Scaling up nature based-solutions for climate change adaptation and mitigation

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What are nature-based solutions (NbS)?

Working towards resilience and sustainability

Haywood (2016)

Use of the “nature-based solution” term

Sandin et al. (2022)

NbS is an umbrella concept

NbS may include both climate adaptation and mitigation

NbS-related concepts	Ecosystem-based Adaptation	Ecological Engineering	Ecosystem-based Mitigation
Forest Landscape Restoration	Ecosystem-based Disaster Risk Reduction	Green Infrastructure	Climate Adaptation Services
Natural Infrastructure	Area-based Conservation	Ecosystem-based Management	Ecological Restoration

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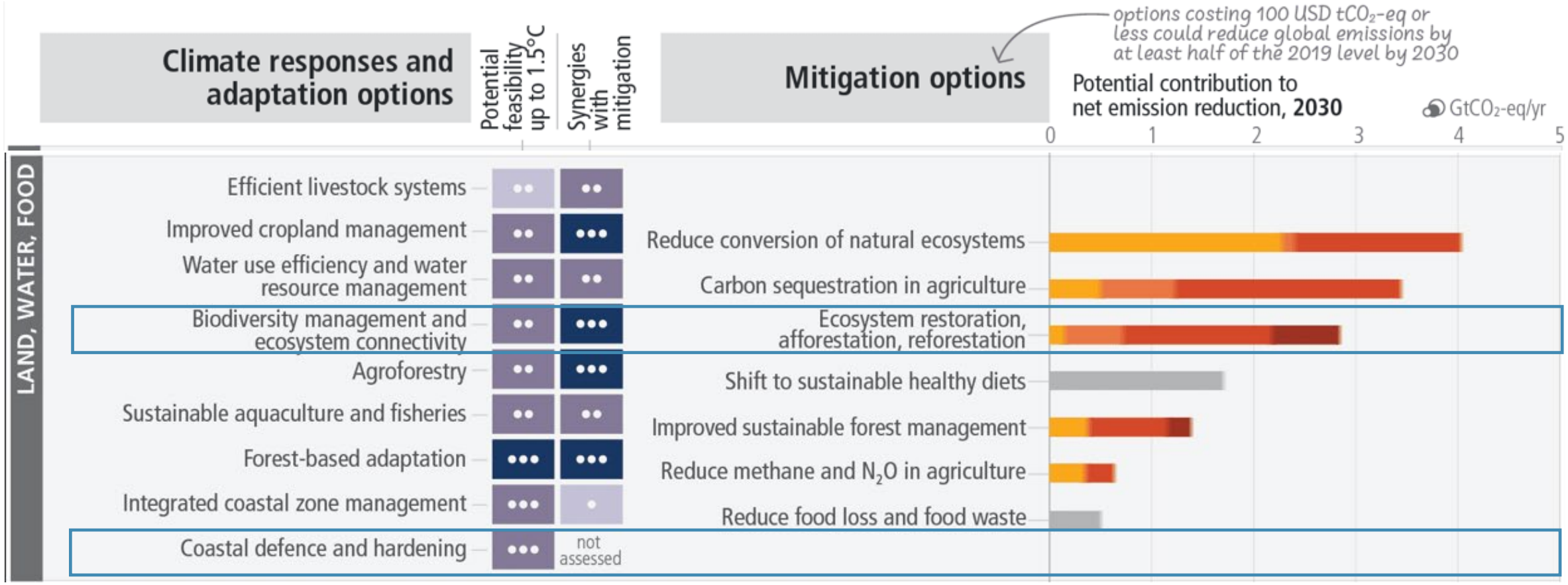
Interactions between adaptation and mitigation



IPCC (2023)

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Is Denmark embracing NbS?
Is scaling up possible?

- Government has not adopted NbS in the legislation, policies or strategies
- NbS term is used by Ministry of Environment (restoration, rewetting of organic rich low-lying land)
- Municipalities have a larger role, since they have adopted policies including NbS (Vejle's storm strategy, and Odense aims to include NbS to their climate action plan)
- Examples of empirical evidence enforce upscaling; however, it should be supported by economic systems, policy frameworks and cultural aspects.

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Sandin et al. (2022)

Examples of NbS in Denmark

Gyldensteen Strand

Source: Viggo Lind

Seden Strand

Source: Odense Municipality

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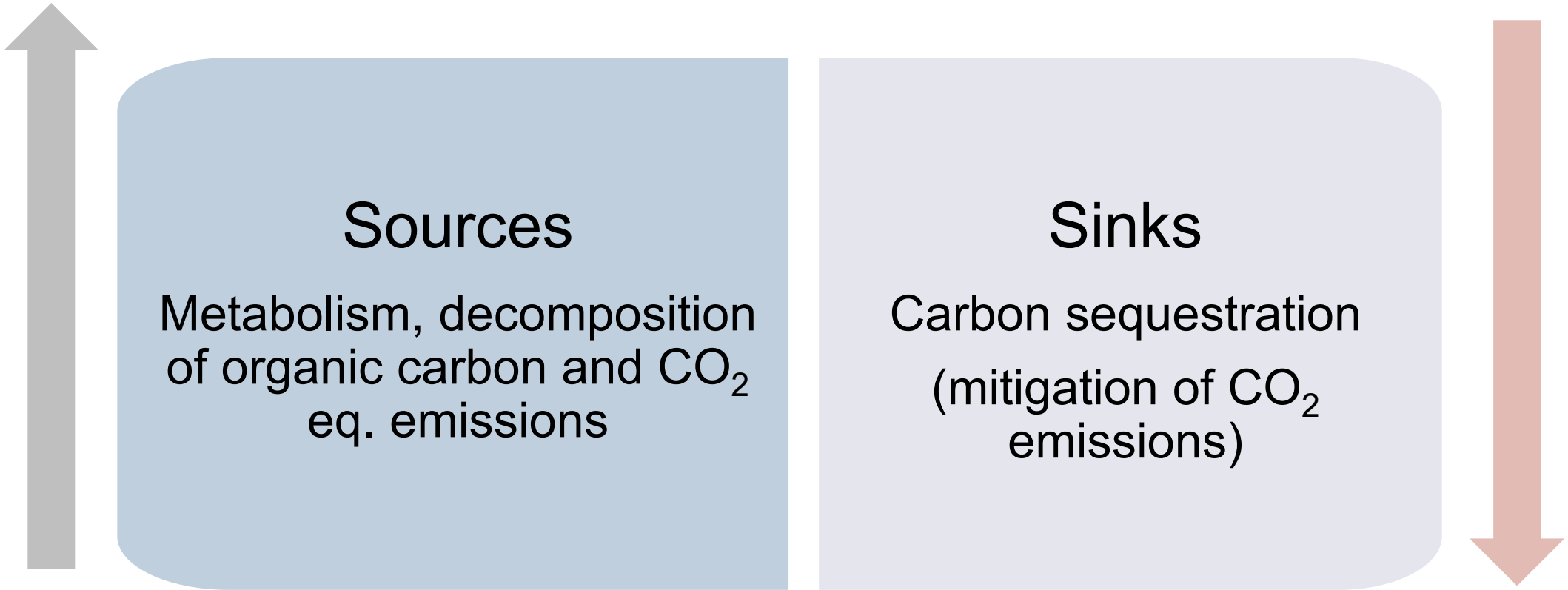
Climate **mitigation** of restored coastal areas as NbS

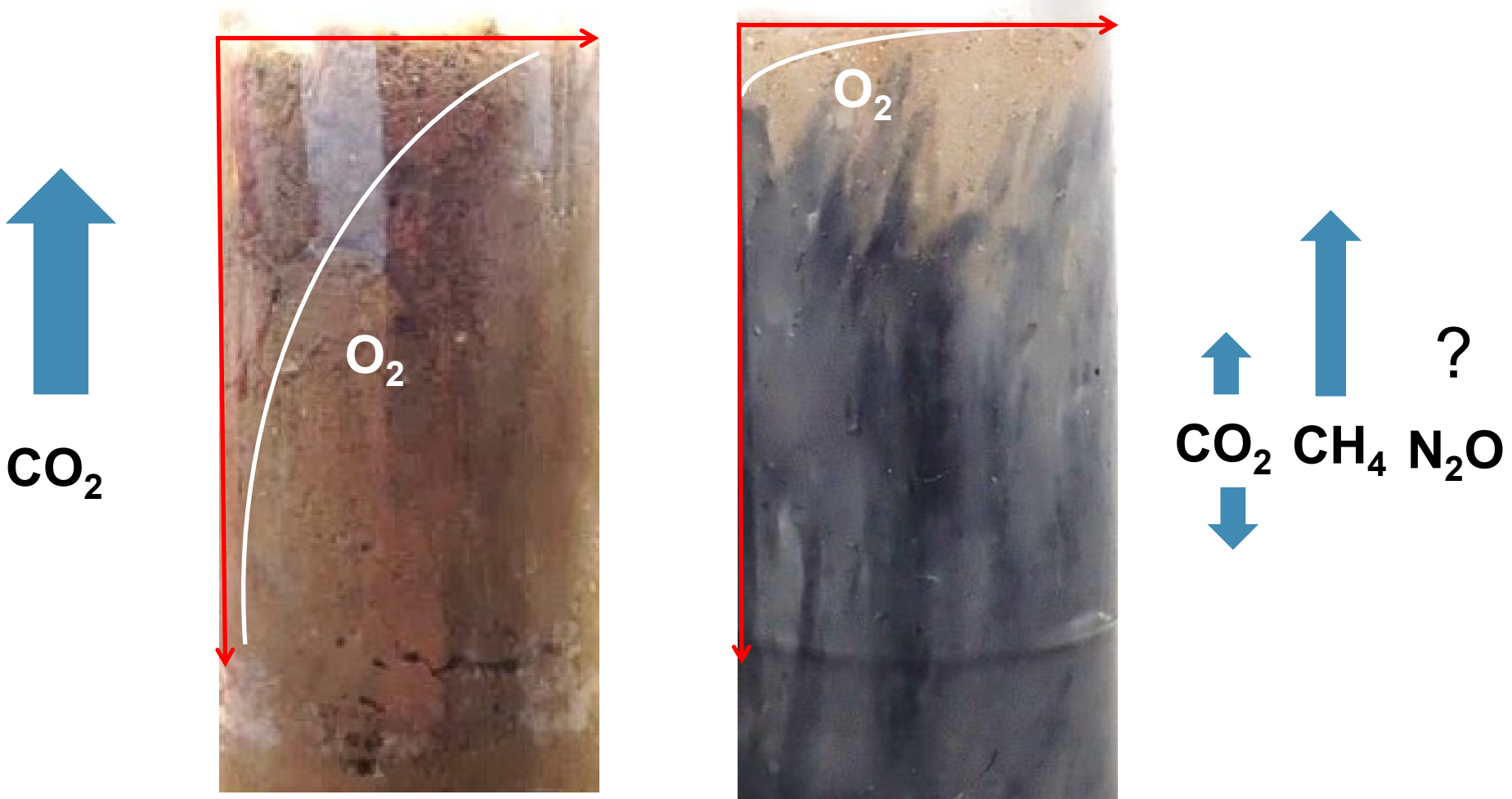


The carbon cycle and climate effect – the role of water

Soil cores

Agricultural fields

Wetlands < 10 salinity



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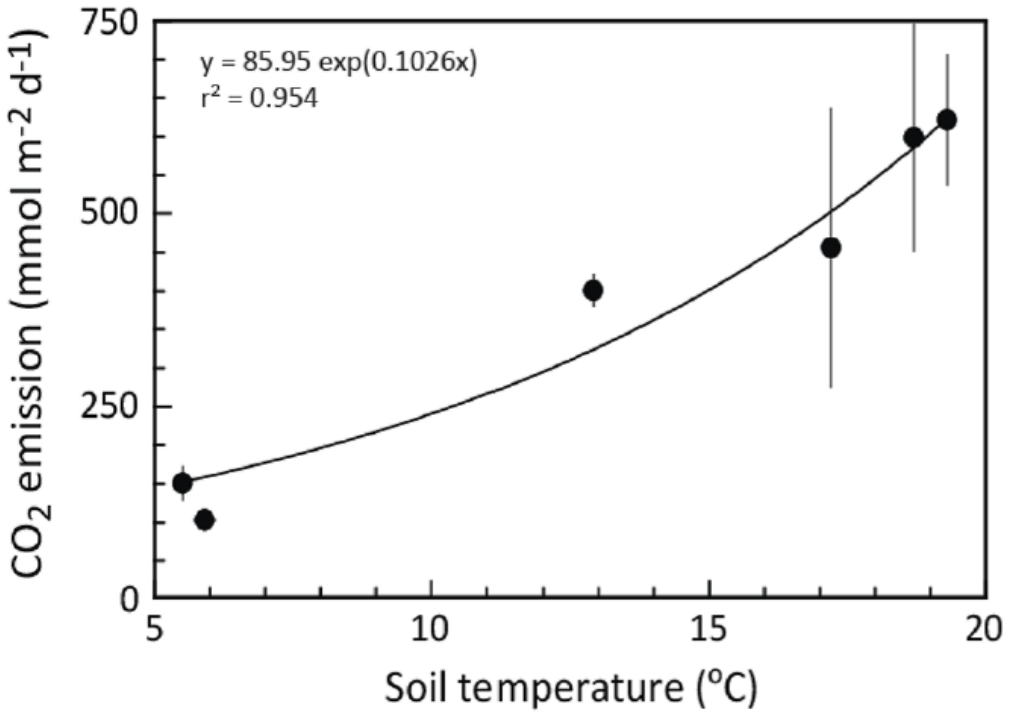
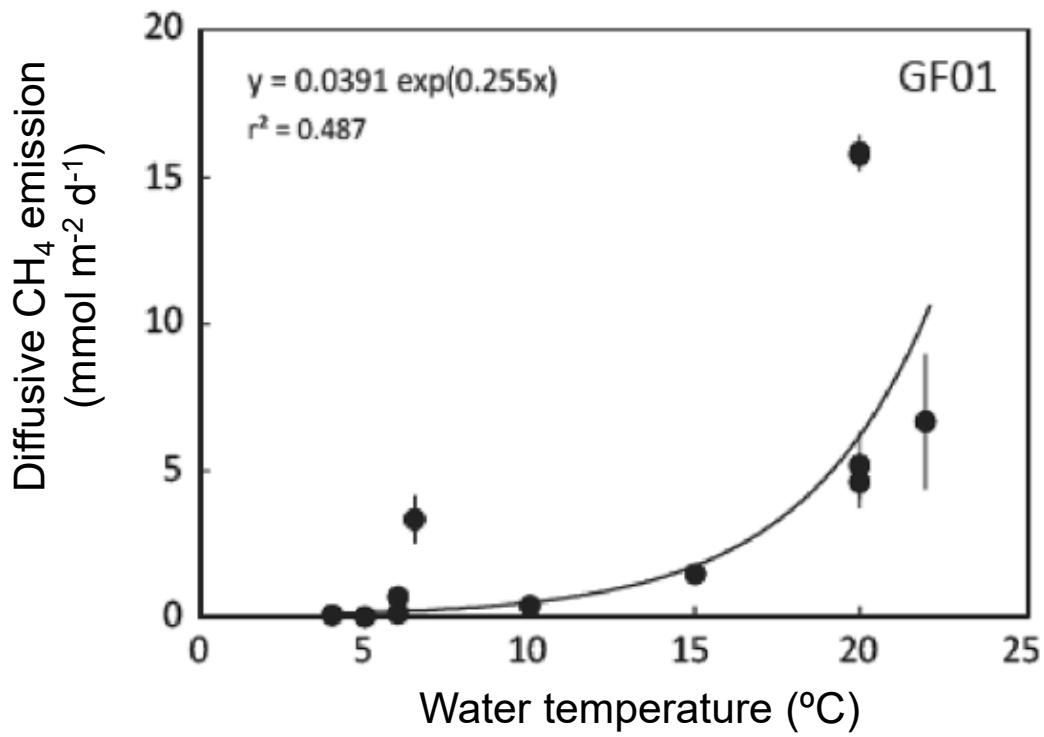
GHG are largely controlled by temperature

CO_2



CH_4



Petersen et al. (2023)

Why do we need to study carbon fluxes in NbS?

- ✓Understand environmental conditions regulating GHG emissions and C sequestration
- ✓Refine estimates of C sources and sinks and build predictive models
- ✓Refine C budget and climate mitigation potential of coastal vegetated ecosystems as NbS

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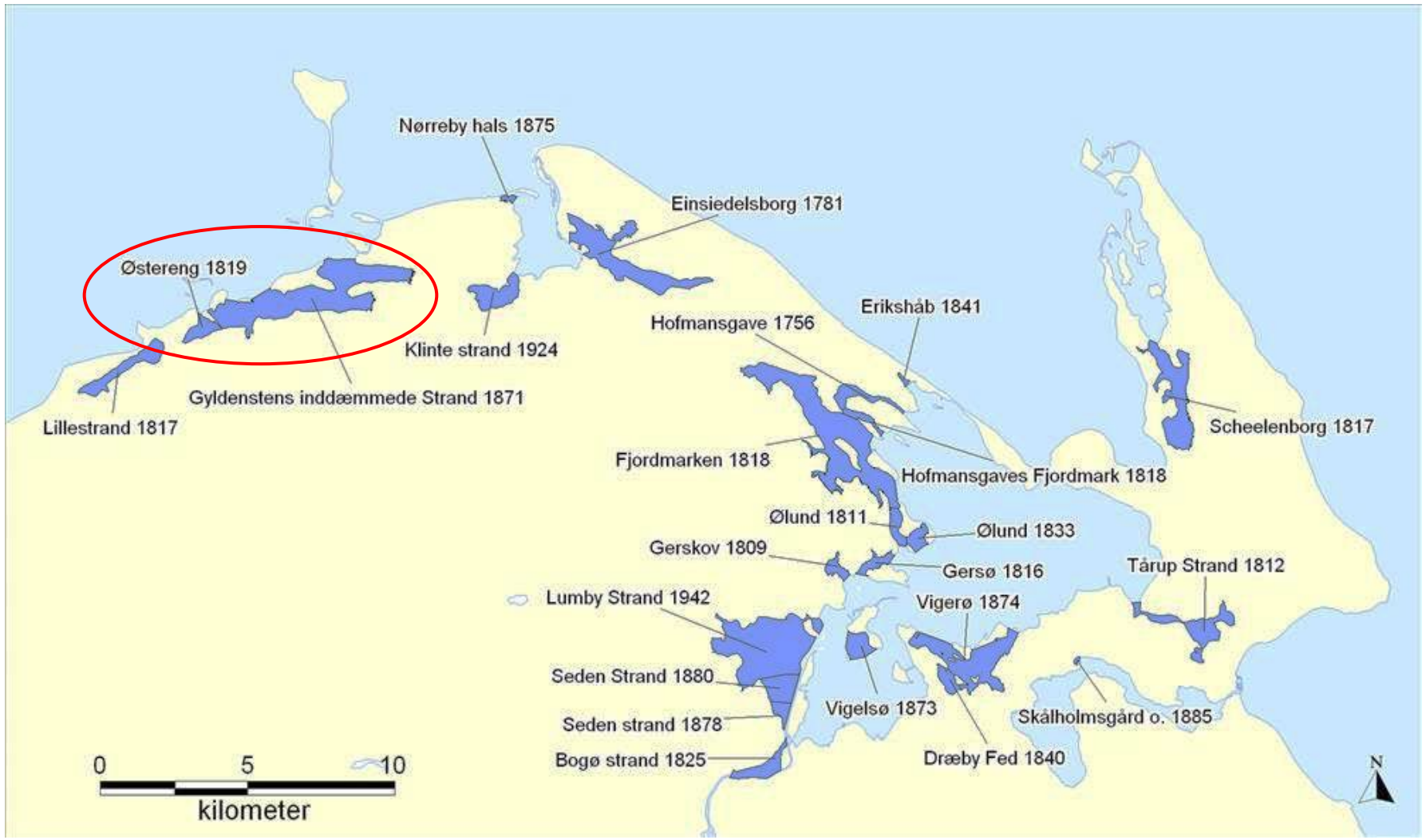
Land reclamations in Fyn



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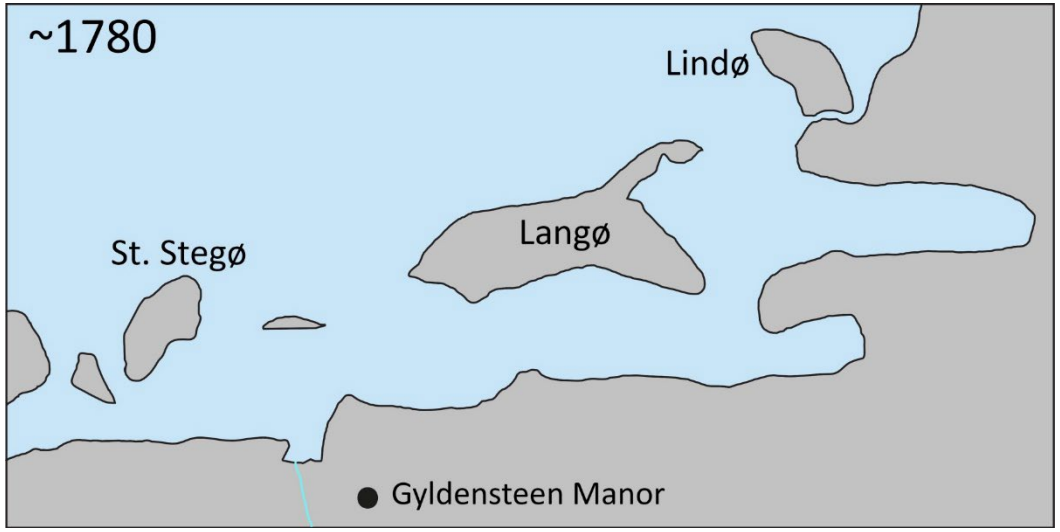
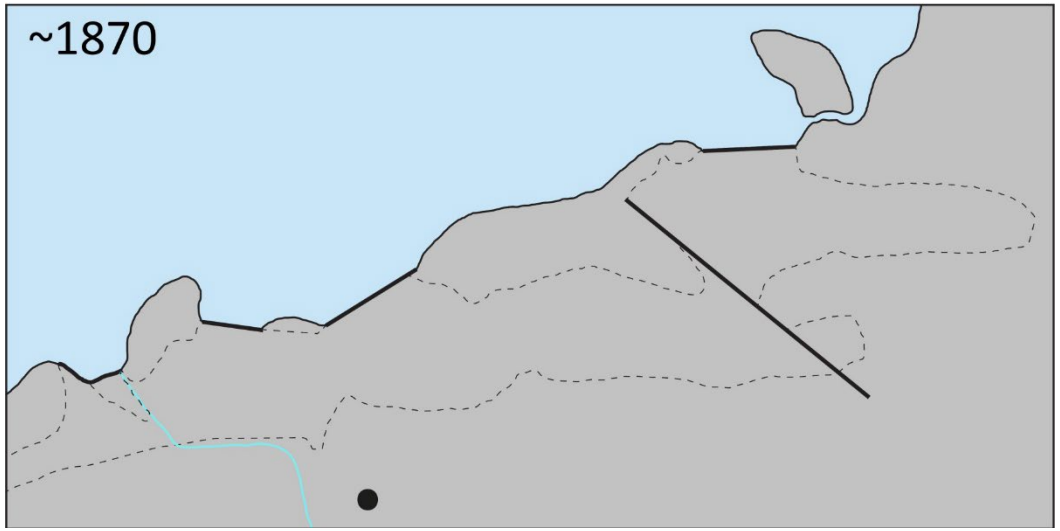
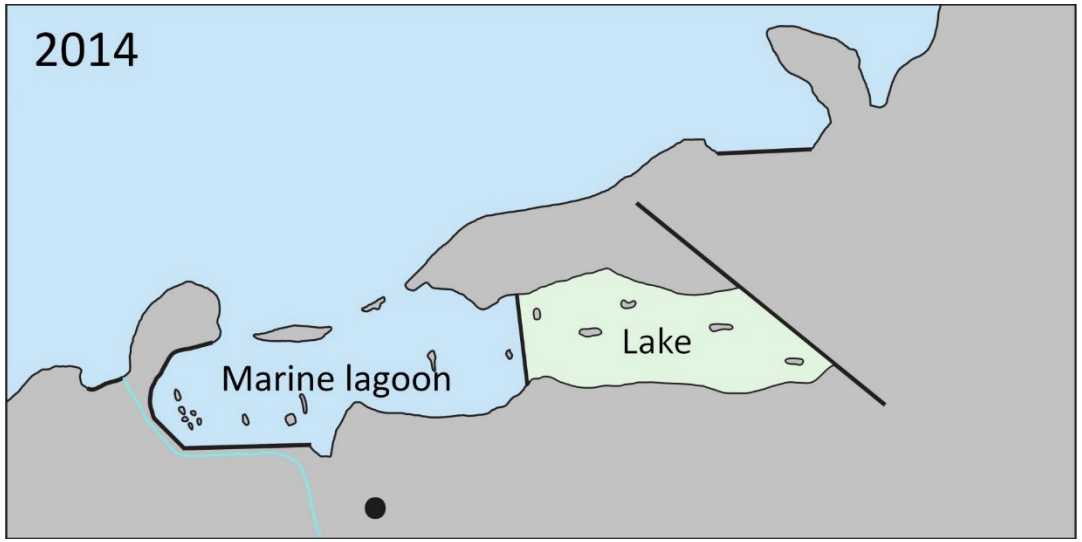
Case study: Gyldensteen Strand

Large-scale restoration/adaptation/mitigation







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Gyldensteen Strand in 2014
After managed realignment - flooding

- Immediate benefit on reducing CO_2 emissions by 6,200 Ton per year – coastal lagoon

- Easier to provide a predictive model due to lack of vegetation and similar soil types

Petersen et al. (2023)

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Gyldensteen Strand
After managed realignment - flooding

	Before flooding 2013		**After flooding 2019**	
	Coastal Lagoon	*Freshwater Lake*	*Coastal Lagoon*	*Freshwater Lake*
CO_2 *(Mg* yr^{-1}*) (DE)*	10,300	6,900	2,000	2,200
CO_2 *(Mg* yr^{-1}*) (NE)*	6,210	4,140	−70	−78
CH_4 *diffusive (Mg* yr^{-1}*)*	~0	~0	~0	8.8
CH_4 *ebullition (Mg* yr^{-1}*)*	~0	~0	~0	294
***CO_2 equivalents** (Mg* yr^{-1}*)*	6,210	4,140	−70	8,400
***CO_2 equivalents** (Mg* yr^{-1}*)*	**10,350**		**8,330**	

Coastal lagoon is a sink: 29 Ton CO_2 ha^{-1} yr^{-1}

Petersen et al. (2023)

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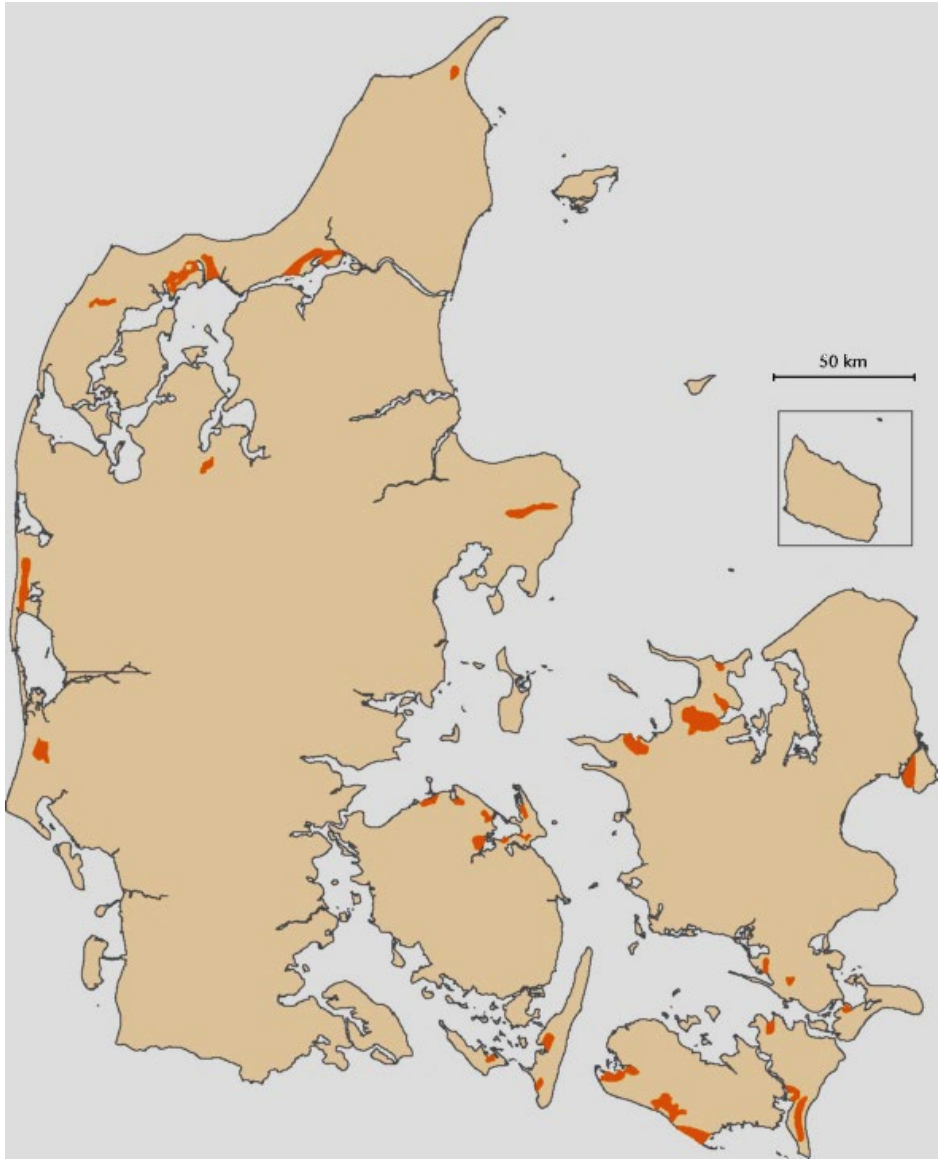
Upscaling of managed realignment in DK

Stenak (2015)

- If all similar low-lying areas near coast are flooded, the CO_2 emission reductions would account for ~2% of national CO_2 emissions



Reclaimed land ~40,000 ha

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Managed realignment is recognized as an effective Nature-based solution

IPBES-IPCC CO-SPONSORED WORKSHOP

BIODIVERSITY AND CLIMATE CHANGE

Scientific outcome

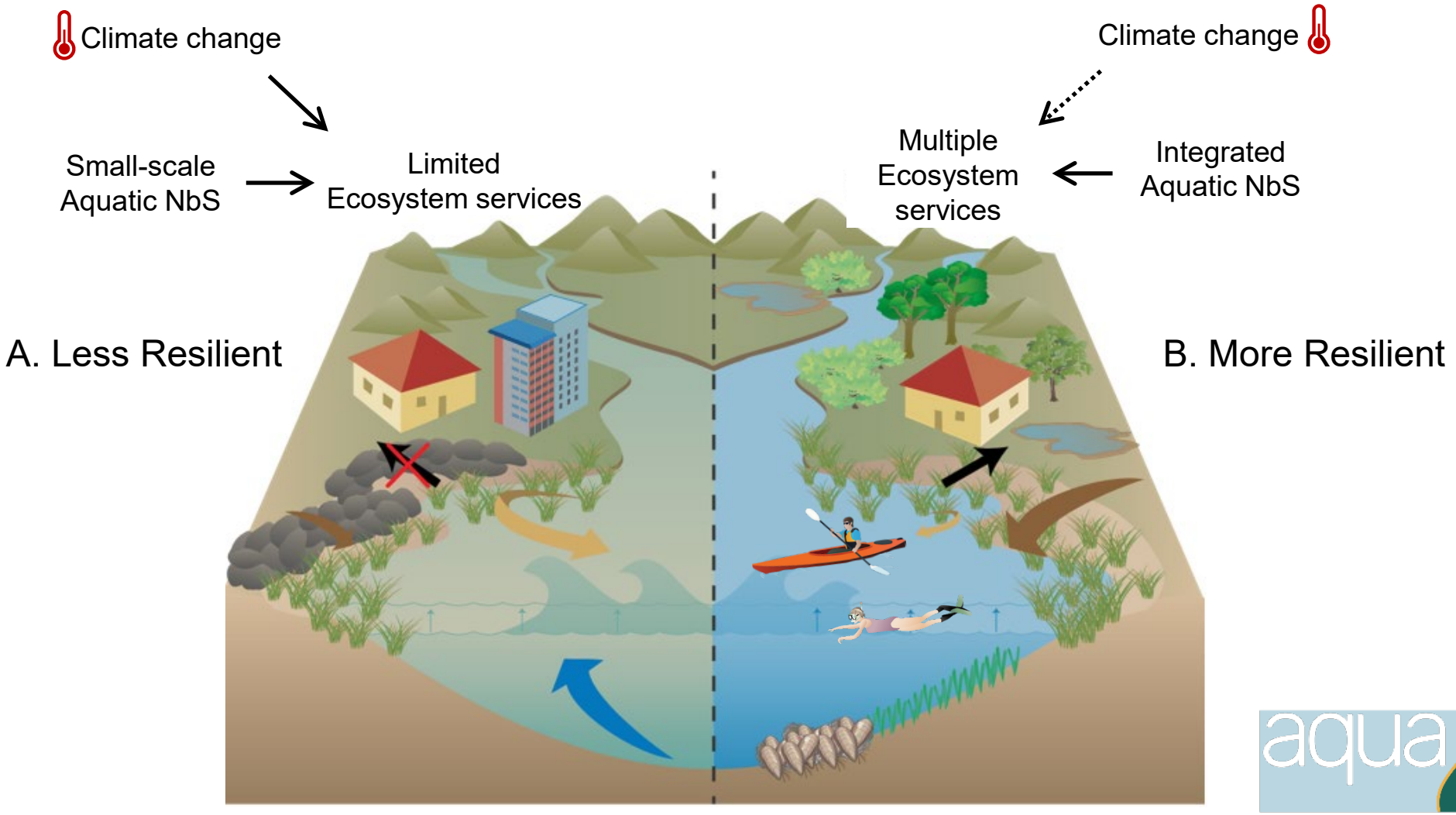
IPBES-IPCC report 2021

4.4.3.3 Coastal protection

Nature-based solutions for coastal flood protection, such as using natural coastal habitats (vegetation or coral reefs) to provide protection from flooding during storm events, increasingly likely due to sea-level rise, is frequently preferred to engineered defences, partly because the former also provide biodiversity benefits whereas the latter may be damaging to biodiversity. The coastal wetlands that naturally provide coastal protection are moving inland and polewards, including poleward expansion of mangroves into saltmarshes, but their extent is generally declining

ecosystem structure. Adaptation strategies include sediment augmentation and restoration of shorelines to natural states to stem the loss of intertidal habitat and vegetation under sea-level rise. Managed realignment can also be effective, converting pasture to saltmarshes, albeit with a slow establishment of the novel habitat as a carbon store, (Burden *et al.*, 2013), while sediment inputs from rivers can counteract effects of sea-level rise.

Centre of aquatic nature-based solutions



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aqua NbS

Take home messages

- ✓ NbS are adopted by municipalities, but there is a need to improve policies/economic framework, and public participation
- ✓ Potential to upscale NbS: managed realignment of reclaimed land
- ✓ Flooding of reclaimed soils provide an immediate climate mitigation by reducing emissions by 29 Tons CO_2 ha^{-1} yr^{-1} at >10 salinity
- ✓ Growing research on C sources and sinks in coastal vegetated ecosystems improve estimated of their climate mitigation potential
- ✓ It is important to coordinate the upscaling of NbS following global standards including the benefits of multiple ecosystem services

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Thank you!
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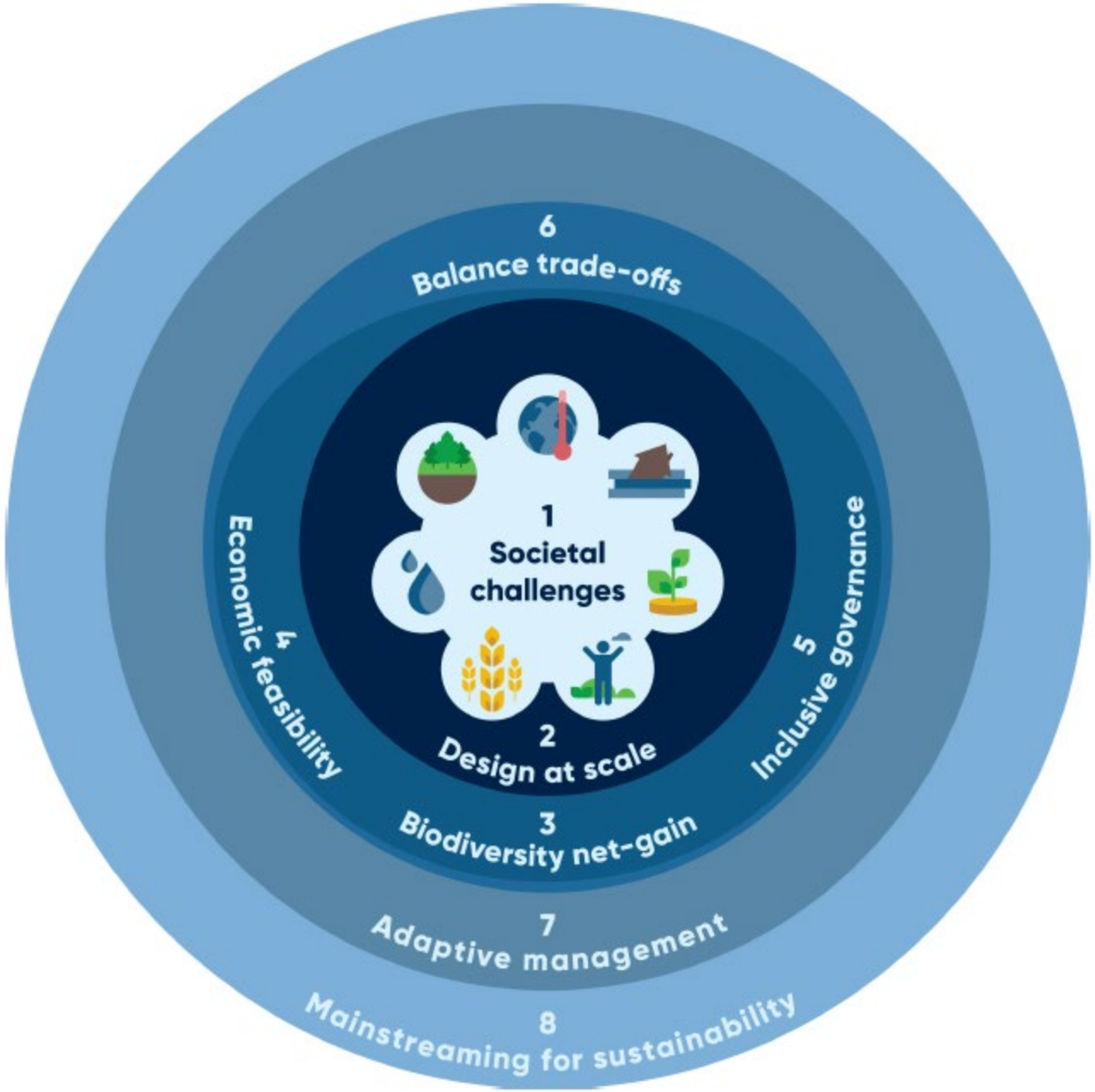
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Balance trade-offs
1
Societal challenges
2
Design at scale
3
Biodiversity net-gain
4
Economic feasibility
5
Inclusive governance
7
Adaptive management
8
Mainstreaming for sustainability

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