Building blocks integrated framework marine low trophic food systems

Integrated framework discussion

12 december 2020

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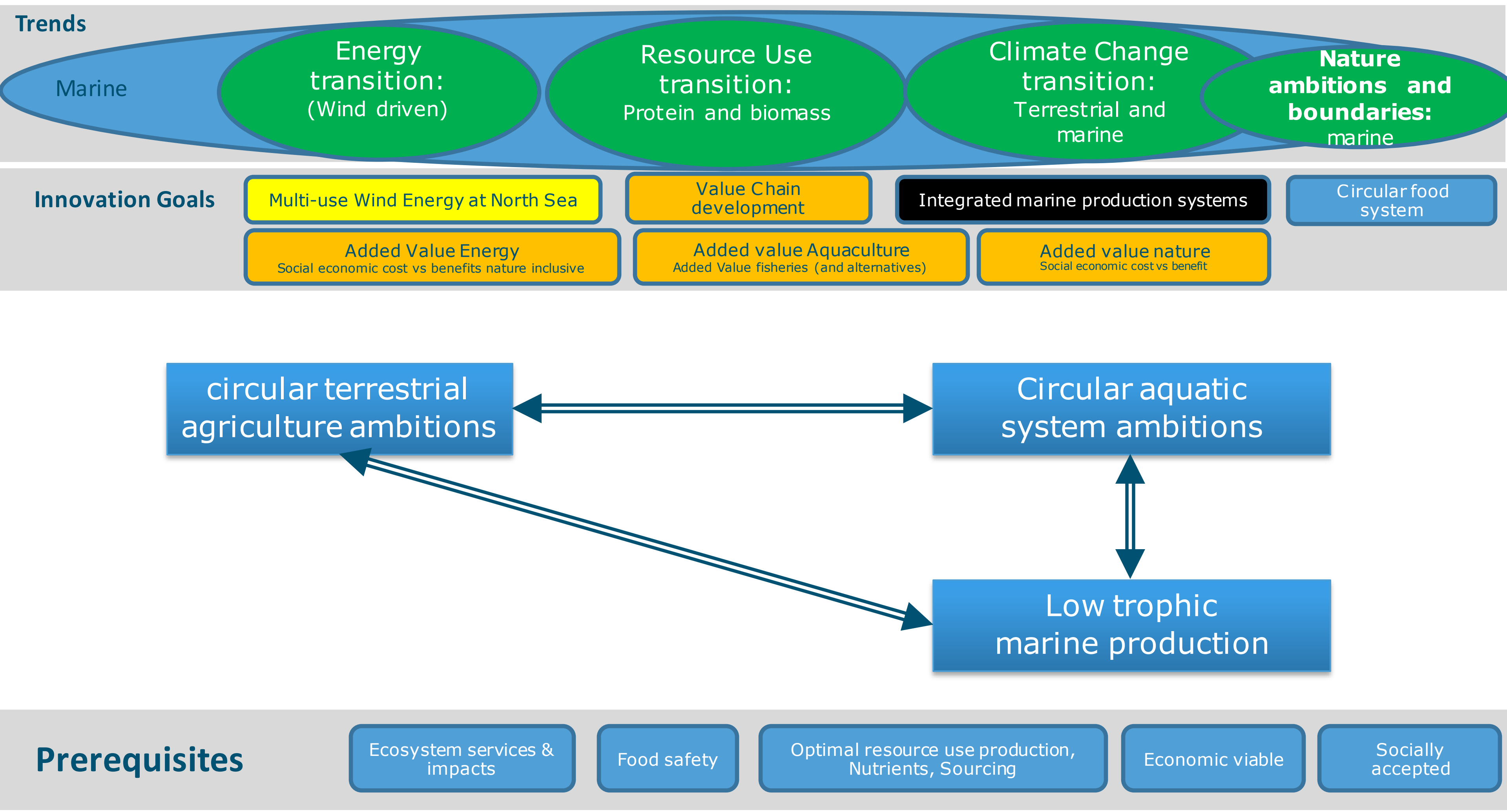
Grand Challenges at sea and land



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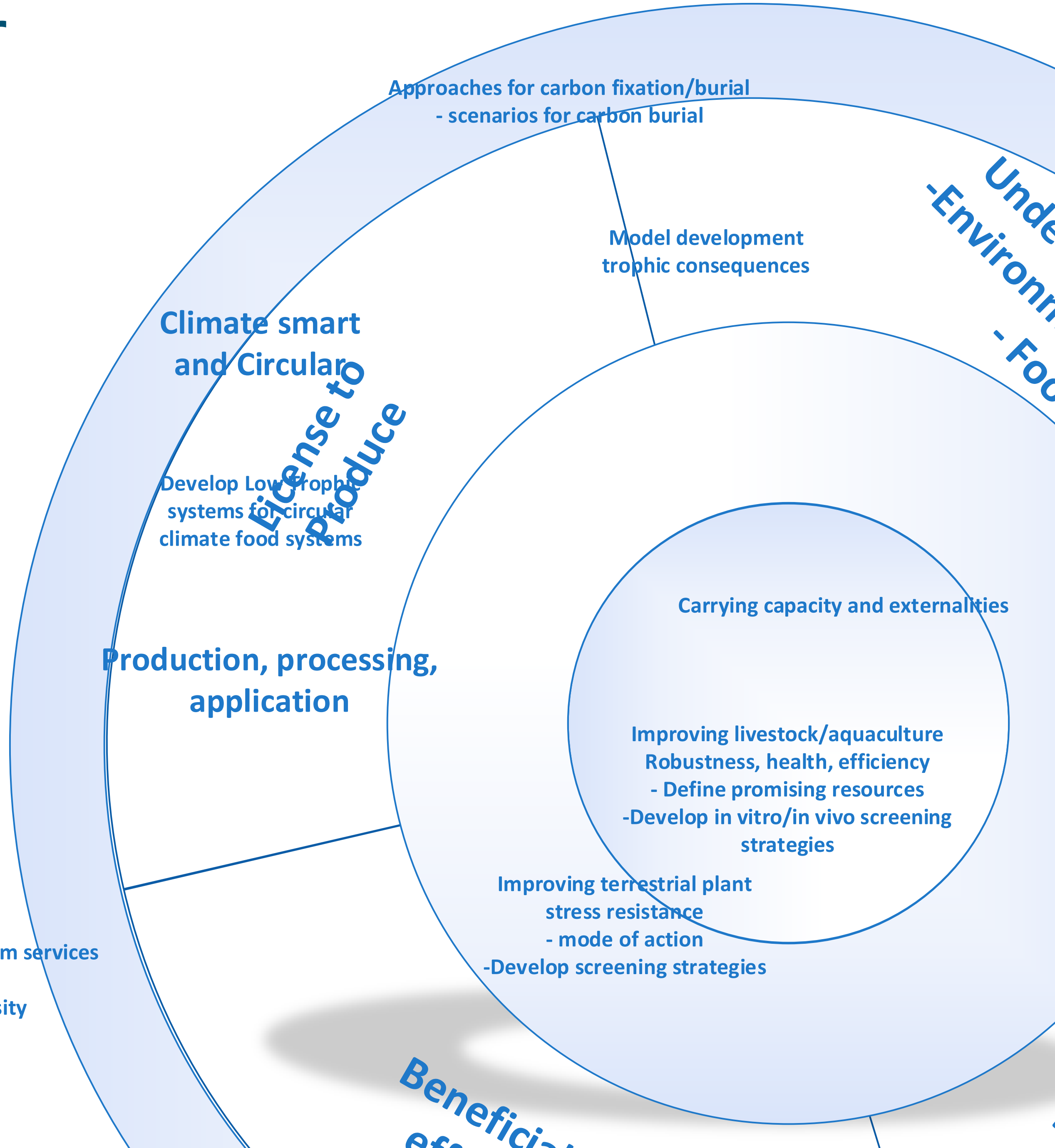
KB34 Circular

Integrated Assessment Framework
- Ecosystem based (towards quantification)
- Safety by design (hotspots for circular chains)

Monitoring tools
eDNA biodiversity, carbon sequestering, ROV, oyster larvae mortality, remote techniques



Method for monetarization ecosystem services
- eg. Carbon sequestering, nutrient extraction, biodiversity

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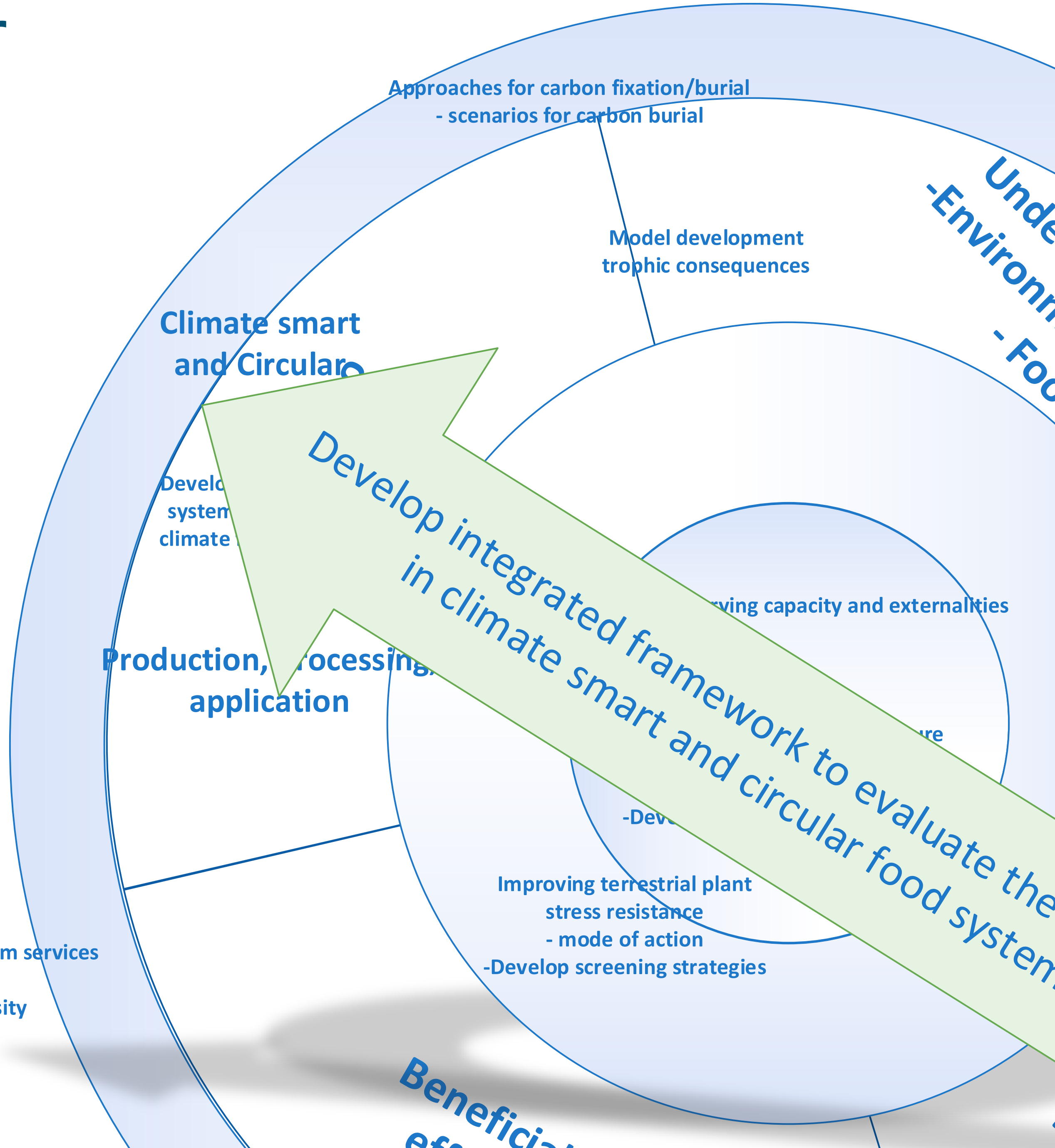

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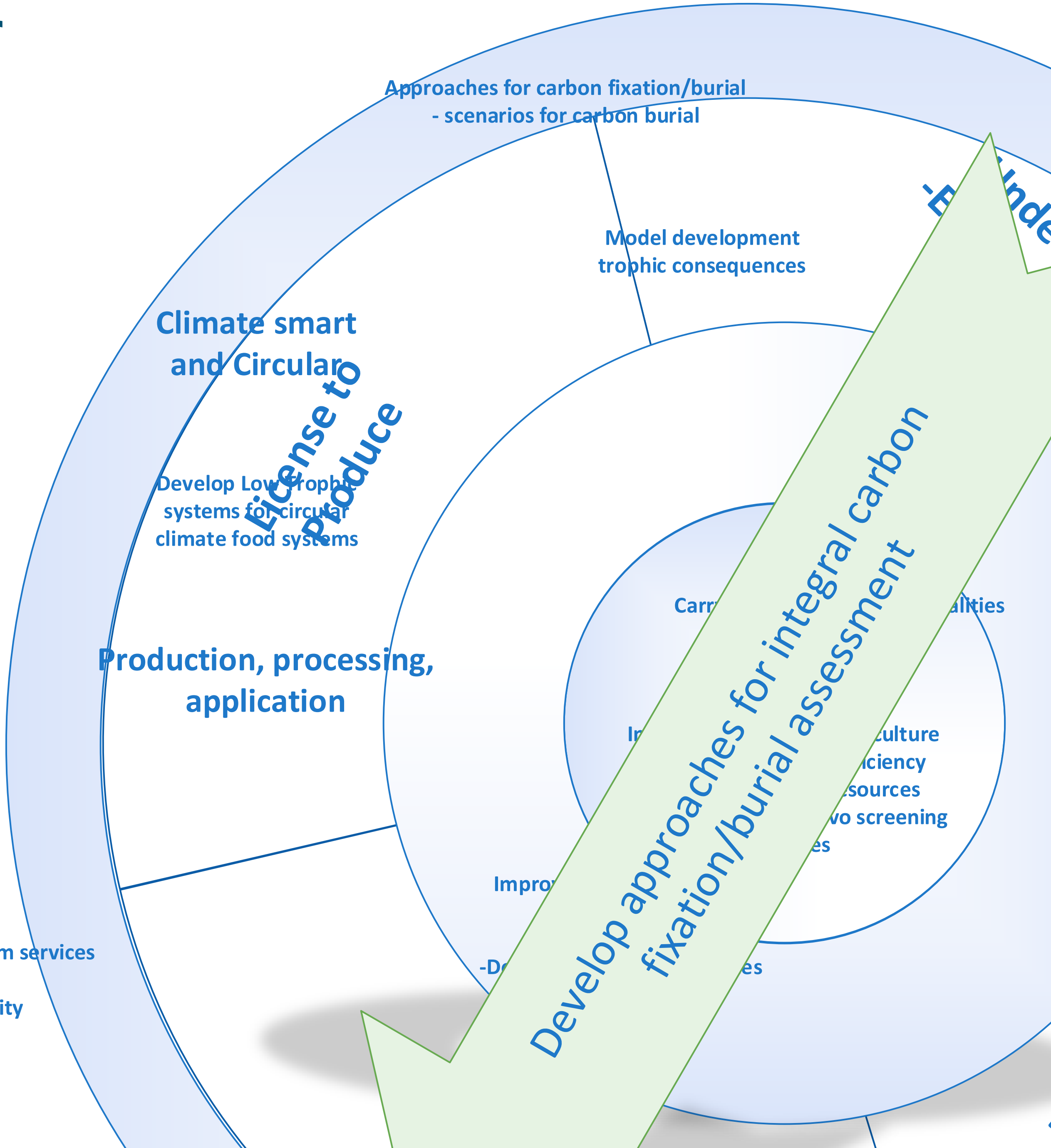

Method for monetarization ecosystem services
- eg. Carbon sequestering,
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Our task

Develop an integrated framework to evaluate the role of marine lower trophic species in climate smart and circular food systems. **Scientific analysis to map the economic and sustainability effects of the development of seaweed chains and thereby provide input to the discussion about the desirable development of the seaweed sector.**	**1) Integrating PowerPoint:** **Building blocks for a position paper on climate smart and circular inclusion of sea and agriculture systems. (prep. Integrated work for paper 2021), including** **a) Integration of data on production, products, applications end combining of gross climate and circular parameters.** **b) Inventory of pros and cons, including data on carbon and nutrient, fixation, burial, harvest, application effects, processing outputs.** **Optimized DIPSR Framework for aquaculture production**

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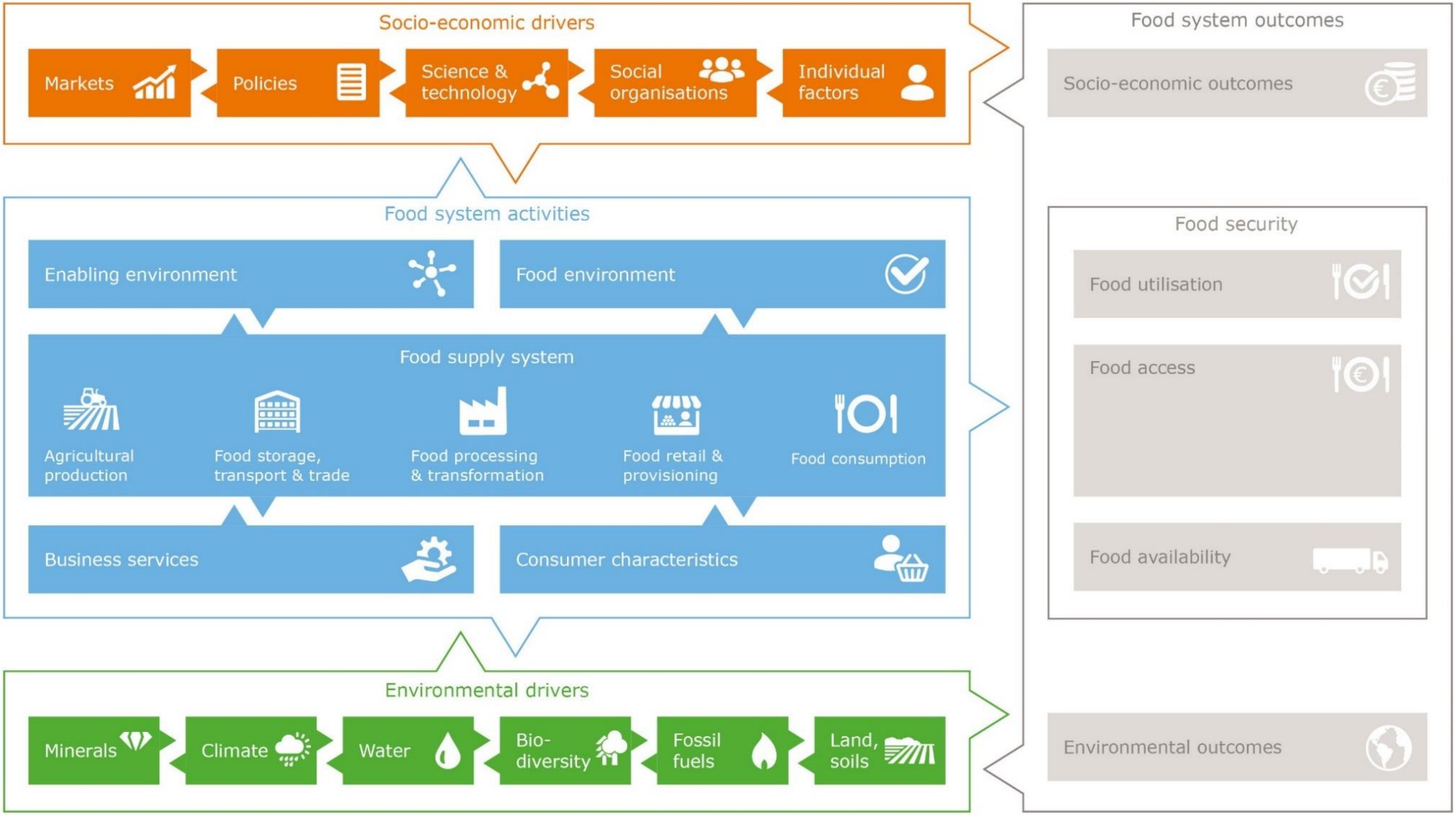
Introductory information

A full list of SDGs and associated targets can be found at UN. 2015a. Transforming our world: The 2030 Agenda for Sustainable Development[7].

Food System approach



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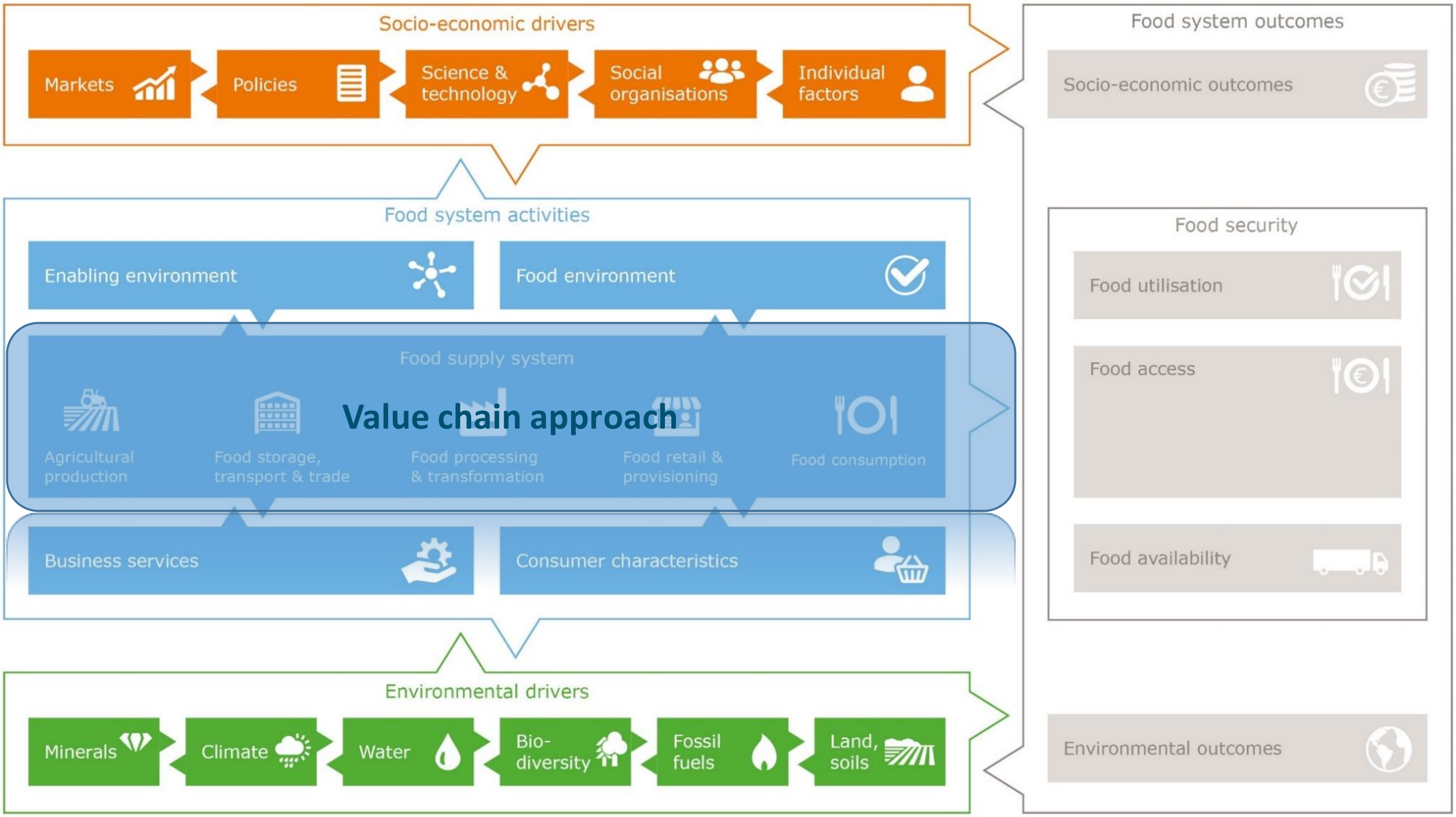
Value Chain Approach



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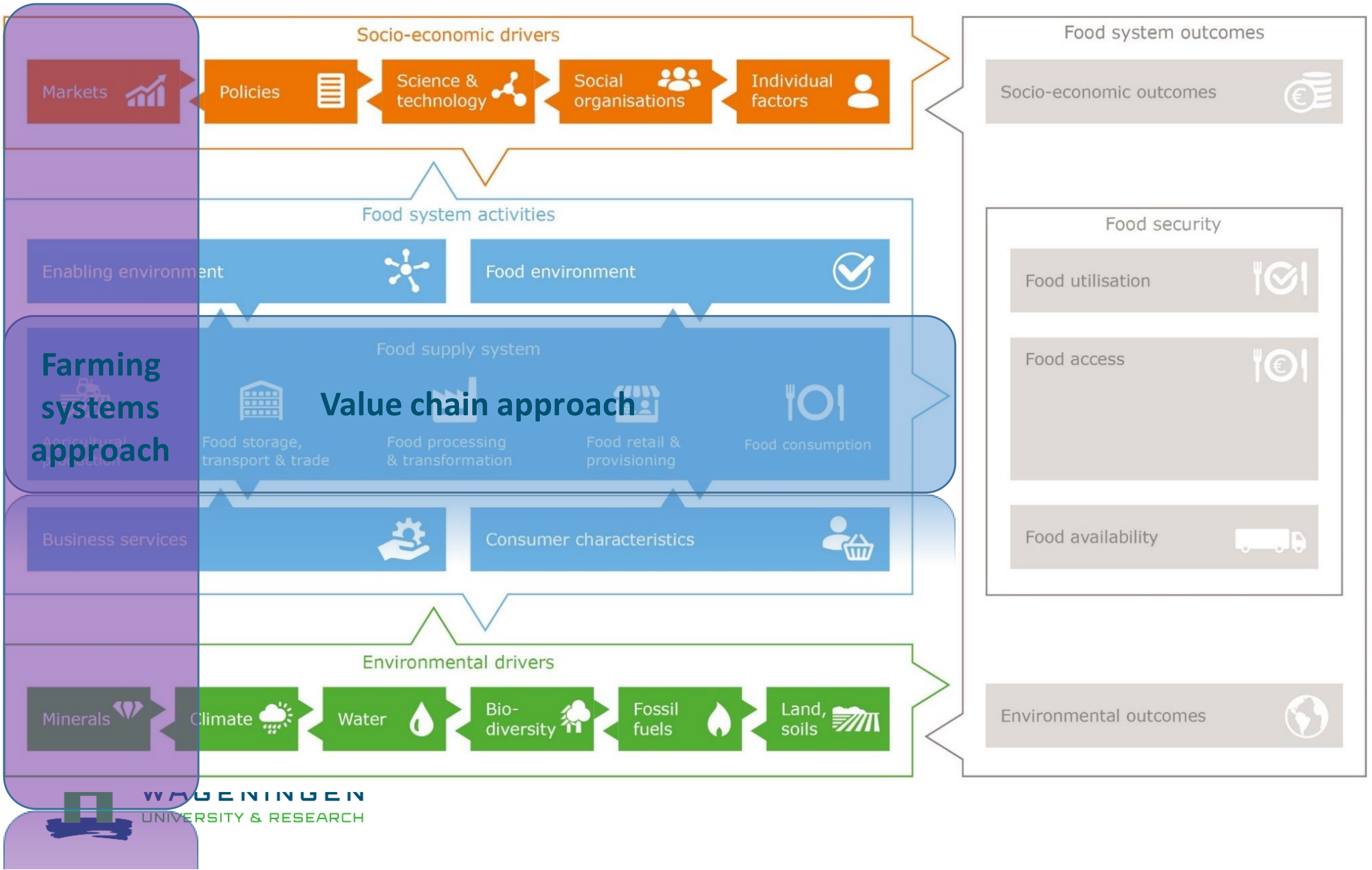
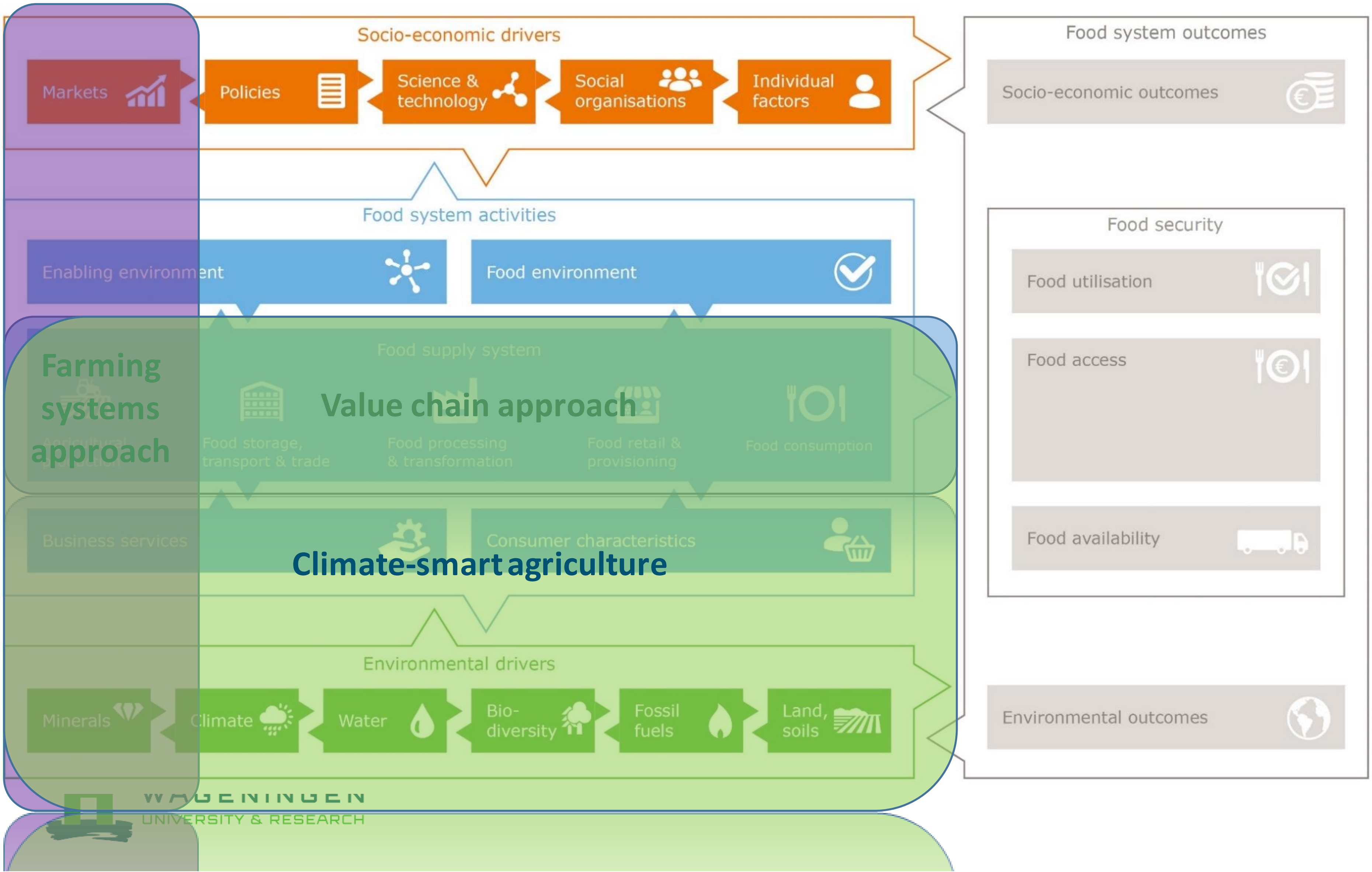
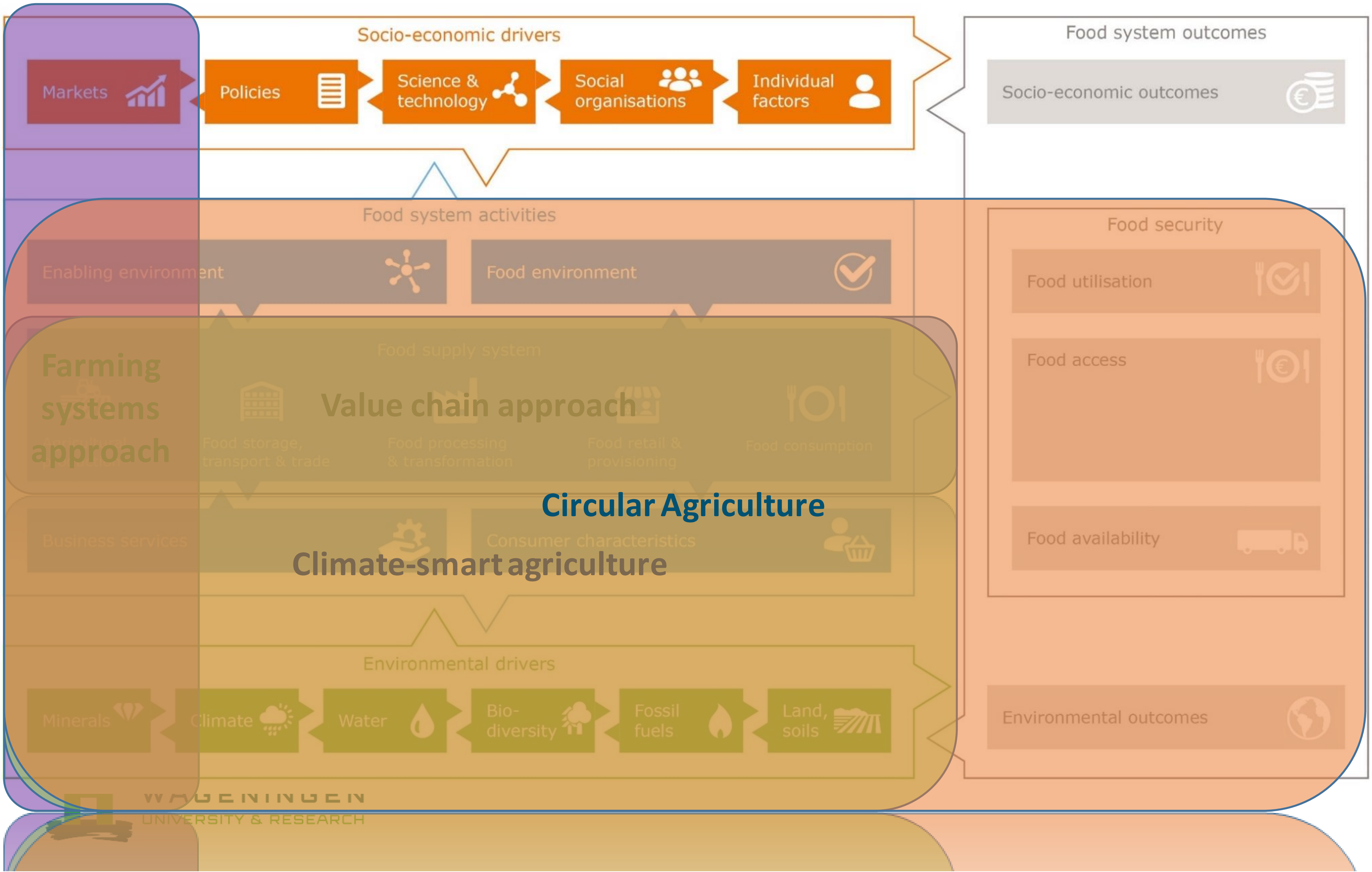
Farming system approach



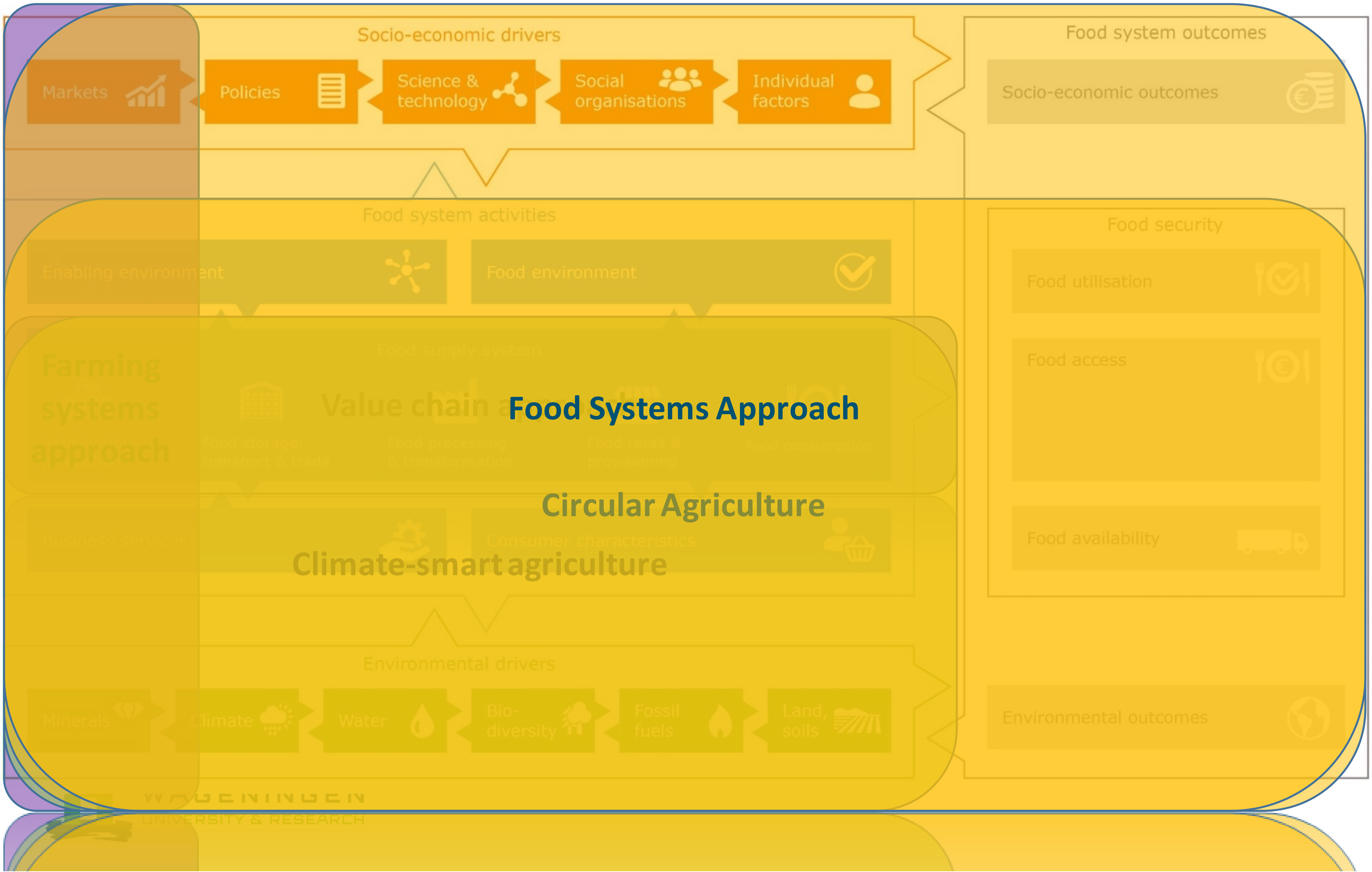
Farming System Approach



Circular Agriculture

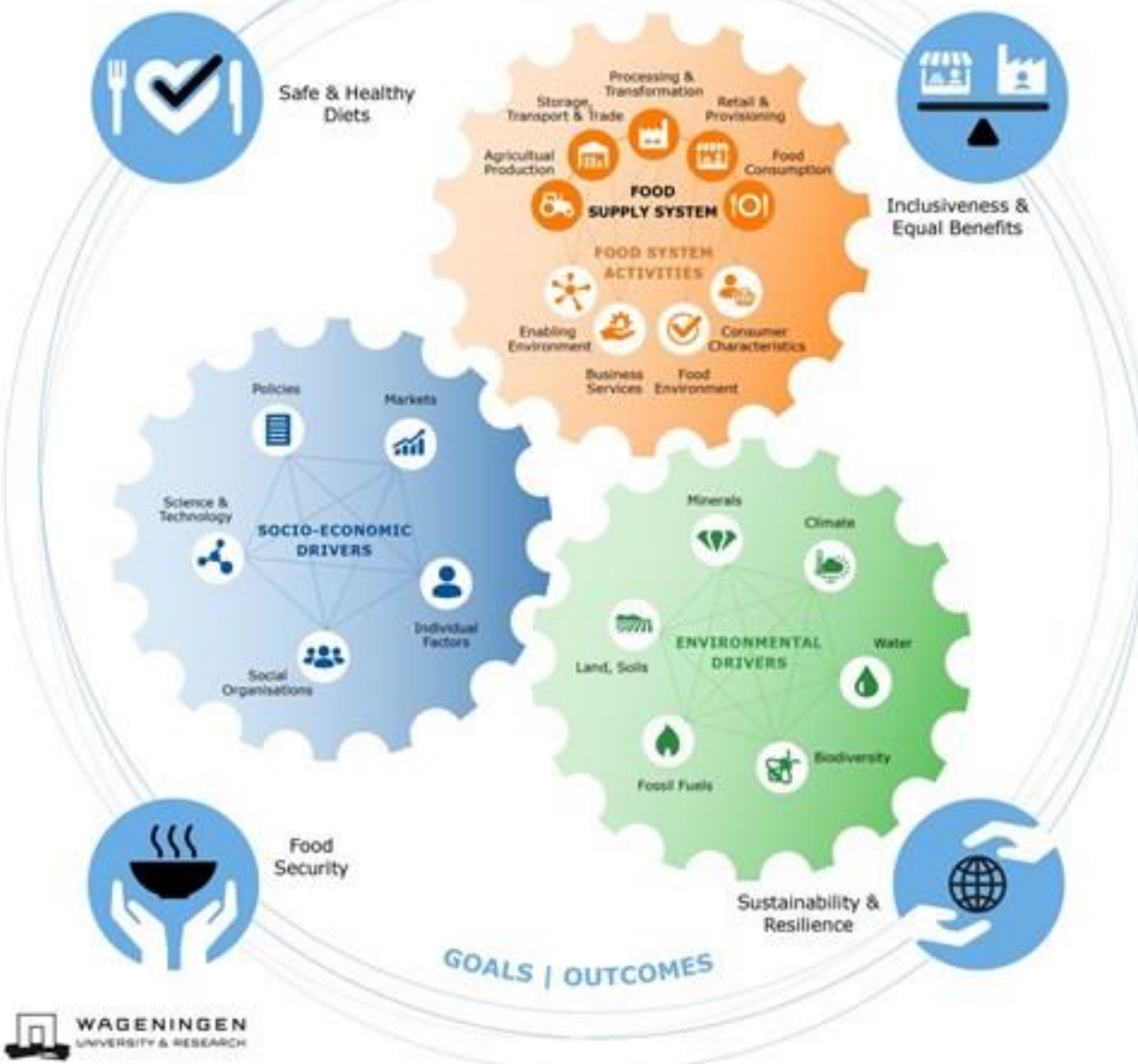


Food System approach



Food systems framework

Van Berkum et al. 2018, Wageningen University & Research



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To a circular economy

Circular economy

Increasing circularity

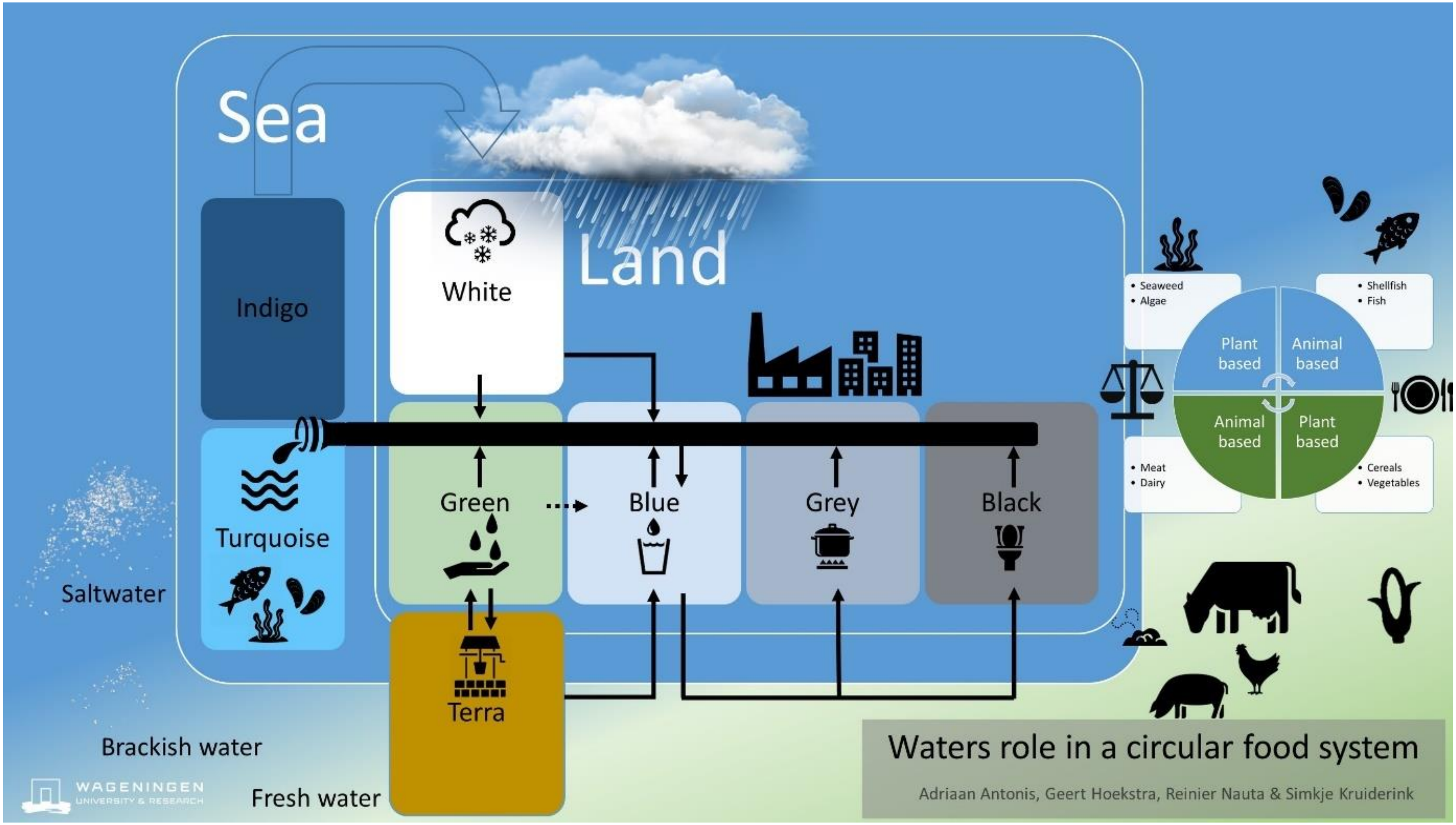
Rule of thumb: More circularity = fewer natural resources and less environmental pressure

Linear economy

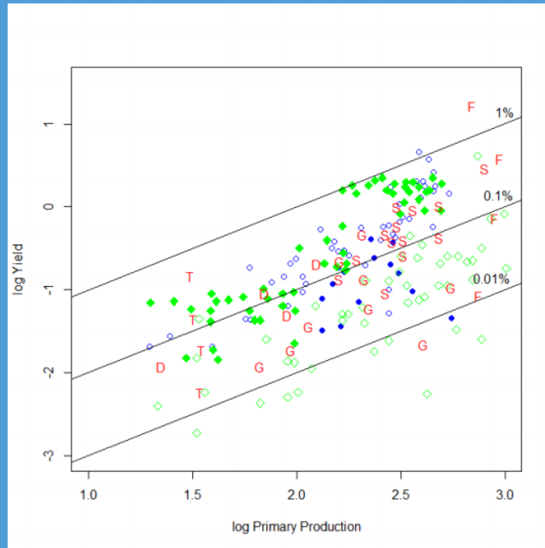
Strategies		
Smarter creation and use of products	R0 Refuse	Turning a product redundant by cancelling its function, or by substituting it with a radically different product.
	R1 Rethink	Intensifying product use (e.g. via product sharing or multifunctional products).
	R2 Reduce	More efficient use and/or manufacture of products through the use of fewer natural resources and materials.
Extending the lifespan of products and parts	R3 Reuse	Reuse of discarded yet still usable product, for the same purpose, by a different user.
	R4 Repair	Repair and maintenance of broken or malfunctioning product, to enable continuation of its original function.
	R5 Refurbish	Refurbishing and/or modernising an older product, so that the improved version can be used in the product's original function.
	R6 Remanu-facture	Using parts of a discarded product in a new product of the same function.
	R7 Repurpose	Using discarded products or their parts in new products with a different function.
Usefull application of materials	R8 Recycle	Processing of materials to achieve the original high-quality or reduce to low-quality.
	R9 Recover	Incineration of materials, recovering their energy.

pbl.nl

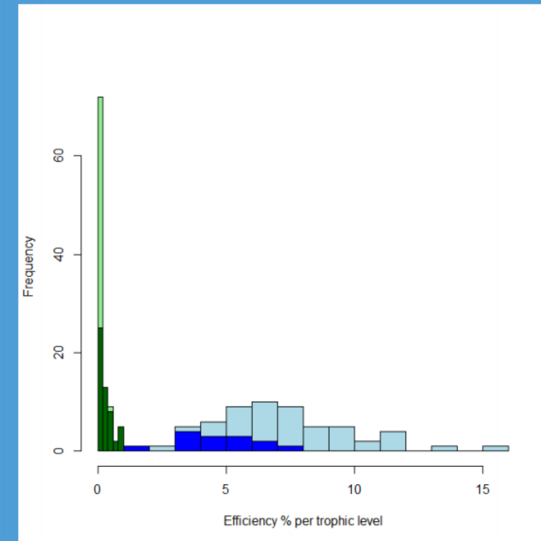
Water's role in a circular food system



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



Lindeman efficiëntie



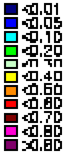
Landbouw

- 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

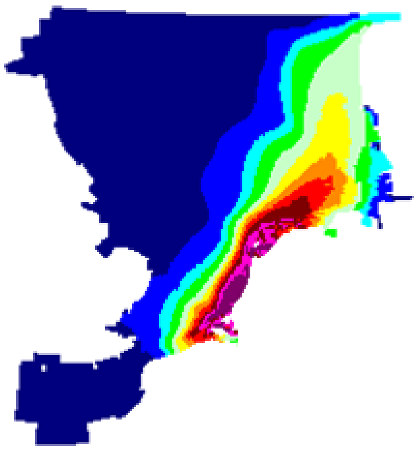
Lessen uit de ecologie en de landbouw

- 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 …

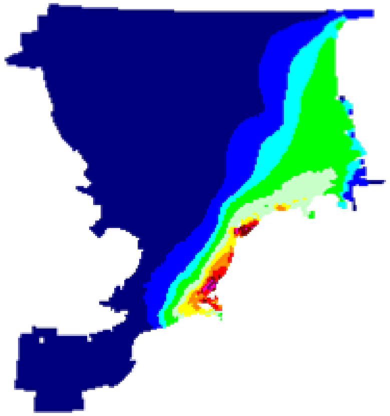
Van der Meer, 2020



Nutrientfluxen



Primary production Nitrogen fraction from Dutch freshwater sources



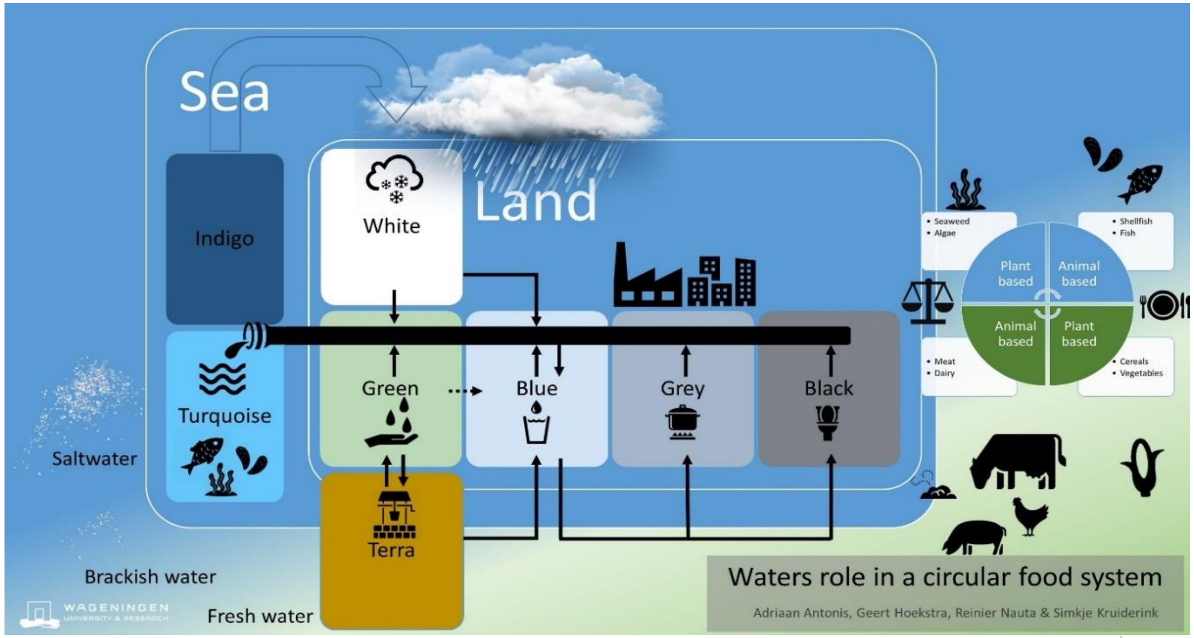
Primary production Phosphorus fraction from Dutch freshwater sources

Blauw et al. 2006

P fixation (vision in prep)

Return P leach fraction

Return P excessive



P through consumer

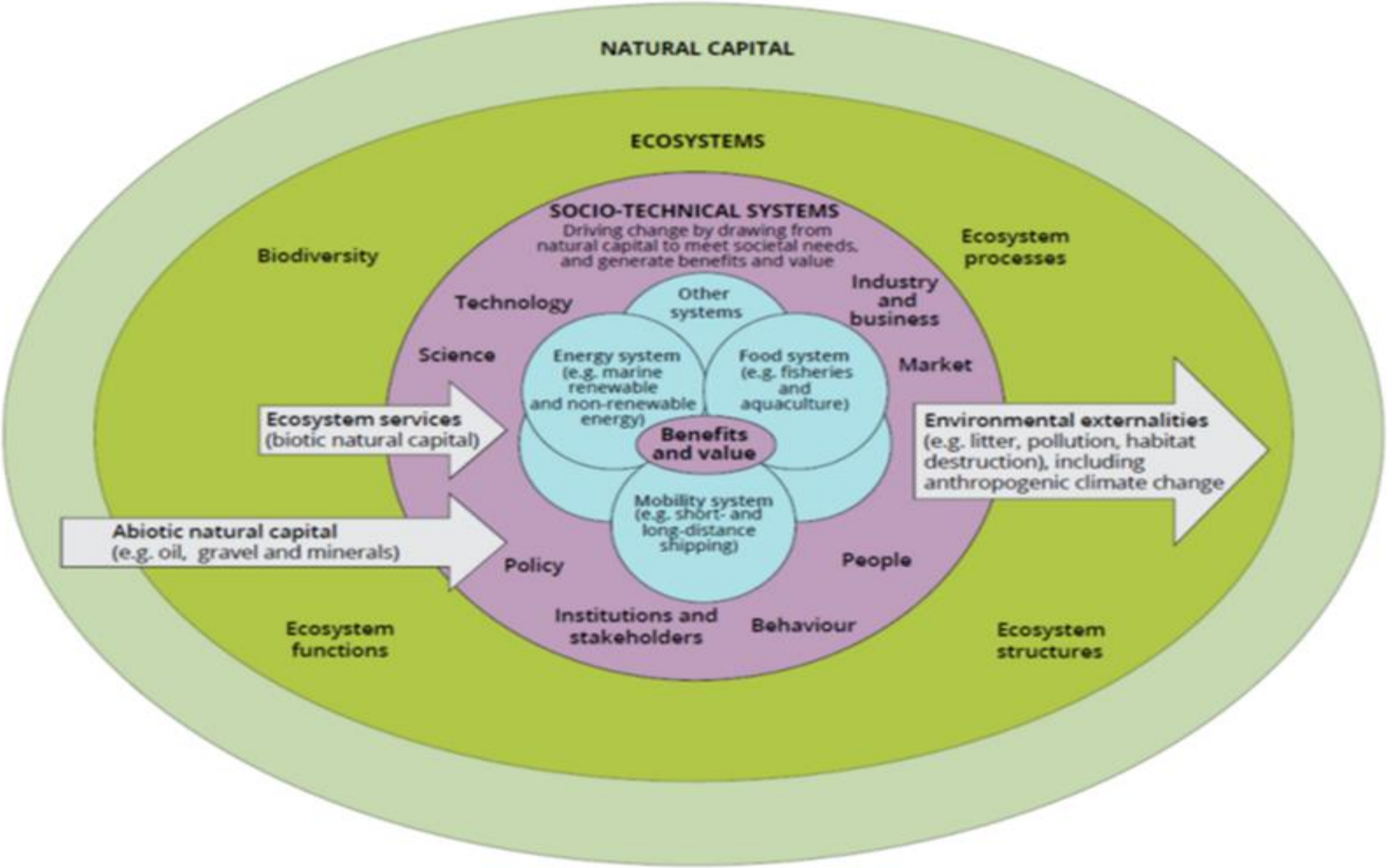
P return

P through by products

Problem:
optimal N:P 20:1,
current N:P 375:1
Non fitting N:P ratio
Concentration N:P high

Challenge:
N reduction through input
N reduction through crop selection / utilisation

In the overall context of Sustainability!



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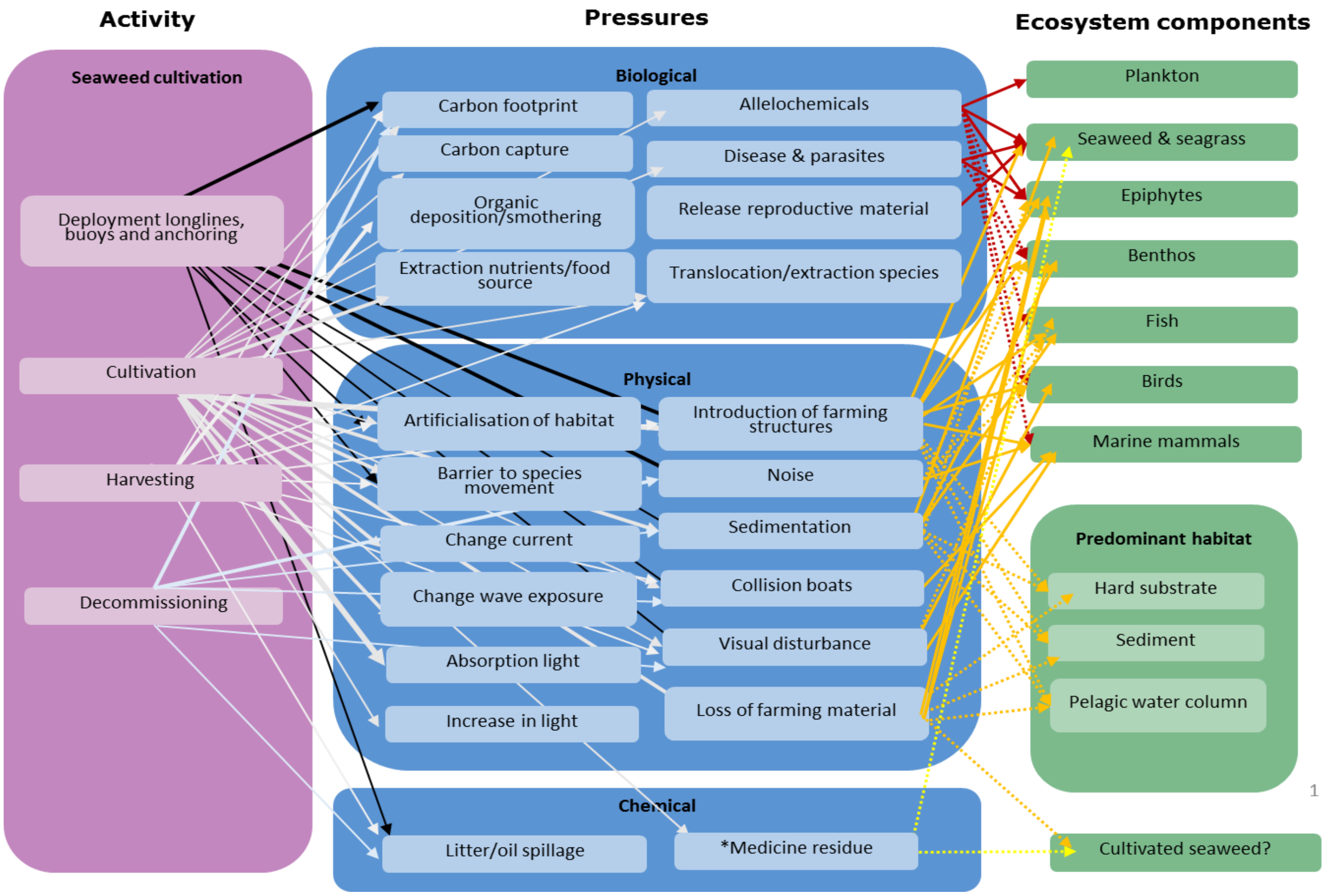
Required ingredients

A DIPSR framework



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

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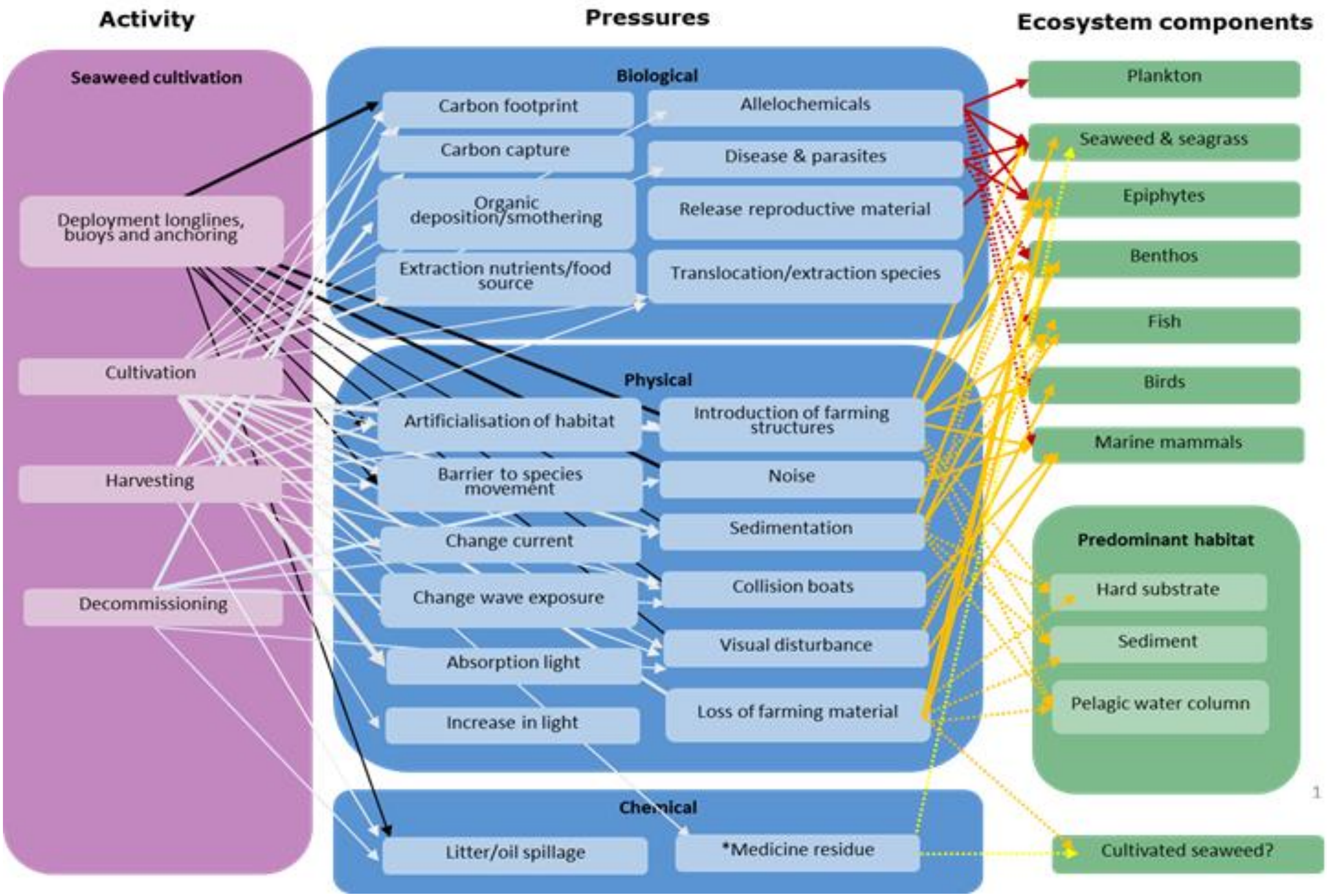

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Tonk et al, in prep

Outcome of the C-Team

3P's	Meetlat LNV visie	Door WMR voorgestelde aquatische KPI's (per sector/visserij)
Ecologisch	#1: Sluiten van kringlopen	Nutriënten stromen (N, P) en primaire productie (C) bekend; optimaal benutten (input/output) voor medegebruik (natuur, visserij, schelpdieren, voer, blauwe eco etc)
	het terugdringen emissies	kg food/kg koolstof
	vermindering van verspilling	kg food/kg gevangen (incl discards&uitslacht) kg food+feed/kg gevangen kg mosselzaad/kg commerciële mossel
	#2: Duurzaam bestandsbeheer visserij zonder schade aan de natuurlijke omgeving	kg gevangen & beheerd volgens MSY / totale kg gevangen aantal soorten gevangen & beheerd volgens MSY / totale aantal soorten gevangen
	#4: Klimaat	C-footprint sea-food C-fixatie (mn door aquacultuur schelpdieren/ schelpen)
	#6: Ecosystemen, biodiversiteit en de natuurwaarde	Biodiversiteit: Beschikbare geschikte KRM indicatoren die de Goede Milieu Toestand (GMT) beschrijven relateren aan voedselproductie. Bijvoorbeeld voor Zeebodem Habitat: Spreiding en ruimtelijke omvang fysieke verstoring per kg voedsel
	#7: Dierenwelzijn	# bedrijven met dierenwelzijn certificaat; kg sea-food verkocht met dit certificaat

Outcome of the C-team

Sociaal	#3: Versterken van de sociaaleconomische positie van de visser/schelpdieren/zeewier boer(innen) #5: Bijdrage aan vitale gemeenschappen in rurale gebieden #8: Bijdrage aan erkenning van waarde van voedsel en het versterken van relatie visser/kweker en burger	#familiebedrijven(schipper - eigenaar) #vergunninghouders # medewerkers rentabiliteit inkomen % jongere vissers (<30 jaar tov ouder) kg sea-food verkocht in NL aan NL consumenten met een duidelijk NL/regionaal verhaal per kg sea-food geconsumeerd door NL consumenten
Economisch	#9: Versterken van de positie van NL als exporteur van integrale oplossingen voor klimaat slimme en ecologisch duurzame voedselsystemen	# projecten en € waarin kustinrichting/ watermanagement en voedselzekerheid zijn gekoppeld

SDG framework as a reference

Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development

Sustainable Development Goal indicators should be disaggregated, where relevant, by income, sex, age, race, ethnicity, migratory status, disability and geographic location, or other characteristics, in accordance with the Fundamental Principles of Official Statistics.[1]

Goals and targets (from the 2030 Agenda for Sustainable Development)	*Indicators*
Goal 1. End poverty in all its forms everywhere	
1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day	1.1.1 Proportion of the population living below the international poverty line by sex, age, employment status and geographic location (urban/rural)
1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions	1.2.1 Proportion of population living below the national poverty line, by sex and age
	1.2.2 Proportion of men, women and children of all ages living in poverty in all its dimensions according to national

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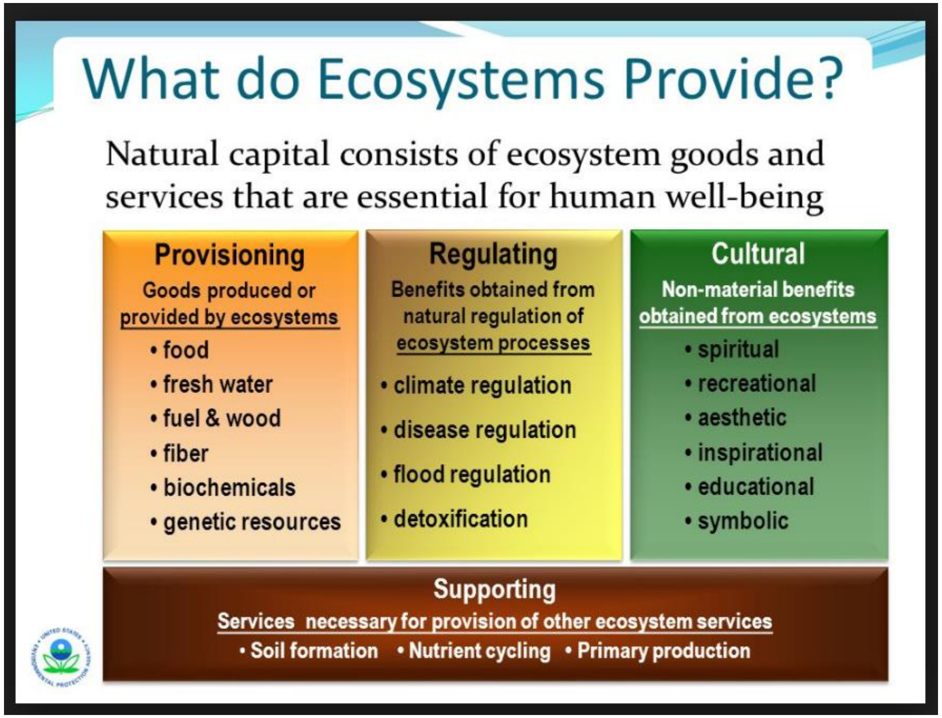
Goods and services in multi-use applications for wind farms

Seaweed



	Ecosysteem diensten – Positieve effecten	Ecologische impacts - Aandachtspunten
Plankton	(W) zeewier neemt nutriënten op wat het doorzicht in de waterkolom verbetert en daarmee de biodiversiteit van planktonsoorten (W) zeewier kan planktonsoorten aantrekken door bepaalde stoffen uit te scheiden (allelopathie) (K) zeewier voorziet zoöplankton van bescherming en voedsel	(W) competitie om nutriënten van zeewier met fytoplankton (micro-algen) kan effect hebben op de draagkracht van het ecosysteem en zo de biodiversiteit verminderen. Met andere woorden het zou dus kunnen dat bij teveel zeewier er niet genoeg nutriënten overblijven voor het fytoplankton
Zeewier en zeegras	(K) het kweeksysteem vormt substraat voor andere wieren, die zich bijvoorbeeld aan de boven lijnen of boeien vasthechten en hiermee de diversiteit vergroten (K) gebruik van lokale zeewiersoorten kan de genetische variatie binnen die soort bevorderen	(W) bij teveel geteeld zeewier blijven er eventueel niet genoeg nutriënten over voor het natuurlijk voorkomend zeewier en zeegras. Deze competitie om nutriënten kan de biodiversiteit verminderen. (K) zeewier of het kweeksysteem zelf kan als stepping stone voor verspreiding van exoten dienen
Epifyten	(K) zeewier kan als substraat voor epifyten dienen – en daarmee de biodiversiteit vergroten (S) zeewier trekt grazers aan wat een hogere biodiversiteit tot gevolg heeft	(K) het zeewier scheidt stoffen uit en kan hiermee andere organismen afstoten (allelopathie) dit kan de biodiversiteit verlagen (K) zeewier kan als substraat voor epifyten ongewenste algensoorten, bacteriën, virussen en schimmels aantrekken met een afname in zeewier biomassa als gevolg
Kleine bodemdieren (macrobenthos)	(K) zeewier biedt habitat, aanhechting, en bescherming (K) zeewierteelt trekt kleine bodemdieren aan en vergroot daarmee de biodiversiteit: op 1 kelpwier zijn tot 40 soorten en 8000 individuen te vinden (B) stukjes zeewier kunnen als voedsel voor filter-feeders en grazers dienen	(K) zeewier kan als stepping stone voor de verspreiding van exoten dienen (K) teveel aangroei van organismen kan het kweeksysteem beschadigen (B) bodemdieren kunnen geplet worden door ankerpunten (B) bezinking van losgeraakt zeewier beïnvloedt biochemisch processen in de bodem en daarmee eventueel de biodiversiteit van bodemleven
Vissen	(K) zeewier dient als kraamkamer voor kleine visjes (K)(S) drijvende constructies op open zee trekken pelagische en bodemvissen aan t.b.v. diversiteit en voedselvoorziening	(K) substraat en habitatmogelijkheden bevorderen connectiviteit voor meer zuidelijk voorkomende vissen (K)(S) zeewierteelt kan als stepping stone voor verspreiding van exotische vissen dienen
Vogels	(S) zeewier kan bijdragen aan de voedselvoorziening voor zeevogels door het aantrekken van prooidieren (K) boeien kunnen als rustplek voor trekvogels dienen (maar zie gevaren in combinatie met windpark)	(K) combinatie van zeewierteelt met windpark kan gevaren opleveren voor vogels (B) veranderingen in samenstelling en abundantie bodemleven kan de voedselvoorziening voor kustvogels beïnvloeden
Zoogdieren	(S) zeewier kan bijdragen in de voedselvoorziening voor zoogdieren door aantrekken van prooidieren zoals bijv vissen (K) boeien kunnen als rustplek dienen voor migrerende zeehonden	(K) verstikking of verwonding van zoogdieren door teeltsystemen (K) verplaatsing leefgebied van zoogdieren

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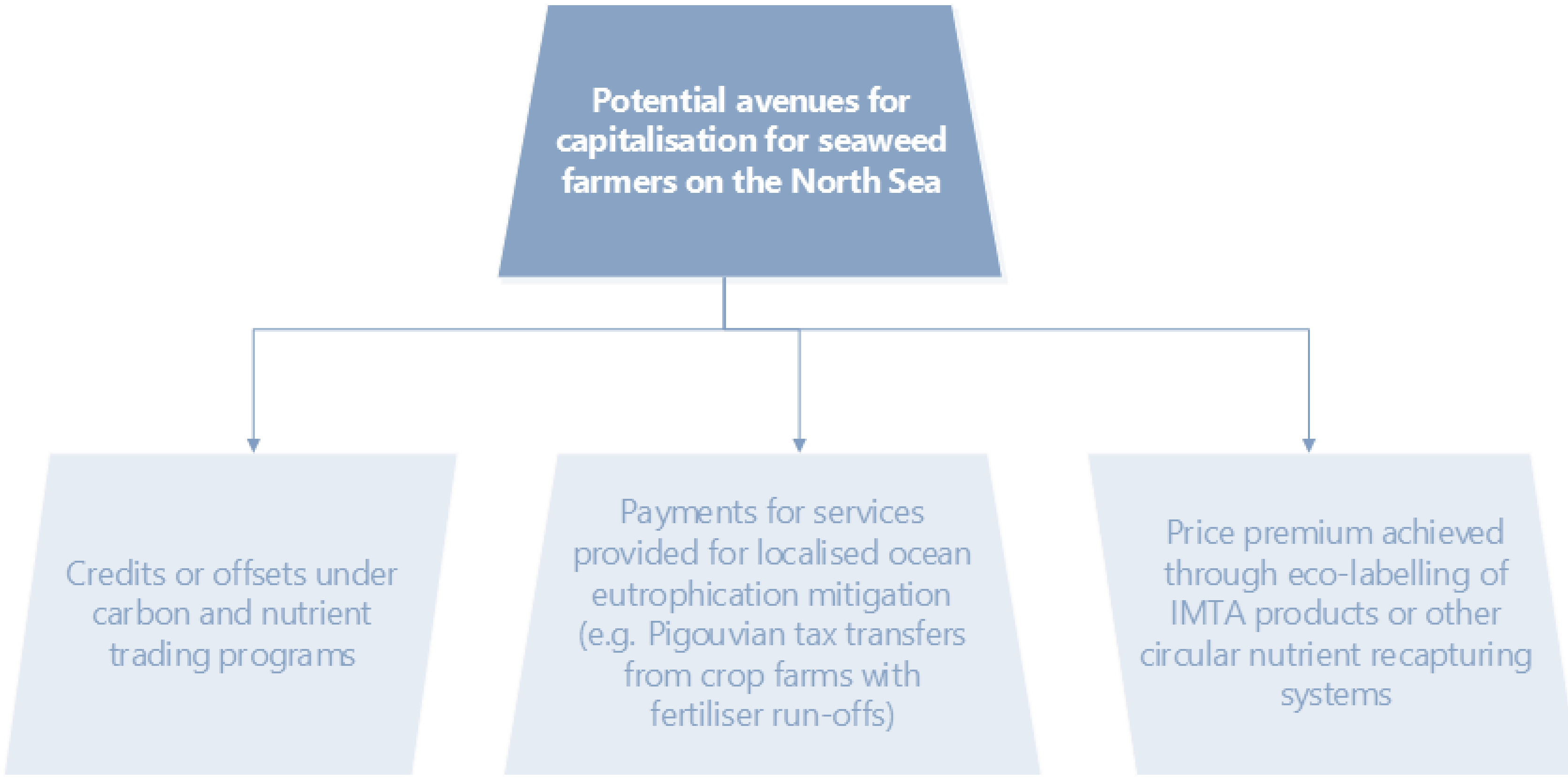
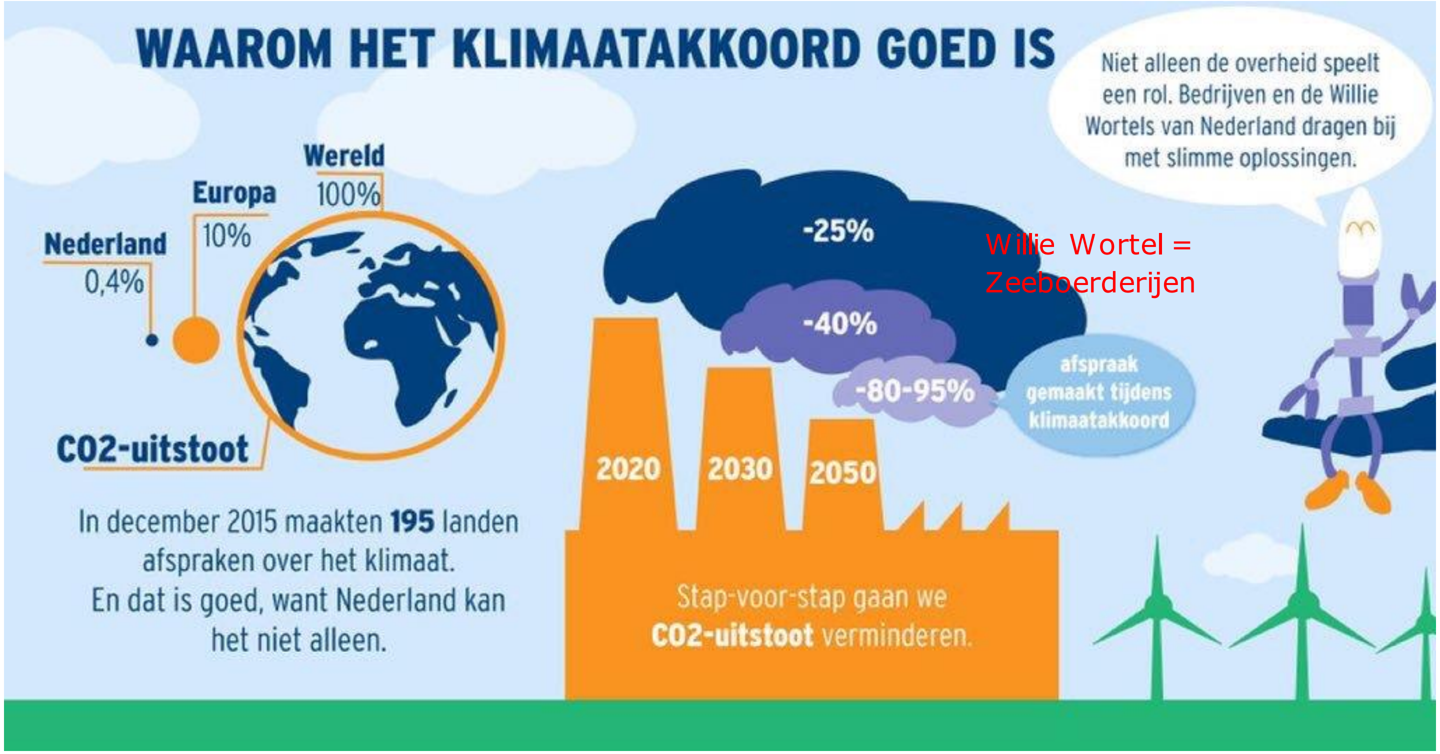
Avenues to capitalise

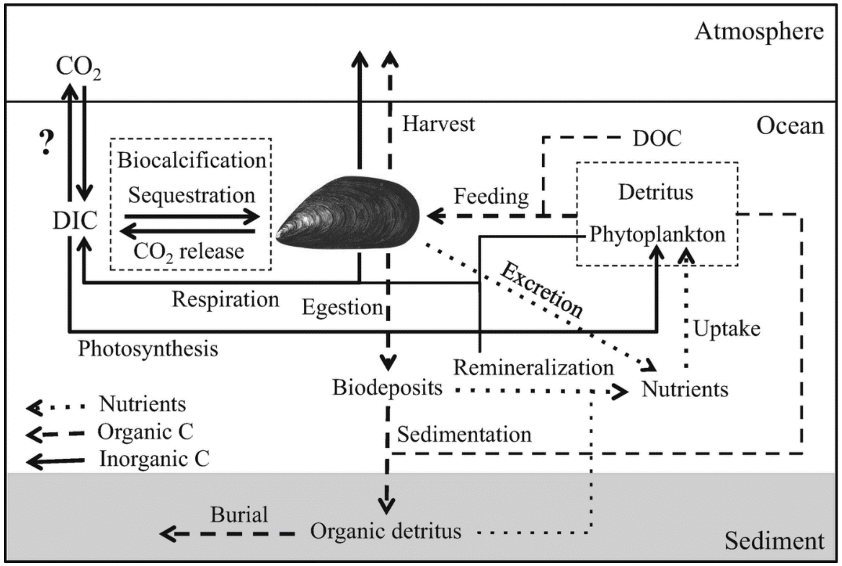


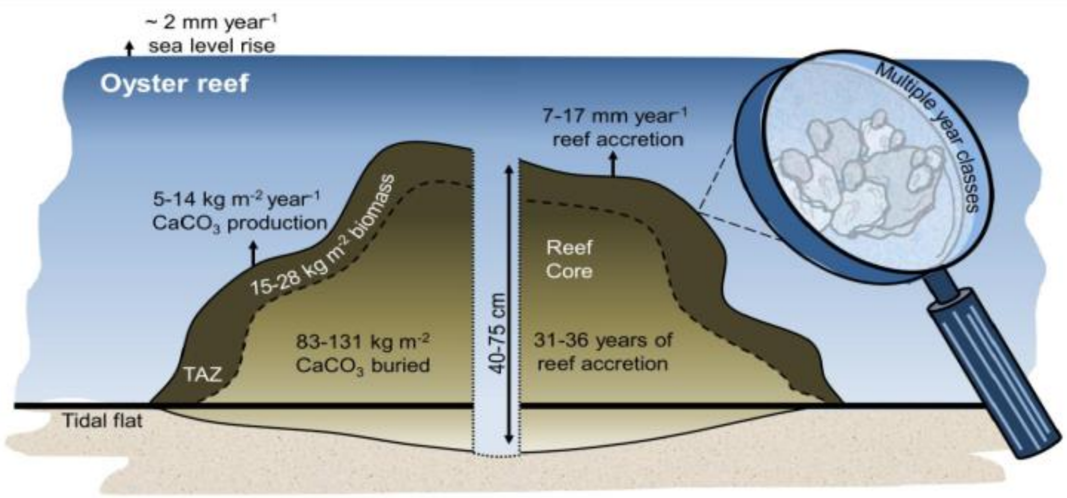
Societal relevance Blue Carbon

- Food production from land to sea
- Paris Agreement: emission reduction & verification
- Challenge: climate positive marine food production



Carbon capture as a climate tool in shellfish, seaweed and energy production





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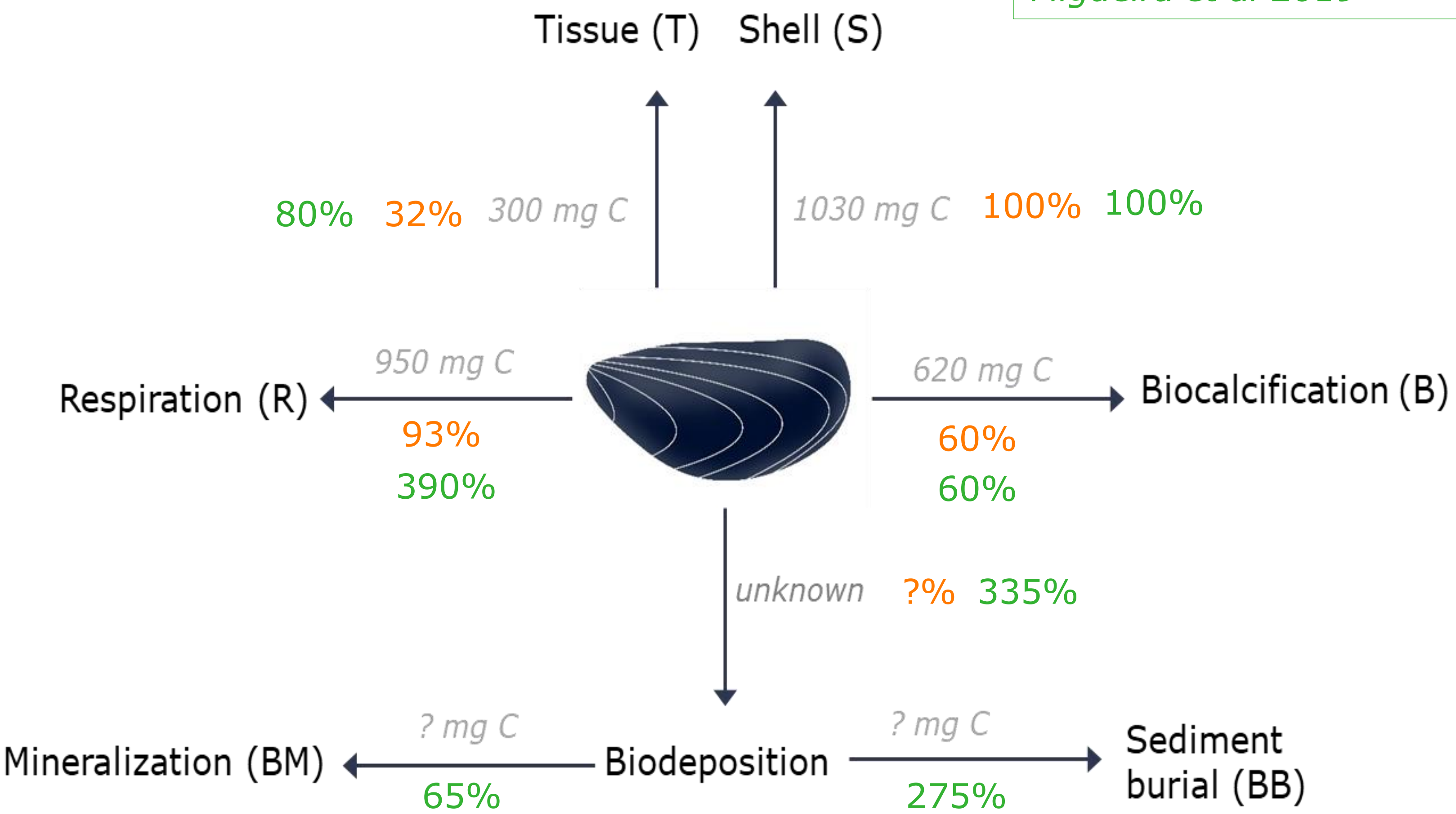
2. Individual

Example Norway:
- Suspended culture
- Low temperature
- Low food conditions

Filgueira et al 2019



What do these numbers say?

How much shellfish to compensate ‘your’ car?

- Average distance: 13.000 km year^{-1}
- Useage 1:14 = 930 l gasoline year^{-1}
- 2.8 kg CO_2 per liter gasoline = 2.6 ton CO_2 to compensate

= 1.1 ha mussel bottom culture (under a maximum scenario!)

Nitrogen– ‘the next hot item’

- “Stikstofcrisis”
- What is the role of shellfish in nitrogen management?
  > only in tissue

- Gross balance:
  <1kg N / 100 kg mussels
- Denmark: mussel used for mitigation cultures
- Low in comparison to lifestock

Relevant in Waddensea and Delta?

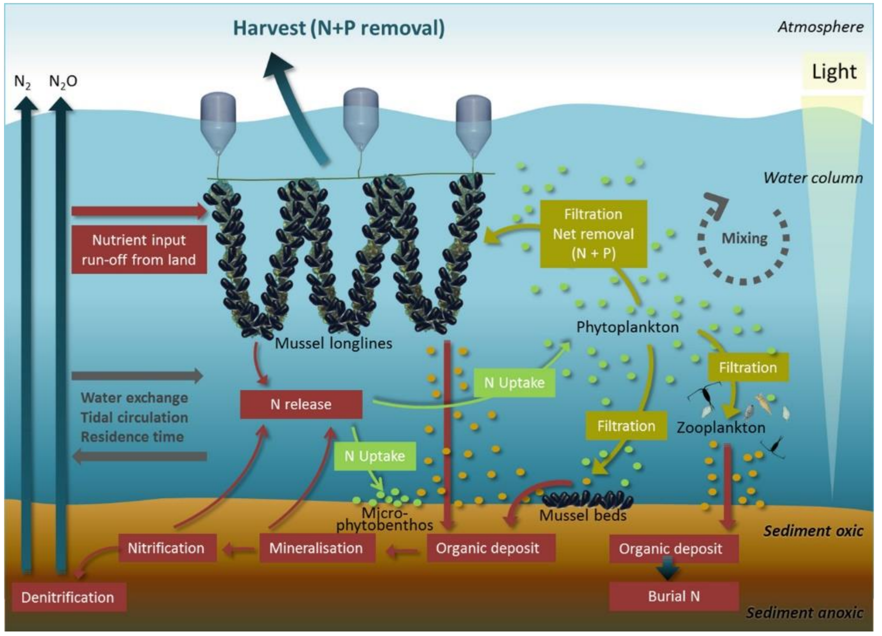
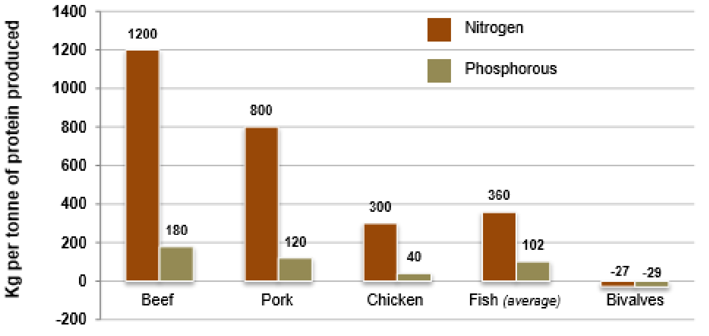


Figure 8 Nitrogen and phosphorous emissions for animal production systems



ICES Journal of
Marine Science

ICES CIEM International Council for the Exploration of the Sea Conseil International pour l'Exploration de la Mer

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.

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Case study: seaweed cultivation in the North Sea

Seaweed species	**Kelp (*Saccharina latissima*)**	***Laminaria digitata***	***Chondrus crispus***
Space available	145 km^2	350 km^2	~250 km^2
Dry weight eqv.	145,000 mt	350,000 mt	250,000 mt
Carbon content	45,820 mt (eqv. 31.6%)[1]	105,000 mt (eqv. 30%)[2]	75,000 mt (eqv. 30%)[2]
Nitrogen content	4,785 mt (eqv. 3.3%)[1]	4,900 mt (eqv. 1.4%)[3]	5,000 mt (eqv. 2%)[3]
Traded price	N: US$30/kg, C: US$10-30/mt[2] N: US$11/kg, C: US$6-60/mt[4]		
Economic value	**€48.3m**	**€50m**	**€50.7m**

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Criteria for the feasibility study

- Climate Policy needs ("rapportages")
- Manageable / user-friendly (model/report tool)
- Technical Applicability (including opportunities)
- Scientific logic (Do I measure the right thing)
- System approach
- Cost-effective
- Possibility to benchmark CO_2 seq. for private partners (seafarmers, wind energy, etc.) [JEROEN]

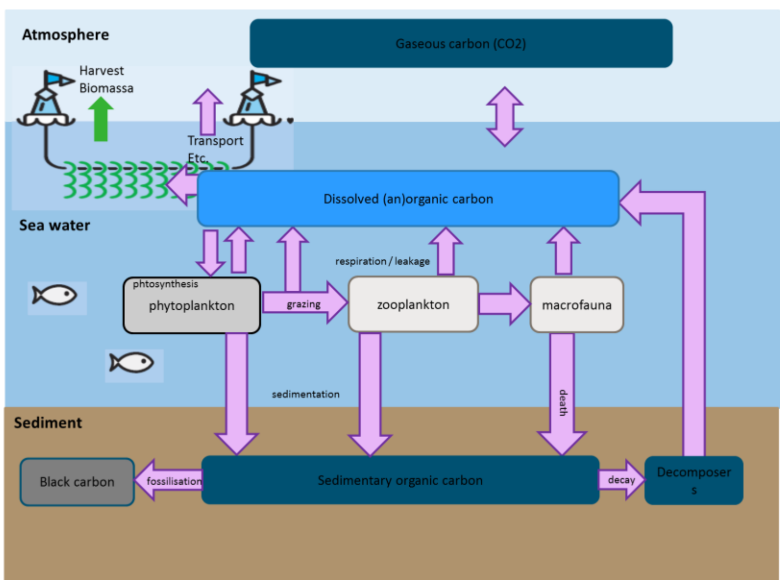
E-DNA en plankton

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

eDNA



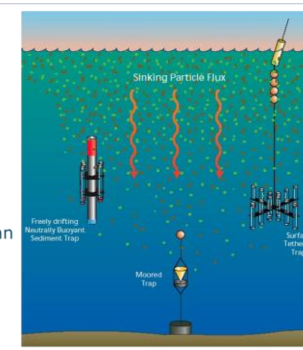
Sediment traps (Mandy Velthuis)

Voordelen:

- Gecombineerd toepasbaar op korte en langere periode
- Low-cost methode (inhangen, ophalen, drogen en wegen; evt koolstof bepalingen)

Nadelen:

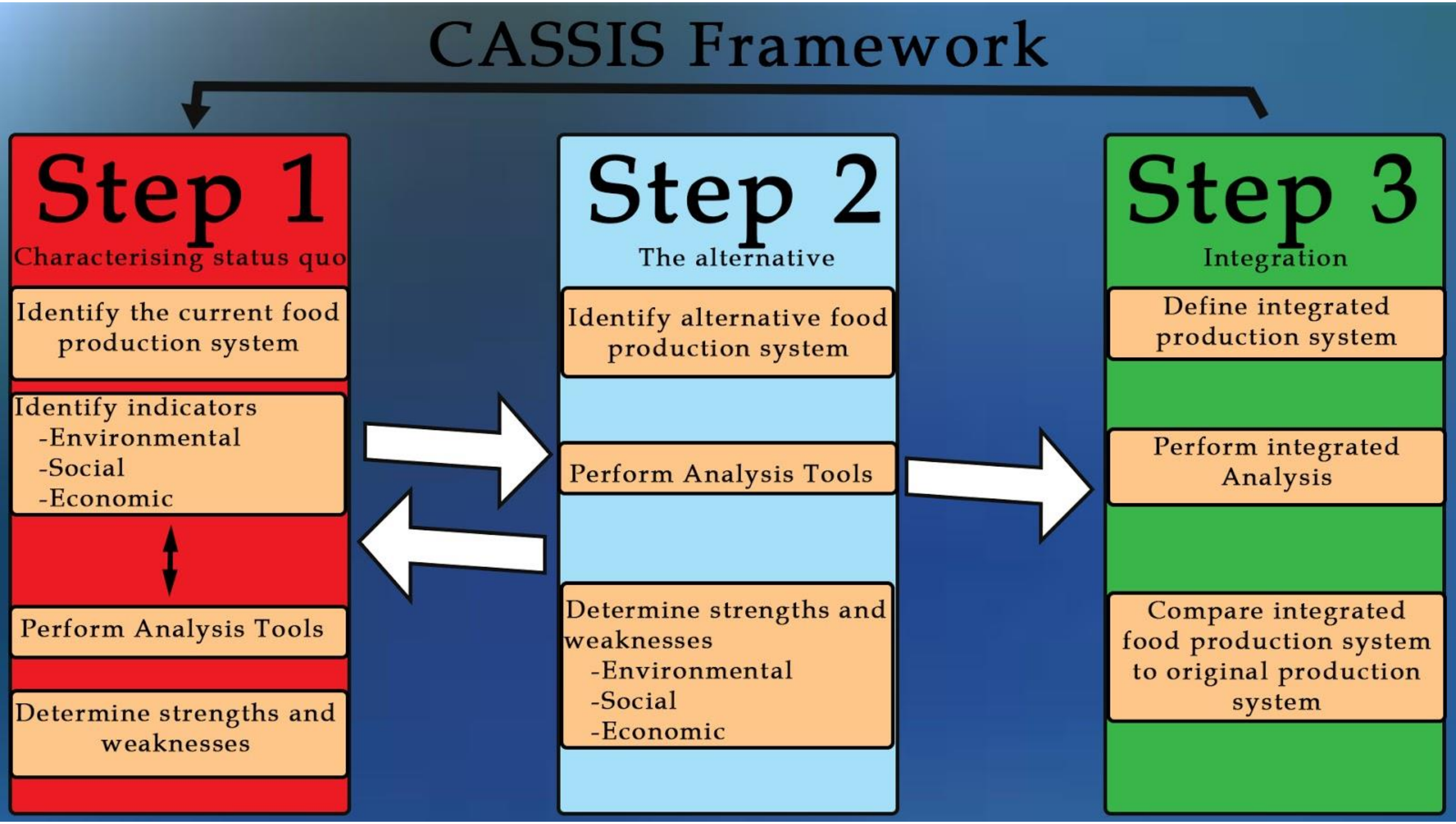
- Geen contact met bodem:Onderschatting van decompositie?
- Te weinig inval bij minder productieve systemen?
- Langer inhangen: sedimentatie + decompositie
- Waterdiepte: uitdaging op Noordzee?



Correlatie Δsedimentatie en CO_2 en CH_4 flux Kosten et al., in prep.

First glance on the development

CASSIS designed by ACT (as background)



Test run CASSIS (ACT) as background

Table 1. Values of environmental indicators for the baseline scenario (only soy included in animal feed) and the integration scenario (1.6% seaweed replacement in the animal feed). The numbers are based on 1 Kg of protein.

	Scenarios		
	Baseline	1.6% Seaweed replacement	% change
Indicator			
CED (MJ kg protein)	6.97	8.12	16.6
Diesel (L kg protein)	0.04	0.05	23.5
Water consumption (L kg protein)	4700.00	4624.80	-1.6
GHG (kg CO_2-eq kg protein)	1.74	1.71	-1.6
N input (kg N kg protein)	0.0071	0.0070	-1.6
P input (kg P kg protein)	0.075	0.074	-1.6
NH_3 leaching (kg NH_3 kg protein)	0.077	0.076	-1.6
P leaching (kg P kg protein)	0.00044	0.00043	-1.6
Arsenic (mg kg protein)	0.017	0.09	431.1
Cadmium (mg kg protein)	0.0116	0.013	9.7
Lead (mg kg protein)	0.02154	0.022	0.4
Zinc (mg kg protein)	17.6	17.35	-1.4
Chromium (mg kg protein)	0.48	0.47	-1.3
Copper (mg kg protein)	3.68	3.62	-1.5
Iron (mg kg protein)	32	31.79	-0.7
Nickel (mg kg protein)	0.88	0.87	-1.5
Cobalt (mg kg protein)	0.024	0.02	-1.4

Integrated Comparative Assessment

Framework context
- GHG emissions
- Resource security
- Nitrogen crisis
- Phosphate depletion
- Water depletion
- Energy use
- Ecosystem services

Framework components
- Carbon sequestering
- Resource security
Food security
Nutrient security
- Nitrogenous dynamics
- Phosphate depletion
- Circular water vision
- Net Nutriënt Flow
- Ecosystems impact and service

Marine Production
- Environmental indicators

Land production
- Economic indicators

Integrated food system
- Social indicators

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Integrated Assessment Framework

Framework context

- GHG emissions
- Resource security
- Nitrogen crisis
- Phosphate depletion
- Water depletion
- Energy use
- Ecosystem services

Framework components

- Carbon sequestering
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Food security
Nutrient security
- Nitrogenous dynamics
- Phosphate depletion
- Circular water vision
- Net Nutriënt Flow
- Ecosystems impact and service

Environmental indicators

- Net Nutriënt Flow
- Carbon balance
- Nitrogen balance
- Phosphate depletion
- Fresh water use
- Pesticide use
- Biodiversity
- Land use
- Ocean use
- Cummulative Energy use
- Externalities

Economic indicators

- Food security
- Cost/benefit per hectare
- Cost/benefit per kg
- Cost/benefit per kg of protein
- Carbon crediting
- Phosphate crediting
- Biodiversity crediting
- Nitrogen crediting
- Local reliance
- Valuing nature

Social indicators

- Consumer Drivers and Barriers
- Employer opportunities balance
- Labour conditions
- Subsidies
- Spatial planning
- License to produce
- Willingness to change
- Health impacts
- Health benefits
- Disease risks

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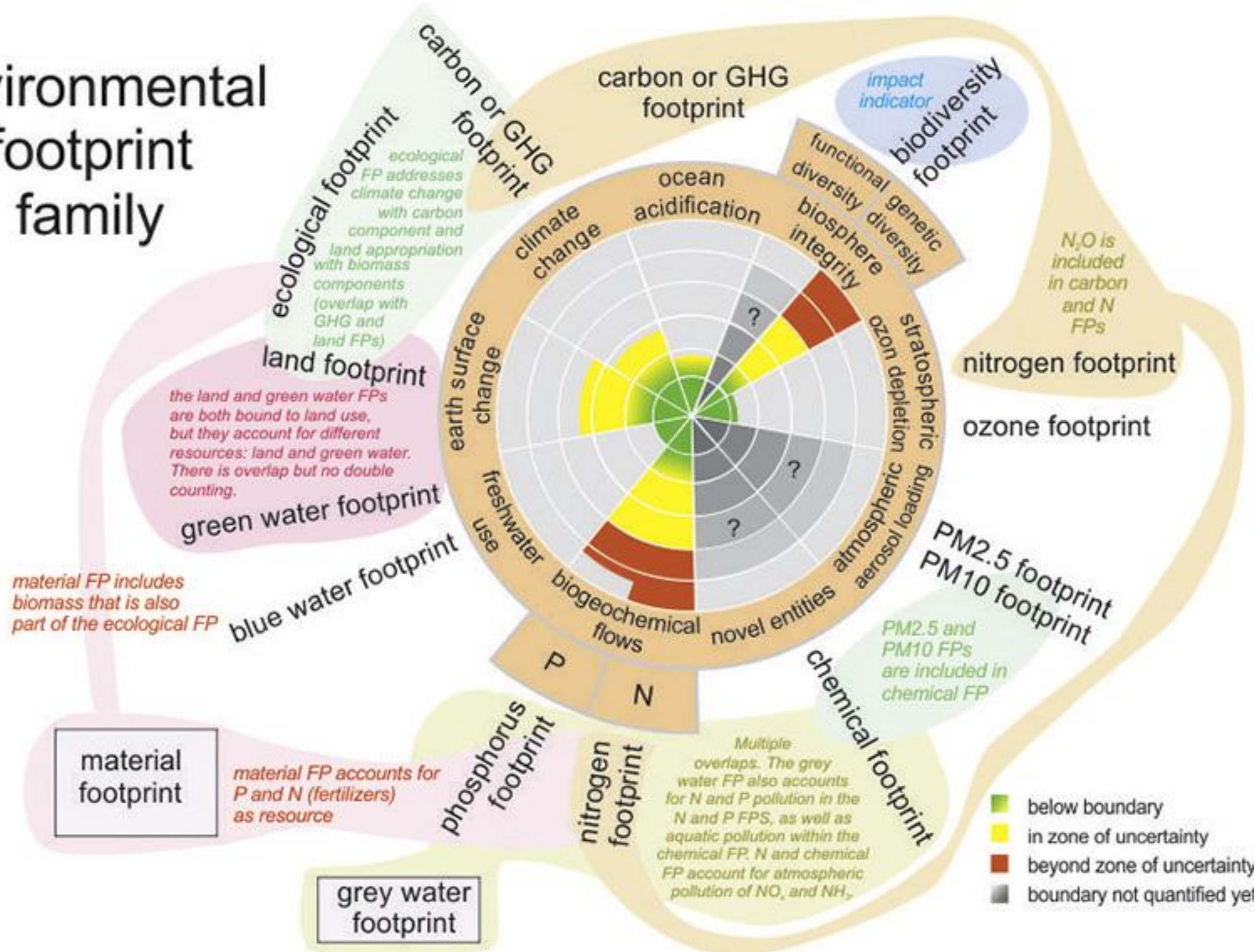
environmental footprint family



Building blocks for development of n integral framework

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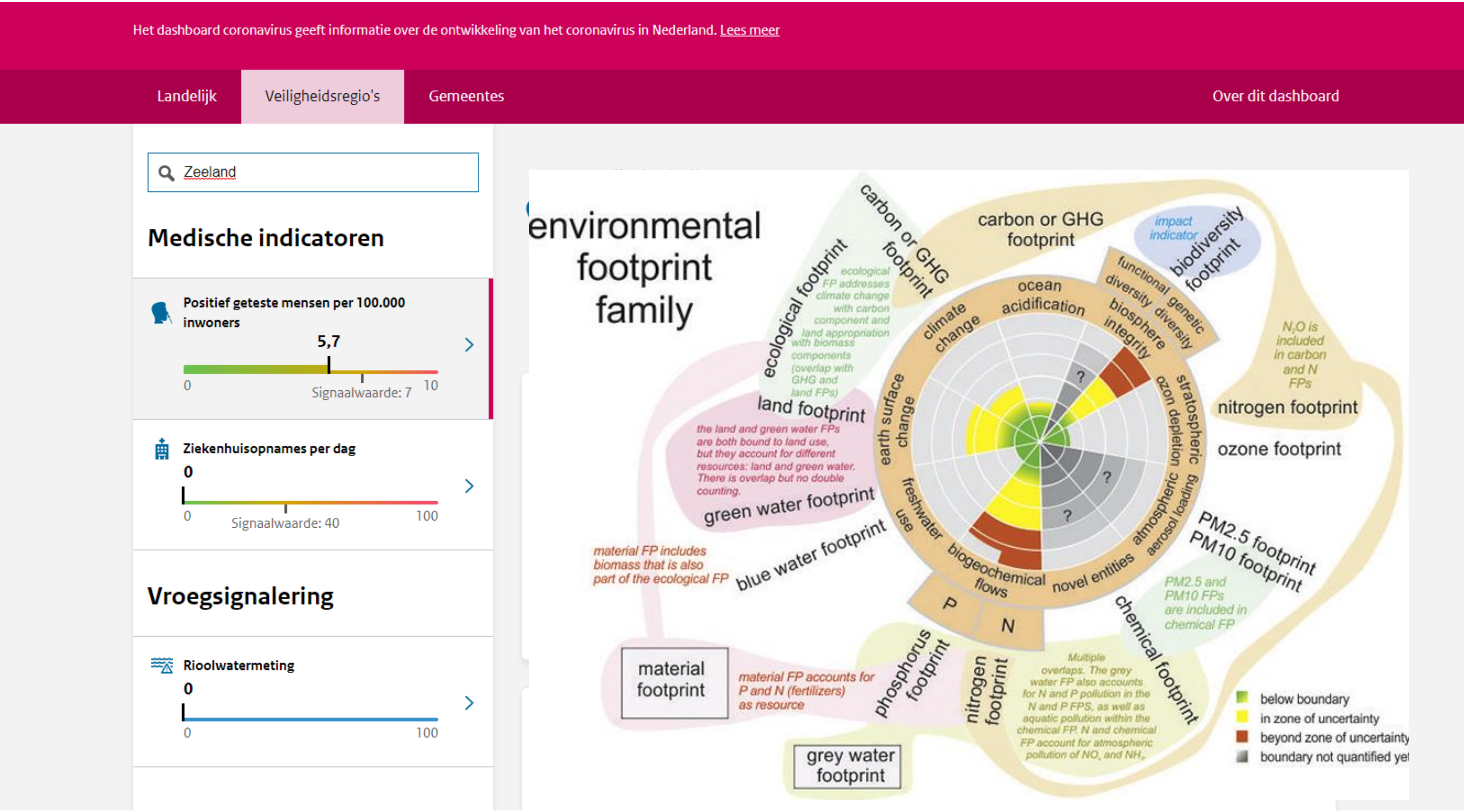
Corona dashboard to marine circularity Dashboard



Ultimately to Circularity indicators

Production drivers

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)

Beneficiary impact

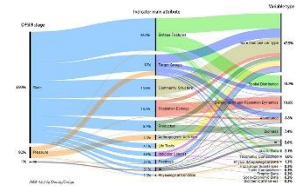
Increase crop yield
Decrease CO2 eq
Imporvement production efficiency
Replacement resources (MAGNET)
Food safety risks

Viable economic sectors

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

Resource Security drivers

Efficiency in Production: % primary production utilized
Proportion of stocks and production within biologically sustainable levels (MSY indicator)
Proportion of stocks generating beneficiary effects
% Captured P (P uptake - P lost)
% Utilisiation (waste ratio)
Carbon sequester scenarios (land versus sea)



Climate action drivers

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

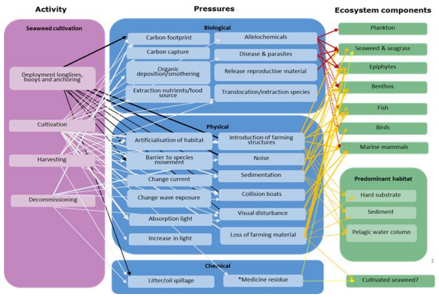
Support framework

Human Well-being

SDG Indicators under ILO custodianship

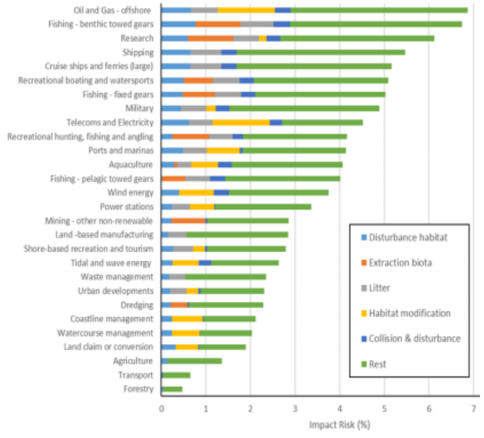
Ecosystem/Biodiversity conservation and restoration

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



Affordable and clean energy

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



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First via scenario based framework

Production options

Scenario 160 ha seaweed, 100tons ww
Scenario 5million tons shellfish

Production drivers

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)

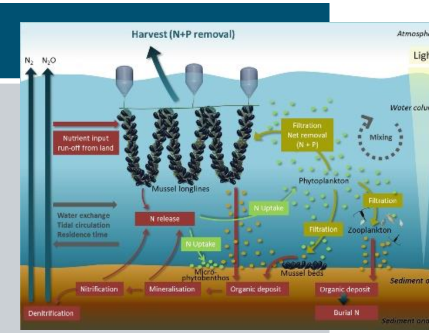
Viable economic sectors

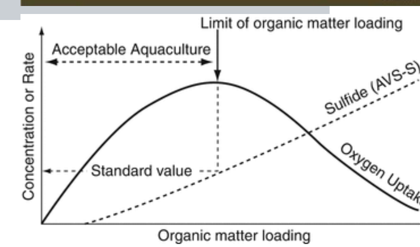
Cost-benefit per surface area
Employment opportunity balance
Quality index jobs
Quantity index jobs

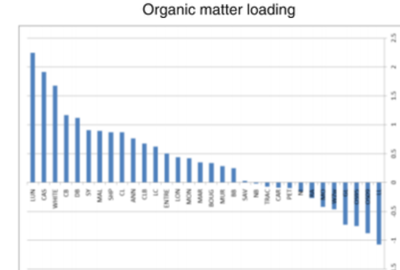
Resource Security drivers

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)
Captured P uptake (P uptake - P lost)

Indicator carrying capacity
MSY indicator





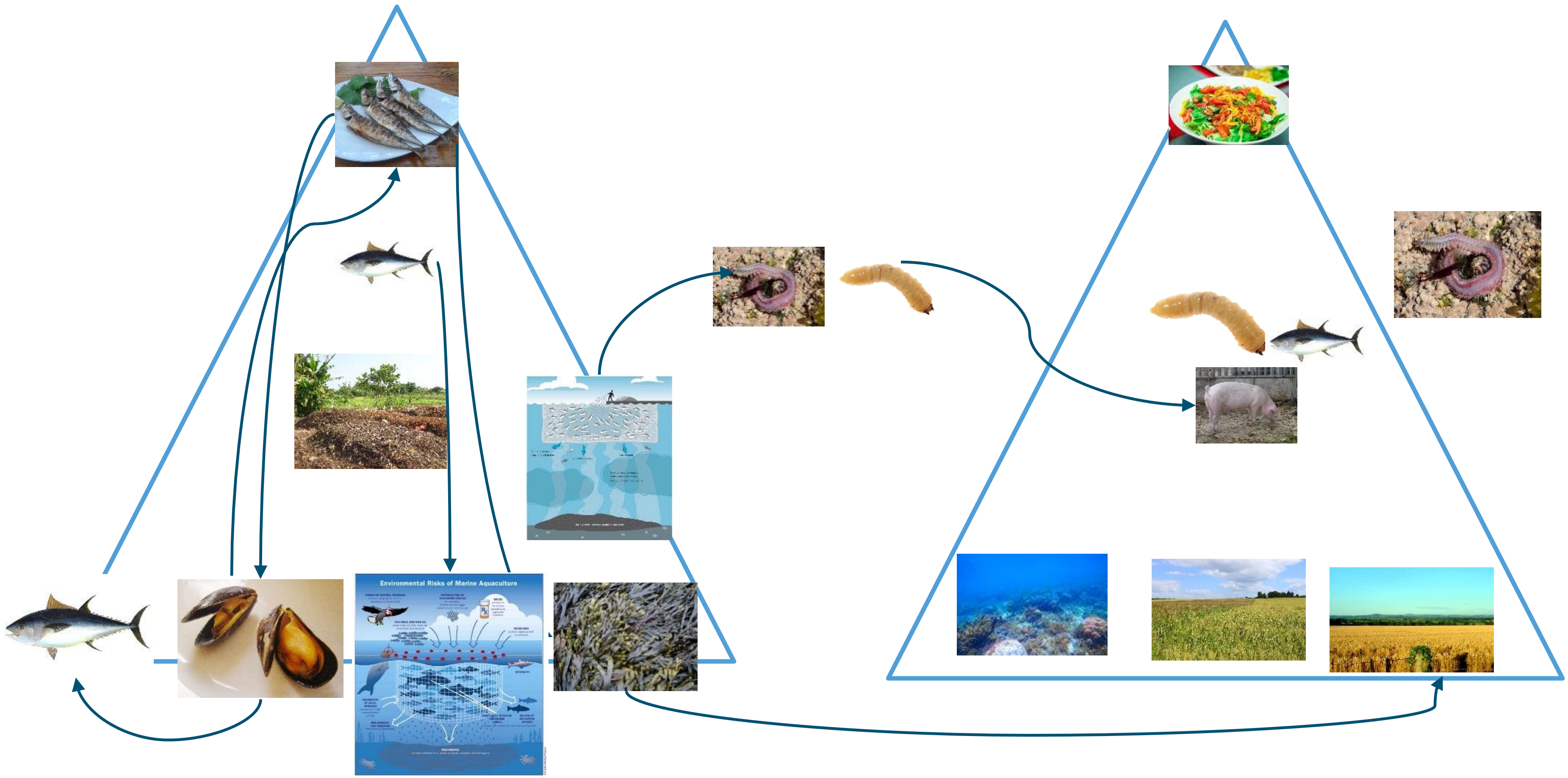


Climate action drivers

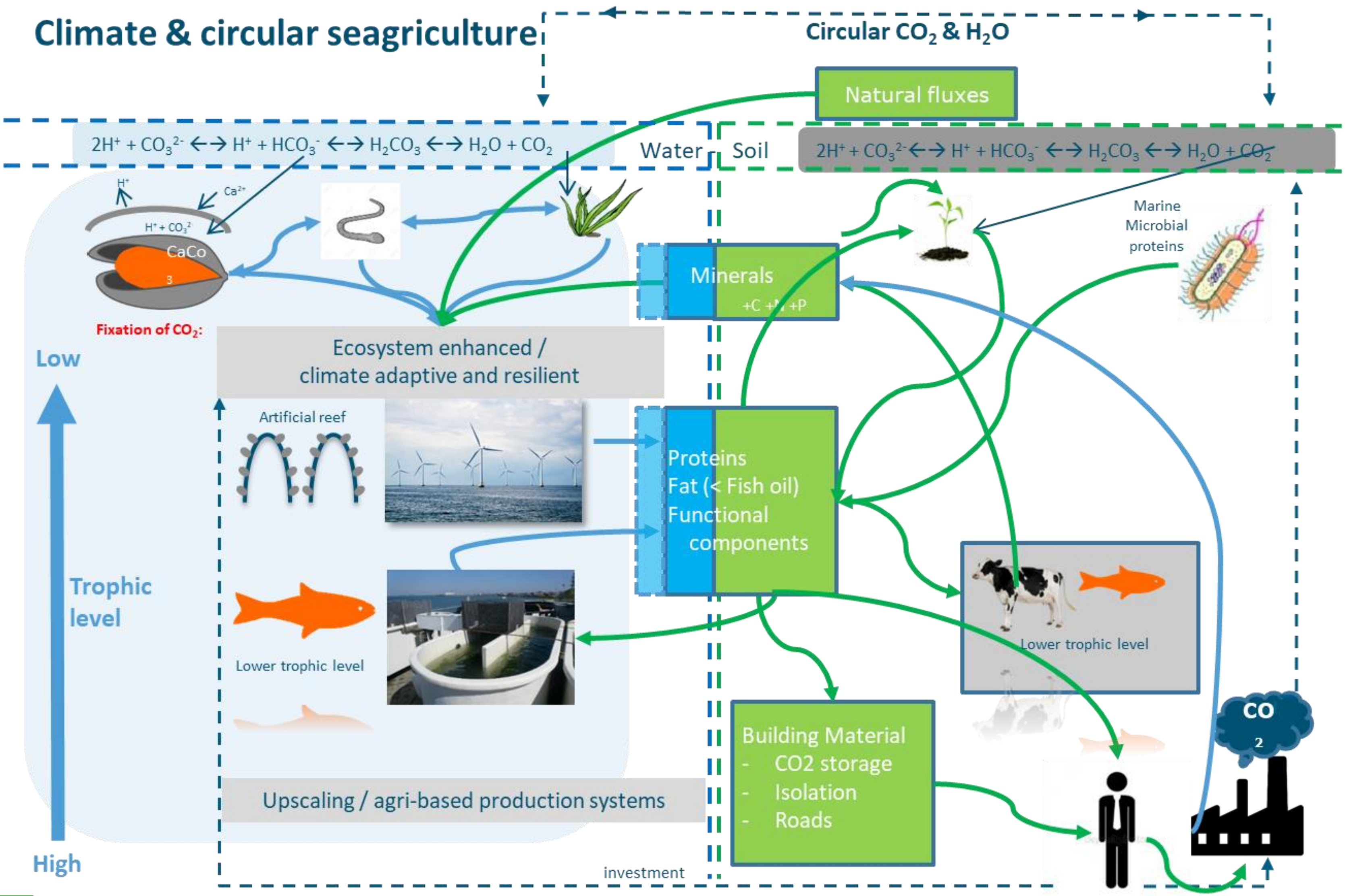
Kg production / MJ fossil fuel
CO_2 emission / production
Carbon capture / Kg production (this can be negative if capacity is compromised)
NOx eq / product
Carbon balance disruption factor??
M3 fresh water used
M3 fresh water : water scarcity index
M2 areal used / unit

Next steps 2021

Circular marine vision



Ter inspiratie



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How to deal with?

- Future waterscarcity -> role for marine
- Future water dynamics (rain intensity)
- How to include processing options (and effects)
- Stakeholder inclusion
- International context

- Projectplan

Om het in het werkplan aandacht te besteden aan de link tussen mariene productie systemen en land based productie systemen en de links te noemen zoals je ze ook al in de laatste update noemde?

Questions

- Wat verstaan we onder een framework? Het is een term die makkelijk op veel manieren te interpreteren is.
- Interpretatie: een framework beschrijft welke stappen je moet doorlopen om te beoordelen of (in dit geval) voedsel productie op zee circulair en climate smart is.
- De volgende vragen zijn dan natuurlijk:
  - Wat is circulair (https://weblog.wur.eu/biobased-economy/how-does-the-sea-fit-into-the-circular-bio-economy/)
  - Wat is climate smart
  - het moet ook het ecosysteem niet teveel beinvloeden (--> wat is dat precies?)