A roadmap to a circular land-sea framework

10 December 2020

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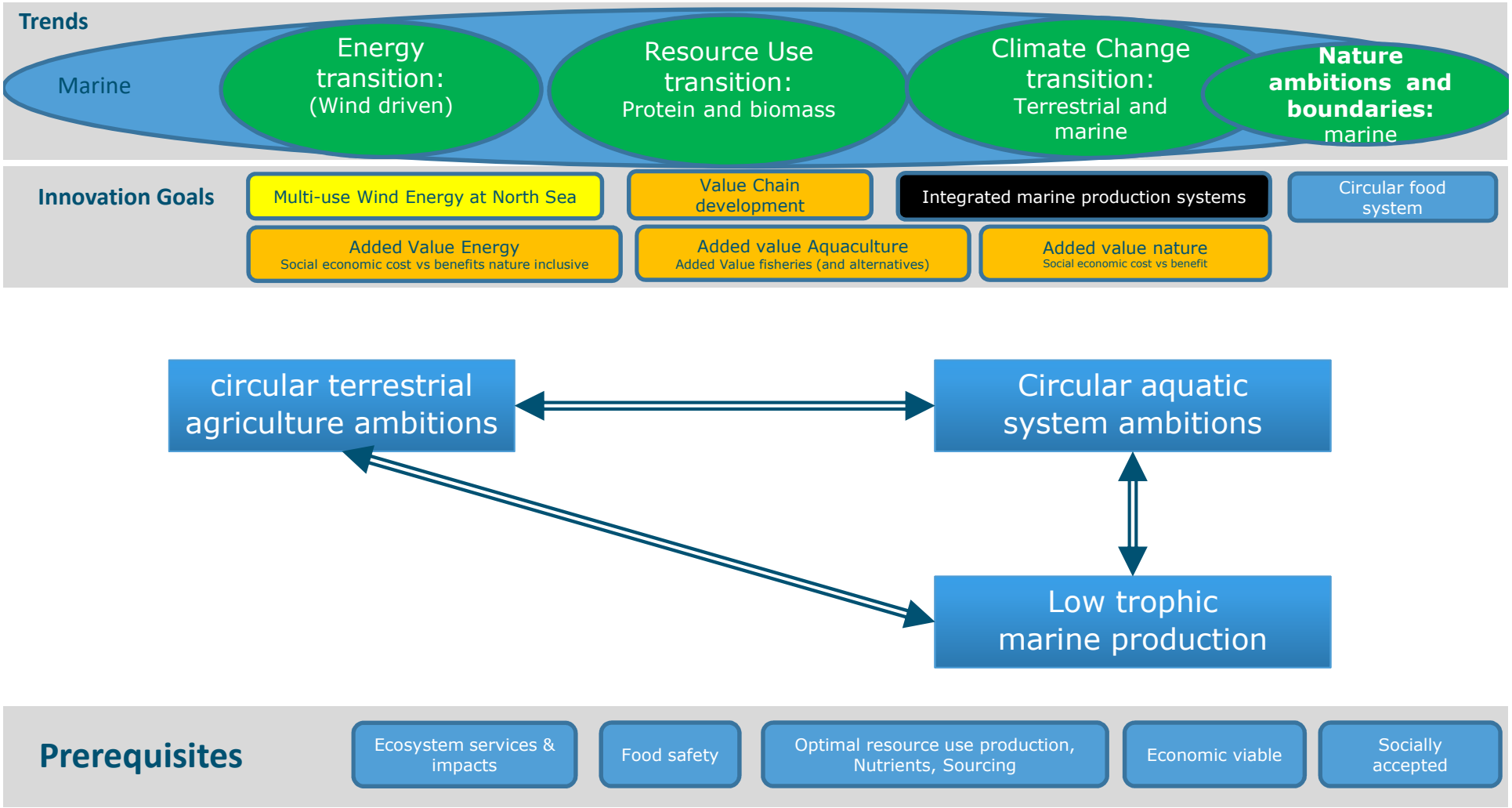
Grand Challenges at sea and land



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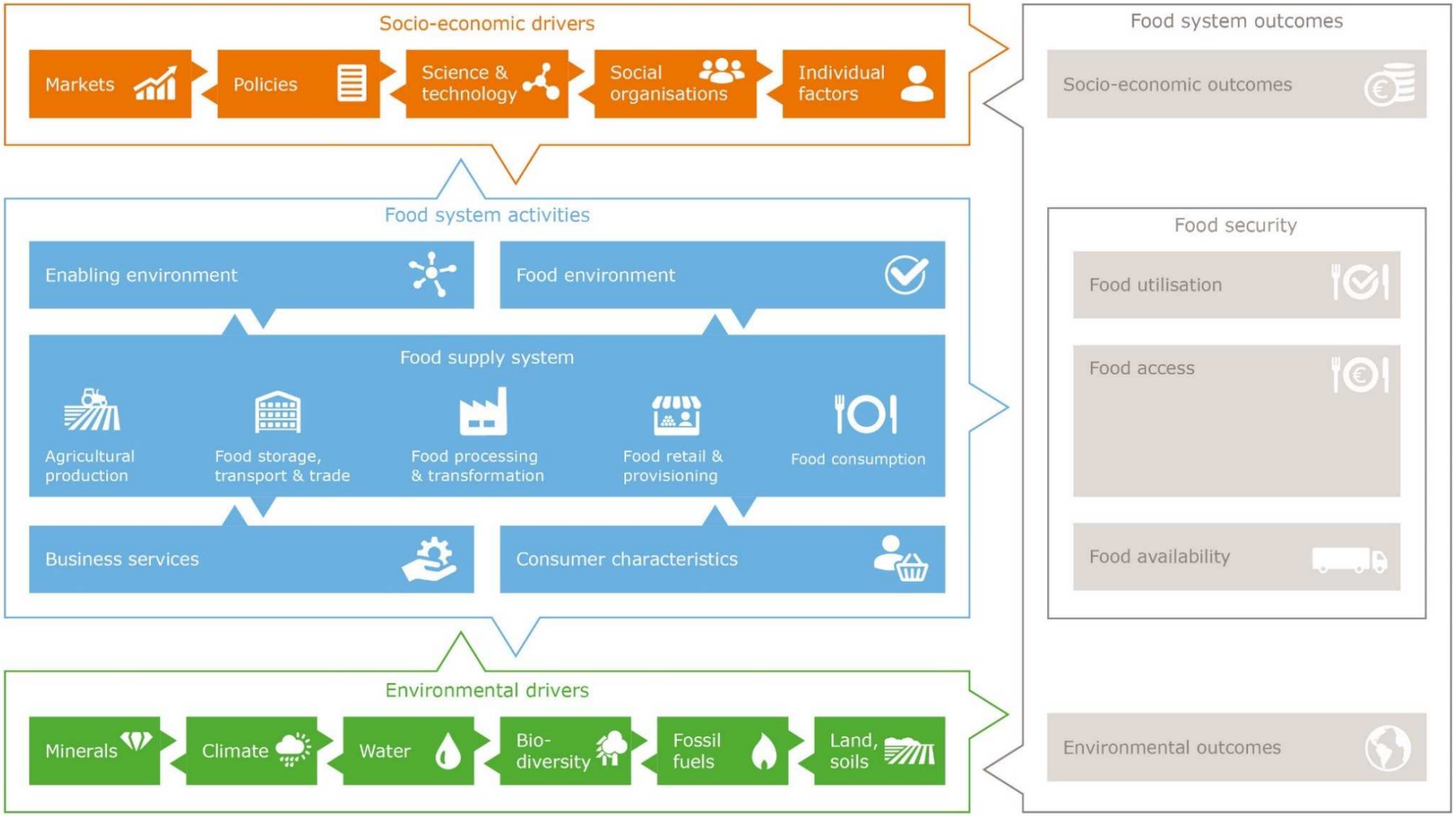
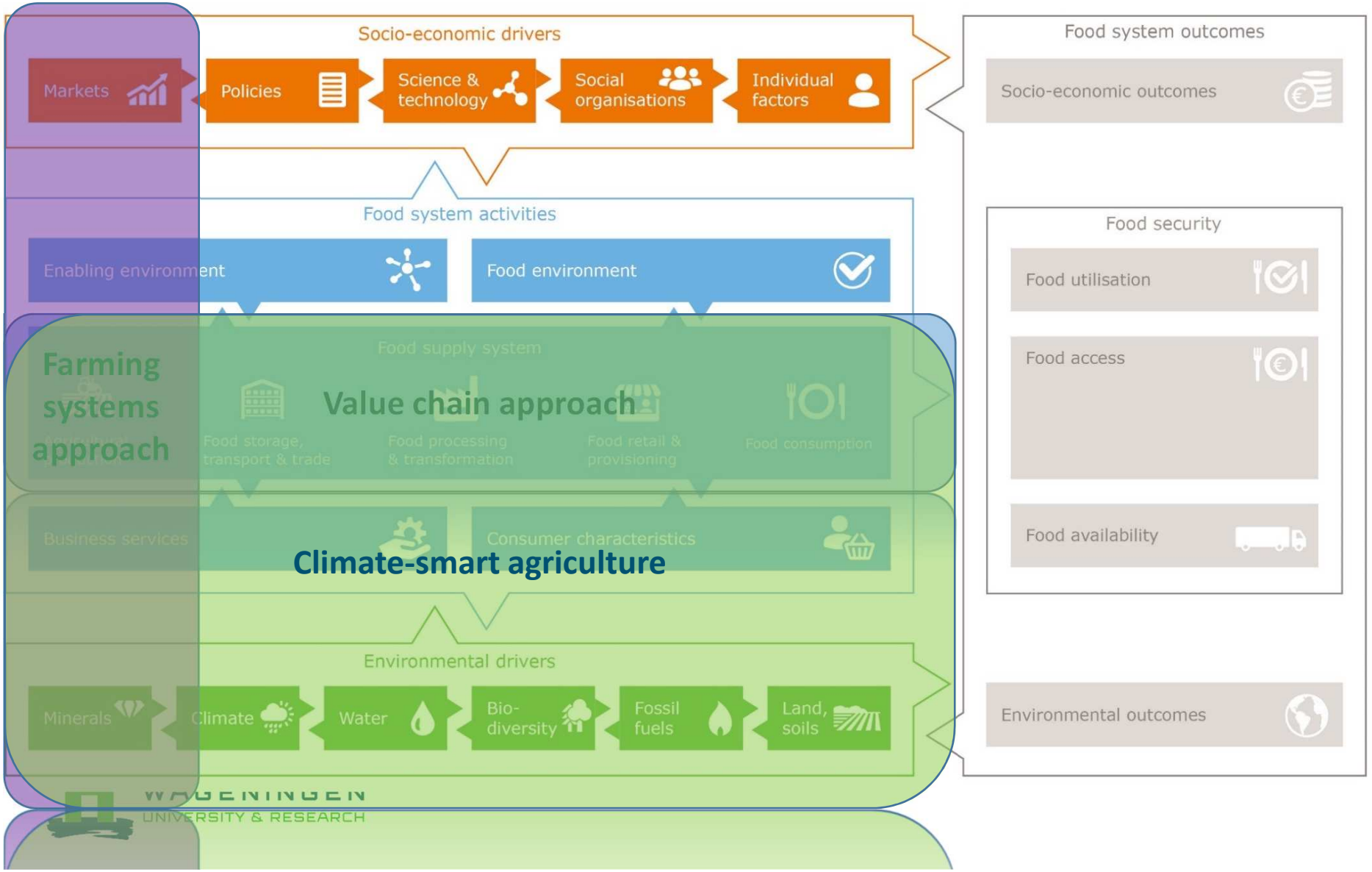
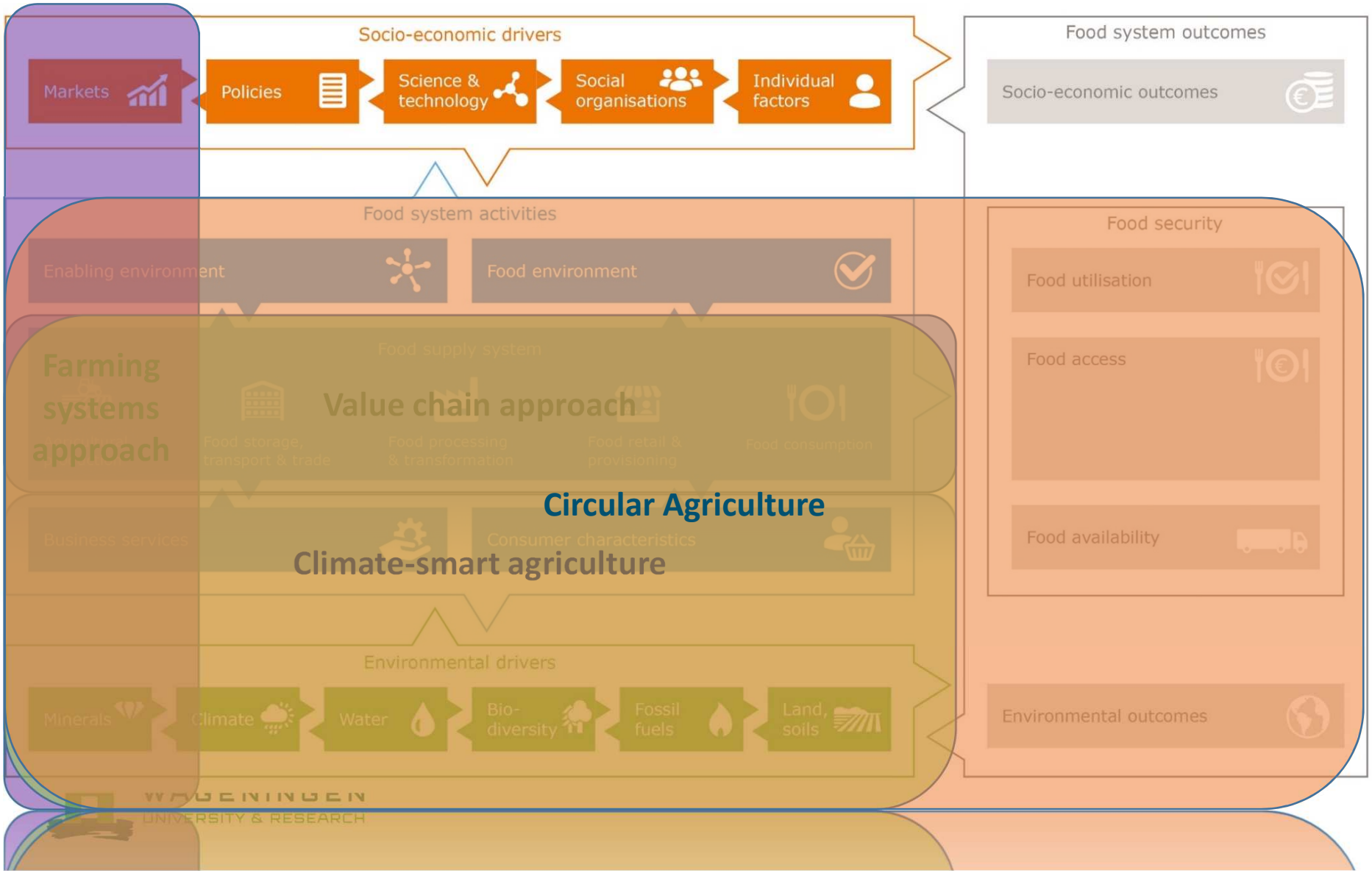
Food System approach

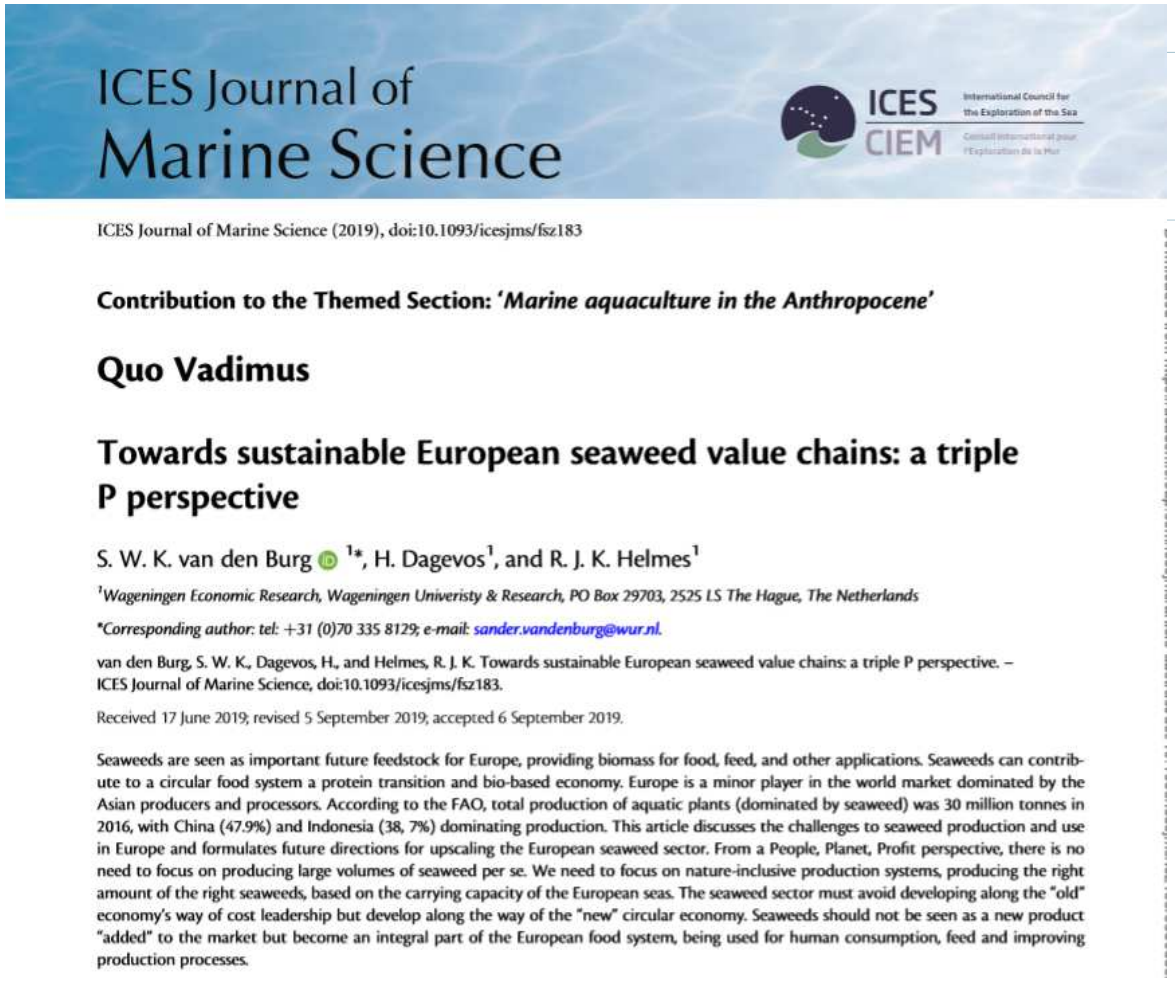


Farming System Approach



Circular Agriculture





ICES Journal of Marine Science

ICES Journal of Marine Science (2019), doi:10.1093/icesjms/fsz183

Contribution to the Themed Section: '*Marine aquaculture in the Anthropocene*'

Quo Vadimus

Towards sustainable European seaweed value chains: a triple P perspective

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van den Burg, S. W. K., Dagevos, H., and Helmes, R. J. K. Towards sustainable European seaweed value chains: a triple P perspective. – ICES Journal of Marine Science, doi:10.1093/icesjms/fsz183.

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Seaweeds are seen as important future feedstock for Europe, providing biomass for food, feed, and other applications. Seaweeds can contribute to a circular food system a protein transition and bio-based economy. Europe is a minor player in the world market dominated by the Asian producers and processors. According to the FAO, total production of aquatic plants (dominated by seaweed) was 30 million tonnes in 2016, with China (47.9%) and Indonesia (38, 7%) dominating production. This article discusses the challenges to seaweed production and use in Europe and formulates future directions for upscaling the European seaweed sector. From a People, Planet, Profit perspective, there is no need to focus on producing large volumes of seaweed per se. We need to focus on nature-inclusive production systems, producing the right amount of the right seaweeds, based on the carrying capacity of the European seas. The seaweed sector must avoid developing along the "old" economy's way of cost leadership but develop along the way of the "new" circular economy. Seaweeds should not be seen as a new product "added" to the market but become an integral part of the European food system, being used for human consumption, feed and improving production processes.

The seaweed sector must avoid developing along the “old” economy’s way of cost leadership but develop along the way of the “new” circular economy. Seaweeds should not be seen as a new product “added” to the market but become **an integral part of the European food system**, being used for human consumption, feed and improving production processes.

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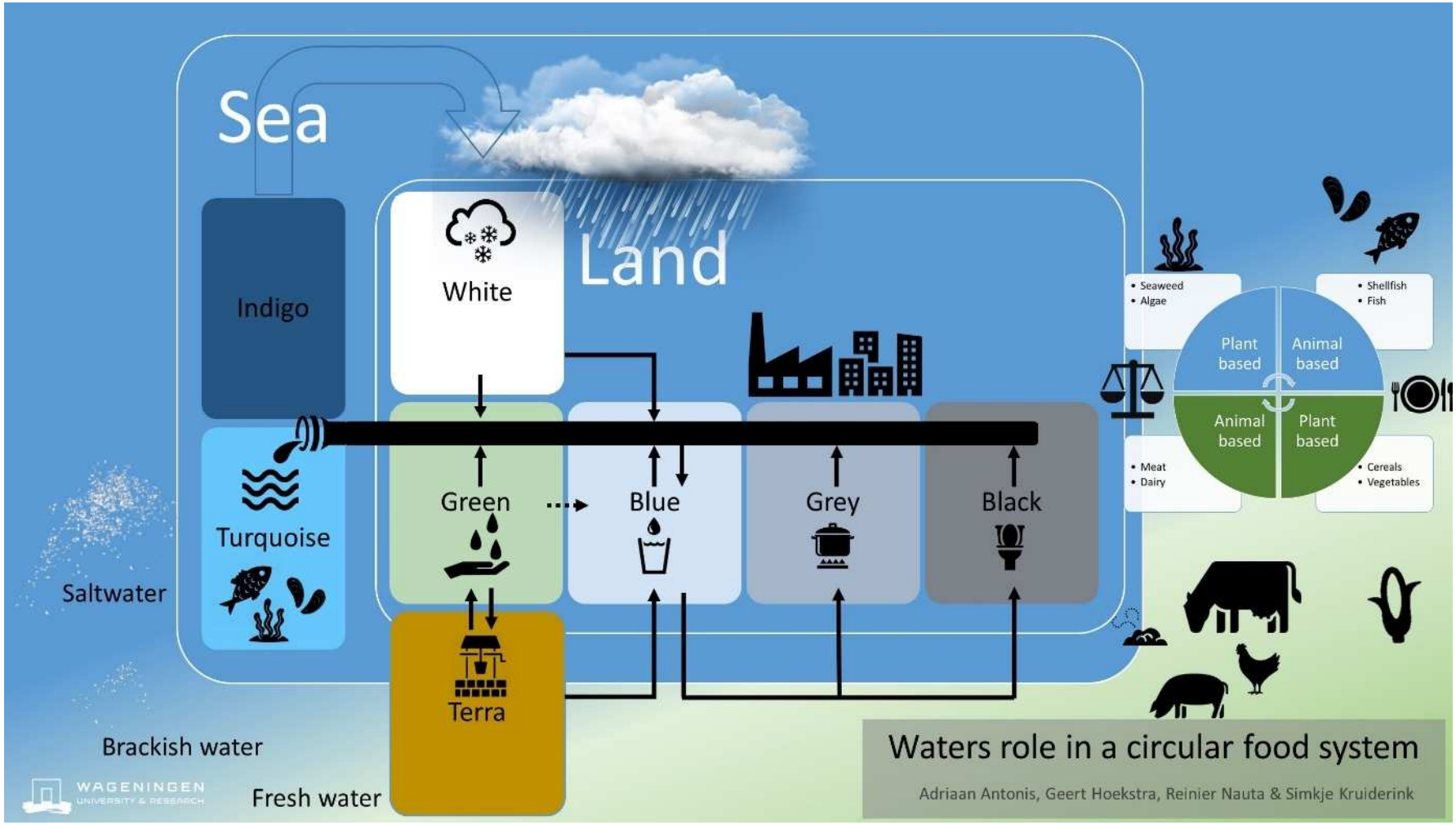
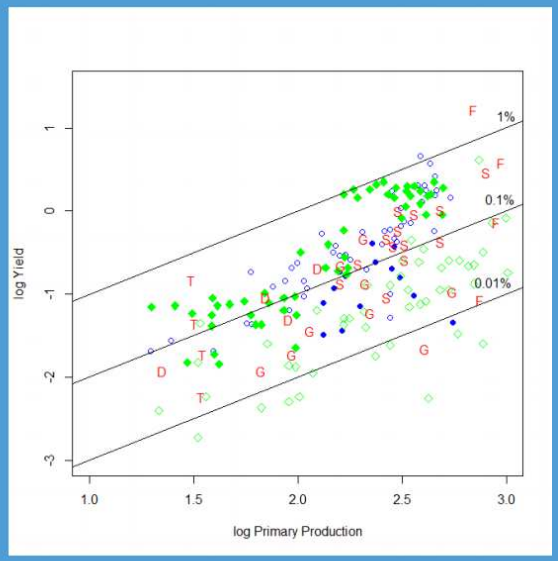
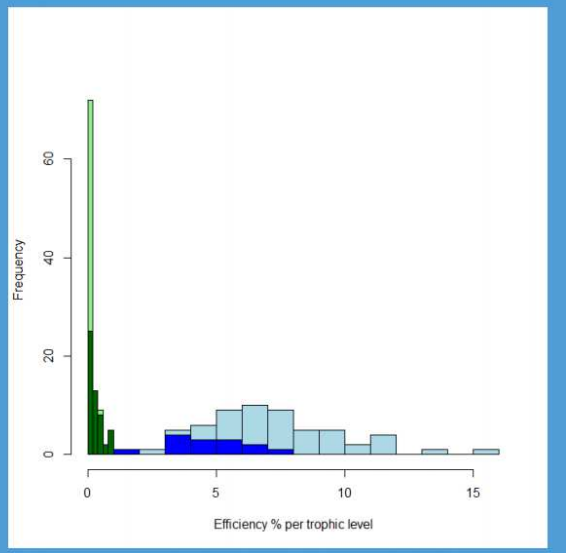
Water’s role in a circular food system



Secondaire en primaire productie (log10 gC m^{-2} y^{-1})



Lindeman efficiëntie



Landbouw

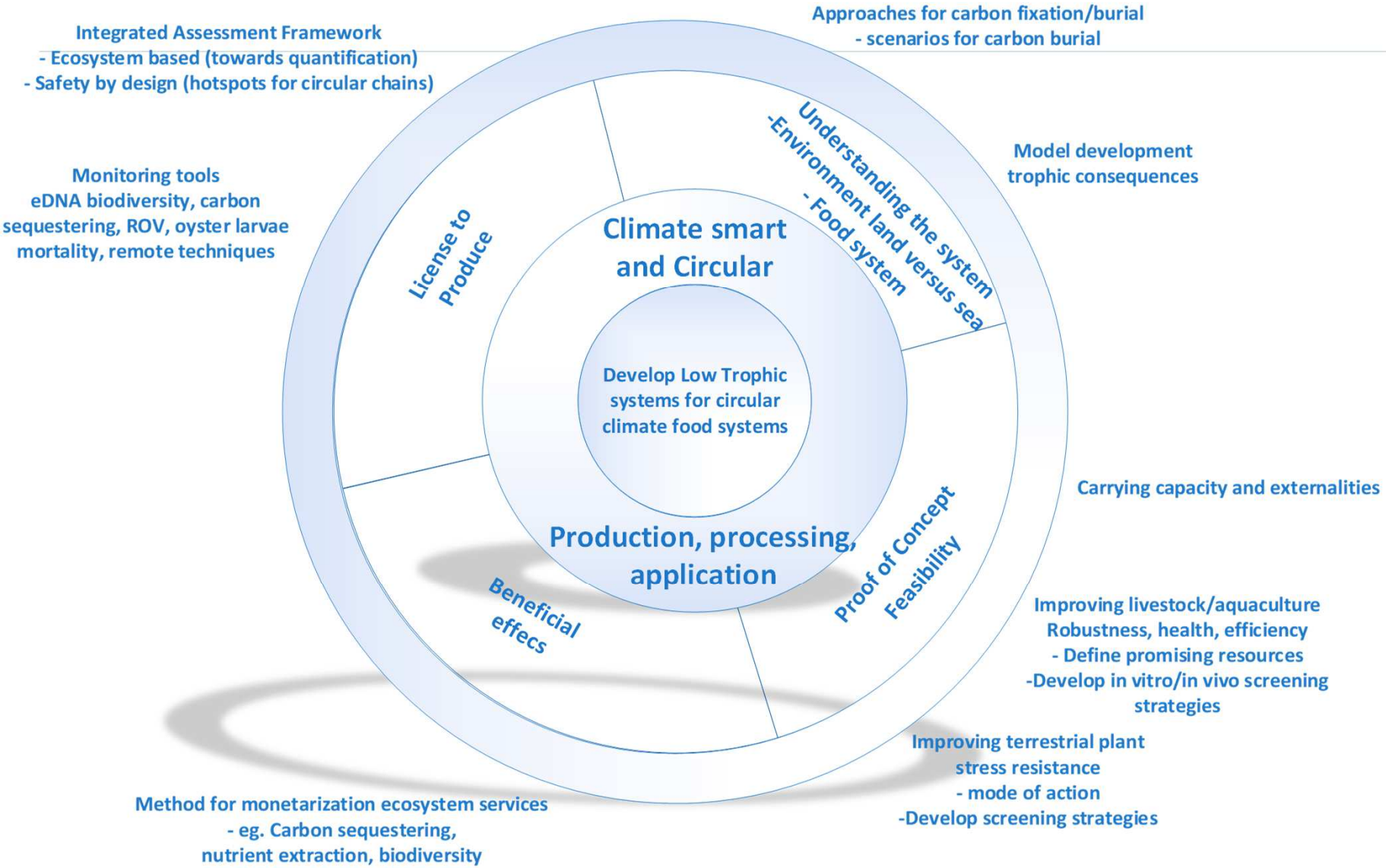
- Geen substantiële toename van de primaire productie
  - Bemesting
  - Irrigatie
- Toegenomen efficiëntie richting productie-organismen
  - Bejagen van predatoren/grazers en concurrenten
  - Veredeling en selectie
  - Aanleggen van voedselvoorraden om perioden van schaarste te overbruggen

Lessen uit de ecologie en de landbouw

- Een substantiële toename van de primaire productie valt niet te verwachten
- Verhoogde efficiëntie is onwaarschijnlijk
- Enige optie is 'fishing down the food web', maar de practische problemen zijn groot, en ...

Van der Meer, 2020

KB34 Circular



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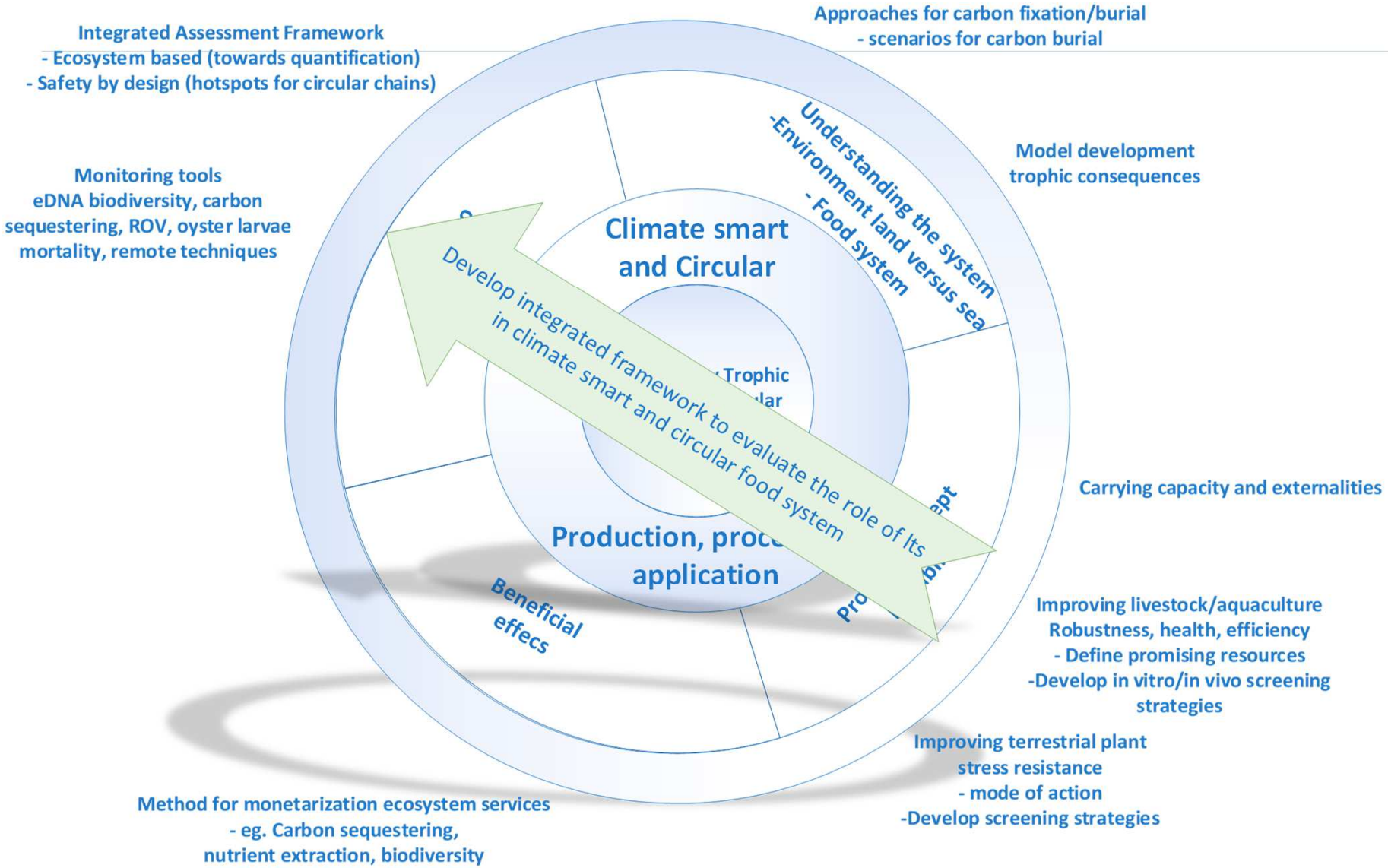
KB34 Circular



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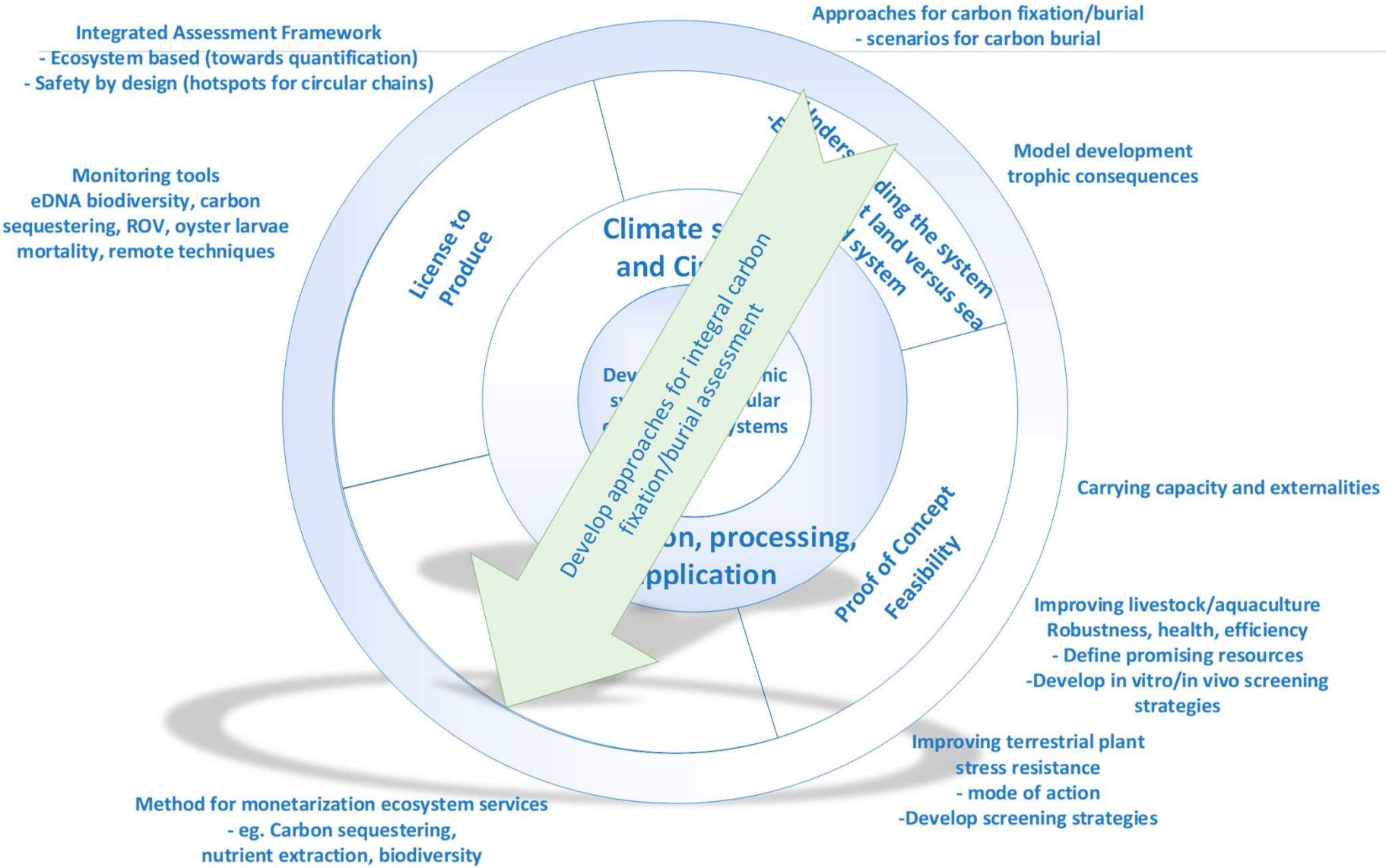
KB34 Circular



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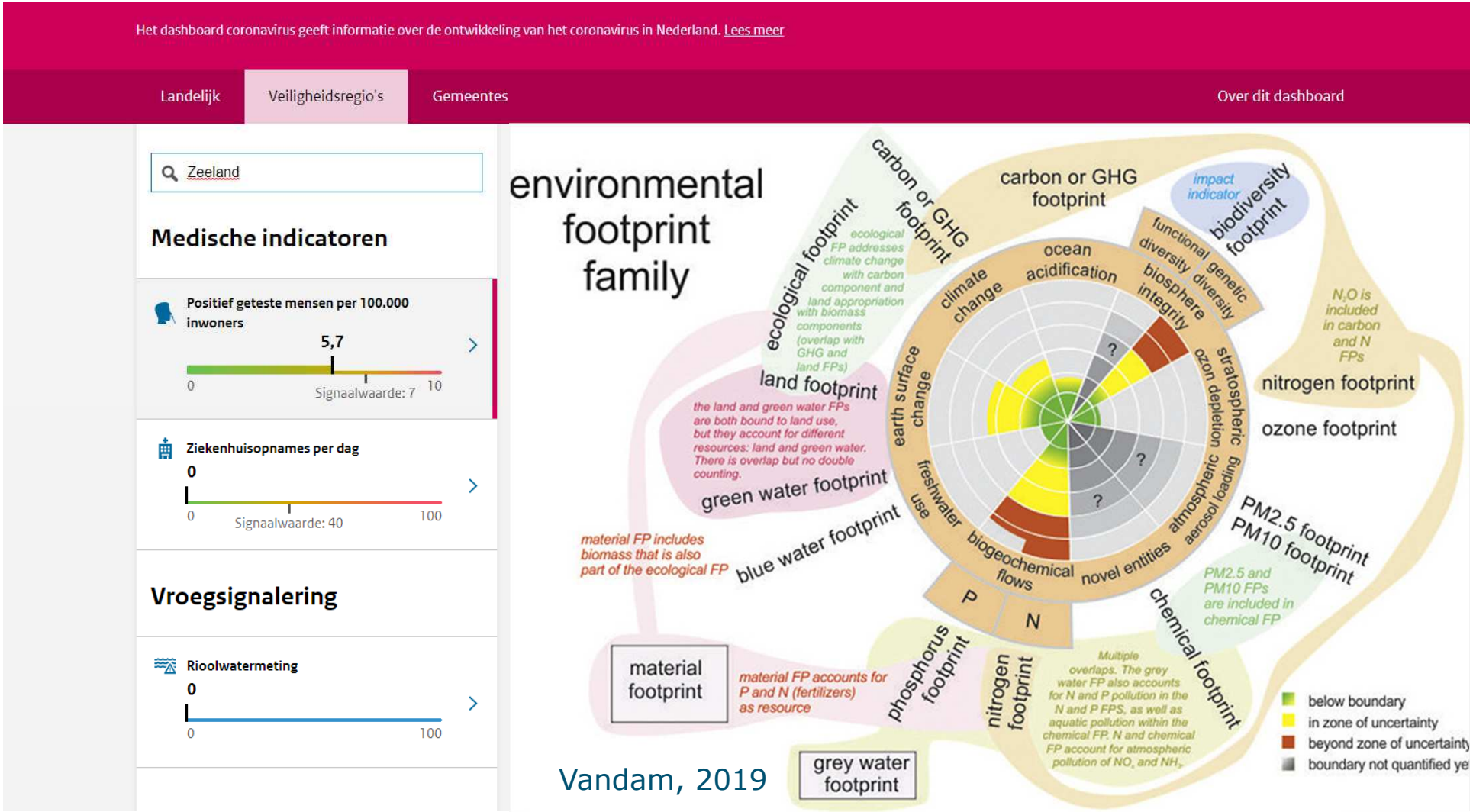
Corona dashboard to marine circularity Dashboard



Vandam, 2019

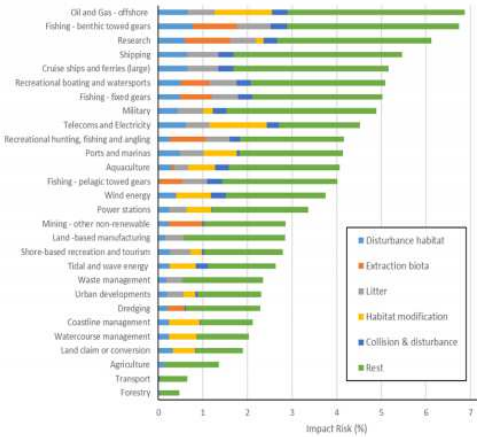
Ultimately to Circularity indicators

Production indicators

Kg food consumer (protein)
Kg food consumer (carbo hydrate)
Kg food (micronutrients)
Kg feed (protein)
Kg landed biomass (food+feed) /unit
Discard ratio (Kg catch landed + discards / discards)

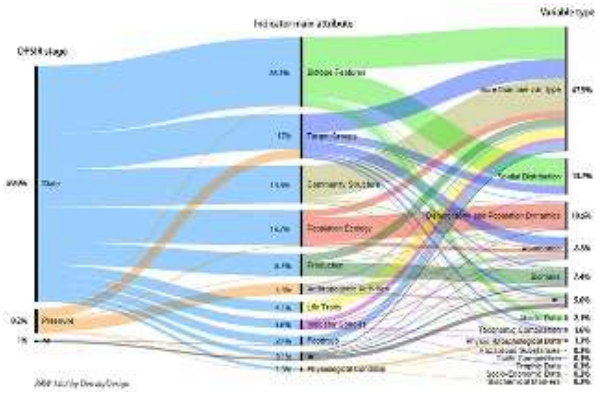
Include Beneficiary impact circular

Increase crop yield
Decrease CO2 eq
Improvement production efficiency
Replacement resources (MAGNET)
Food safety risks



Resource Security indicators

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
% Captured P (P uptake - P lost)
% Utilisation (waste ratio)
Carbon sequester scenarios (land versus sea)



Climate action indicators

Kg production / MJ fossil fuel
CO2 eq emission / production
Carbon capture / Kg production (this can be negative if capacity is compromised)
NOx eq / product
M3 fresh water used
M3 fresh water : water scarcity index
M2 areal used / unit

Affordable and clean energy

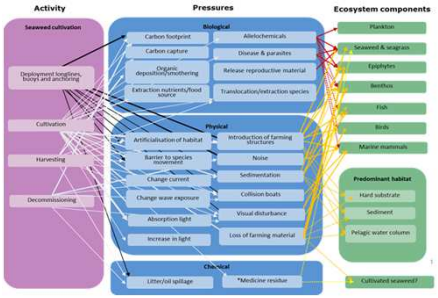
% renewable energy sources
% dependence fossil fuel
GHG emission per kWh
CED (Cumulative Energy Demand) production

Support framework

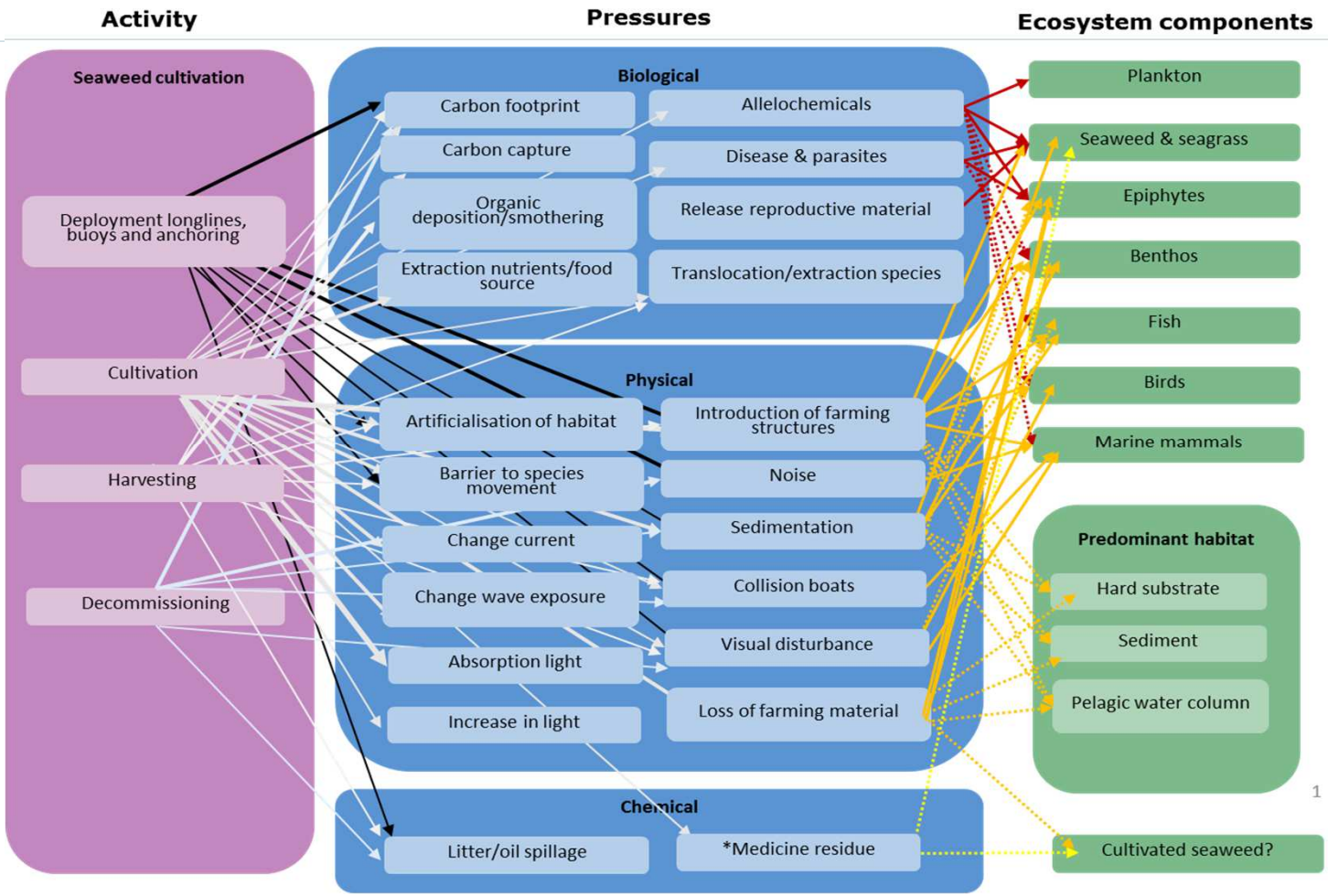
Human Well-being	Viable economic sectors
SDG Indicators under ILO custodianship	Cost-benefit per surface area

Ecosystem/Biodiversity conservation and restoration

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



A DPSIR framework



Including development of a Toolbox for measurement of Seaweed-Ecosystem interactions

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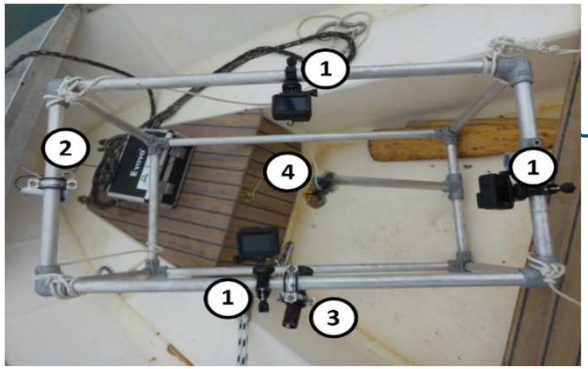
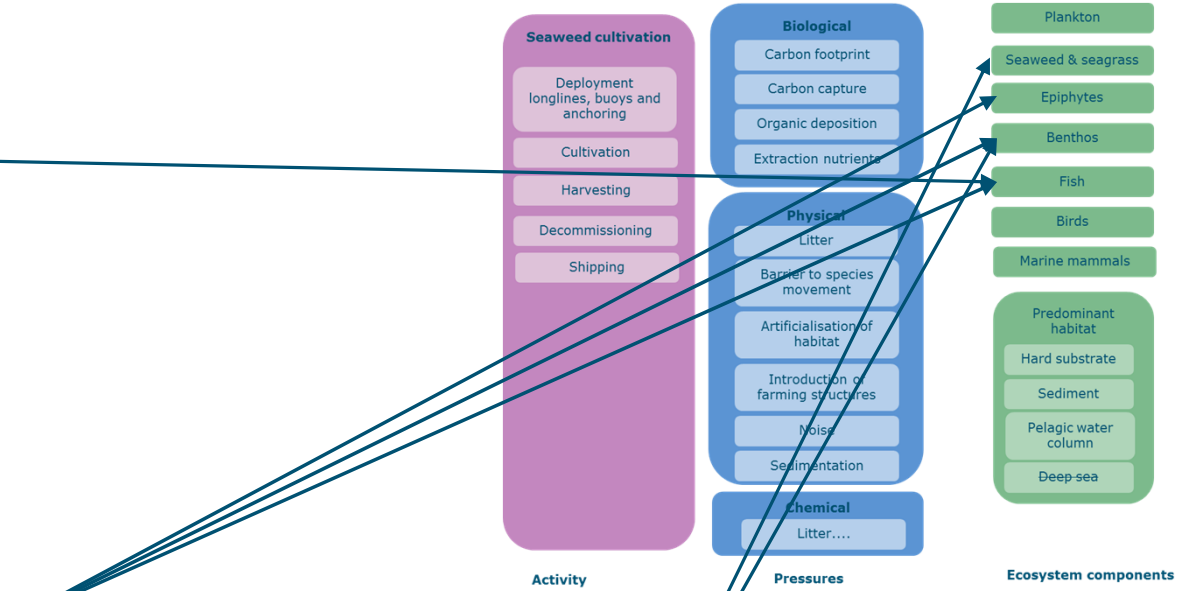
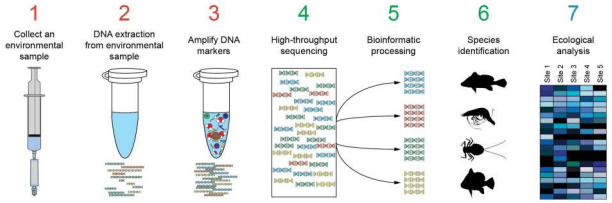
Autonomous and remote tools (seaweed)





DNA analyse

- DNA analyse kan alles waar DNA van aanwezig is identificeren (mits er een referentie-sequentie bekend is)

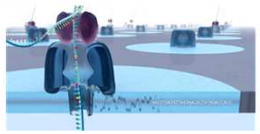


Nanopore DNA sequencing met de MinION

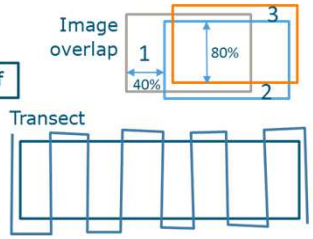
Kleine, handzame DNA sequencer, aanschaf: 900 €

Draagbaar, in te zetten in het veld

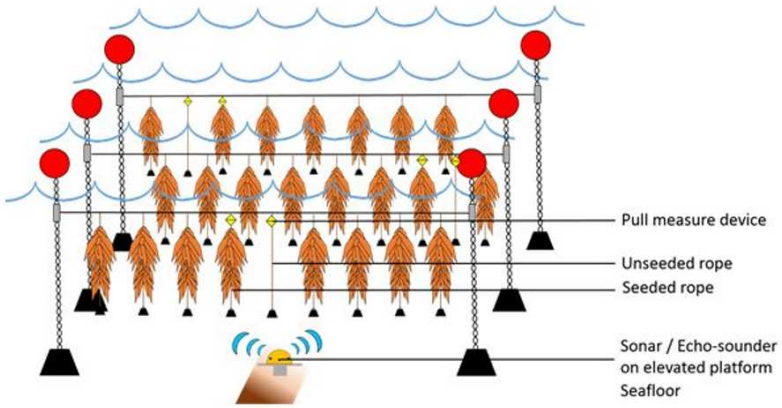
Van (water)monster naar soortenlijst in 4 a 5 uur

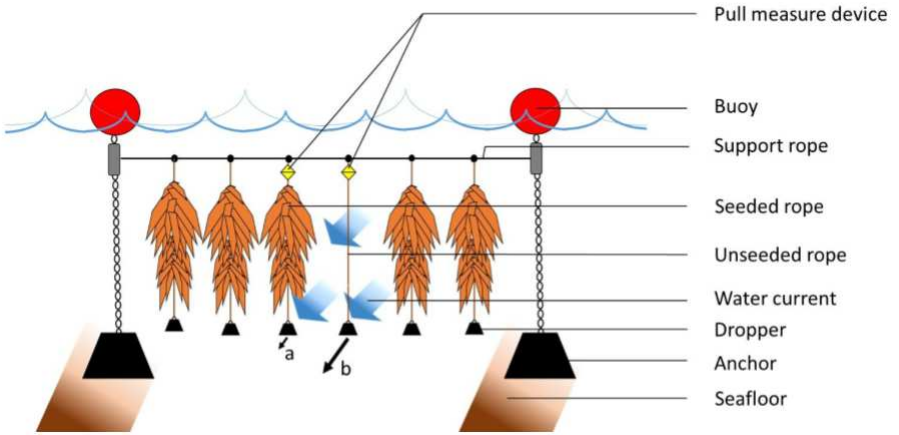


Stitch & geo-ref



Remote monitoring of seaweed (pre-feasibility study)





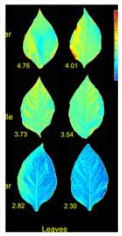
Measuring nitrogen content

- *Ulva* sp.: N content correlated to proteins, ash, starch and fiber

- *S. latissima*: No clear correlation
→ is it useful to monitor nitrogen content in kelps?

Method to measure nitrogen:

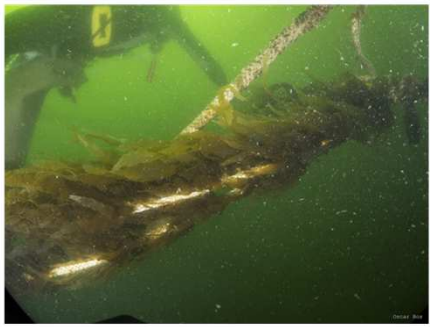
- Hyperspectral imagery
- Fluorescence



Underwater cameras

- Numerous models are available
- Data easily human interpretable
- Simultaneous biodiversity assessment

- Huge data files
- High energy demand
- Vulnerable to bio-fouling
- North sea is turbid



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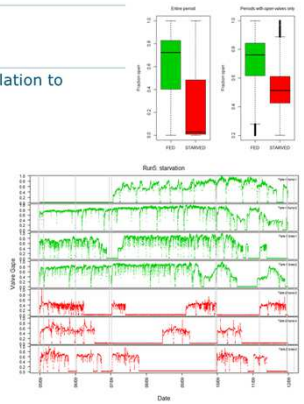
Autonomous and remote tools (shellfish)

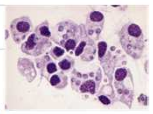
Valvometer

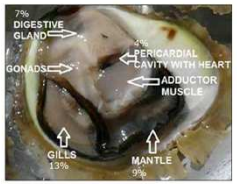
- Monitor shell gape in relation to environmental factors



Bonamia-free oysters

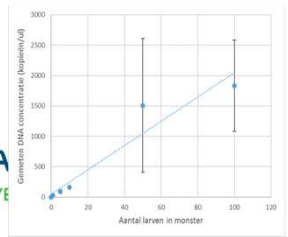
- Non destructive sampling: anaesthetise, cut piece of gill, keep dry until results of analysis available, separate into Bonamia postive and negative
- Is gill representative?

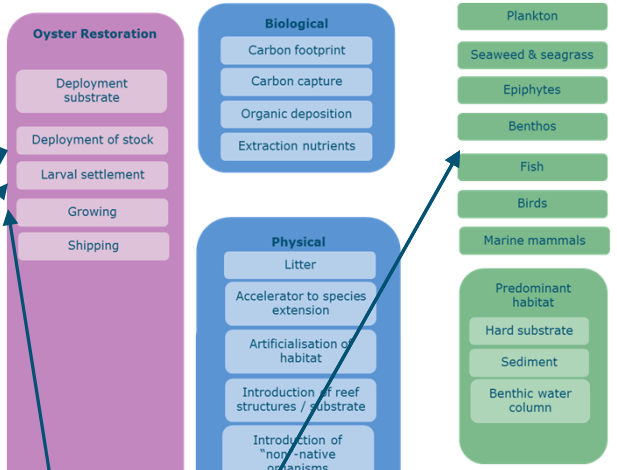


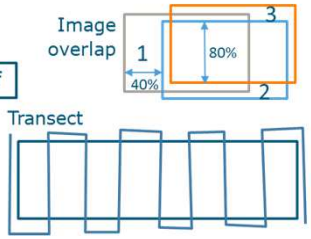


qPCR for larval detection (Arjen)

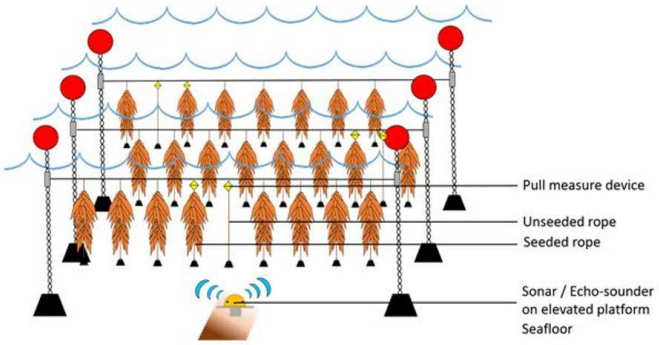
- Larval concentrations low in new oyster areas
- Difficult to detect microscopically

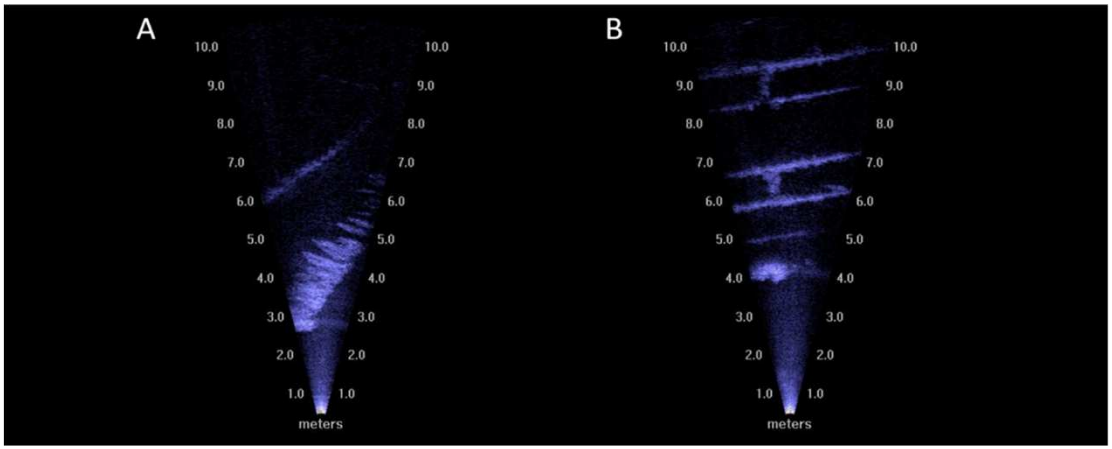


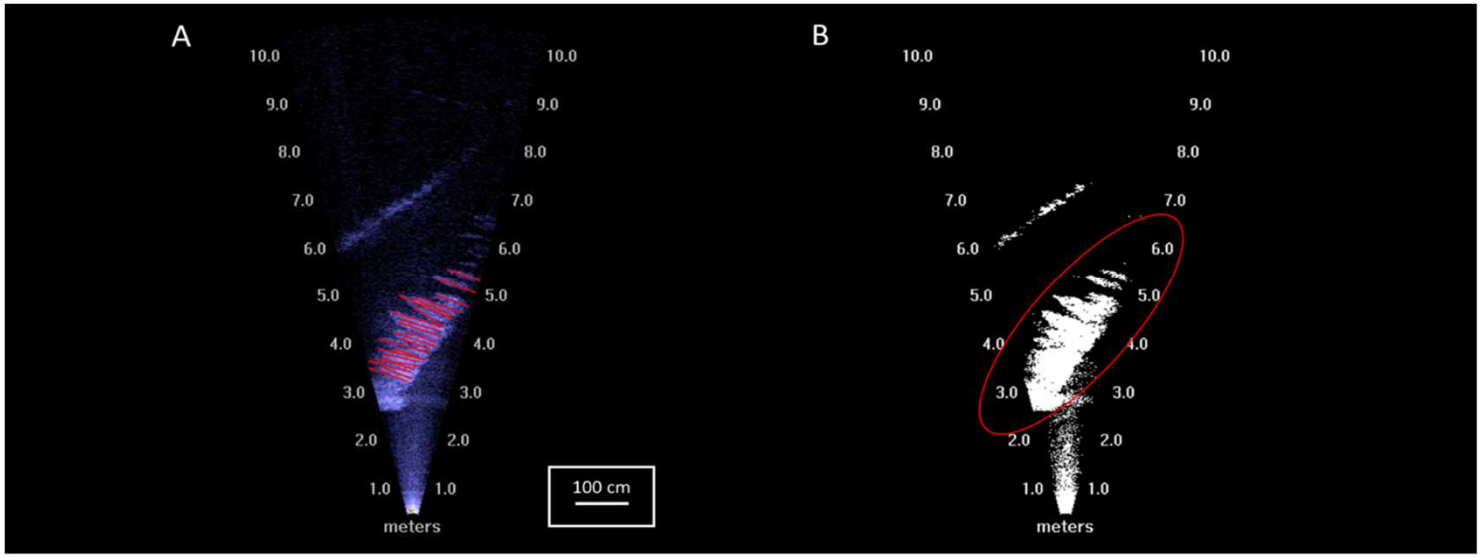




Sonar applications in production







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MinIon implementation (MAE-WMR-WEcR) Sessile biomass

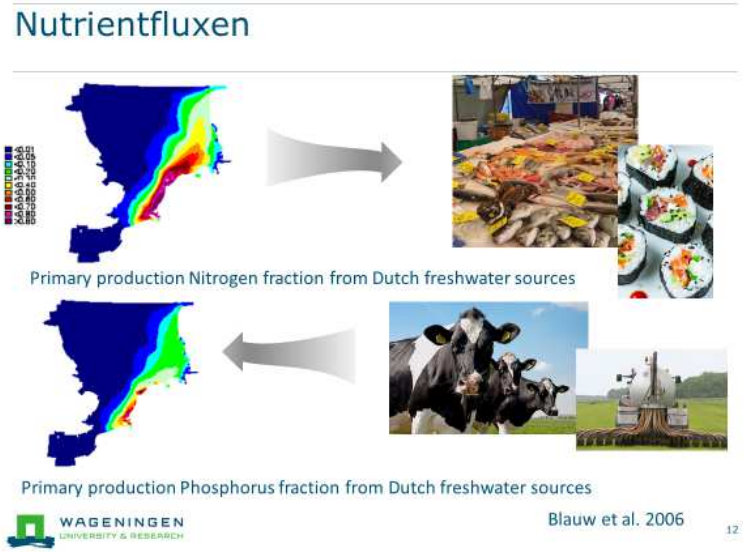
Small handheld sequencer
Initial costs: 1000 US$

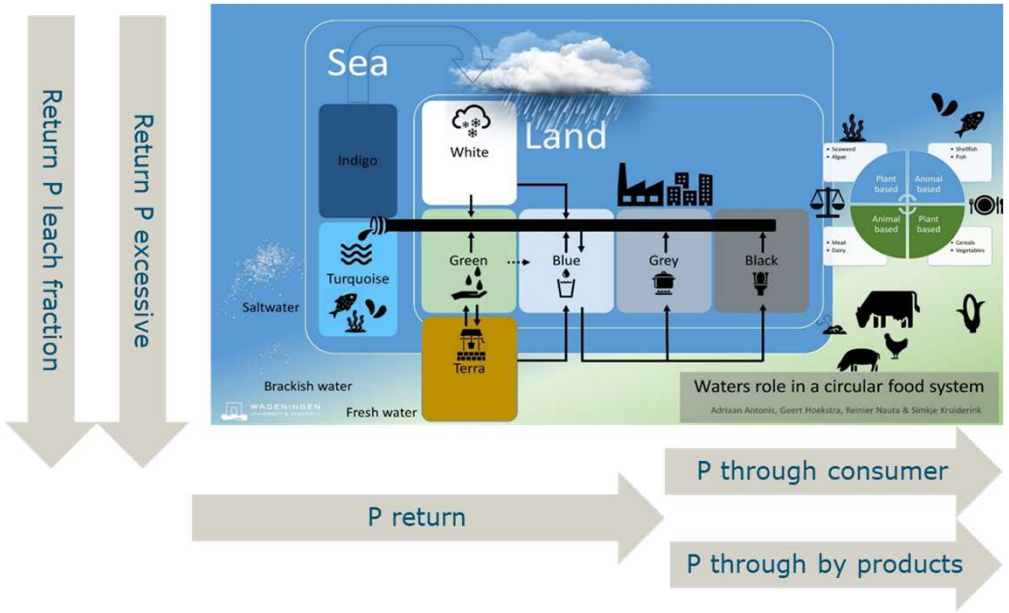
→ MinION: enables rapid and affordable iterations of protocols!

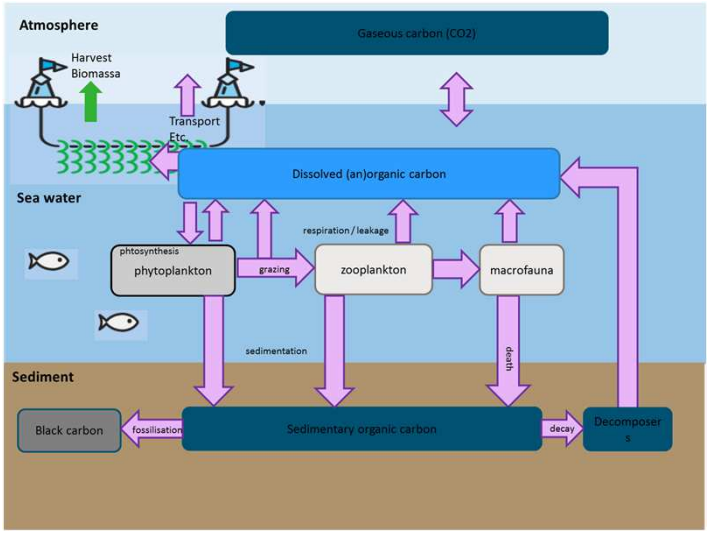
Raw read quality: avg. 90-95% identity
Assembly: 99.5%, polished: 99.9%

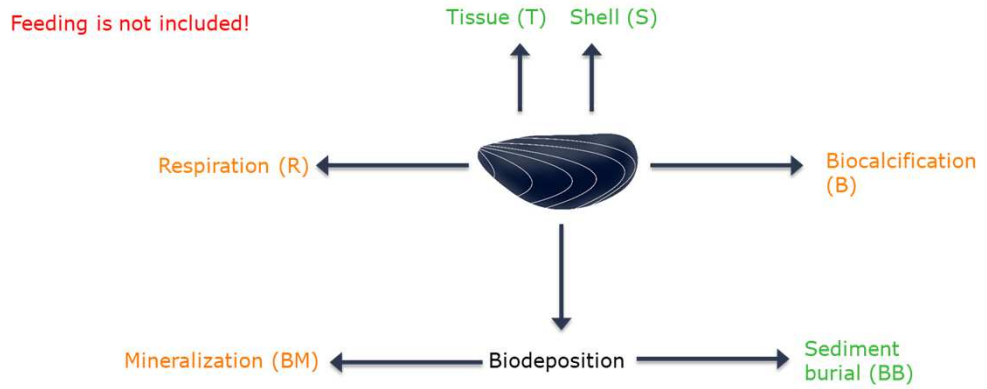
https://github.com/rrwick/Basecalling-comparison

In development

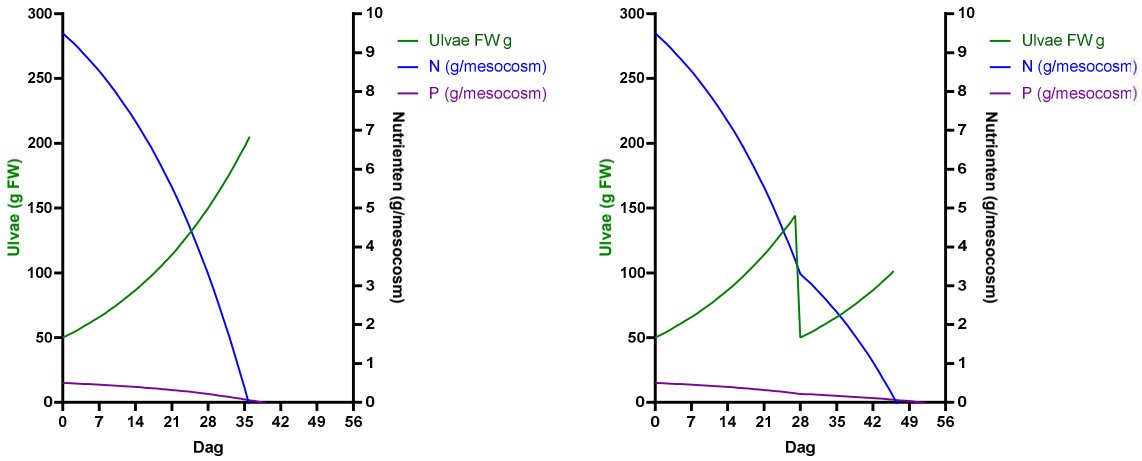








Proof of concept CO2 changing zooplankton

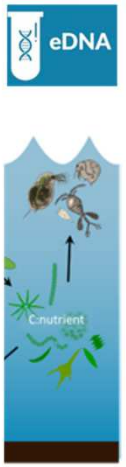


E-DNA en plankton

Mogelijke proxies voor C-burial onder zeewier:

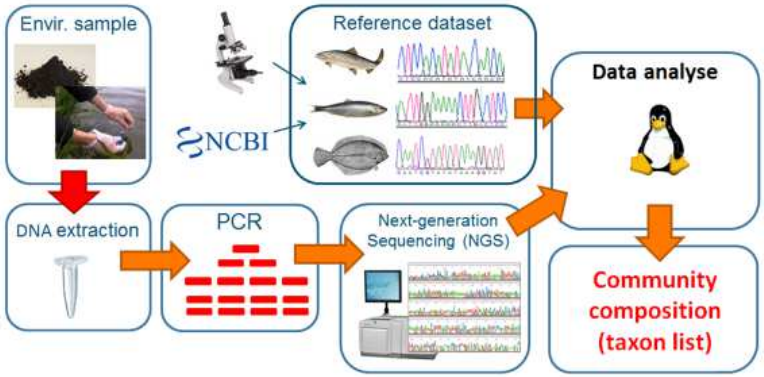
- Verhouding silicate phytoplankton versus overig
  (Bopp et al. 2005;Reinfelder 2010; Treguer & Pondaven 2000)
- Verhouding micro vs mesozooplankton
  (Beaugrand, 2010; PNAS)
- Diversiteit van mesozooplankton

Kortom: brede diversiteitscreening = metabarcoding approach, in combi met schatting van totale biomassa per groep

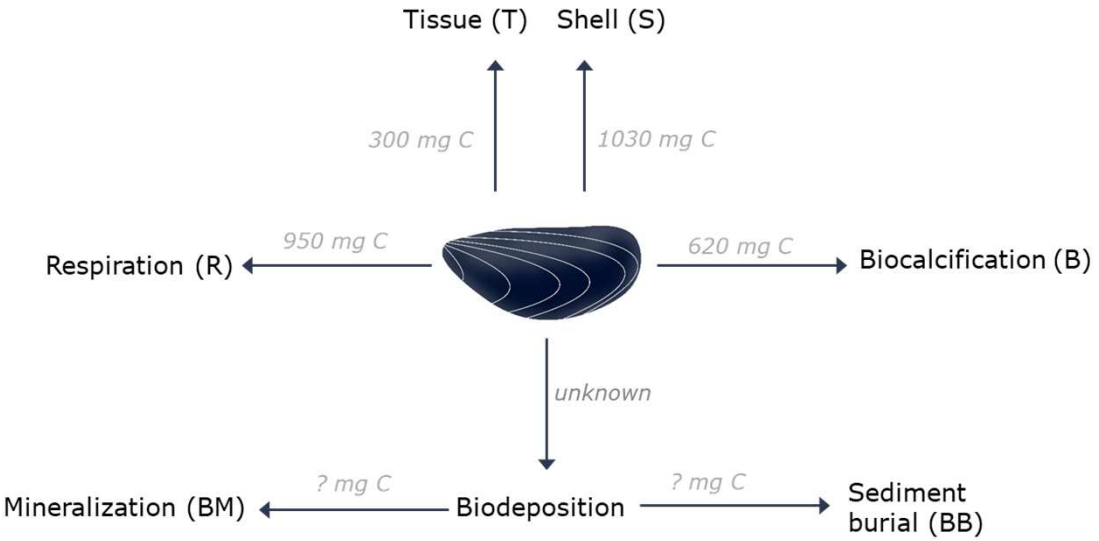


(e)DNA metabarcoding

- *DNA-barcode:* fragment of DNA that varies among species
- Result: species list per sample
- NB: relative instead of absolute abundances



Cabron Sequestration Scenarios



Approach	Individual mussel (g C per production cycle)
1. Mass balance of shell material [CSP=S]	**1030**
2a. Mass balance of individuals, correcting for CO_2 fluxes [CSP=S-B-R]	**-541**
2b. Same to 2a with partitioning between shell/meat [CSP=S-B-10%R]	**317**
3. Mass balance of individuals, including all metabolic processes [CSP=S+T+BB-B-R-BM]	**Unknown due to data unavailability**

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Agriculture-aquaculture combinations

Demonstrating health-promoting properties of marine resources using sole as model fish

Mar. Drugs 2010, 8, 2038-2064; doi:10.3390/md8072038

Marine Drugs
ISSN 1660-3397
www.mdpi.com/journal/marinedrugs

Review

Prebiotics from Marine Macroalgae for Human and Animal Health Applications

Laurie O'Sullivan [1], Brian Murphy [1], Peter McLoughlin [1], Patrick Duggan [1], Pradar G. Lawlor [2], Helen Hughes [1,*] and Gillian E. Gardiner [1]

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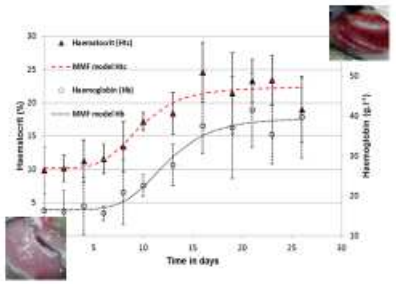
Sole fed ragworm/mussel recovers from their anaemia (Kals, 2017)



To test the effect of low-trophic marine resources on anaemia status of sole

Extracts as biostimulants and/ or stress alleviators

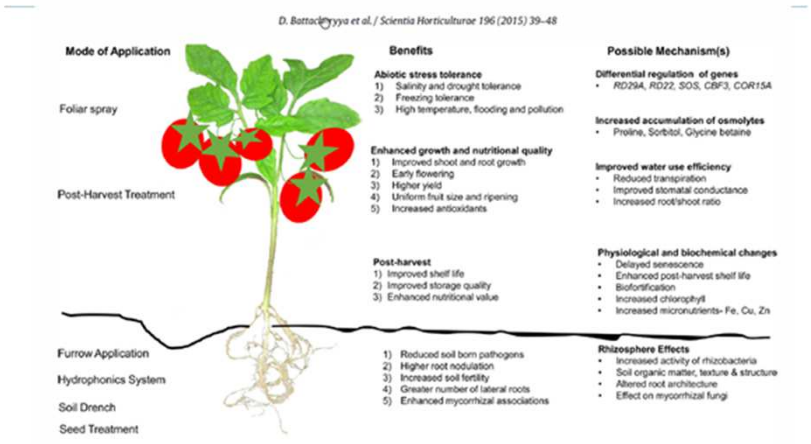


Fig. 1. Schematic diagram depicting methods of application of seaweed extracts, and their effects on plant and mechanisms of action.

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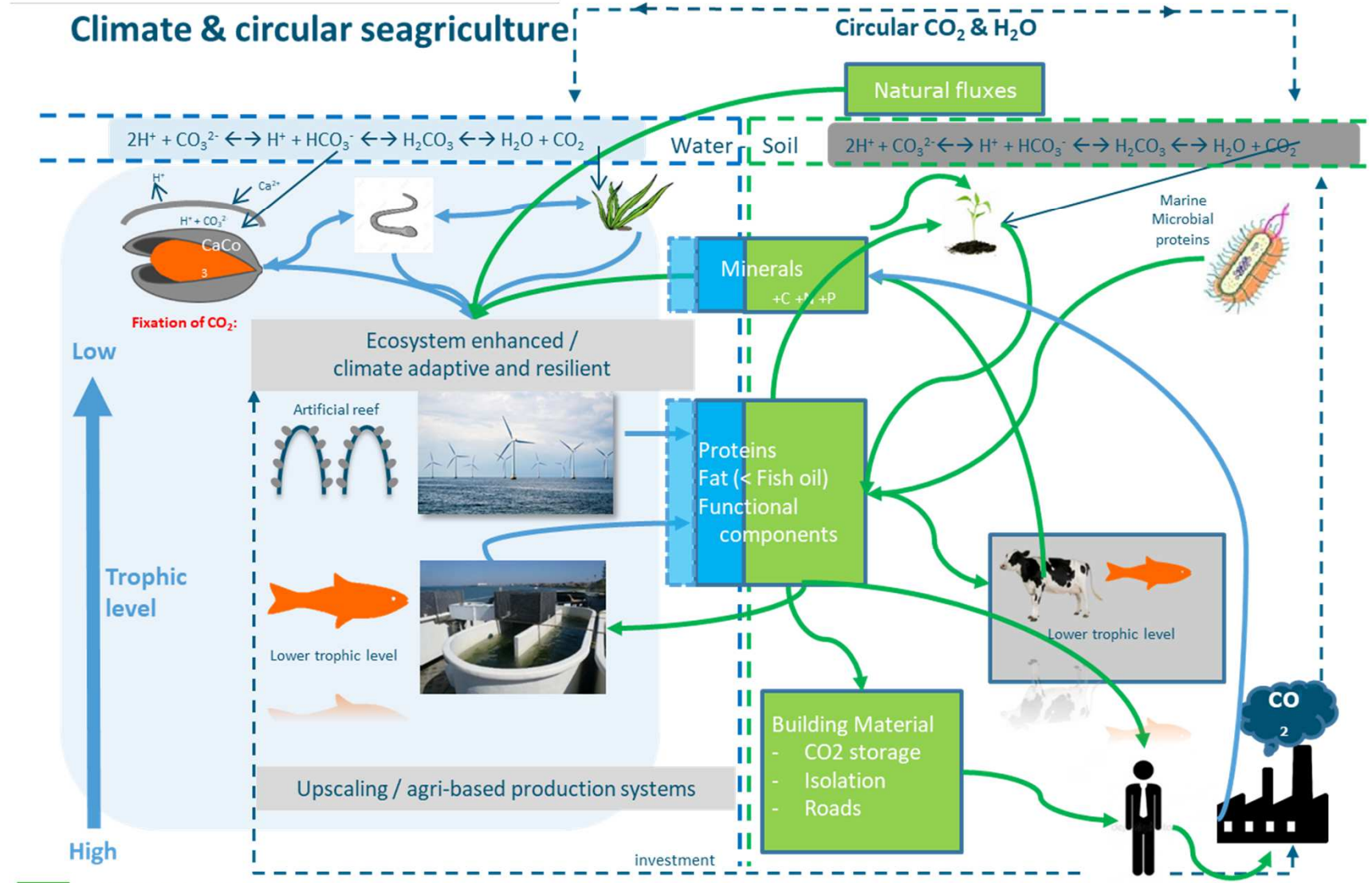
Avenues to capitalise

Inspirational



Conclusions

- Many unknowns in knowledge base (vertical and horizontal circularity)
- Integration of marine in food system necessary
- Tools become available for policy development

- Broad vision on circular marine not yet developed

Bedankt

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