

*Unlocking the potential of
macroalgae for a thriving
European blue
bioeconomy*

2022



Specification of methodology, data collection and research plan for LCA & ES

SEAMARK DELIVERABLE 9.1

Wageningen University



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SEAMARK DELIVERABLE 9.1: SPECIFICATION OF METHODOLOGY, DATA COLLECTION AND RESEARCH PLAN FOR LIFE CYCLE ASSESSMENTS AND ECOSYSTEM SERVICES

OPEN ACCESS

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Abstract

This deliverable provides the framework to the data collection for life cycle assessments (LCA) and ecosystem services (ES). It guides the consortium through the process and thus preventing data losses, delays and facilitating the collection process itself. For the final data collection further decision with the consortium need to be made, thus this framework provides the necessary information to discuss with the partners on what data collection is feasible. For LCA it includes a list of potential parameters to monitor, an overview of how this data can be collected and the decision process for specific partners to decide and plan the final data collection. The final data collection protocol will be tailored to the three products chosen for LCA.

For the ecosystem services (ES) this report provides an overview of categorized ecosystem services, an overview of methodologies used to quantify and value ES and the decision process for specific partners to decide and plan the final data collection. The data collection should commence before the first growing season, therefore the decision for the ES to analyse will be made in the course of January/February of 2023. The practical protocols for the selected ES will then be made.

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LIST OF ABBREVIATIONS

| Abbreviation | Description |
|--------------|--|
| ALG | ALGAIA |
| ALGP | ALGApplus |
| ALO | Algolesko |
| CICES | Common International Classification of Ecosystem Services |
| CO2 | Carbon dioxide |
| ES | Ecosystem Services |
| FAO | United Nations Food and Agricultural Organization |
| FEXP | Fermentation Experts |
| IPBES | Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services |
| LCA | Life Cycle Assessment |
| M | Month |
| MAIA | Mapping and Assessment for Integrated ecosystem Accounting |
| NCAVES | Natural Capital Accounting and Valuation of Ecosystem Services |
| OCE | OCEANIUM |
| ORF | Ocean Rainforest |
| pH | Potential of hydrogen |
| WEcR | Wageningen Economic Research Institute |
| WUR | Wageningen University |
| WP | Work Package |

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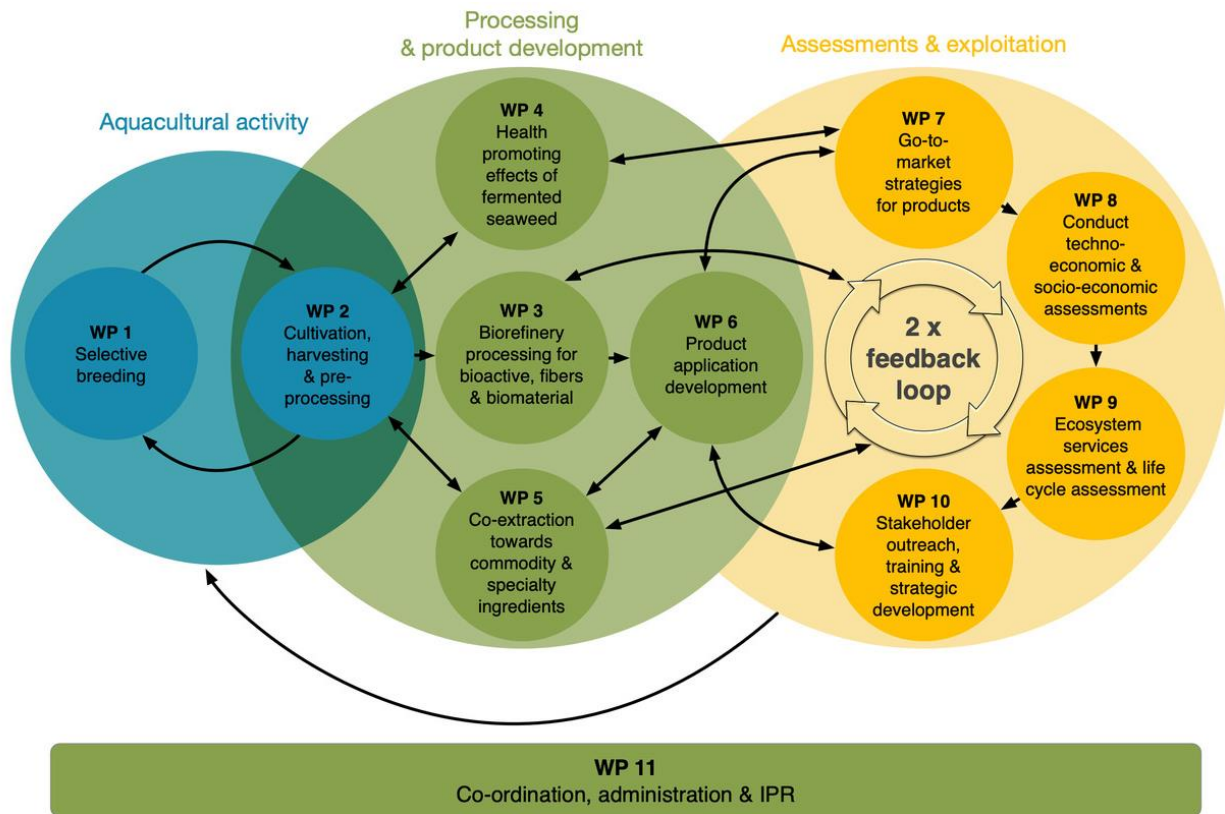


Figure 1: Work package overall structure and interrelation.

INTRODUCTION

Work package 9 will document, quantify and evaluate the environmental impacts of upscaled seaweed cultivation. This includes Life Cycle Assessment (LCA) of selected products and assessments of ecosystem services provided and their value. The results are used to guide innovation in macroalgae production and processing and in further developing the business case for seaweed cultivation and policy making.

The LCA activities only start in the second feedback loop (view Figure 1), after a choice for specific products could be made. The Ecosystem service assessments do not directly depend on the products, but on the cultivation and harvesting of the raw biomass. Therefore the decision on the data collection has to be done earlier, before the first growing phase of the seaweed.

Data collection for these tasks is complex and demands collaboration and preparation.

This report is the framework for the data collection, guiding the consortium through the process and thus preventing data losses, and delays, and facilitating the collection process itself. The target audience of this deliverable is the consortium partners. This framework doesn't provide the final practical data collection protocol yet, but it provides the necessary information to discuss with the partners what data collection is feasible. In detail, the framework includes:

For LCA

- An overview of how this data can be collected

- Decision process for specific partners to decide and plan the final data collection

For ecosystem services

- An overview of categorized ecosystem services
- An overview of methodologies used to quantify and value ES
- Decision process for specific partners to decide and plan the final data collection

This deliverable feeds into the key exploitable result 5: Good practice recommendations on LCA.

LIFE CYCLE ASSESSMENT

Aim

The aim of this section of the data collection methodology is to describe the data collection process for the Life Cycle Assessment (LCA). The task description states the following: "Task 9.5 LCA of most promising products developed in SeaMark. The existing list of the most promising products will be evaluated, concluding in a choice of three products to base an LCA on. Before carrying out the three analyses, there will be data collection in collaboration with partners at the farm sites and desk research for land-based LCA studies".

Partners in the task include WUR, ORF, FEXP, OCE, ALG, ALO, ALGP. Task 9.5 runs in the Months M25-M46.

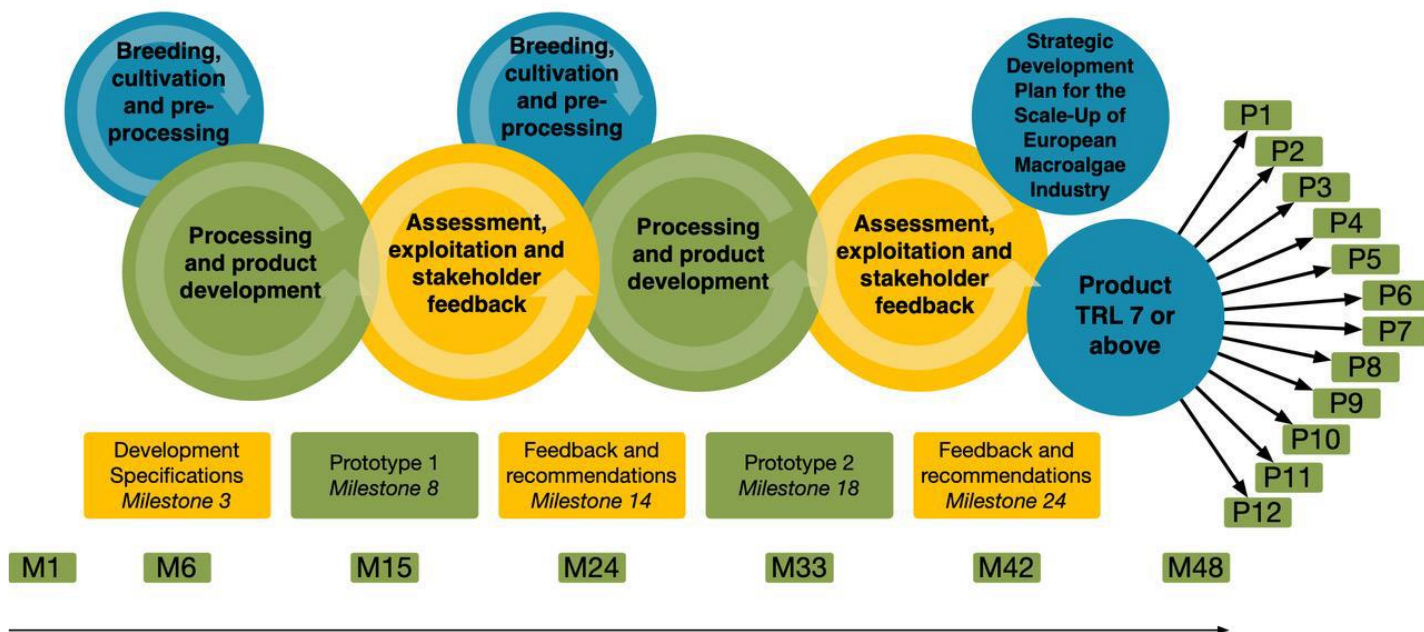


Figure 2: Process flow of SeaMark with two feedback loops

METHODOLOGY

It is proposed to follow the commonly accepted LCA methodology as described in ISO 14044:2006. ISO 14044:2006 specifies requirements and provides guidelines for life cycle assessment (LCA) including: Definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, relationship between the LCA phases, and conditions for use of value choices and optional elements.

Application within SEAMARK

The task description points to two specific actions to take in the context of SEAMARK:

- The choice of three products to analyse using LCA methodology
- Data collection in collaboration with partners.

Choice of three products

Referring to the visualization of WP interactions above (see Figure 1), the LCA activities are expected to commence in the 2nd feedback loop, when a choice for specific products can be made.

Data collection

For a proper LCA, proper data is key. The data needed will be provided by the consortium partners and can, if needed, be supplemented with data from literature. Risks to data collection and mitigation actions are described in the Table 1.

Table 1: Risks and mitigation actions for the data collection

| Risk | Mitigation action |
|---|---|
| No data is made available | <p>Early discussion with the consortium partners on data needs.</p> <p>Clear instructions on data to be collected, including preparation of questionnaire for data collection.</p> <p>If necessary, site visits for collection data and insights ourselves.</p> |
| Data is too confidential | <p>Early discussion on ability to share data (first year of the project).</p> <p>Discussion on the possible ways to present data (e.g. should it be absolute numbers or relative numbers)</p> |
| Data gaps | Can be supplemented with data from literature |
| Data would cover hypothetical production processes, not yet developed | Inclusion of scenario and sensitivity analysis can make the results relevant for consortium partners, as results would be useful to guide future innovation |
| Difficulties to apply LCA methodology to algae cultivation | This is likely risk as we can expect this to be the case. The SEAMARK project explicitly aims to provide best practices recommendation for LCA as a results of applying the method to algae production and processing |
| No suitable comparable product available | LCA analysis often compares a product with another product with the same functionalities. Should such a product not be available, the LCA will limit itself to identification of environmental hotspots, providing guidance to future innovation in the production process. |

To address these risks and because the LCA team considers it important to discuss objectives and data needs for LCA earlier on, questions on LCA have been included in the questionnaires jointly conducted by WP7, WP8 and WP9.

In preparing the questionnaire, the starting point was that no quantitative data is needed at this moment, but rather we aim to understand what data will be able to gather at a later stage. To this end, the following questions were included:

1. We understand that profits shouldn't be visible in any public document, and we will assure this. Are there further concerns when it comes to sharing and publishing data and how can we address them?
2. The analysis focuses on the flagship products only. This means we do not need full data on a company's Profit & Loss and production process of all products. We are trying to find out if the process varies a lot from the other products we are analysing and if we need to prepare differently. So, we don't need a full description now, but could you describe very briefly the different steps in the production process of the flagship product? (Enough to say the number of steps and title of steps)
3. Do you have the economic data on investment, revenues, cost and value of each step/activity in producing this flagship product available? Not needed now, but we need to know if it is available.
 - a. If not, is it possible to gather this information?

4. Do you have the data for LCA of each step/activity in producing this flagship product available? Not needed now, but we need to know if it is available.
 - a. If not, is it possible to gather this information?
5. We understand that profits shouldn't be visible in any public document, and we will assure this. Are there other concerns?
6. Is there real-life data on the process available or should we make assumptions on what the future processing should look like?
7. For LCA, we would like to compare the product with 'conventional' products. What would be a good product to compare within your case?

Replies to these questions have come in recently and will be processed in preparing for the next steps (see timeline below).

Overview of data needed

At the time of writing, it is not possible to give a tailored description of the data needed. This is dependent on the products chosen for LCA.

Timeline

The timeline below describes the activities foreseen and indicates in which period these are to take place. Exact moments for decision making, in particular for choice of products, will be linked to consortia and/or WP leaders meetings.

| Activities | July-Sept 2022 | Oct-Dec 2022 | Jan-March 2022 | April - June 2022 | July-Sept 2023 | Oct-Dec 2023 | Jan-March 2024 | April - June 2024 | July-Sept 2024 | Oct 2023 onwards |
|--|----------------|--------------|----------------|-------------------|----------------|--------------|----------------|-------------------|----------------|------------------|
| | M1-M3 | M4-M6 | M7-M9 | M10-M12 | M13-M15 | M16-M18 | M19-M21 | M22-M24 | M25-M27 | M28- onwards |
| Methodology development | | | | | | | | | | |
| Clarify wishes and demands with partners* | | | | | | | | | | |
| Prepare draft questionnaires | | | | | | | | | | |
| Choice of products | | | | | | | | | | |
| Prepare final questionnaires for data collection | | | | | | | | | | |
| Data collection | | | | | | | | | | |
| Data checks and additional collection | | | | | | | | | | |
| LCA analyses | | | | | | | | | | |

Table 2: Timeline of the data collection process for LCA

The timeline is geared towards data collection in the second year of SEAMARK, with a start of the LCA analysis in October 2023. View Table 2.

* Includes analysis of questionnaires

ECOSYSTEM SERVICES

Aim

The aim of this section is to outline the different ecosystem services (ES) that are there to consider, an overview of data collection practices and the decision path to decide which ones will be assessed within SeaMark.

There is no 'one methodology' for data collection for the quantification and valuation of ES. It is also out of the scope of this project to analyse all ES of a seaweed cultivation site. A choice for the ES to be analysed needs to be made with specific consortium partners. As a preparation for the decision-making process, the study teams needed an overview of the available methodologies for data collection and which ES can be, and are, valued and monetized. It is important to keep in mind, that this data collection for ES, will be the basis for the following tasks, where ES services are valued and monetized. This deliverable therefore goes beyond just a methodology of data collection. It provides first sets of data so that an informed decision with consortium partners can be made.

This deliverable is part of task 9.1, which is described as follows: "Under the lead of ORF, WUR will develop a methodology for ecosystem service (ES) quantification. Following this methodology, data will be collected, and during the second year of the project this data will be synthesized, analysed and compared." Contributing partners include ORF, ALO. The task 9.1 runs from the very beginning of the project until Month 24.

METHODOLOGY

The sections below outline the proposed methodology for this task. Some steps have already been taken and results will be presented in the following section.

Step 1: overview of ES, general classification

As a first step, an overview was created with internationally accepted general ecosystem service classifications based on work from the Food and Agricultural Organization¹, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (IPBES, 2019), the European Environment Agency creating the Common International Classification of Ecosystem Services (CICES) for Integrated Environmental and Economic Accounting² and the 'Monetary valuation of ecosystem services and ecosystem assets for

¹ <https://www.fao.org/ecosystem-services-biodiversity/en/>

² The revision (V5.1) of the first fully operational version CICES (V4.3) was published in 2013, was looked at (Haines-Young & Potschin, 2018). Other

ecosystem accounting' report from NCAVES and MAIA (2022). To specify the ecosystem services further towards the ecosystem of seaweed cultivation, the ecosystem services for ocean, and coastal marine ecosystems were matched to the global services from four more references (Halpern et al., 2012; Hasselström et al., 2018; Heckwolf et al., 2021; Okada et al., 2019). Please view the supplementary material sheet 2 for details.

Step 2: ES related to seaweed farming

Literature

To understand which ES are specifically related to seaweed and to then identify the methodologies for assessing them, a literature review was conducted via Scopus. Searching in the title, abstract and keywords two search strings with the following words were formulated:

- "seaweed aquaculture" OR "seaweed farm*" OR "seaweed cult*" OR "macroalgae* aquaculture" OR "macroalgae* farm*" OR "macroalgae* cult*" AND
- "ecosystem service*"

The resulting 42 papers were first scanned for relevance leaving 13 documents to read in detail. The publications provided further references, that were not part of the initial list of documents, 8 documents were added and also read. Supplementary material sheet 1, provides the list of documents. Based on information from these documents the study team extended the list of ecosystem services, now matching the seaweed-specific ecosystem services. Then the quantification of ES methodologies as well as valuation methodologies differentiating if these were quantitative, qualitative and also ecological or socioeconomic data were extracted.

Survey

As part of a bigger survey for WP7 and WP8, the seaweed cultivators of the SeaMark project, were asked questions around the services of their ecosystem. Data collection on ecosystem services and on life cycle analysis will start in 2023. For this, we are preparing a methodology to assure that data collection runs smoothly and that we are conducting our analysis on data that is realistically and readily available. Questions included in the questionnaire are the following:

1. Please tell us which of the following ecosystem services (preliminary list was provided) you consider to be relevant for you and for which you might already collect some data through measurements or monitoring: [preliminary list]
2. For all those where measurements or monitoring is happening, please describe what kind of measurements or monitoring, what kind of data is being gathered.

material including excel files with services were also looked at under <https://cices.eu/resources/>

3. When is a good time for further data collection, when exactly is your seeding, cultivation and harvesting time?

These answers were not available for this deliverable but are part of the further decision-making process.

RESULTS

General ecosystem services

FAO, CICES and IPBES all refer to similar services but categorize them slightly differently. Table 3 provides an overview based on the general categories (i) provisioning services, (ii) regulatory services, (iii) supportive services and (iv) cultural services in line with FAO and CICES. Regulating services are for example advantages derived through the management of ecological processes, such as the regulation of climate and

water. Provisioning services are "products obtained from ecosystems, such as genetic resources, food and fibre, and fresh water," and cultural services are "the non-material benefits people obtain from ecosystems, such as cognitive development, reflection, recreation, and aesthetic experience" (Thomaz, 2021). The IPBES services are classified in (a) material, (b) non-material and (c) regulation of environmental processes, which the study team aligned with the FAO and CICES categories. While CICES provided examples of the services, IPBES provided informative indicators. Supporting services or ecological functions, are, by some, described as "intermediate services"; CICES does not cover the classification for these services as they seek to identify the final services that link to the goods and benefits that are valued by people (Haines-Young & Potschin, 2018). The approach to the cultural services was different from IPBES to the other two sources. The more complex overview, compiling ES from global to coastal to seaweed ecosystems services, can be found in supplementary material sheet 2.

Table 3: Overview of the general Ecosystem services

| FAO | | CICES | IPBES | |
|--|---|---|---|--|
| Categorization of ES | Service | Example using their "class" category | Services | Indicators |
| Provisioning services | Food | Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes | Food and feed | <ul style="list-style-type: none"> Extent of agricultural land—potential land for food and feed production Abundance of marine fish stocks |
| | Raw materials | Fibres and other materials from cultivated plants, fungi, algae and bacteria for direct use or processing | Material and assistance | <ul style="list-style-type: none"> Extent of agricultural land—potential land for material production Extent of forested land |
| | | Plants cultivated by in- situ aquaculture grown as an energy source | Energy | <ul style="list-style-type: none"> Extent of agricultural land—potential land for bioenergy production Extent of forested land |
| | freshwater | Freshwater surface water used as energy source/ coastal and marine water used as energy source/ surface water for drinking | Regulation of freshwater and coastal water quality | Extent of ecosystems that filter or add constituent components to water |
| | Medicinal resources | ----- | Medical, biochemical and genetic resources | <ul style="list-style-type: none"> Fraction of species locally known and used medicinally Phylogenetic diversity |
| Regulating services | Local climate air quality | Regulation of chemical composition of atmosphere/ regulation of temperature and humidity, including ventilation and transpiration | Regulation of air quality | Retention and prevented emissions of air pollutants by ecosystems |
| | Carbon sequestration and storage | Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals | Regulation of ocean acidification | Capacity to sequester carbon by marine and terrestrial environments |
| | | | Regulation of climate | Prevented emissions and uptake of greenhouse gases by ecosystems |
| | Moderation of extreme events | Buffering and attenuation of mass movement/ storm and fire protection | Regulation of hazards and extreme events | <ul style="list-style-type: none"> Ability of ecosystems to absorb and buffer hazards |
| | Waste-water treatment | Regulation of the chemical | See above: Regulation of freshwater and coastal water quality | Extent of ecosystems that filter or add constituent components to water |
| Erosion prevention and maintenance of soil fertility | Control of erosion rates/ decomposition and fixing processes and their effect on soil quality | Formation, protection and decontamination of soils and sediments | Soil organic carbon | |

| | | | | |
|---------------------|--|---|--|--|
| | pollination | Pollination or 'gamete' dispersal in a marine context | Pollination and dispersal of seeds and other propagules | <ul style="list-style-type: none"> • Pollinator diversity • Extent of natural habitat in agriculture |
| | Biological control | Pest control (including invasive species) | Regulation of detrimental organisms and biological processes | <ul style="list-style-type: none"> • Extent of natural habitat in agricultural areas • Diversity of competent hosts of vector-borne diseases |
| | Regulation of water flow | hydrological cycle and water flow regulation (including flood control) | Regulation of freshwater quantity, location and timing, | Ecosystem impact on air-surface-ground water partitioning |
| Supporting services | Habitat for species | ----- | Habitat creation and maintenance | <ul style="list-style-type: none"> • Extent of suitable habitat • biodiversity intactness |
| | Maintenance of genetic diversity | ----- | | |
| Cultural services | Recreation and mental and physical health | Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through active or immersive interactions | --- | --- |
| | Tourism | Elements of living systems used for entertainment or representation | --- | --- |
| | Aesthetic appreciation and inspiration for culture, art and design | Characteristics of living systems that are resonant in terms of culture or heritage | --- | --- |
| | Spiritual experience and sense of place | Elements of living systems that have symbolic meaning | --- | --- |
| | --- | --- | Learning and inspiration | <ul style="list-style-type: none"> • Number of people in close proximity to nature • Diversity of life from which to learn |
| | --- | --- | Physical and psychological experiences | Area of natural and traditional landscapes and seascapes |
| | --- | --- | Supporting identities | Stability of land use and land cover |
| | --- | --- | Maintenance of options | <ul style="list-style-type: none"> • Species' survival probability • Phylogenetic diversity |

Table 4: The final list of ecosystem services

| Ecosystem services by Eklipse report and in line with the other sources | | Further specification from other sources |
|---|--|---|
| Provisioning | Food | |
| | Feed | |
| | Biomass & Hydrocolloids | Fertilizer (Heckwolf et al., 2021) |
| | | Raw material, natural products (Halpern et al., 2012) |
| | | Fibres (Duarte et al., 2021; Haines-Young & Potschin, 2018) |
| | | Resource and biotechnology (Biofuel, biogas, biomethane production) (Okada et al., 2019), Energy (Heckwolf et al., 2021) |
| | | Medicine (Duarte et al., 2021; IPBES, 2019) and biomedical products (Okada et al., 2019) |
| Genetic resources (Haines-Young & Potschin, 2018; Heckwolf et al., 2021; IPBES, 2019) | | |
| Climate regulation | CO ₂ draw down (Chung et al., 2017), carbon uptake (Duarte et al., 2021), carbon sequestration (Heckwolf et al., 2021), carbon storage (Okada et al., 2019), halocarbon retention (Heckwolf et al., 2021) | |
| | pH increase (Duarte et al., 2021), pH regulation (Heckwolf et al., 2021), regulation of ocean acidification (IPBES, 2019) | |
| | Coastal protection (sediment retention) (Chung et al., 2017), | |
| | Water quality | Nutrient cycling (Chung et al., 2013), nutrient assimilation (Duarte et al., 2021), suspended material removal (Okada et al., 2019), regulation of eutrophication (Heckwolf et al., 2021) |
| | | Improving water quality (Chung et al., 2017) |
| | Biological regulation | Biodiversity species (Duarte et al., 2021; Okada et al., 2019), rare species (Okada et al., 2019) and habitat (Chung et al., 2017; Duarte et al., 2021) |
| | | Photosynthesis (Duarte et al., 2021) |
| Cultural | Recreation and tourism | |
| | Symbolic aesthetics | Cultural heritage (Heckwolf et al., 2021) |
| | | Sense of place (Okada et al., 2019) |
| | Education and learning | Inspiration (Heckwolf et al., 2021) |
| | Scientific knowledge | |
| Social welfare | Coastal livelihoods and economics (Halpern et al., 2012) | |

Ecosystem services specific to seaweed

From the overview in supplementary material sheet 2, it can be noticed, that some ecosystem services listed in the global overview, like 'pollination' do not show up in the ocean and coastal overviews, as they are specific to terrestrial environments. Others listed in the ocean and coastal overviews, like pH regulation, are not specifically listed in the global overview, as they are specific to the marine environment. Ecosystem services reoccurring in every source

are food provisioning, water quality regulation, carbon storage and habitat support. There are small inconsistencies how the services were categorized, under regulating, provisioning or supporting, for this reason the service categories were listed for all coastal ecosystem service references.

The services provided by an ecosystem with seaweed cultivation, that were found in the studied literature were then matched to the general services and ocean and coastal-specific

Table 5: ES with available data collection methodologies and valuation methodologies

| ES | ES further specification from other sources | Data collection methodology available | Valuation method available |
|---------------------------|---|---|---|
| Biomass and Hydrocolloids | Fertilizer, raw material, natural products, fibers, resource and biotechnology, energy, medicine and biomedical products, genetic resources | (Andrade et al., 2020) | |
| Climate regulation | CO2 draw down, uptake | (Pereira et al., 2021) (Dolliver & O'Connor, 2022) | Carbon pricing: (Sondak et al., 2017) |
| | CO2 sequestration, storage | (Sondak et al., 2017) (Chung et al., 2013) | Carbon pricing: (Sondak et al., 2017) Carbon sequestration: (Röhr et al., 2016) |
| Water quality | Nutrient cycling, nutrient assimilation, suspended material removal, regulation of eutrophication | C, N & P content: (Kim et al., 2015) (Pereira et al., 2021) N removal from nearshore waters: (Barrett et al., 2022) N removal from surrounding waters: (Grebe et al., 2021) Bioextraction (C & N): (Kim et al., 2017) Biomitigation (C, N & P): (Chopin & Tacon, 2021) | Economic valuation of N removal: (Barrett et al., 2022) Economic valuation of bioextraction (C, N & P): (Chopin, 2014), ³ (Chopin & Tacon, 2021) |
| | Improving water quality | Supply of clean drinking water: (Sumeldan et al., 2021) | |
| Biological regulation | Biodiversity species, rare species and habitat | (Hynes et al., 2021), (Theuerkauf et al., 2022), (Sumeldan et al., 2021), (de Carvalho et al., 2017), (Radulovich et al., 2015), Habitat provision: (Corrigan et al., 2022), (Barrett et al., 2022) | |
| Recreation and tourism | Tourism | | (Rani et al., 2020) |

³ <https://www.globalseafood.org/advocate/seaweeds-top-mariculture-crop-ecosystem-service-provider/>

services, further specifying the examples to a marine ecosystem with seaweed cultivation. We want to point out, that it is not the seaweed alone that is providing these services, but rather the ecosystem surrounding it that, thanks to the seaweed, can provide these services. For instance, it isn't the seaweed itself that provides habitat for small fish, but the protective space created around the seaweed that serves as a refuge. Other services like nutrient uptake seem even more related to the seaweed itself, but here again, the nutrients come from the surrounding water and form an interconnected system that can provide the service. The final list of services within an ecosystem with seaweed cultivation can be found in Table 4 and in supplementary material sheet 3.

Available and tested methodologies

The 13 publications found from the Scopus search and the 7 later added publications were read in detail and searched for the methodologies for quantifying and valuating ecosystem services from seaweed cultivation.

From the literature review we collected the available and tested methodologies for data collection, and the tested methodologies for ecosystem service valuation. Table 5 provides an overview of the publications with these methodologies. In the supplementary material sheet 4, the details of the methodologies can be found, as well as a differentiation between quantitative or qualitative data collection for both ecological and socioeconomical data. This overview provides relevant input to the feasibility of ES quantification and valuation within this project. One can see that ecosystem services like nutrient cycling, carbon uptake (storage) and habitat provisioning have been quantified by 7 publications each. Other ES like improving water quality have not been covered and only one publication on cultural services. Food and feed provisioning boils down to the kg per ha or per km of cultivation and will be covered by the project for other analysis. The valuation of ES was collected but not analysed in detail, as this comes later in the project. It can be seen though, that carbon and nutrient credits are covered by the publications as valuation methods.

Application within SeaMark

This overview of the methodologies will be presented to the project partners in December 2022. Further steps to decide

which ES will be quantified and valued will be taken with the involved consortium partners. The timeline for this process is 2 months, as data collection potentially starts with the growing seaweed which is February – April. The involved partners include:

- Cultivators: Representatives of Ocean Rainforest and Algolesko.
- Project coordination: Ólavur Gregersen or Urd Bak.
- Researchers conducting the analysis: Sander van den Burg, Sophie Koch, Marcia Arredondo Rivera.
- Potentially researchers developing the business exploitation plans (WP8).
- Potentially other individual key partners, judged to be relevant by the consortium for these following decisions and discussions.

Step 1: Presentation of relevant ES

Parallel to this report the results of the survey will be received, delivering further insights on the relevance of the ecosystem services to the cultivators and which data they are already collecting. The study team will present to the involved consortium partners, the survey results, the availability of methodologies and a list of ES which could actually be valued and monetized within the project.

Step 2: Feasibility

This list of relevant ES for the project will then be assessed for feasibility. Based on the available methodologies from the overview provided by this report, the practical necessities for sampling can be deducted. With the discussion group, it needs to be checked whether the selected ES sampling is feasible, looking at the frequency of sampling, the availability of the equipment, capacities available within the cultivators team to do the sampling and when does the sampling need to start (during growth phase). The timeline for this decision process is the course of January.

Step 3: Practical protocols for data collection

The final relevant and feasible list of ES will be available. For those, the research team of WEcR will design practical protocols for the sampling and will also organize the equipment needed. The deployment of equipment, its monitoring and the sampling will be done by the members of

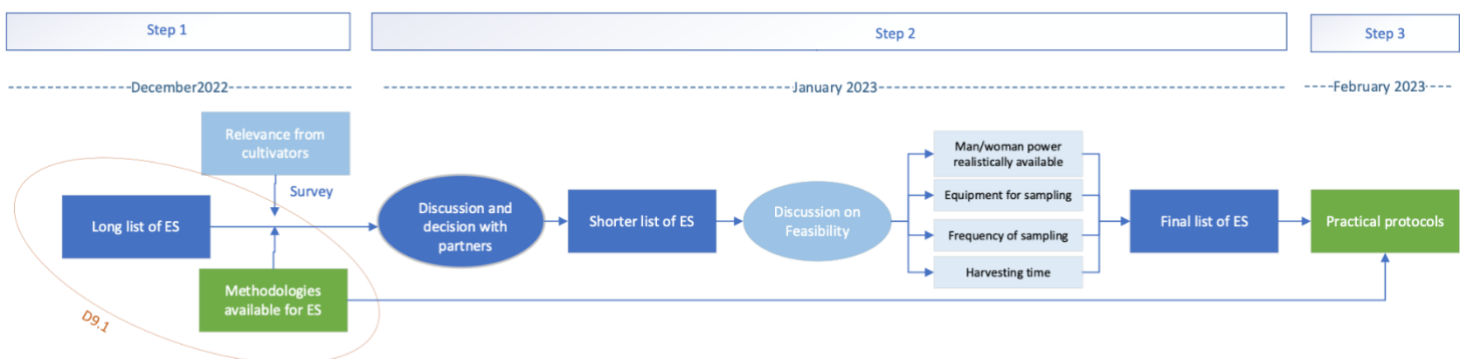


Figure 3: Decision making process for the ES

the cultivators during the months to follow until harvesting. Together with the involved partners, it will also be decided, when the cycle of data collection starts and ends. Potentially the equipment will stay in the water and sampling will continue for another year to have data on 2 cycles of seaweed growth.

CONCLUSION

The data collection for life cycle assessment can only start once a decision on the products to be assessed is made. This starts in the second feedback loop. This report provides an overview over the decision process and the methodology to follow for the assessment. For the ecosystem service quantification and valuation, there needs to be a decision, if the ES relevant for valuation, are feasible within the project to quantify. This decision will be done with the involved consortium members in January so that the data collection can start before the first growing phase of the seaweed. As a preparation for this decision, this report provides first results of the collected existing methodologies. It outlines also the decision-making process to arrive at a final list of services within an ecosystem of seaweed to analyse.

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