Integral framework for marine low trophic food systems
KB 34 Circular and climate neutral

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Supportive text for building block presentation

Context:
The Dutch government expressed its vision and ambitions regarding the development of the bioeconomy in the Netherlands to be in line with the European Union's bio-economy strategy that aims to improve and scale up the sustainable use of renewable resources to address global and local challenges such as climate change and sustainable development (EC 2018, EZ 2018). According to these visions, the circular (bio)economy should be seen as a means to reach more sustainability and not as a goal in itself. Therefore we start with an overview of the relevant societal goals and policy objectives, which are in part, part of the US Sustainable developments goals (SDG). By using the main global and EU documents together with the indicators to measure the performance towards achieving those goals/objectives.

This is then followed by an overview of the existing approaches/processes/methods/tools and their knowledge requirements that can be applied to guide the transition toward a more sustainable and hence climate-neutral society. As such this forms the basis to develop the knowledge base to guide the transition towards a circular and climate neutral bioeconomy.

One of the tools is to prepare a marine circularity dashboard, where it is possible to balance the activities on the marine environment and verify what the possible implications are for resource utlisation, ecosystem, human well-being, and energy efforts. This includes CO_2 sequestration/emissions, biodiversity, or protein production when a certain part of the sea is used for a specific activity. This way policy makers can obtain insights on the consequences of their choices could be on some of the key elements of the marine system. The goal of this KB project is the device a roadmap toward a circular economy, at the moment we live in a linear economy where there is a lot of waste. The earth has finite resources and should be made use of in a better more sustainable way if we want to keep being able to feed our self and future generations. To get to a circular (bio) economy there has to be a willingness to change. A roadmap can give insight in what and how things have to change. Figure 1 gives a good example of such a road map.

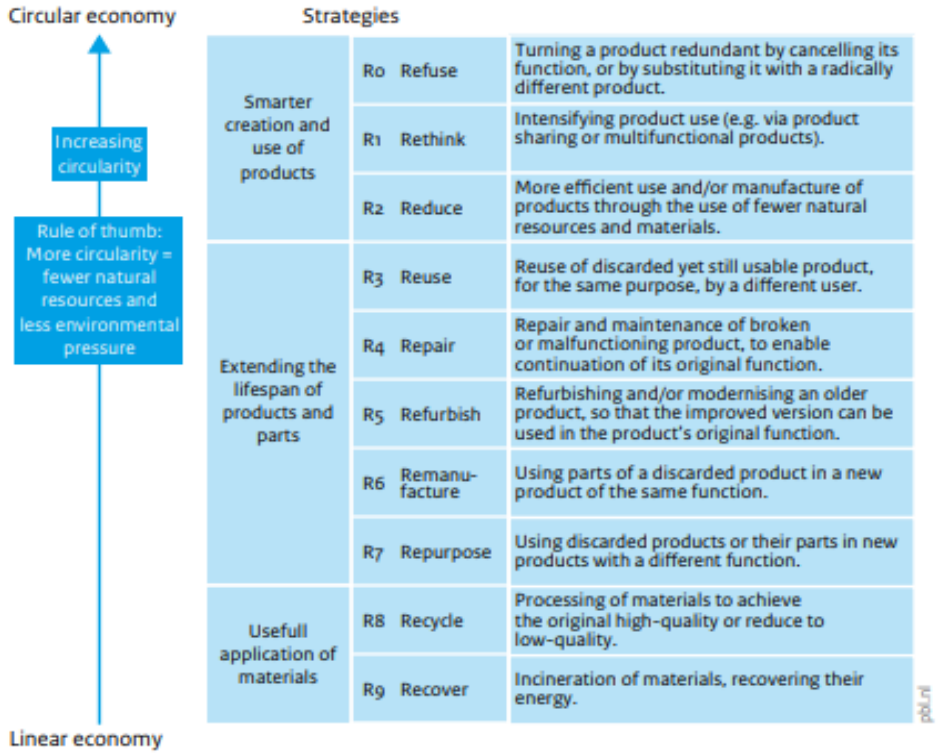


Figure 1. Road map from a linear economy to a circular economy.

Resource security

An increasing world population will put even more pressure on food production. To achieve this greater food demand the primary resources needed to grow this food must be secured. Resource security for marine food production systems mainly look at the basis of the food web, Phosphorus and Nitrogen which are the main macro nutrients on which the rest of the food chain is built. Since nutrients come from land it is the best practise to look at both land and sea food systems. Additionally to create a truly circular food system, the role of water needs to be integrated into the framework. By coupling the land based agriculture and the marine food production, and see them as one system, water and nutrients can be secured. To do this indicators are needed to give insight into the current usage and to change practices where the value chain is not jet circular. To achieve this the principles of efficient use of nutrients need to be applied. Particularly for those resources which are scarce, this can be done by reducing the material losses and waste which are currently high. In general this means that the efficiency of the resource use needs to be measured (N, P, C, Water, Soil, Air and Land).

Indicators:

- Captured P uptake in relation to P lost in the ecosystem (P uptake - P lost)
- M^3 fresh water used
- M^3 fresh water : water scarcity index (indicates resourced of water versus available water)
- M^2 areal used / unit
- Efficiency in Production: % primary production utilized
- Proportion of stocks and production within biologically sustainable levels (MSY and Carrying capacity indicator)
- Proportion of stocks generating beneficiary effects
- % Utilisation (waste ratio)
- Carbon sequester scenarios (land versus sea)

To encourage circular food production a system of nutrient crediting could by initiated. Where there would need to be an credit system to offset the amount of nutrients used by mitigation efforts.

Affordable and clean energy

This goal is directly taken from the UN's SDG
The energy sector is one of the main contributors to climate change, according to the UN 60% of the worlds greenhouse gas (GHG) emissions come from the energy sector. In the last decade many countries have already taken steps to increase the renewable energy sources and decrease the dependence on fossil fuels. Decreasing the GHG emissions is one of the best ways to combat climate change. To do this the circularity principle here is simple, reduce the amount of fossil fuels and increase renewable energy sources.
Indicators for this goal are:

- % renewable energy sources
- % dependence fossil fuel
- GHG emission
- CED (Cumulative Energy Demand) production

By reducing the amount of GHG in the atmosphere there is also less CO2 in the marine system since the oceans are a reservoir for CO2. Hereby decreasing ocean acidification which is a threat to calcifying species, such as bivalves.

Zero hunger

After years of decline in world hunger the trend is reversed and is increasing again, and with the increase in population the amount of people who don't have access to enough nutrition will further rise. To reverse this increasing trend once again there must be a change in out methods of food production and agriculture. By using a more circular approach to land an sea food production it not only becomes more sustainable there will also be less waste and therefor more food will be available for those who need it the most.

The main method to achieve zero hunger, is to give more food security. To achieve this by using the circularity principles there needs to be a maximum utility of products, so that there is an optimum use of biomass and food. So there needs to be a methods to measure the utility of biobased products, to ensure a reduction of residual streams and to stimulate high efficiency in biomass use. For a circular food production that means production at maximum sustainable yield (MSY) and to get a measure of production efficiency. Indicators for this are:

- Net contribution (EU supply, Mondial, food scarcity nations)
- Indicator of food price anomalies (IFPA)
- Kg food consumer (protein)
- Kg food consumer (carbohydrate)
- Kg food (miconutrients)
- Kg feed (protein)
- Kg landed biomass (food+feed) /unit
- Discard ratio (Kg catch landed + discards / discards)

Climate action

Besides decreasing GHG emissions there is the other side of the climate equation which would help balance the system. Carbon sequestration, would decrease the amount of CO_2 in the oceans and atmosphere. Additionally the nitrogen release though NOx gasses is also one which is often forgotten, but should also be taken into consideration. To goal is to reduce the emissions of GHG, to be able to do this you need indicators that measure the effect of the GHG emissions, show when systems are in balance and when they are not. The indicators used are:

- Kg production / MJ fossil fuel
- CO_2 emission / production
- Carbon capture / Kg production (this can be negative if capacity is compromised)
- Carbon balance disruption factor??
- NOx eq / product

By using these indicators in the circular food production system, a measure of the products that cost a lot of CO2 or fossil fuels per production unit can be identified. On the other hand de production of some low trophic products can help mitigate climate change by actively contributing to carbon capture per unit of production. The release of NOx gasses needs to be taken into account as these are also part of GHG.

Ecosystem/Biodiversity, conservation and restoration

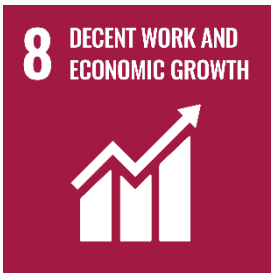
The ocean plays a key part in the balance on earth, it regulates the our climate and supports a large portion of our economic, social and environmental needs. At the same time the marine systems is facing, unsustainable depletion practises, pollution, environmental destruction and carbon saturation, which causes ocean acidification. This has all let to a decline in marine biodiversity, ecosystem deterioration, and disappearing habitats. To reach the goal of a circular system the importance of the oceans needs to be taken into account by protecting vulnerable areas, employing sustainable fishing practises and firm pollution policies. This will often mean a trade of between environmental and socio-economic impacts. To achieve this the indicators need to be able to measure the environmental, social and economic sustainability:

- Desired Production per amount of externalities (i.e. pressures) created and their impacts on the social-ecological system (i.e. biodiversity/functioning and human well-being)
- Impact assessment shows all pressures and the potential impacts they cause
- Ecosystem service supply
- Index of coastal eutrophication
- Habitat Index
- Biodiversity index (BISI, NCAI)

To encourage policy makers to implement more sustainable practices concerning biodiversity and stimulate the conservation and restoration of ecosystems mitigation measures can be applied. These mitigation techniques can additionally monitor the workings of the indicators.

- The implementation of marine protected area's (MPS)
- Compose a biodiversity crediting system
- Implement marine spatial planning as part of any activity at sea
- Implement a DIPSR analysis to assess the connection between indicator and the measured effect

Viable economic sectors



While it is important to conserve van restore the marine environment, it also imperative that we keep the economic sector sustainable. It is important to increase the quantity and quality of jobs the marine employment sector while keeping in mind the environmental factors. This will often mean a trade-off between the environmental and socio-economic impacts. One way to do this is to increase the efficiently of the jobs, however it is vital that this will not just benefit the big companies, equity should be a main principle with more focus on small and local businesses. To keep the marine economic sector viable and include the circular system it will need measurable indicators to keep track of the changes. One why to do this is to monitor the consumer drivers and barriers, and the profitability sectors. Indicators for this are:

- Cost-benefit per surface area
- Employment opportunity balance
- Quality index jobs
- Quantity index jobs

to increase the quality and quantity of jobs in the maritime sector and become a true circular (bio) economy the sector will need to make some necessary changes, there will need to be more focus on the smaller local businesses and sustainable trade-offs between the environmental and economic impacts need to be included in all marine activities. With will require a willingness to change from within the sector itself, and from the consumers.

Human Well-being

Compared with many other countries is the Human wellbeing in the Netherlands very good, however improvements can always be made to increase our health and improve work conditions. To embrace the circular (bio)economy is going to require a lot of change in the way we live, work and consume products. To make sure human wellbeing is not compromised in the process indicators looking at labour conditions need to be in place. In a circular (bio)economy more focus will be places on local and smaller food chains, this goes against the globalisation that we have developed in the recent past. Additionally with the outbreak of the COVID-19 pandemic more focus has been placed on the prevention of diseases.

Indicators for human wellbeing in the marine sector are therefore mainly focused on working condition and risks control. The indicators are already set up by the international labour organisation (ILO) and have been written with the UN's SDG in mind.

Land- sea framework: Blue carbon

In table 1 a summary of the societal goals and policy objectives related to the circularity principles and potential indicators to monitor progress towards these goals/objectives can be seen. These goals are linked to the UN's Sustainable development goals (SDG). One of the ways we can reach these goals is to link the land and sea food production and to invest in blue carbon. Blue carbon can be used to decrease the carbon concentration in the atmosphere and reduce the emissions, hereby working towards multiple of the SDG. The Carbon capture, will act as a climate tool in shellfish, seaweed and energy production. one of the emissions that is a "hot topic" now is the nitrogen crisis, because the agriculture is not yet truly circular, there is a surplus of nitrogen in the rearing of animals for our food production. By combining the land with the sea production the surplus nitrogen can in part be used for the production of bivalves and seaweed as can be seen in in figure 2.

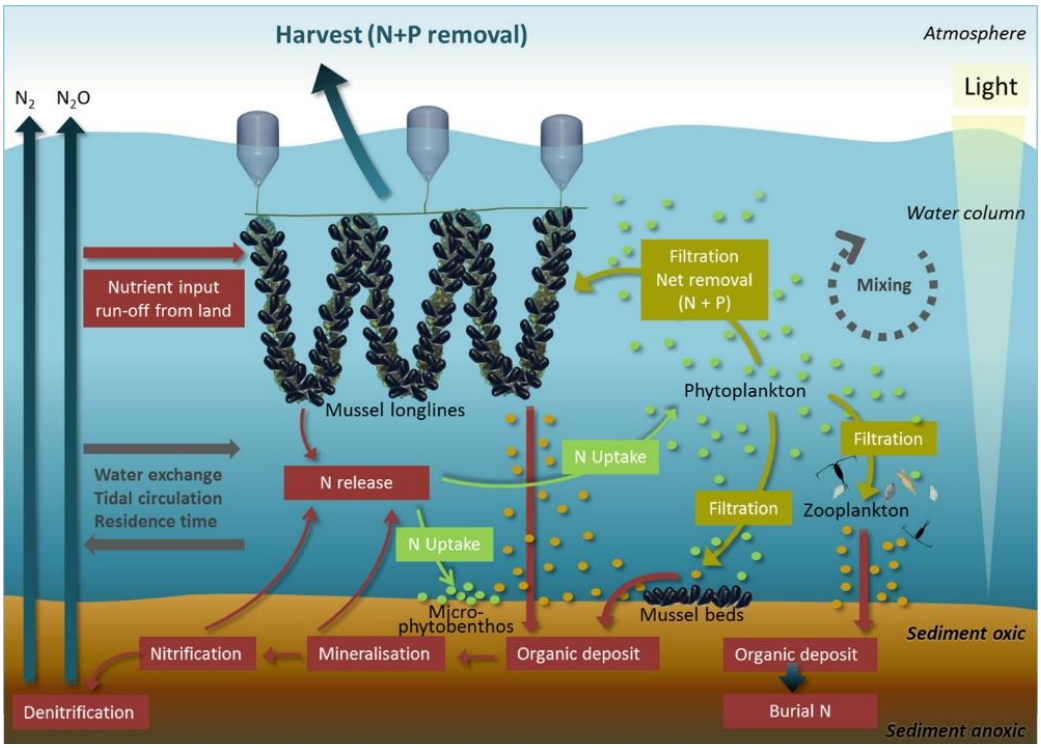


Figure 2. nutrient cycle of seaweed and bivalve production.

Table 1. Overview Indicators for an integral Framework to assess low trophic food systems in a circular context.

Societal goals/Policy objectives	**Principles**	**Indicators general**	**Indicators /drivers**	**Indicators specific**	**Mitigation**
Resource security Phosphate depletion Water depletion (circular water vision)	Efficient use of resources, particularly those that are scarce, including through the reduction of material losses and waste	To measure efficiency in resource use (N, P, C, Water, soil, air and land)	Production contribution Water utilisation P uptake, loss e and capture N uptake, loss and release	Production: - Kg food consumer (protein) - Kg food consumer (carbo hydrate) - Kg food (miconutrients) - Kg feed (protein) - Kg landed biomass (food+feed) /unit - Discard ratio (Kg catch landed + discards / discards) - Captured P uptake (P uptake - P lost)	Phosphate crediting Carbon crediting Nitrogen crediting
Affordable and clean energy Energy efficiency Renewable energy	Increasing the use of renewable resources, particularly those that are an alternative to fossil resources so that they reduce the fossil dependency	That measure dependence on fossil resources	Use of renewable energy: Hydrogen Bio-based material (e.g. nets	- % renewable energy sources - % dependence fossil fuel - GHG emission - CED (Cumulative Energy Demand) production	
Zero hunger Food security	Maximize the utility of products in that there is optimum use of biomass and food	That measure the utility of biobased products ensuring a reduction of residual streams and high efficiency in biomass use.	Production at MSY Production efficiency Increase crop yield Decrease CO2 eq Improvement production efficiency Replacement resources (MAGNET) Food safety risks	Efficiency in Production: - % primary production utilized - Proportion of stocks and production within biologically sustainable levels (MSY indicator) - Net contribution (EU supply, Mondial, food scarcity nations) - Indicator of food price anomalies (IFPA)	
Climate action GHG emissions Carbon sequestering Nitrogen release	Reduce the emissions of Green House Gas	That measure effects on GHG emissions, balance, climate mitigation		- Kg production / MJ fossil fuel - CO2 emission / production - Carbon capture / Kg production (this can be negative if capacity is compromised) - Carbon balance disruption factor?? - NOx eq / product - M3 fresh water used	

				- M3 fresh water : water scarcity index - M2 areal used / unit	
<u>Ecosystem/Biodiversity conservation and restoration</u> Reduce/avoid adverse impacts Zero pollution Implement MPAs (10% or more)	Trade-offs between environmental and socio-economic impacts	That measure impacts on the environmental, social and economic sustainability		General: - Desired Production per amount of externalities (i.e. pressures) created and their impacts on the social-ecological system (i.e. biodiversity/functioning and human well-being) Environmental: - Impact assessment shows all pressures and the potential impacts they cause - Ecosystem service supply - Index of coastal eutrophication - Habitat Index - Biodiversity index (BISI, NCAI) - Index of coastal eutrophication - Zooplankton Index	MPA implementation Biodiversity crediting Spatial planning Implementation (DIPSR)
<u>Viable economic sectors</u> Efficiency Equity Increase the number and quality of maritime jobs	Trade-offs between environmental and socio-economic impacts	That measure impacts on economic sustainability	Economic Profitability sectors Consumer drivers and barriers	- Cost-benefit per surface area - Employment opportunity balance - Quality index jobs - Quantity index jobs	Local food chains Willingness to Change
<u>Human Well-being</u> Healthy Health impact			Labour conditions Willingness to change Disease risk Globalisation chains	SDG Indicators under ILO custodianship	

Climate smart and circular

The key to a climate smart and circular food system is to link the land an sea production and to look into the production of low trophic products. To reach this goal multiple steps have to be taken and the indicators of the preciously mention SDG need to be in place. Furthermore we need to know the drivers and pressures of the still to be developed food systems in the marine environment. To do this we need to have a better understanding of the system. Furthermore the government need to approve and create new policy for the production ad sea as this will inevitably require different policy's than on land. Monitoring tools need to be developed to be able to adequately measure the indicators. All these steps and requirements can be seen in the figure below, a lot of work is still need to be done, but at the core it should lead to a the development of a low tropic system for circular climate food systems.

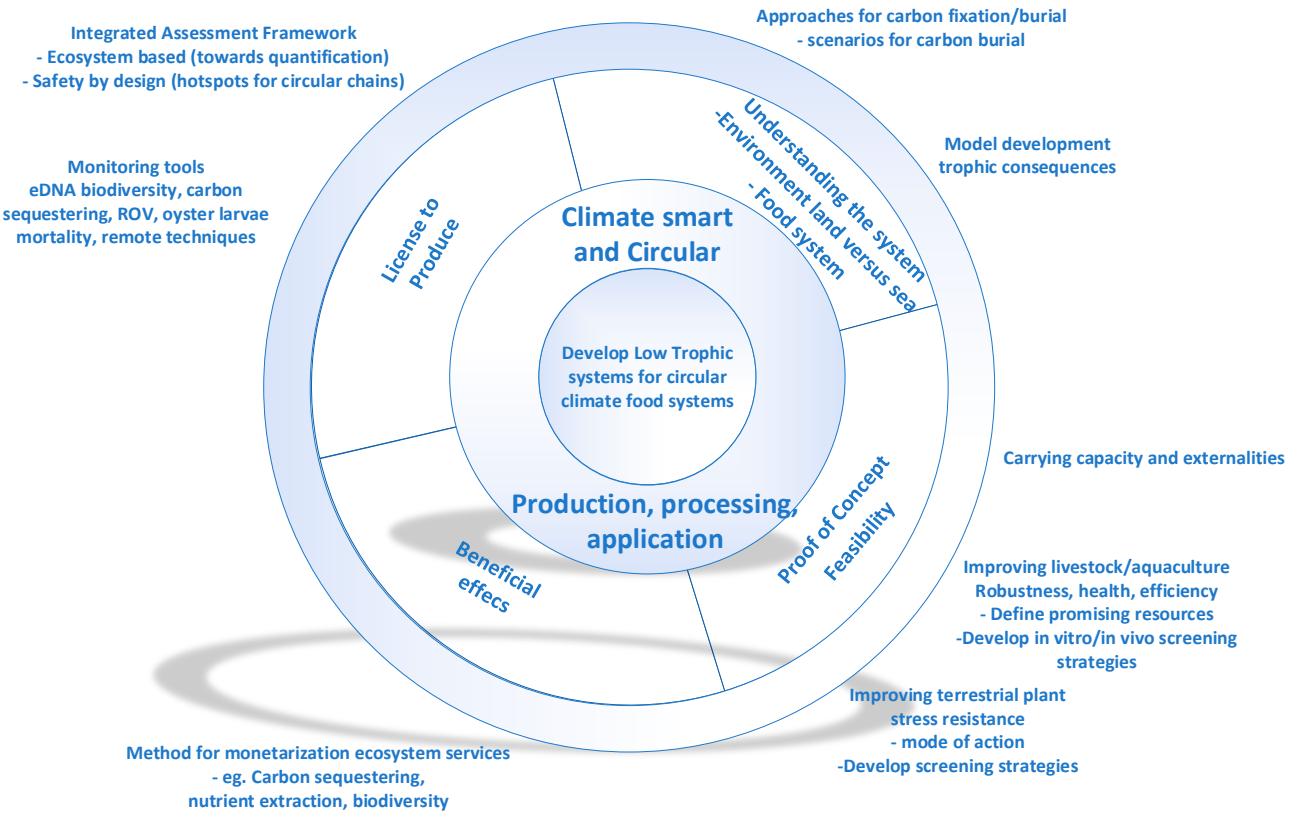


Figure 3. Project plan WUR to a circular low trophic food system.