CEDA-IADC CONFERENCE

Dredging for SUSTAINABLE INFRASTRUCTURE

Central Dredging Association

IADC INTERNATIONAL ASSOCIATION OF DREDGING COMPANIES

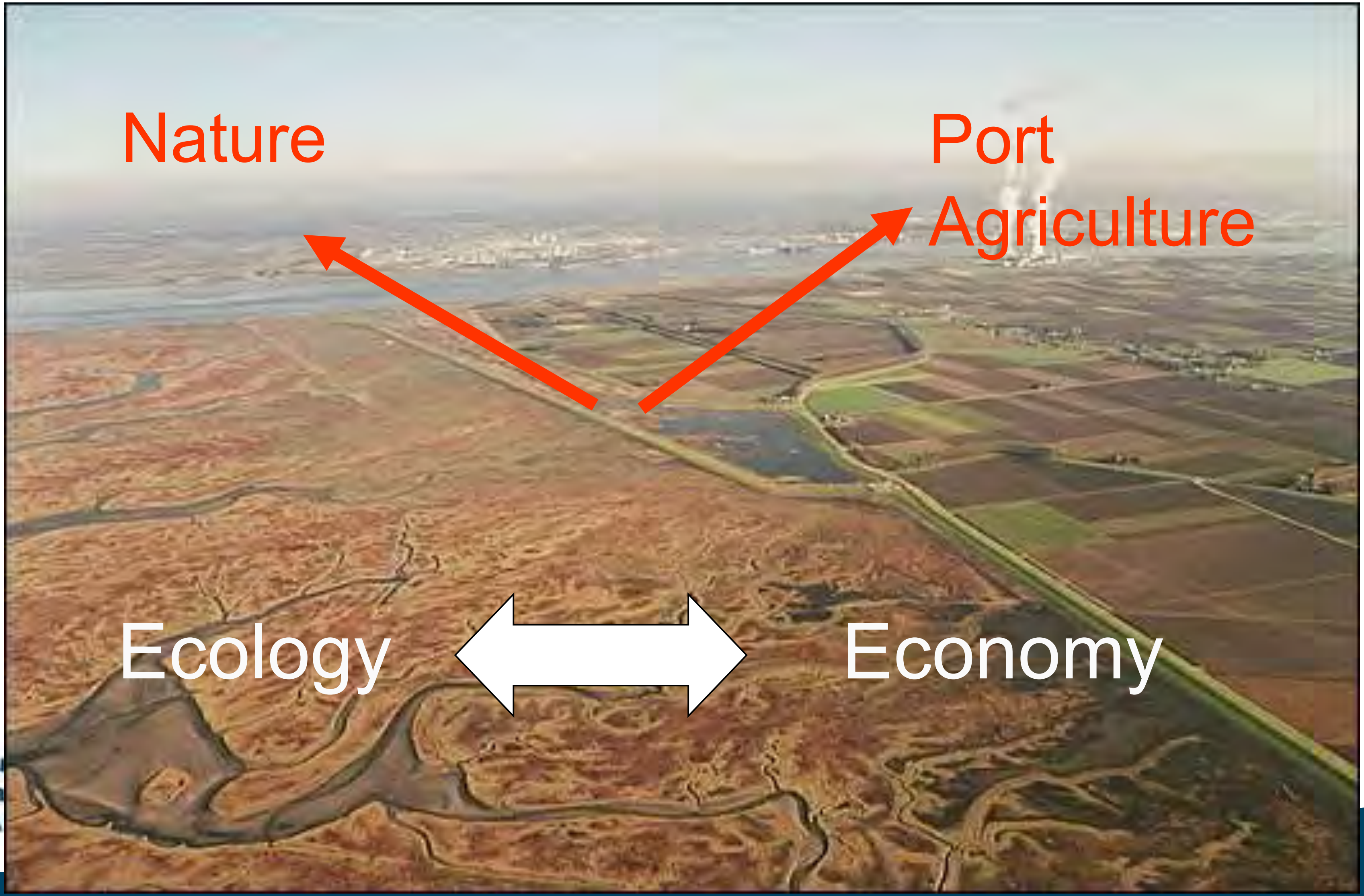
Dredging Today.com

USING AN ECOSYSTEM APPROACH

Patrick Meire, University of Antwerp,

Ecosystem management research group

Environmental issues still seen as hindering economic development !



Salmon mousse with corn salad

Fillets of Norman Sole with puree of potatoes

Jaffa-fondant cake

Salmon mousse on cornsalad

	Ingredients
1	cornsalad
2	coriander leaves
3	celery leaves
4	shallots
5	cucumber
6	lemon
7	black pepper
8	olive oil → olives
9	smoked salmon
10	sour cream → cows

fillets of Norman Sole with puree of potatoes

	Ingredients
11	fillets of sole
12	broth of fish → different species
13	white wine → grapes
14	mussels
15	shrimps
16	mushrooms
17	flour → wheat
18	eggs → chickens
19	lemon
20	parsley
21	potatoes

Jaffa-fondantcake

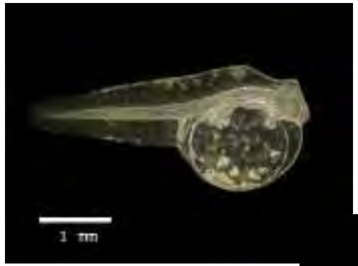
	Ingredients
22	sugar → sugarbeet
23	cacao
24	maizena
25	walnuts
26	oranges

+ aperitif, coffee, etc. → at least 30 species necessary!!

	Ingredients	Price/kg/L
1	cornsalad	12 €
2	coriander leaves	1,5 €
3	celery leaves	1 €
4	shallots	1,5 €
5	cucumber	1 €
6	lemon	2 €
7	Black pepper	15 €
8	olive oil ➔ olives	8 €
9	smoked salmon	25 €
10	sour cream ➔ cows	2,5 €

	Ingredients	Price/kg/l
11	fillets of sole	30 €
12	broth of fish ➔ different species	2 €
13	white wine➔ grapes	5 €
14	mussels	10 €
15	shrimps	20 €
16	mushrooms	4 €
17	flour ➔ wheat	1 €
18	eggs ➔ chicken	0,20 €
19	lemon	2 €
20	parsley	5 €
21	potatoes	1 €

	Ingredients	
22	sugar ➔ sugerbeet	1,5 €
23	cacao	7 €
24	maïzena	1 €
25	walnuts	6 €
26	oranges	2 €



1 Day

2 days

6 days

19 days

28 days

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Ecosystem services

During different growth phases, the sole needs different types of food

From phytoplankton to worms, shells and crustaceans.

Phytoplankton

Zooplankton

Epi and endobenthos

Ecosystem services

The diet of an average juvenile sole and schrimp consists of about 25 species, when adult sole needed more than 70 upto 100 different prey species to get at that stage!

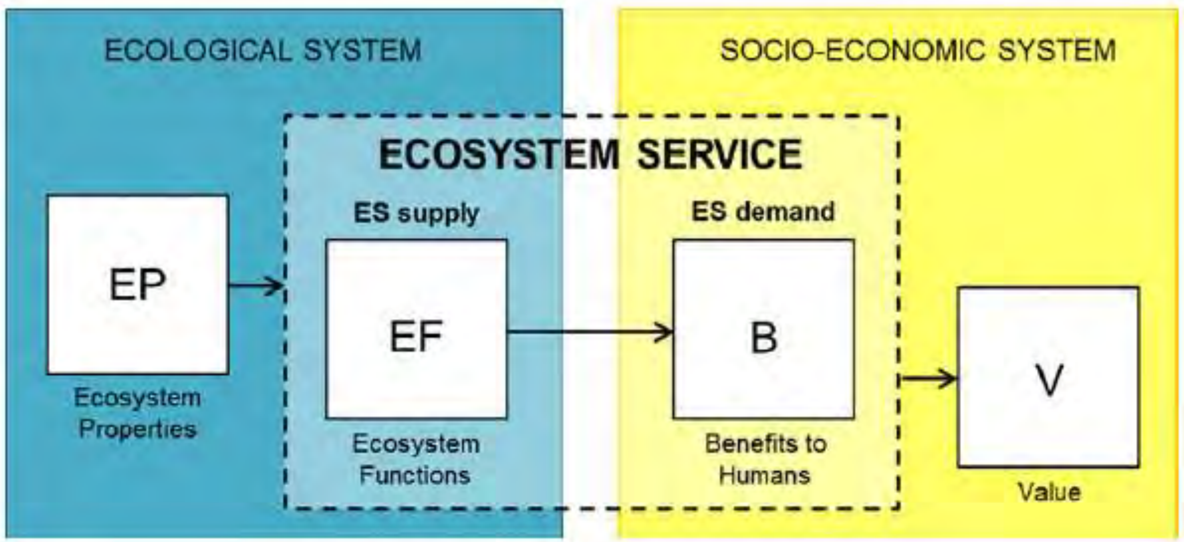
All these species have specific requirements to the environment where they occur and need in their turn other species to feed on!

- Products with a high market value (eg Sole) are dependent on species WITHOUT market value and on specific habitats as well without market value

- Link between essential ecological processes and the good we are using is unknown to most

Ecosystem services

Ecological processes: driving mechanism for biodiversity, ecosystem services and interactions between them.



Boerema, Rebelo et al. 2016

Biodiversity

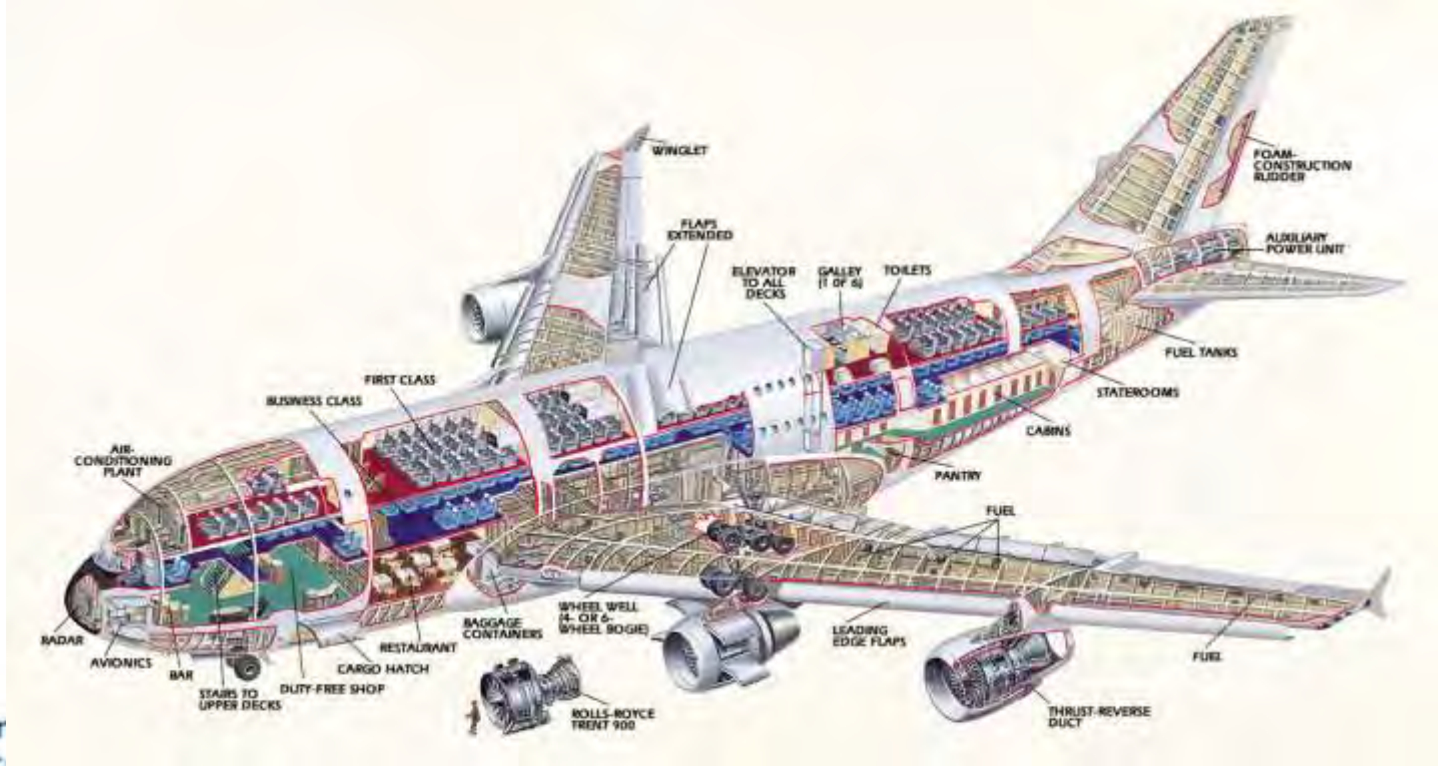
→ Driven by physical, biological and evolutionary processes

Who is going to build this?

An airplane: a system

Several subsystems make the plane to fly

- navigation
- motor
- .....



An airplain: a system in evolution

Powered by **solar energy**

An airplane: is a service provider

Service: transport, food, entertainment,…..

Evolution leads to delivery of more and better services

➔ But requires the functioning of the whole and more and more complex system

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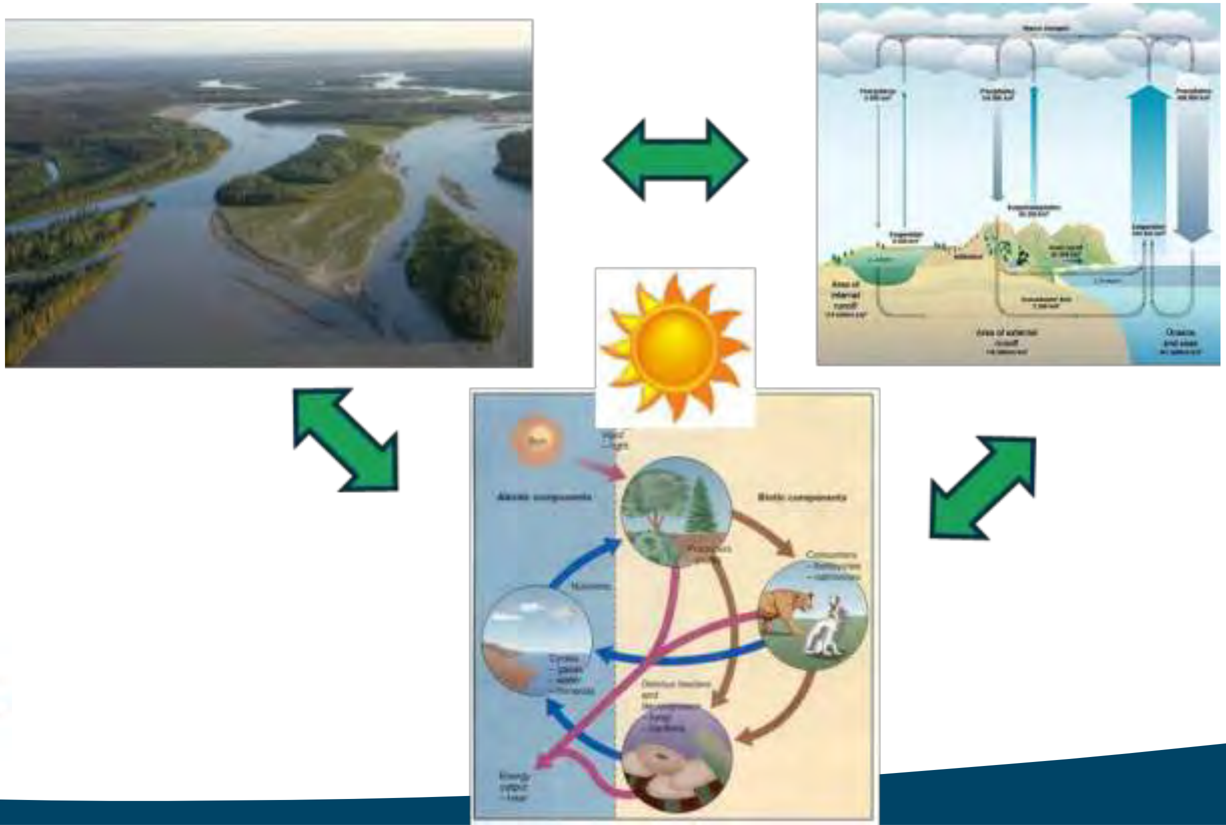
An ecosystem: a system

An ecosystem is a community of living organisms (plants, animals and microbes) in conjunction with the nonliving components of their environment (things like air, water and mineral soil), **interacting as a system**.

Consists of many subsystems, but roughly we distinguish three main systems



An ecosystem: is a service provider

"Ecosystem services: ***The direct and indirect contributions of ecosystems to human well being***" (TEEB, 2010)

	Main service types
	PROVISIONING SERVICES
1	**Food** (e.g. fish, game, fruit)
2	**Water** (e.g. for drinking, irrigation, cooling)
3	**Raw Materials** (e.g. fiber, timber, fuel wood, fodder, fertilizer)
4	**Genetic resources** (e.g. for crop-improvement and medicinal purposes)
5	**Medicinal resources** (e.g. biochemical products, models & test-organisms)
6	**Ornamental resources** (e.g. artisan work, decorative plants, pet animals, fashion)
	REGULATING SERVICES
7	**Air quality regulation** (e.g. capturing (fine)dust, chemicals, etc)
8	**Climate regulation** (incl. C-sequestration, influence of vegetation on rainfall, etc.)
9	**Moderation of extreme events** (eg. storm protection and flood prevention)
10	**Regulation of water flows** (e.g. natural drainage, irrigation and drought prevention)
11	**Waste treatment** (especially water purification)
12	**Erosion prevention**
13	**Maintenance of soil fertility** (incl. soil formation)
14	**Pollination**
15	**Biological control** (e.g. seed dispersal, pest and disease control)

An Ecosystem: a system in evolution

An ecosystem: a system in evolution

Since thousands of years men steared the evolution of ecosystems to increase the delivery of some ecosystem services

Water use

Shipping

energy

Historical development Danube near Vienna 1726 – 2001

Hohensinner, S. & Eberstaller-Fleischanderl, D. (2004)

Still an ecosystem??

An ecosystem: still a system?

- ➔ Regulating of our watersystems resulted in a loss of regulating services
- ➔ Evolution from complex system back to oversimplified systems

- ➔ Technology evolves to ever more complex systems to deliver more and better services whereas the same technological drive reduces the complexity of ecosystems resulting in ever less services delivered.
- ➔ Ecosystems are degraded systems by now!!

No engineer wants to build a degraded system (airplane) however thats what we do with ecosystems!!!

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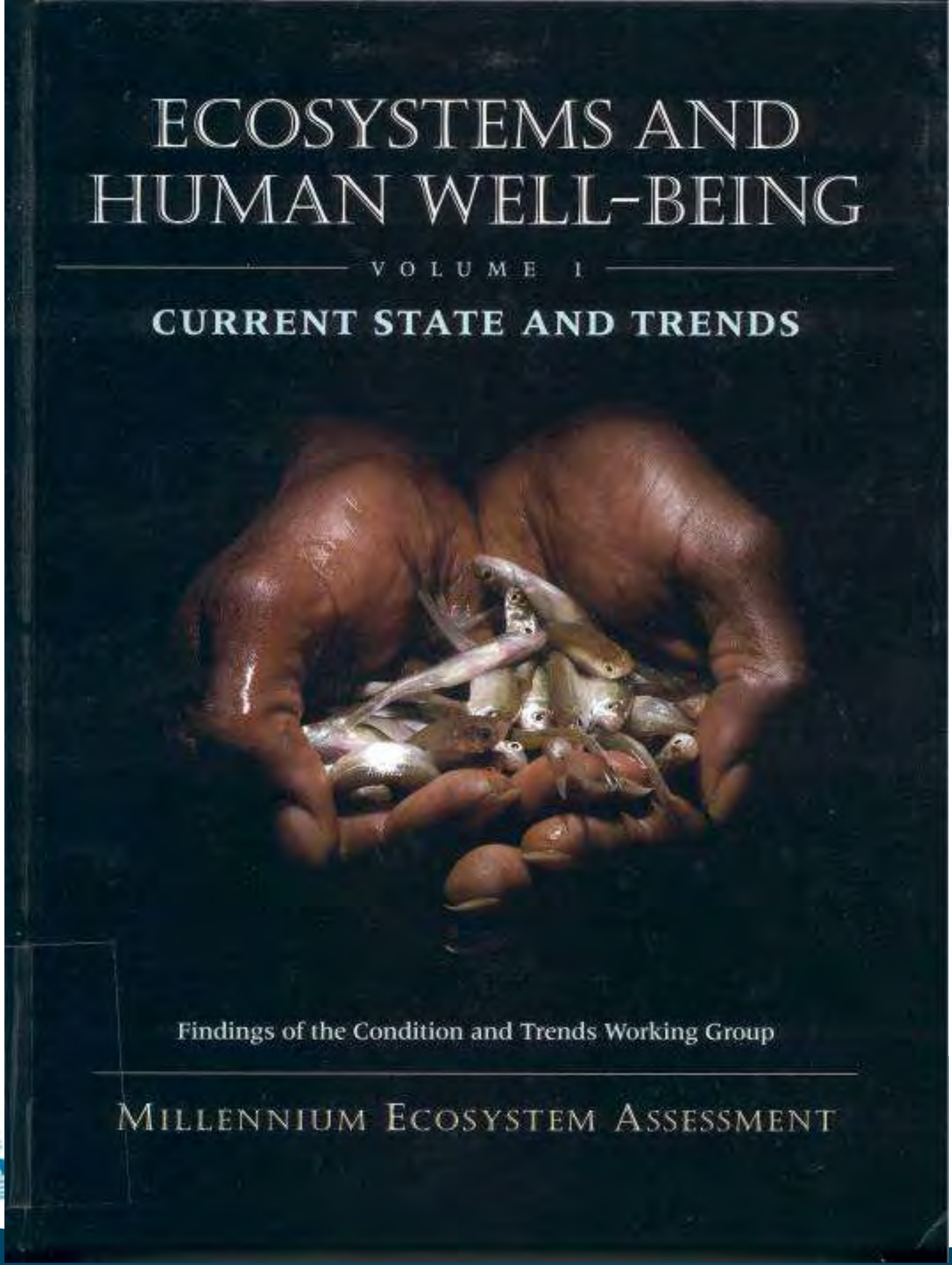
We start to understand the impact and consequences of all these measures from the past:

- Droughts
- Floods
- Changes in tidal characteristics
- Changing sedimentation/erosion patterns
- Impact on productivity,

- → A major loss of ecosystem services!

- A number are compensated by investments in infrastructural works (at high costs), others not, leading to direct losses (eg fisheries) or long term problems (eg loss of filter function and export of nutrients/pollutants)

- Loss of biodiversity, it is expected that half of the species will be extinct by the end of this centuary is irreversibel



articles

The value of the world's ecosystem services and natural capital

Robert Costanza*†, Ralph d'Arge‡, Rudolf de Groot§, Stephen Farber‖, Monica Grasso†, Bruce Hannon¶, Karin Limburg#*, Shahid Naeem, Robert V. O'Neill††, Jose Paruelo‡‡, Robert G. Raskin§§, Paul Sutton‖‖ & Marjan van den Belt¶¶**

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‡ *Economics Department (emeritus), University of Wyoming, Laramie, Wyoming 82070, USA*
§ *Center for Environment and Climate Studies, Wageningen Agricultural University, PO Box 9101, 6700 HB Wageninengen, The Netherlands*
‖ *Graduate School of Public and International Affairs, University of Pittsburgh, Pittsburgh, Pennsylvania 15260, USA*
¶ *Geography Department and NCSA, University of Illinois, Urbana, Illinois 61801, USA*
\# *Institute of Ecosystem Studies, Millbrook, New York, USA*
** *Department of Ecology, Evolution and Behavior, University of Minnesota, St Paul, Minnesota 55108, USA*
†† *Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, USA*
‡‡ *Department of Ecology, Faculty of Agronomy, University of Buenos Aires, Av. San Martin 4453, 1417 Buenos Aires, Argentina*
§§ *Jet Propulsion Laboratory, Pasadena, California 91109, USA*
‖‖ *National Center for Geographic Information and Analysis, Department of Geography, University of California at Santa Barbara, Santa Barbara, California 93106, USA*
¶¶ *Ecological Economics Research and Applications Inc., PO Box 1589, Solomons, Maryland 20688, USA*

The services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the Earth's life-support system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet. We have estimated the current economic value of 17 ecosystem services for 16 biomes, based on published studies and a few original calculations. For the entire biosphere, the value (most of which is outside the market) is estimated to be in the range of US\$16–54 trillion (10^{12}) per year, with an average of US\$33 trillion per year. Because of the nature of the uncertainties, this must be considered a minimum estimate. Global gross national product total is around US\$18 trillion per year.

What next?

Development does not stop!

➔ Land use change is going ever faster

What next?

Climate change:

- Sea level rise
- Changing precipitation patterns
- Changing discharges/ water availability
- Increasing temperature
- Changing human activities (economic,..)
- ….

- ➔ delivery of ES by habitats is likely to further decline resulting in ever increasing costs to society!

What next?

➔ A fundamental paradigma shift is necessary! The fundamental question is no longer, Do these measures have an impact on biodiversity, that we should protect according the directives, but has the loss of habitat and biodiversity an impact on

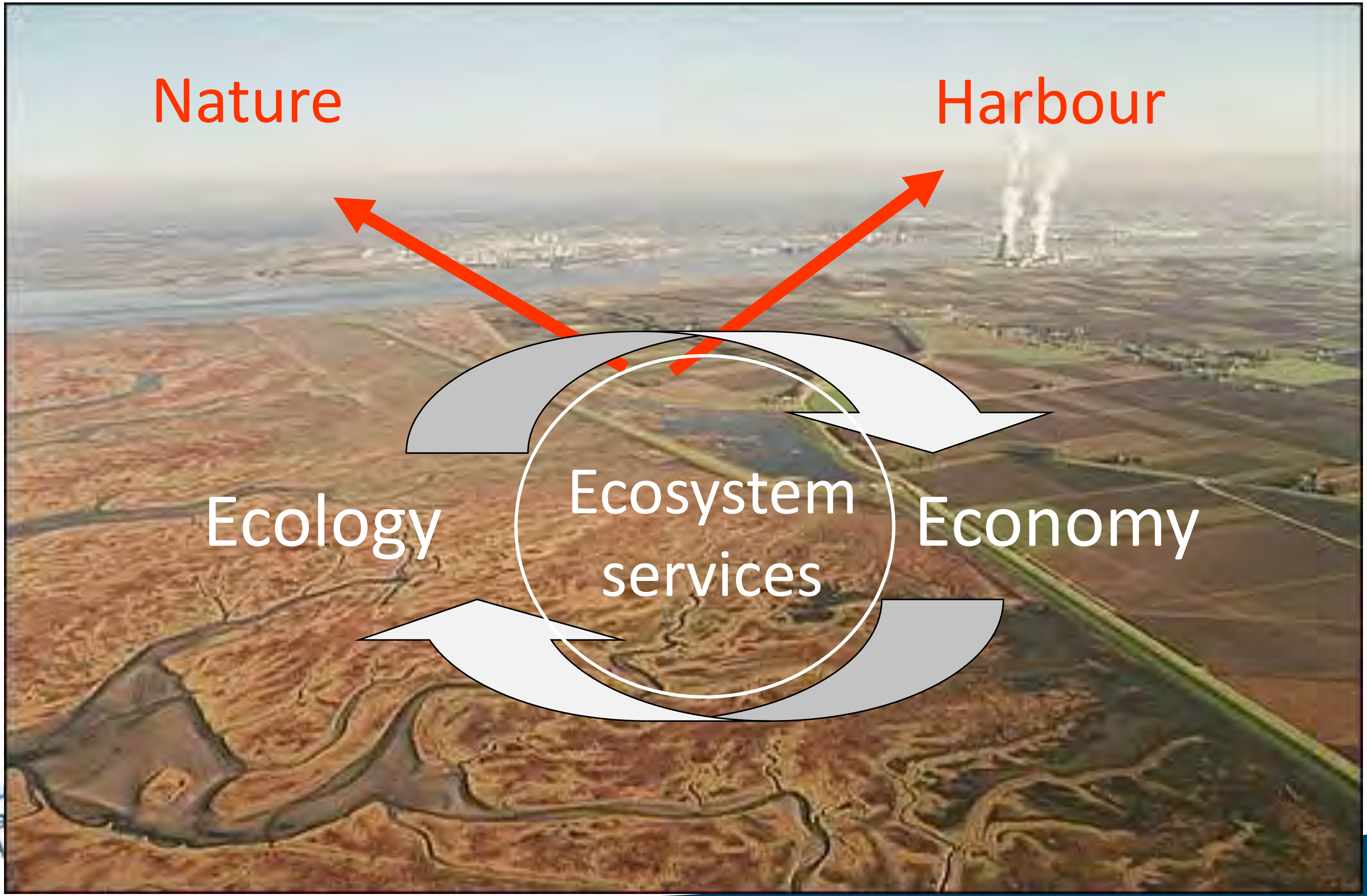
- the economy
- Human well-being

Or, is nature more than just species?

➔ Nature is not the problem but part of the solution

.

Ecosystem services



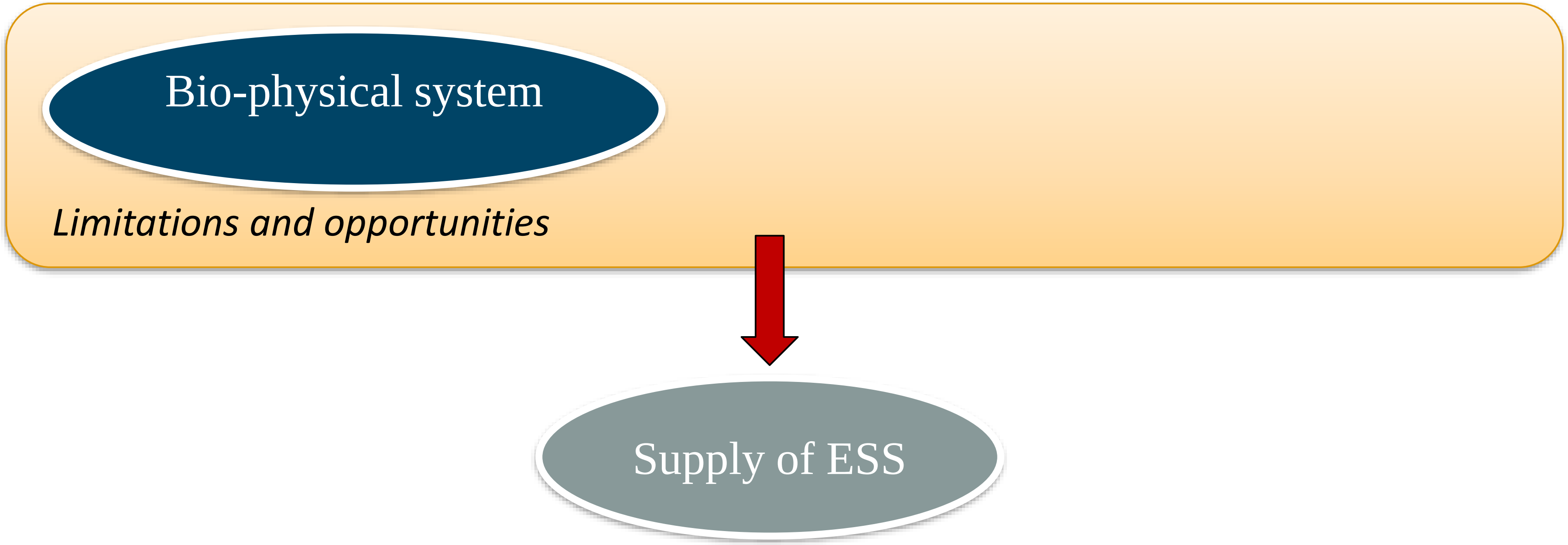
From concept to application:
What does it mean??

- If the ES approach is taken seriously this should result in different types of projects
- ➔ the project must fulfill multiple objectives/goals
  - Can have an impact on the spatial scale of the project

➔ new innovative methods have to be developed combining hard and soft engineering to reach the goals

An ES appraoch requires

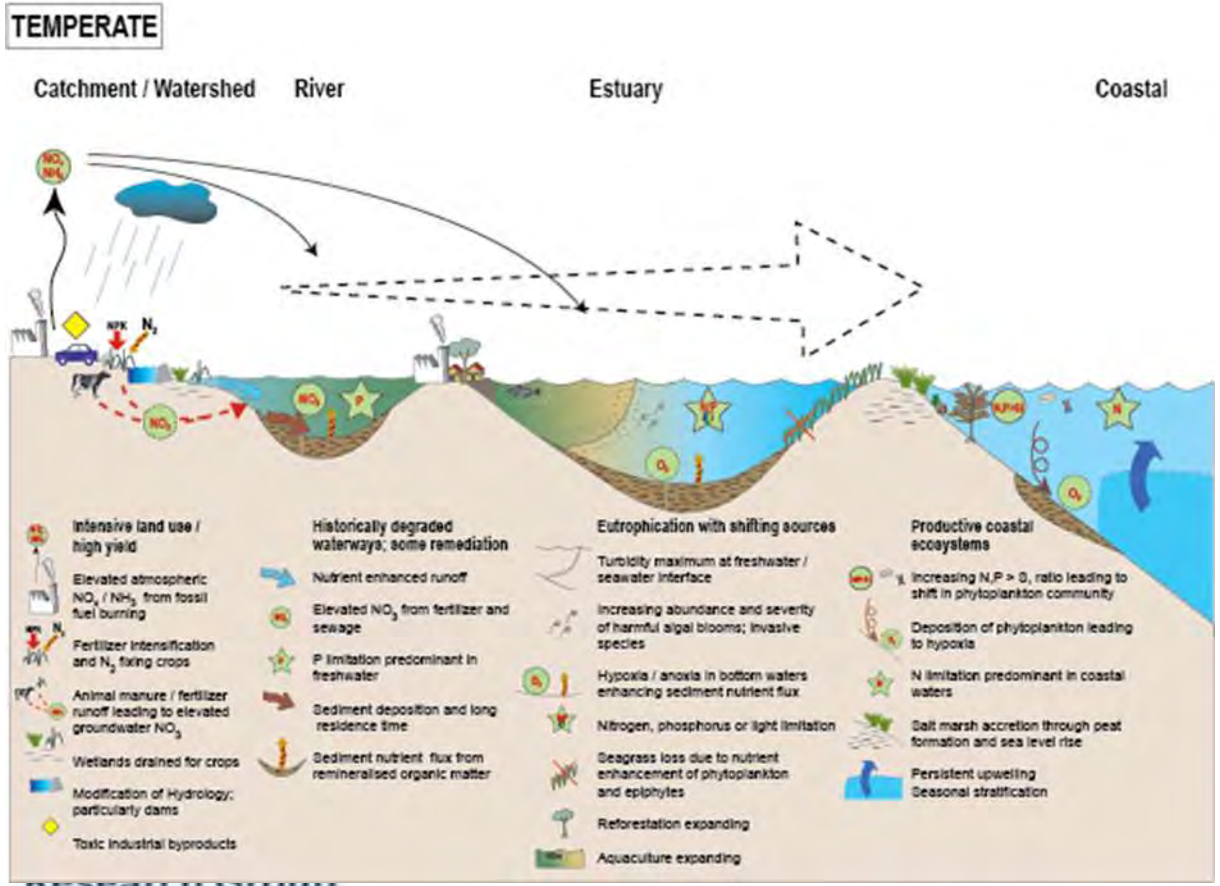
- Systems approach
  - All facets of the system
- Understanding, quantification and mapping of potential ES delivery by a specific ecosystem

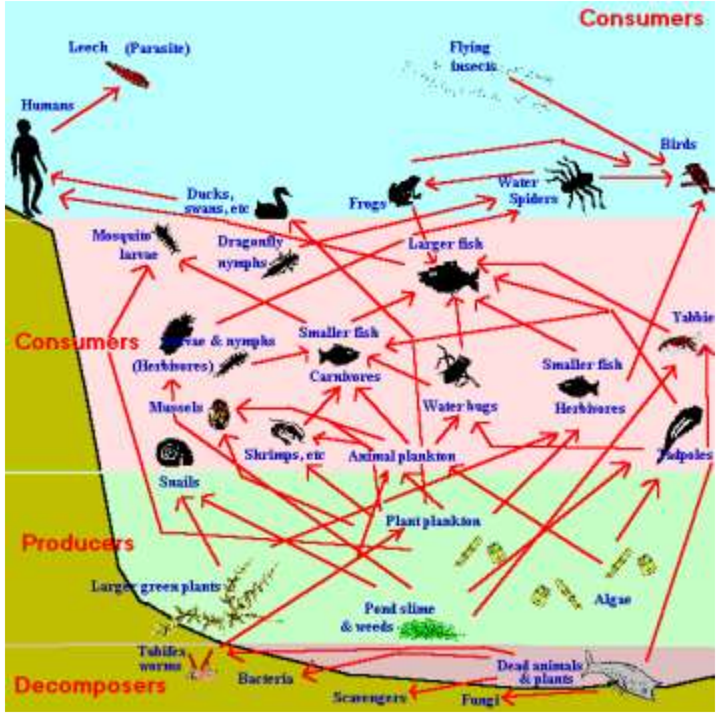


How much are waves attenuated by mangroves/marshes
How much C is sequestered in a forest
………

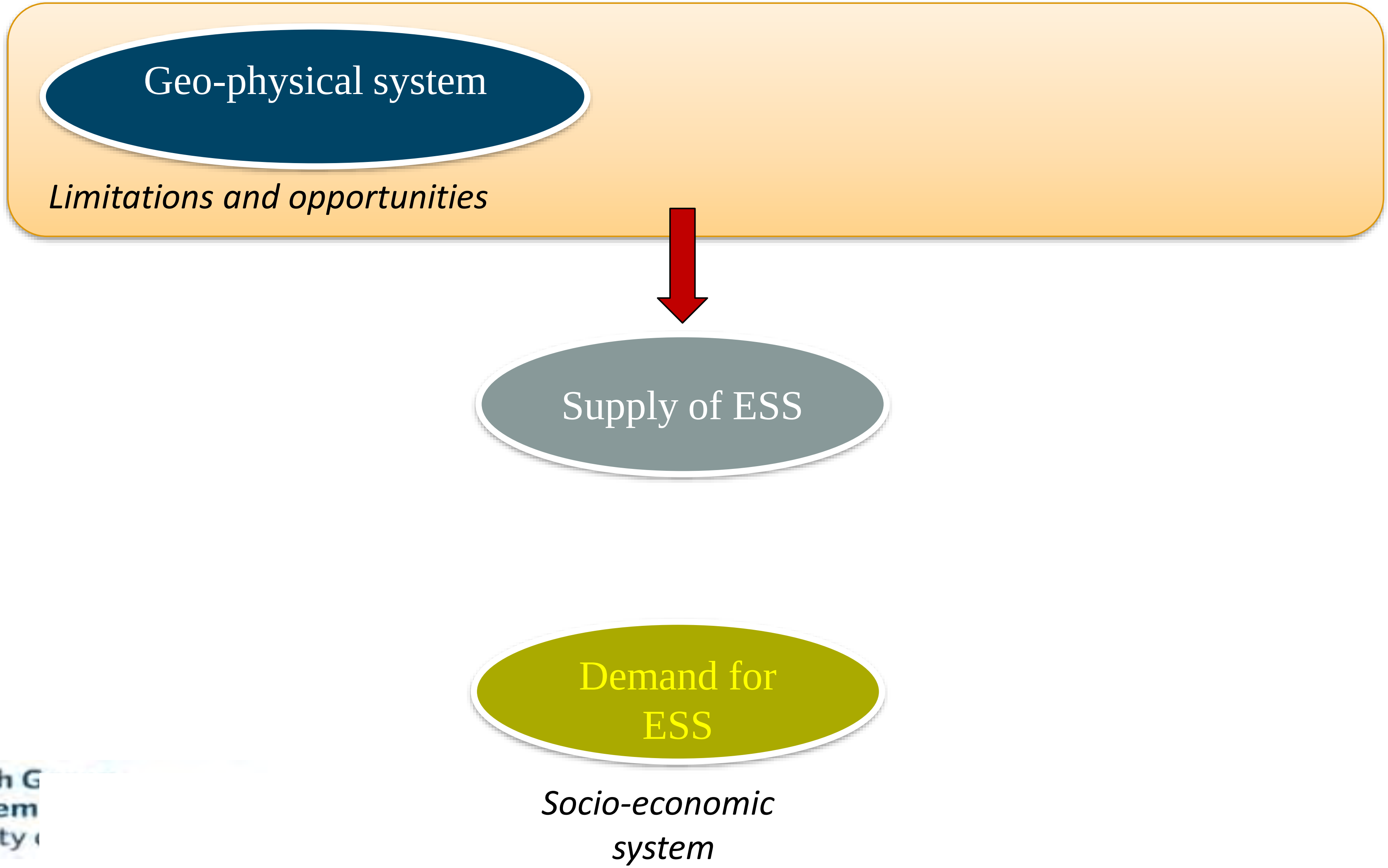
How the ecosystem services are "produced"?

Based on the complex functioning of **ecosystems**





How much of an ES do we need?



Quantification of the demand for ES

The need for ES is very often not obvious as the link between problems experienced by people and the underlying loss of ES delivered by ecosystems causing the problem is very often not understood!

Quantification of the demand for ES

The link between floodings and the loss of:

natural floodplains

infiltration capacity

…….

Is not immedeately obvious and the main reaction is a plea for more engineering works as straigthening or dredging the river, building higher dikes etc., all measures leading again to a loss of ES

Formulating objectives

No longer **only environmental standards** but objectives at the systems level

- Reducing the increase of high waters
- Storing a volume of water
- Reaching a level of cooling
- Reducing an amount of pollutants (nutrients/fine dust,…)
- Guarantee a level of productivity
- Reduce erosion

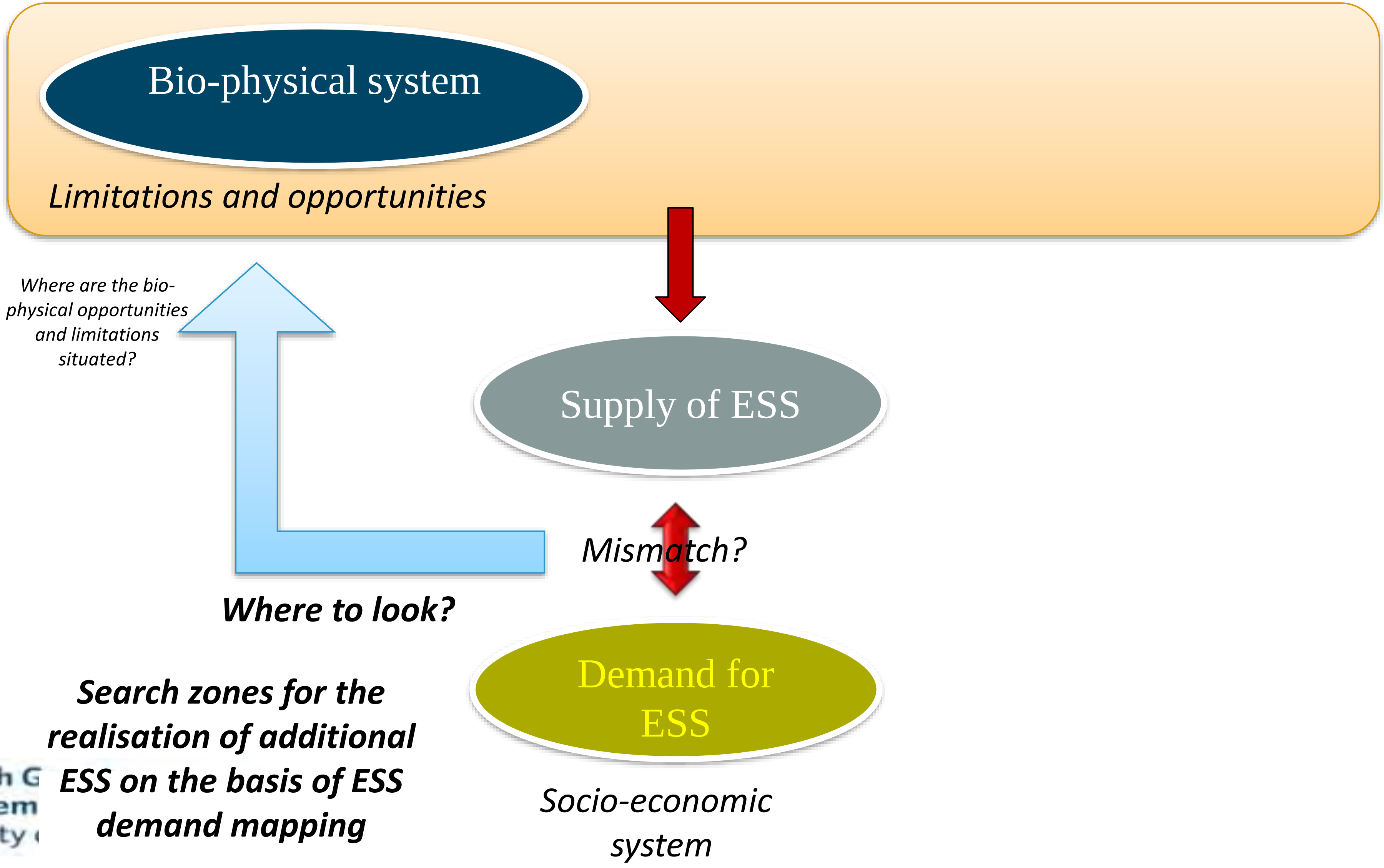
Fundamental change compared to classical environmental policies

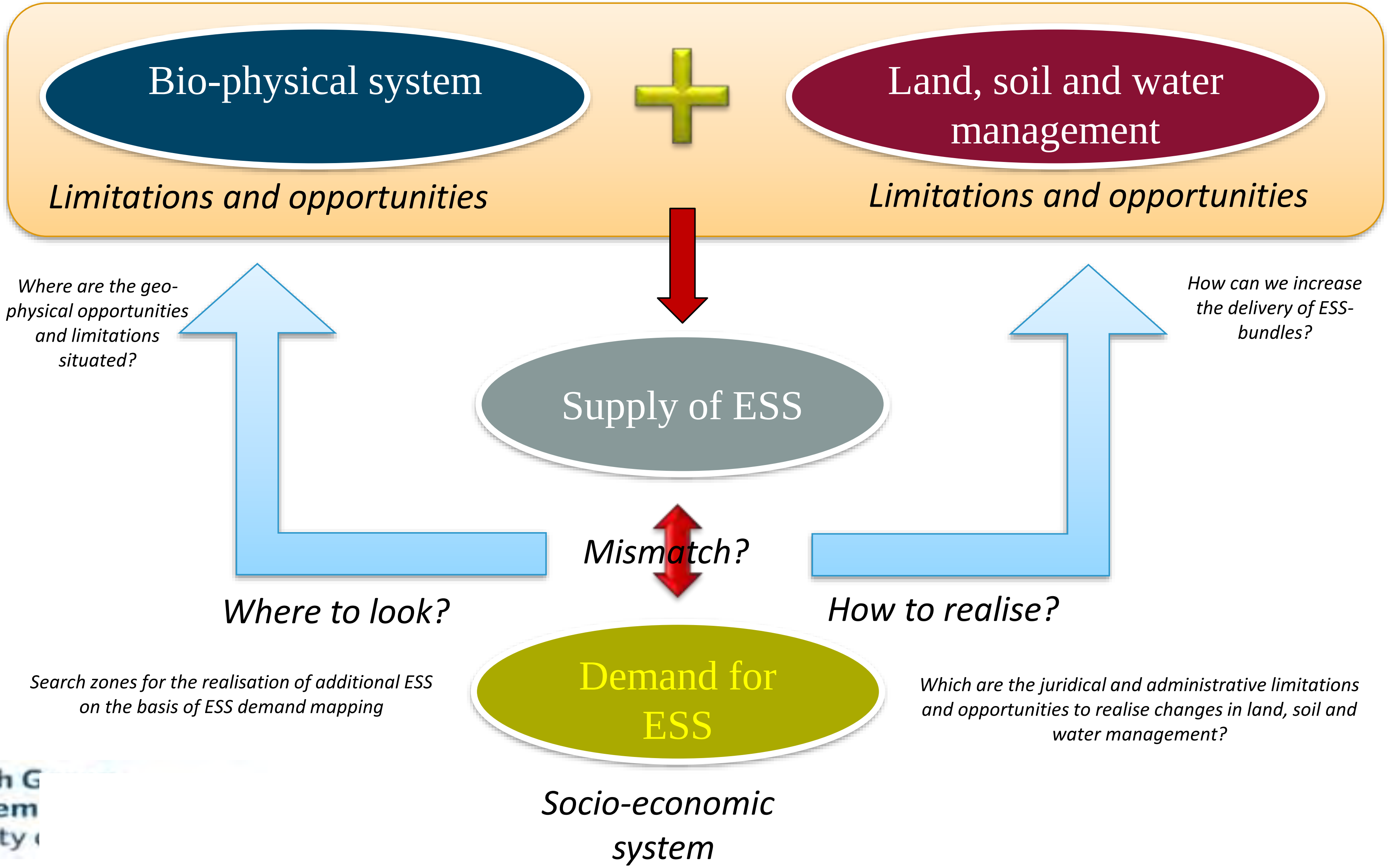
But also

- A given volume of “harvest” (water, wood, food,…)
- Good conditions for navigation
- ….

This must be translated in scenario’s of “hard” and “soft” measures

These scenario’s can be integrated in a societal cost benefit analysis


Bio-physical system
Limitations and opportunities
Where are the bio-physical opportunities and limitations situated?
Supply of ESS
Mismatch?
Where to look?
Demand for ESS
Search zones for the realisation of additional ESS on the basis of ESS demand mapping
Socio-economic system



Bio-physical system
Land, soil and water management
Limitations and opportunities
Limitations and opportunities
Where are the geo-physical opportunities and limitations situated?
How can we increase the delivery of ESS-bundles?
Supply of ESS
Mismatch?
Where to look?
How to realise?
Demand for ESS
Search zones for the realisation of additional ESS on the basis of ESS demand mapping
Which are the juridical and administrative limitations and opportunities to realise changes in land, soil and water management?
Socio-economic system

Key message 1

- The ecosystem delivers a whole series of ecosystem services
  - Habitats and species play a crucial role in delivering these services
- Habitat loss led to a loss of ecosystem services
- A loss of ecosystem services has direct AND indirect societal and economic consequences
- The concept makes the importance of ecosystems towards the human society obvious to a very broad public

Key message 2

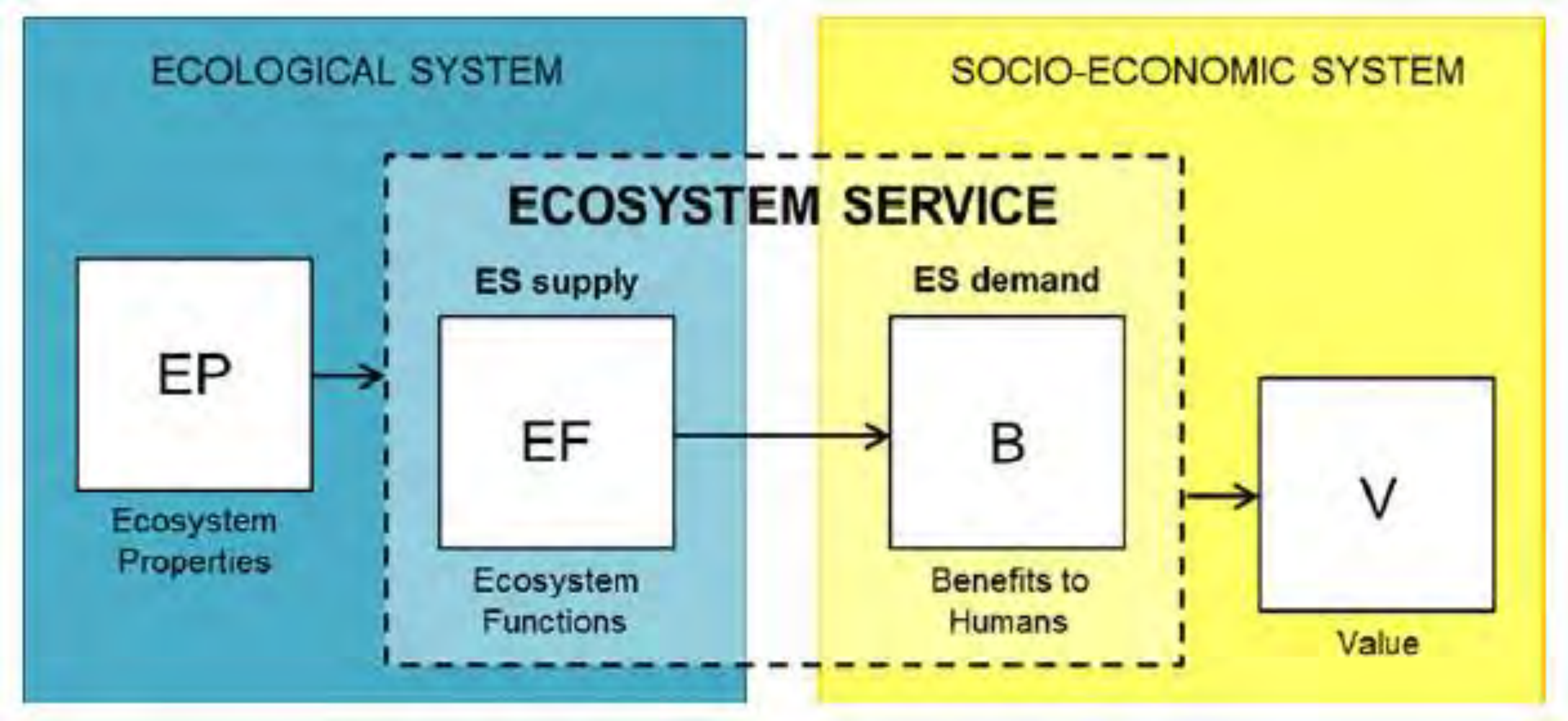
- It is a unifying concept which makes it possible to
  - Make clear to a broader public what are the benefits we get from ecosystems
  - Make a link between ecology and economy as ES can be valued in economic terms

From Theory to Practice

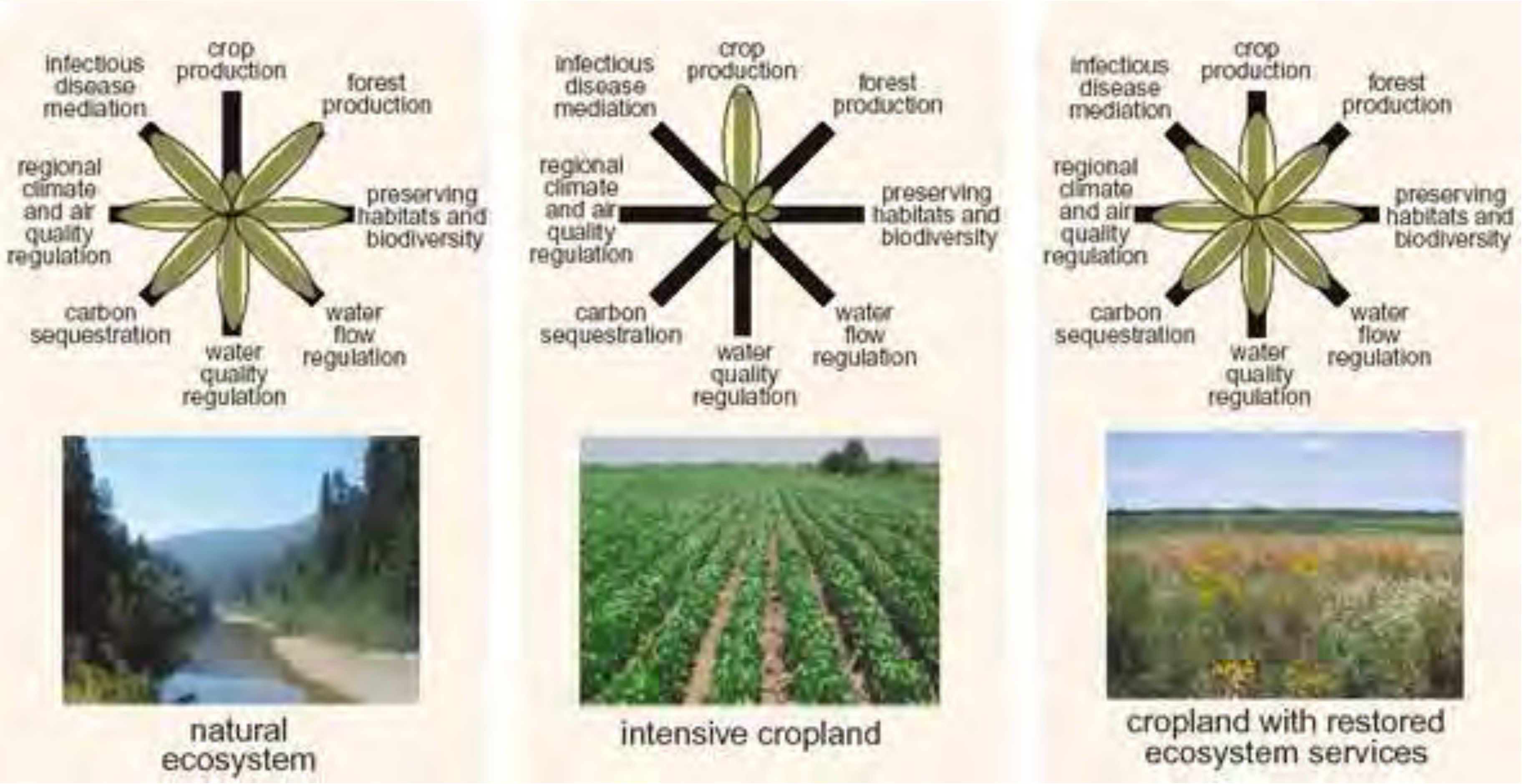
Three cases

- Each case has 4 different options/approaches, each with a different impact on ecosystem services delivered
- Choose one option, most appealing to you based on expertise and passed experience
- Discuss in group the potential impact on ES and why, with the ES cascade in mind

Ecosystem services



Boerema, Rebelo et al. 2016


infectious disease mediation
crop production
forest production
regional climate and air quality regulation
preserving habitats and biodiversity
carbon sequestration
water quality regulation
water flow regulation
natural ecosystem
infectious disease mediation
crop production
forest production
regional climate and air quality regulation
preserving habitats and biodiversity
carbon sequestration
water quality regulation
water flow regulation
intensive cropland
infectious disease mediation
crop production
forest production
regional climate and air quality regulation
preserving habitats and biodiversity
carbon sequestration
water quality regulation
water flow regulation
cropland with restored ecosystem services

	Main service types
	PROVISIONING SERVICES
1	**Food** (e.g. fish, game, fruit)
2	**Water** (e.g. for drinking, irrigation, cooling)
3	**Raw Materials** (e.g. fiber, timber, fuel wood, fodder, fertilizer)
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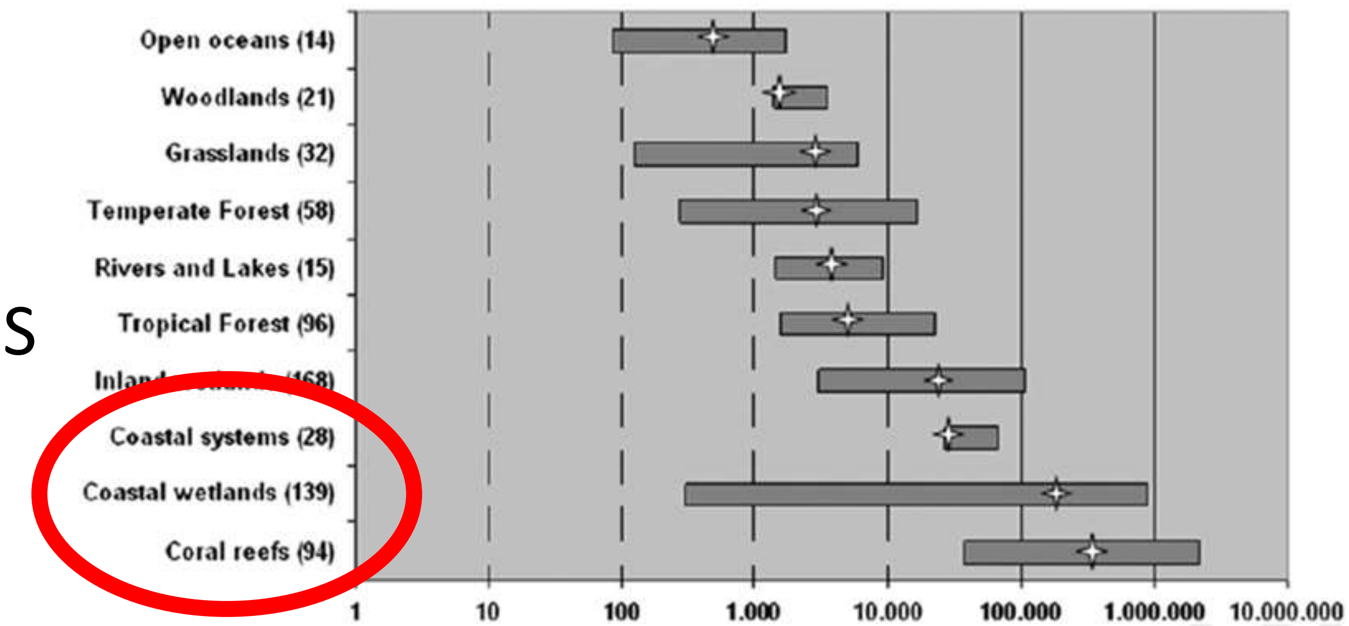
11	**Waste treatment** (especially water purification)
12	**Erosion prevention**
13	**Maintenance of soil fertility** (incl. soil formation)
14	**Pollination**
15	**Biological control** (e.g. seed dispersal, pest and disease control)

	HABITAT SERVICES
16	**Maintenance of life cycles of migratory species** (incl. nursery service)
17	**Maintenance of genetic diversity** (especially in gene pool protection)
	CULTURAL & AMENITY SERVICES
18	**Aesthetic information**
19	**Opportunities for recreation & tourism**
20	**Inspiration for culture, art and design**
21	**Spiritual experience**
22	**Information for cognitive development**

Source: based on/adapted (mainly) from Costanza et al. (1997), De Groot et al. (2002), MA (2005a), Daily, Ehrlich, Mooney, et al. (2008). See Appendix 2 for details.

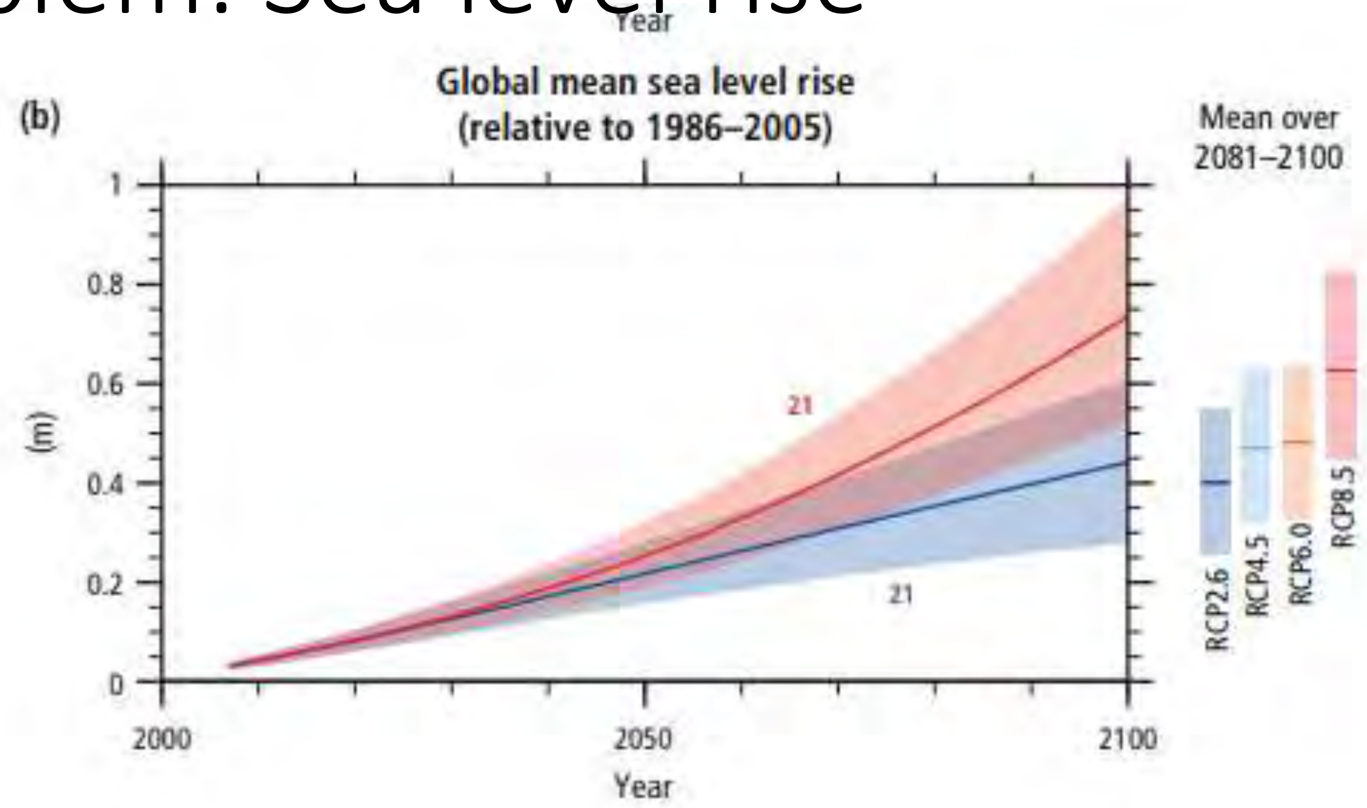
CASE 1: Coastal protection

The coastline



- Provide enormous amount of ES
  - Estuaries
  - Coral reeds
  - Coastline
  - => have the highest values of ecosystem services as compared to other ecosystems
- Large part of the world population lives in close distance to the coast

The problem: Sea level rise



IPCC, 2014: *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

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The problem: coastal development

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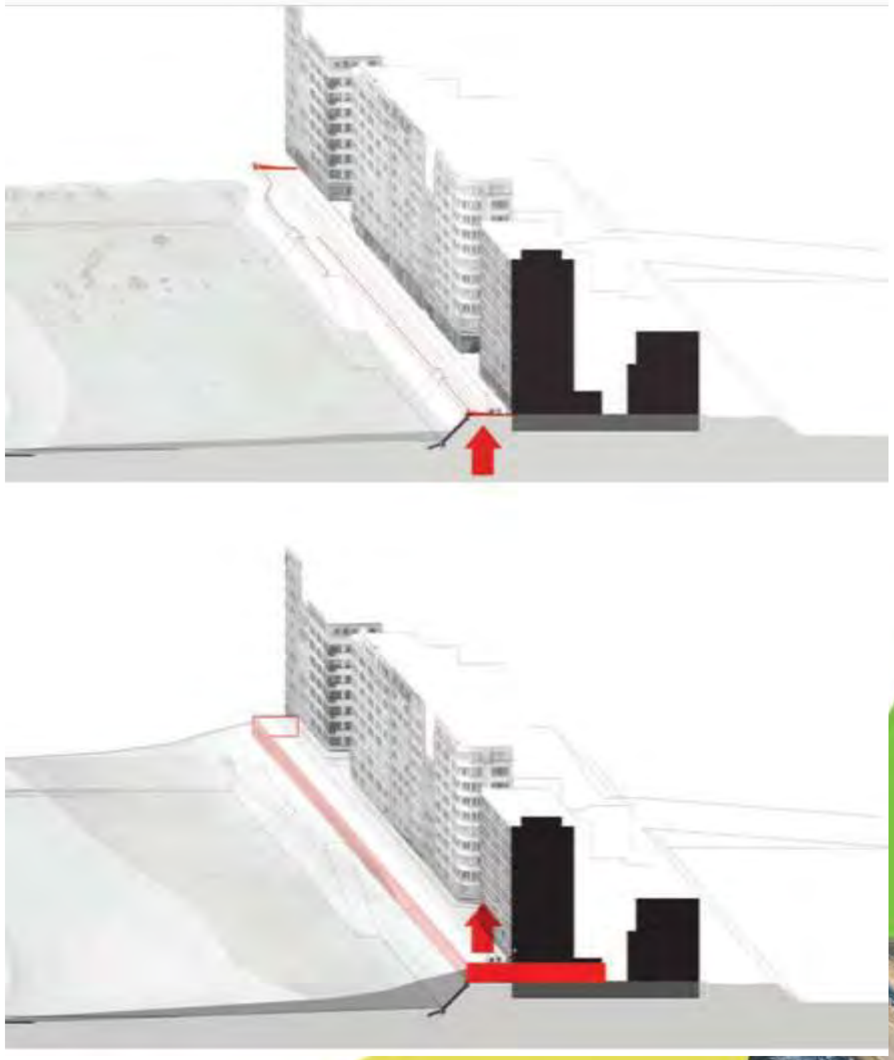
Sea Level Rise

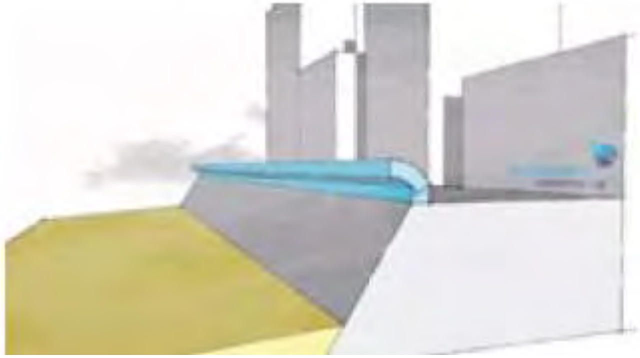
- Coastline protection must take SLR into account
- ➔ HOW?

Gent-aan-Zee

Scenario 1: Hold the line

- Maintain the present coastline by:
- 1) Strengthening present infrastructure





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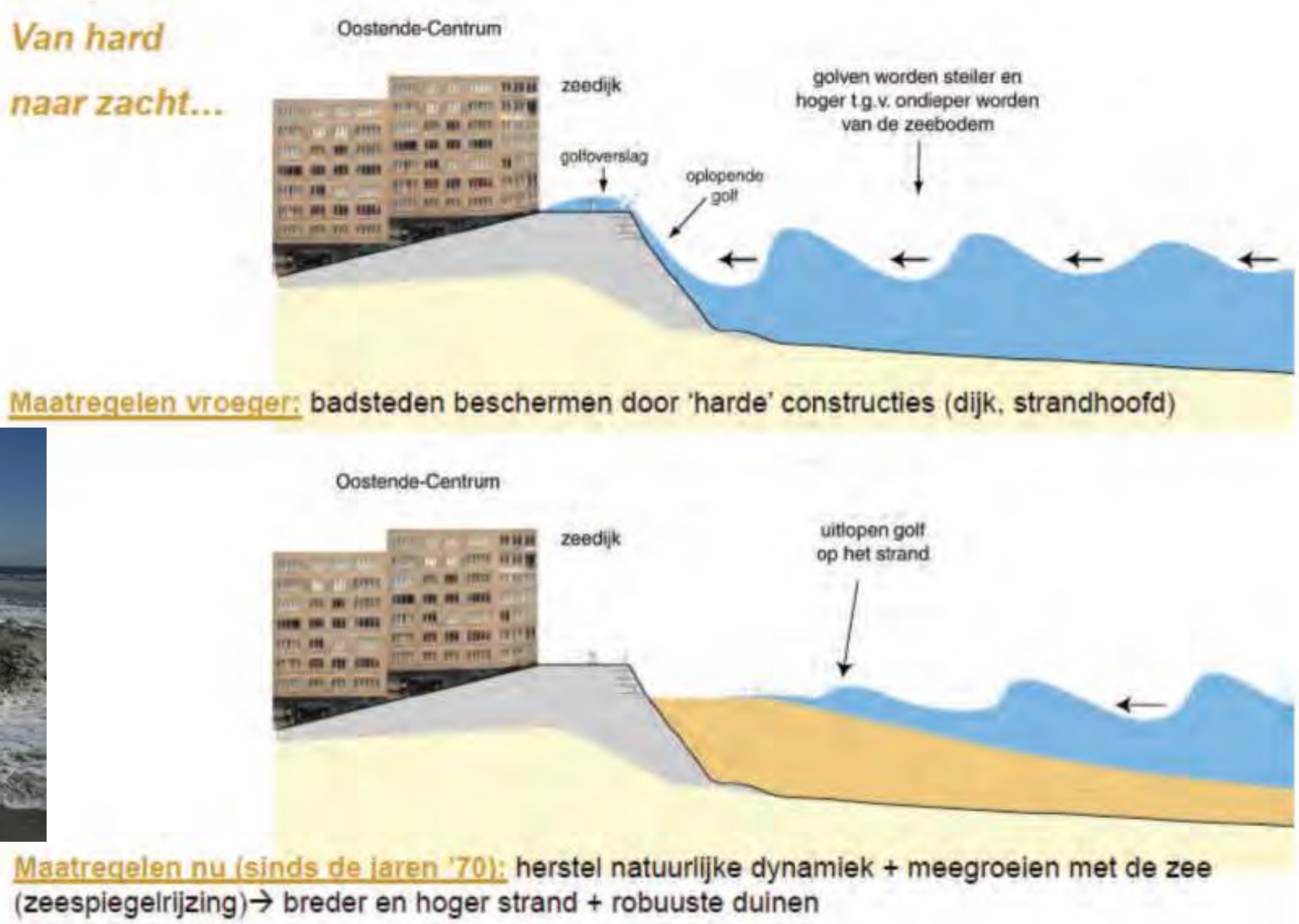
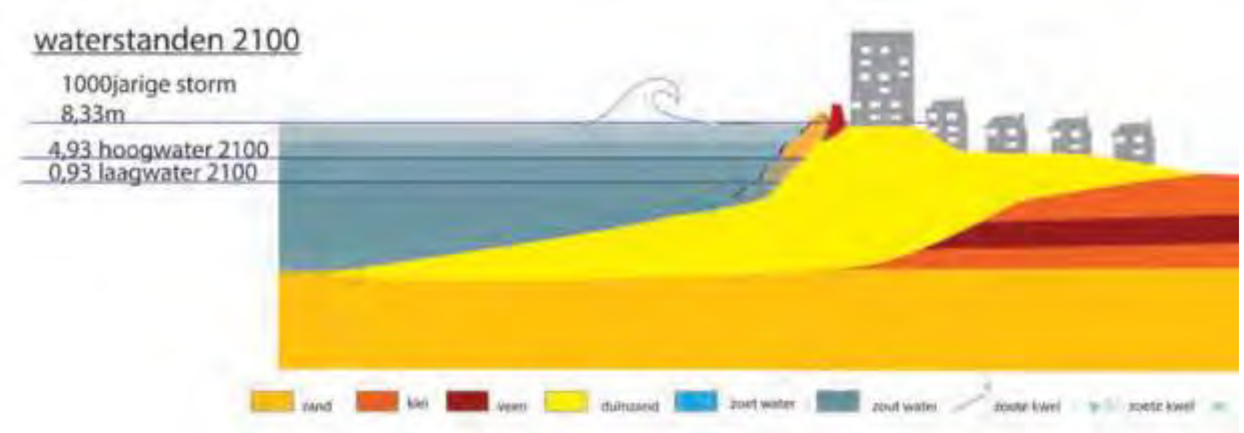
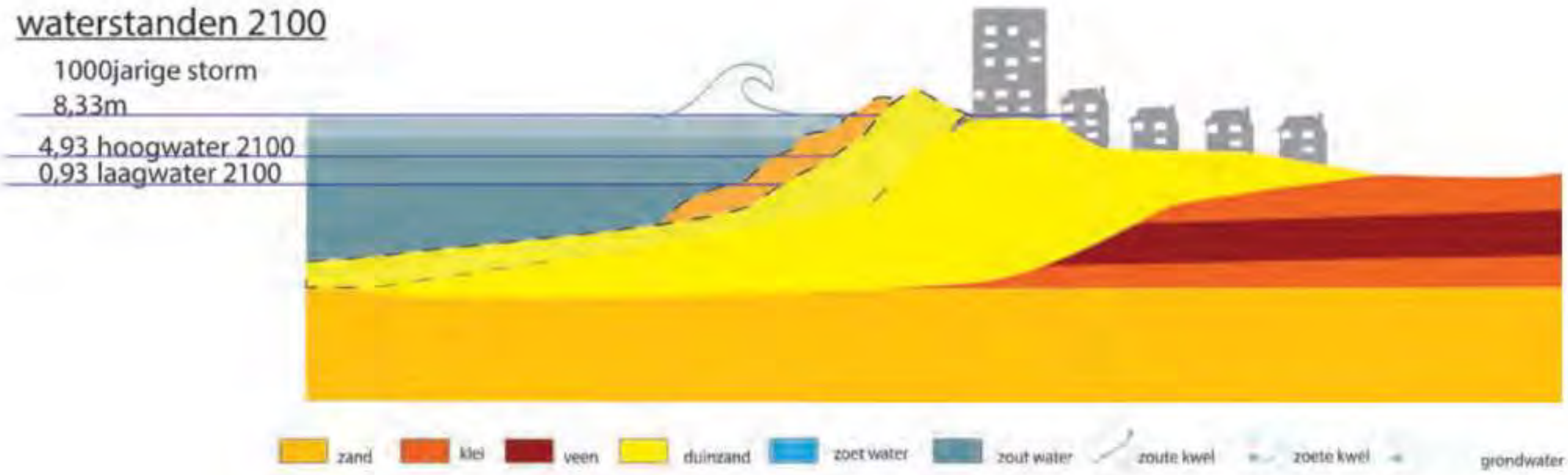
- 2) beach suppletion



Scenario 2: Hold the system





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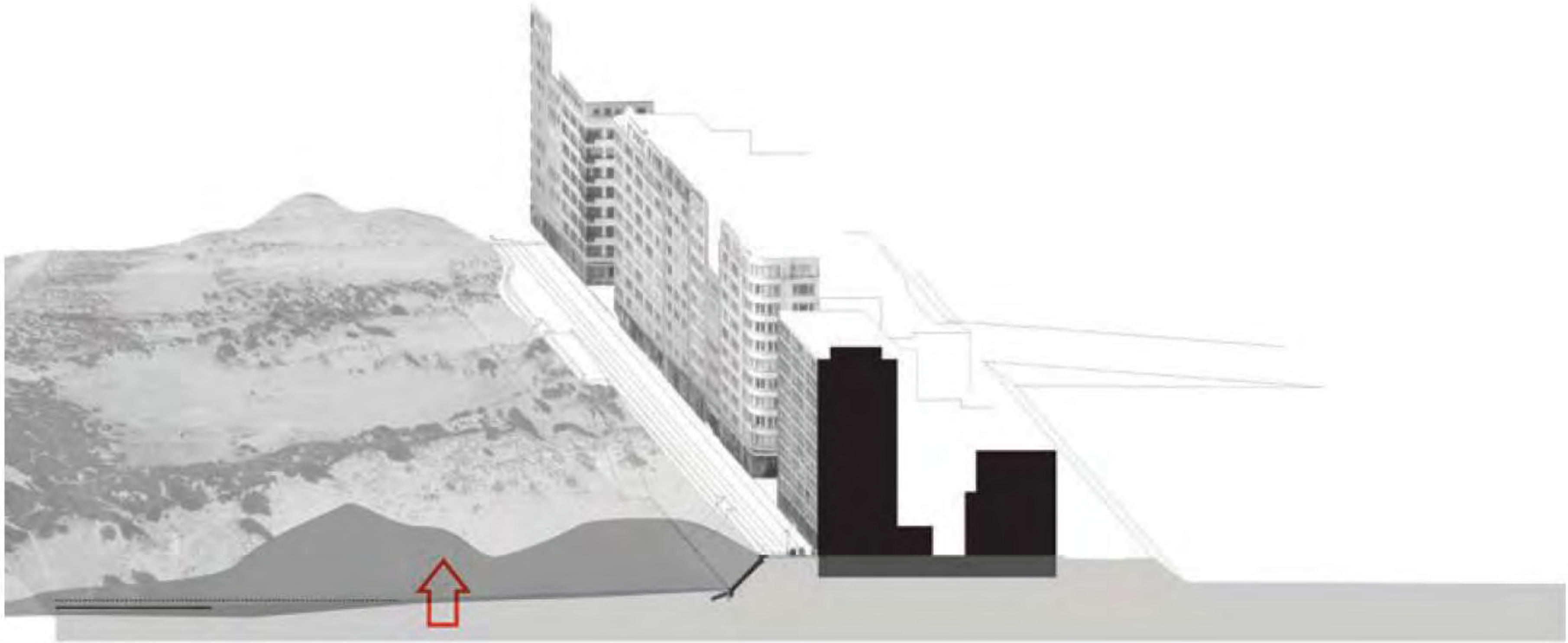
• A much wider impact (kilometers) to restore sand transport, beach and dune formation, with minimal intervention



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Scenario 3: Bring back the islands

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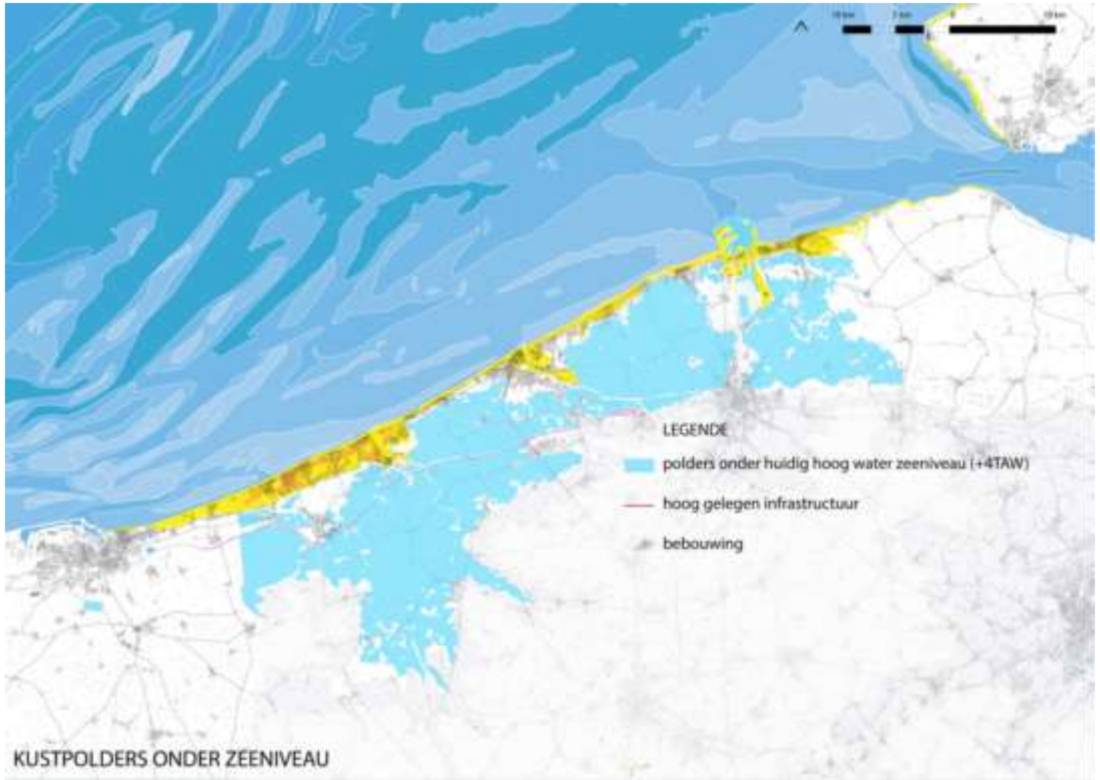
- Create a chain of islands in front
- Of the coast ➔ create low dynamic
- Coast protected from high waves

Figuur 11 - Evoluerende Blauwe Eilanden (Deltares, 2006).

Scenario 4: Partial retreat



- Foto estuarien systeem
- Kaart topogrfaie

Task

- What are the gains and losses of ecosystem services by these 4 options
- In what way do they fullfil demands for ES, on top of coastal protection

Summary

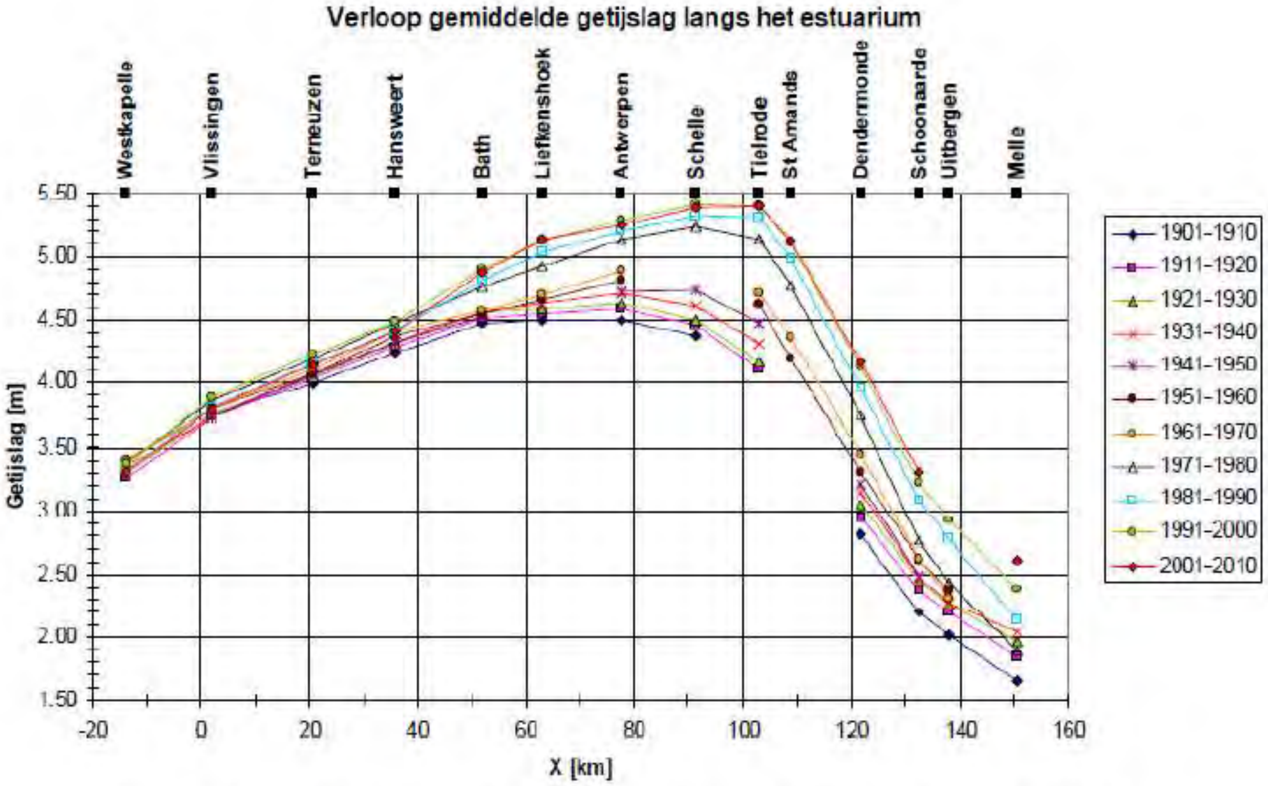
- 1) Hold the line
- 2) Hold the system
- 3) Bring back the islands
- 4) Partial retreat

Case 2: Sea level rive in an estuarine environment

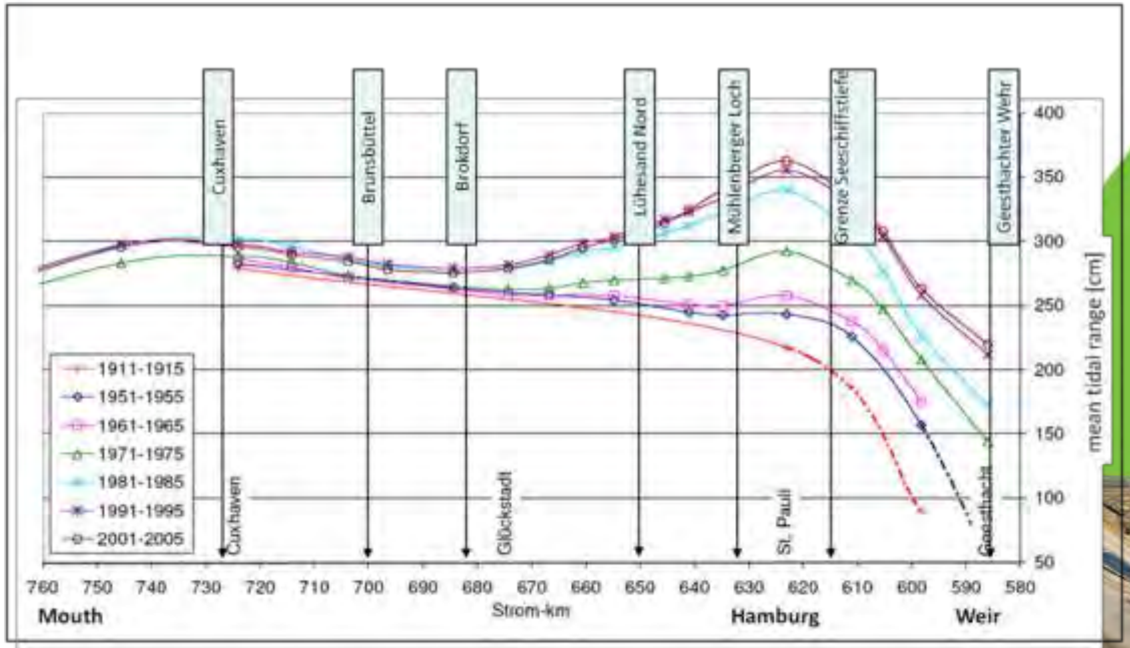
- The Schelde estuary

as a case

Tidal amplitude along the estuary



Figuur 4-23: 10-jarig gemiddelde getijslag voor opeenvolgende decaden tussen 1901 en 2010 (K. Kuijper, 2012).



The problem: Increaing flood risk

Central Dredging Association

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Habitat loss due to increased dynamics

- Hier

Scenario 1: Storm surge barrier/dam

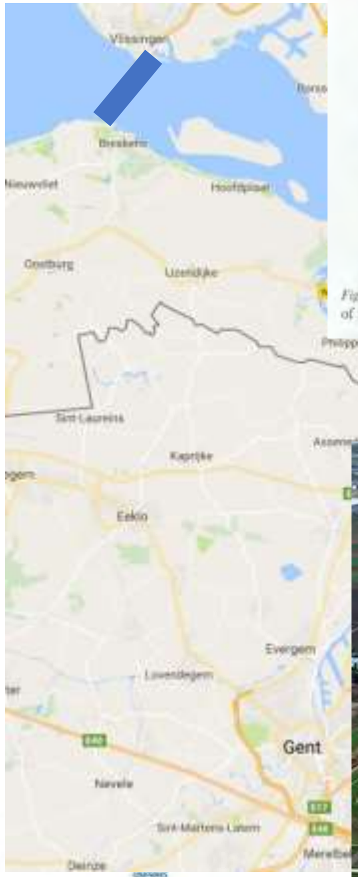
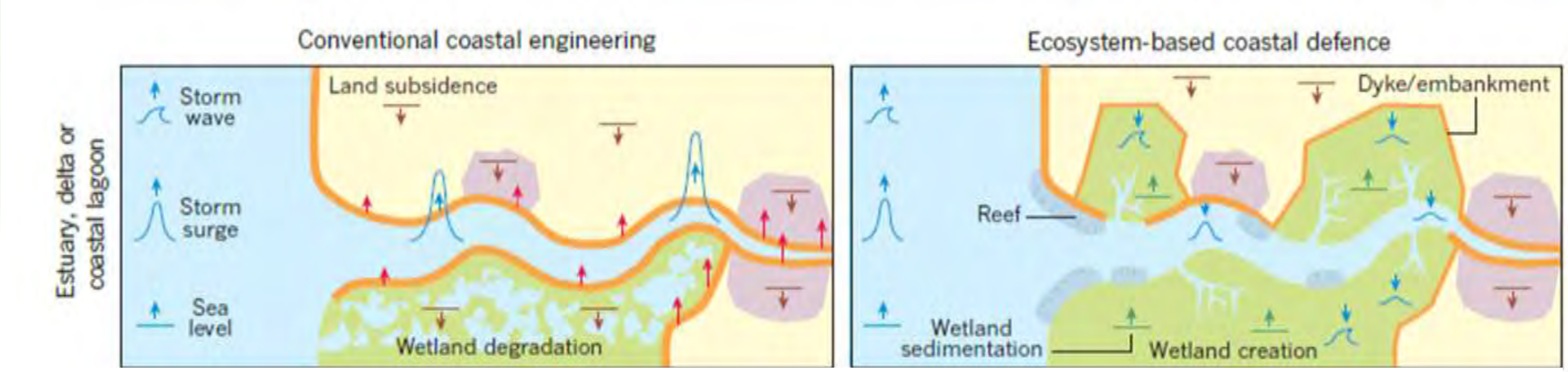
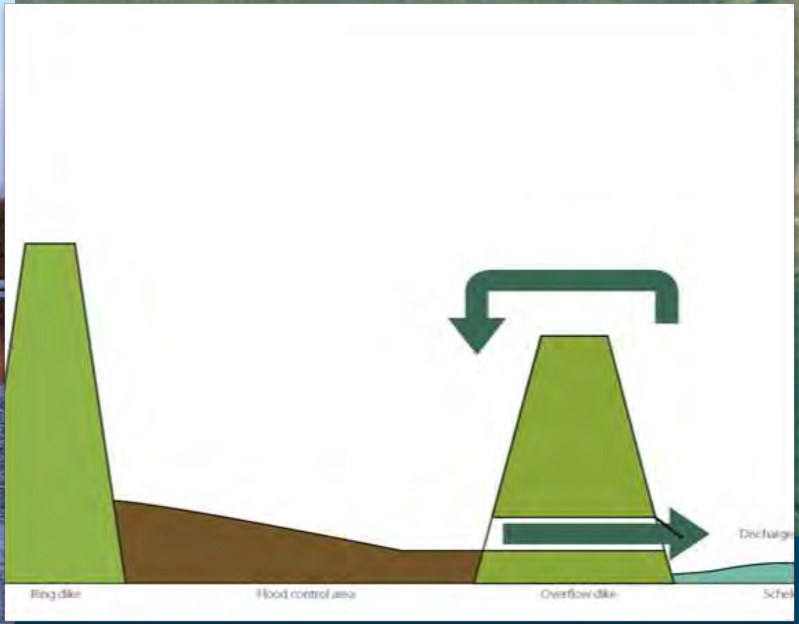


Fig. 8. The storm-surge barrier in open position. The steel gates in between the piers can be raised and lowered, but f
of the time they will be suspended above the waves. Photograph NIOO-CEMO, Yerseke.

Scenario 2: Managed retreat



Scenario 3: Flood control with reduced tides



FCA –CRT Bergenmeersen

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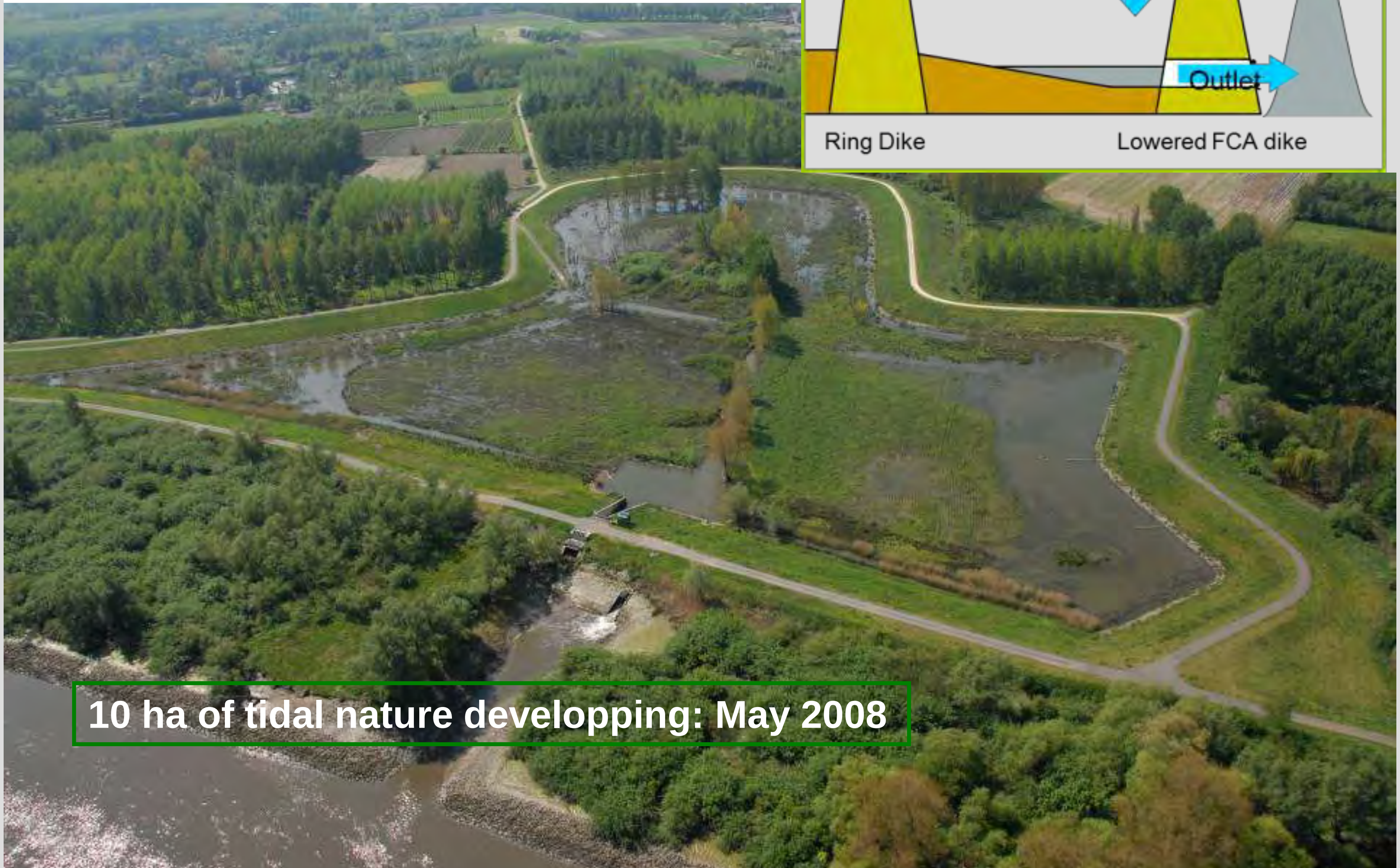
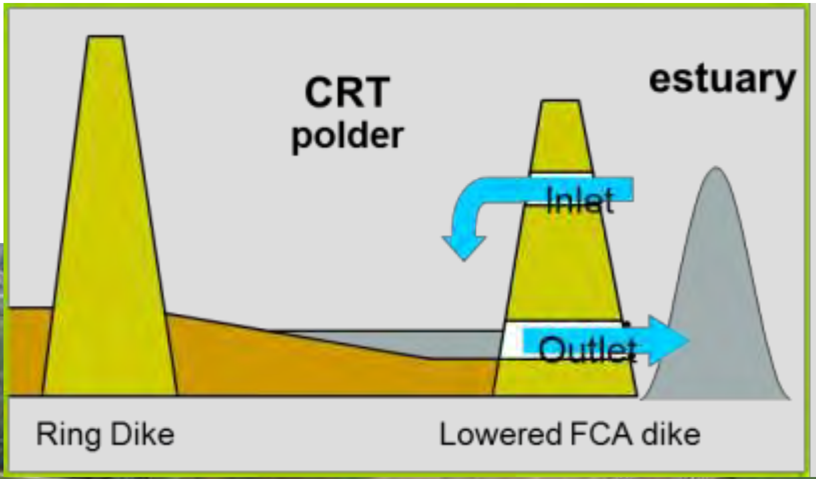
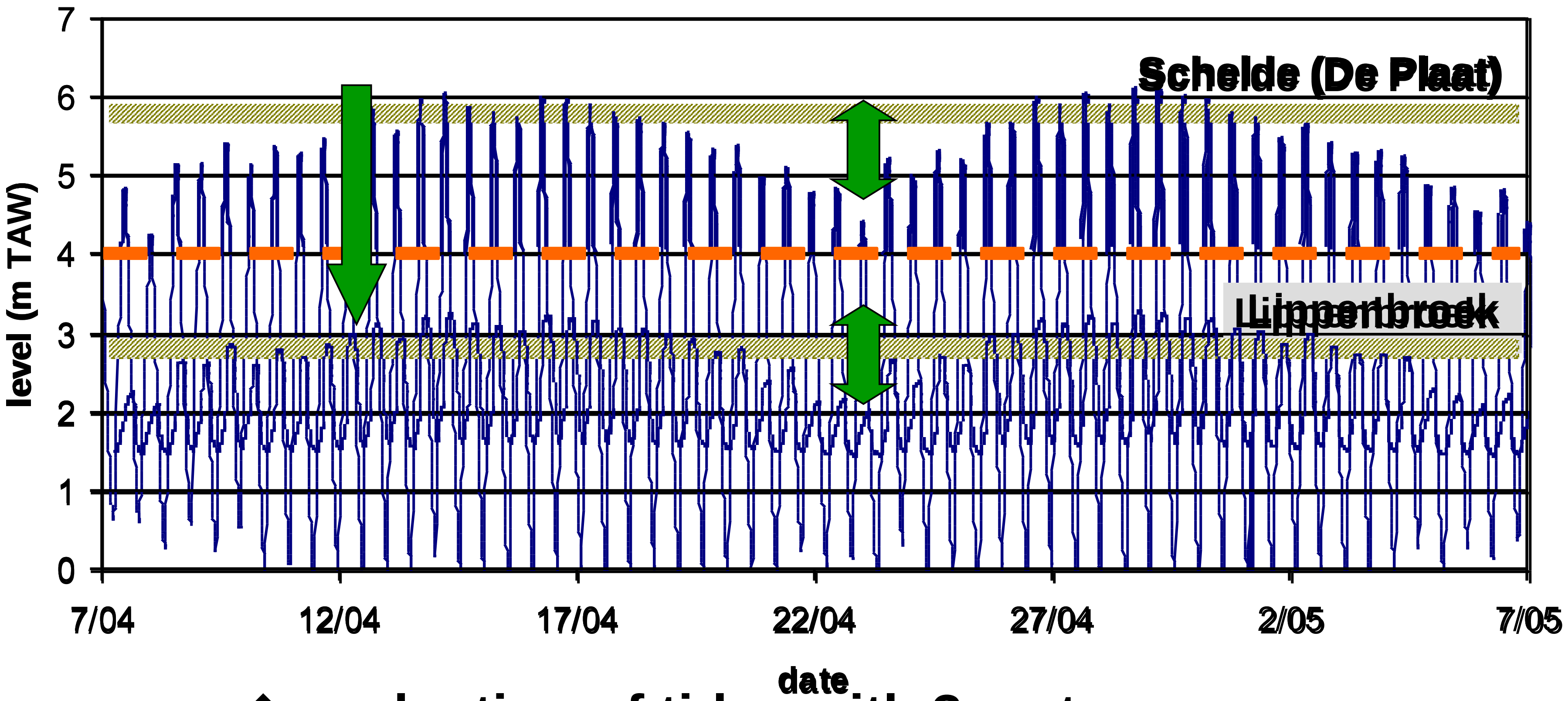
Pilot project Lippenbroek





10 ha of tidal nature developping: May 2008

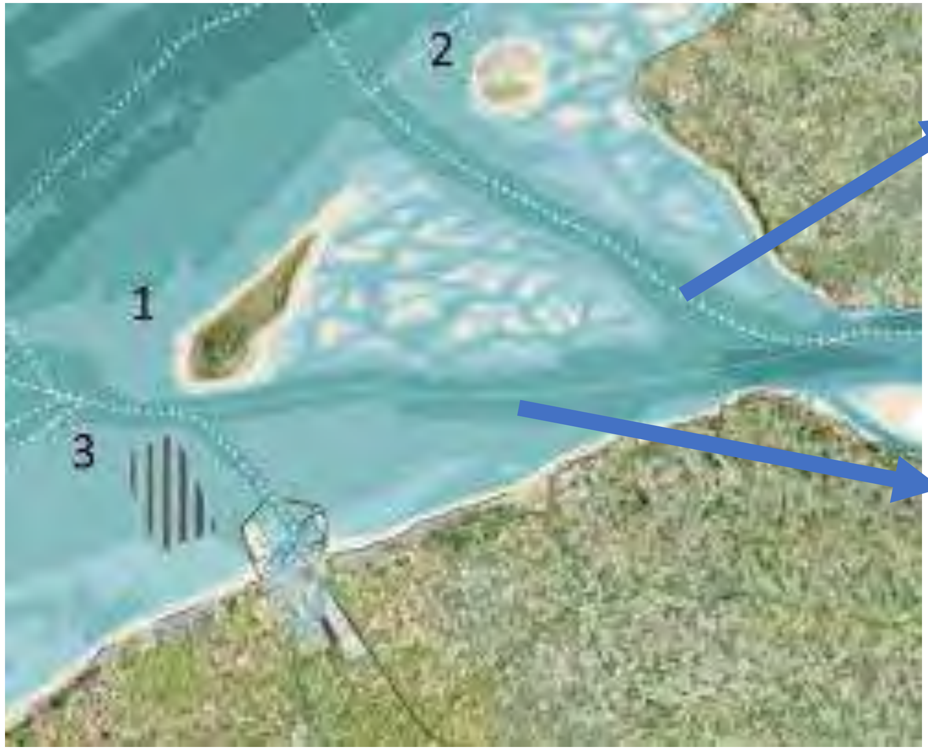
Results: tidal range



- reduction of tides with 3 meter
- No reduction of spring-neap tide variation

Bergenmeersen

Scenario 4: reducing cross section in the mouth area



Fairway

Inland and “estuary” ships

Summary

- 1) Storm surge barrier and lock
- 2) Flood control areas and reduced tides
- 3) Managed retreat
- 4) Reducing cross section in the mouth

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