the most relevant international policies, such as:

- Sustainable Development Goals (SDGs; United Nations),
- Green Deal and Farm to Fork Strategy (European Union),
- Resilience Dashboards (European Union).

4.3.1. SDGs (Sustainable Development Goals)

The identification of the SDGs and their specific applicable targets to which the project contributes will be carried out and an estimate of the quantification of the project will be made for each of the identified goals.

SDGs the project is contributing to, are:

- **SDG2: Zero Hunger**. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.

- **SDG9: Industry, Innovation and Infrastructure**. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. Ensure sustainable consumption and production patterns.
  - INNOAQUA drives innovation in the aquaculture sector through the implementation of advanced technologies such as ultrasound-assisted extraction and enzymatic treatment. This encourages the modernization of industrial infrastructure, improves efficiency and promotes research and development of new products derived from aquatic resources.
  - INNOAQUA promotes sustainable management of aquatic resources, contributing to the reduction of waste in the aquaculture. By recycling byproducts that are traditionally discarded, the project supports the conservation of marine and aquaculture resources.
- **SDG12: Responsible Consumption and Production**. Ensure sustainable consumption and production patterns.
  - INNOAQUA's focus on waste reuse and resource optimization contributes to a more efficient and responsible production model. By reducing waste and maximizing the value of by-products, the project helps minimize the environmental impact of the fishing and aquaculture industry, while promoting more responsible consumption of marine resources.
- **SDG14: Life Below Water**. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
  - The conservation of marine ecosystems and the reduction of fishery waste are key objectives for SDG 14. INNOAQUA promotes the sustainable management of marine resources by reducing the amount of waste generated by the fishing industry and encouraging practices that minimize the overexploitation of species. By taking advantage of waste and transforming it into useful products, the project contributes to a more balanced and sustainable exploitation of aquatic ecosystems.

Quantification of the indicators values applicable to the SDGs specific targets, will be carried out in the next months and reported in the updated version of this deliverable (Deliverable 5.5), to be released in month 30 (M30).

4.3.2. Farm to Fork Strategy

The Farm to Fork Strategy aims to accelerate our transition to a sustainable food system that should:

- have a neutral or positive environmental impact,
- help to mitigate climate change and adapt to its impacts,
- reverse the loss of biodiversity,
- ensure food security, nutrition and public health, making sure that everyone has access to sufficient, safe, nutritious, sustainable food,
- preserve affordability of food while generating fairer economic returns, fostering competitiveness of the EU supply sector and promoting fair trade.

Regarding socio-economic impacts, the analysis of the alignment and contribution of the INNOAQUA project will focus on:

- ensure food security, nutrition and public health, making sure that everyone has access to sufficient, safe, nutritious, sustainable food
- preserve affordability of food while generating fairer economic returns, fostering competitiveness of the EU supply sector and promoting fair trade

4.3.3. EU Resilience Dashboards

Resilience is a new compass for EU policies. Building a more resilient society calls for enhancing the capacity for adaptation and transformation, urging to shift towards a paradigm of a more sustainable growth and societal development path. Through a broad set of indicators, the resilience dashboards assess the relative strengths and weaknesses of countries. They also help Member States to identify areas for further analysis and potential policy actions. The indicators span four dimensions: social and economic, green, digital, and geopolitical. INNOAQUA's alignment and contribution to relevant indicators on social and economic dimension will be assessed.

5. Results

Since most of the tasks needed to collect data for these assessments are under development, results of the implementation of the methodology will be compiled and presented in updated versions of this deliverable, which are Deliverable 5.5, to be released in month 30 (M30), and final report on socio-economic assessments of INNOAQUA's innovations in Deliverable 5.6, to be released at the end of the project (M48).

5.1. Analysis of needs and expectations from stakeholders

To be completed in Deliverable 5.5.

5.2. Socio-economic impacts assessment

To be completed in Deliverable 5.5.

5.3. Alignment to international policies

To be completed in Deliverable 5.5.

6. Conclusions

This document defines the scope and the methodology to carry out the socio-economic impacts assessment throughout the project. Methodology contains 3 different phases:

- **Phase 1: Analysis of needs and expectations from stakeholders.**
- **Phase 2: Socio-economic impact assessment.** Assessment of the socio-economic impacts will be done at 2 different levels:
  - Socio-economic impacts at a project level
  - Socio-economic impacts at products and ingredients level
- **Phase 3: Alignment to international policies.** At this step, the process for the analysis of contribution of the project to most relevant sustainability related international policies is described, such as SDGs, Green Deal and Farm to Fork (F2F) Strategy and EU Resilience Dashboards.

Results of the implementation of the methodology will be compiled and presented in a first step in an updated version of this deliverable, which are Deliverable 5.5, to be released in month 30 (M30).

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