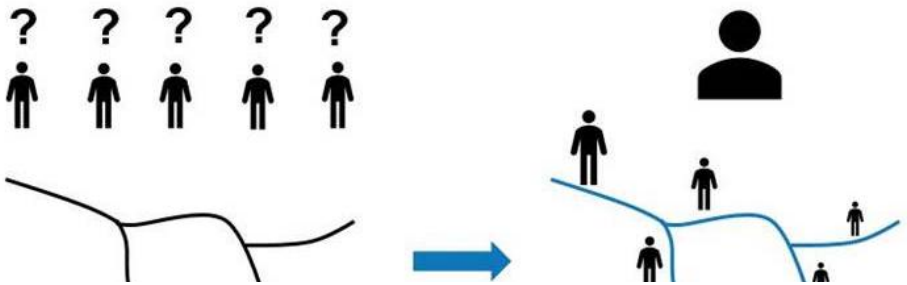
NbS approach to eradicate invasive species

Dong-Fan Xu

Supervisor: Bin Zhao & Martin W. Skov

17/12/2025

Task-based Governance



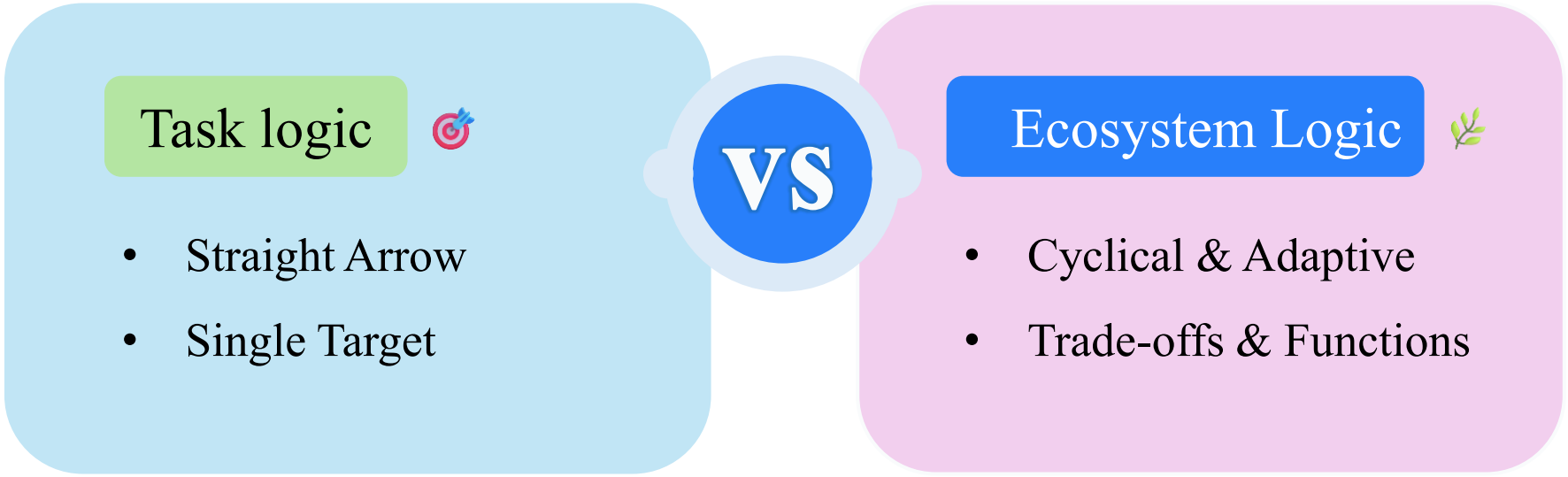
China's ecological governance is essentially

a "**task-based governance**".

121-million-hectare cropland

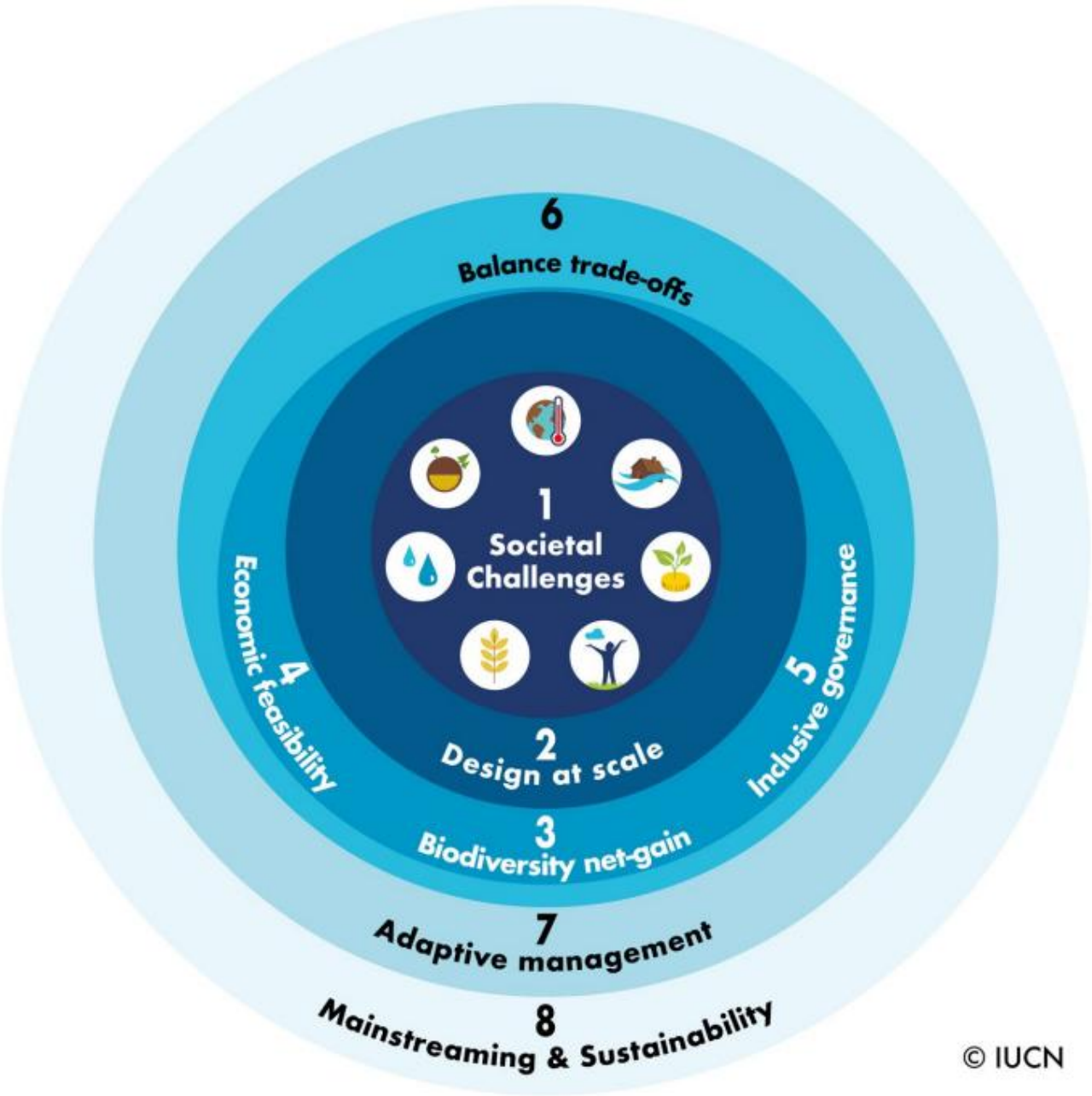
68,000 hectares of salt marshes

Finishing a Task ≠ Restoring Nature



1. Tasks optimize one target; ecosystems balance many.
2. Tasks are linear; ecosystems are adaptive cycles.
3. Tasks focus on completion; ecosystems require ongoing processes.

What is and is not Nature-based Solution?



Misunderstood:

- ✗ large-scale tree planting
- ✗ some ecological indicators
- ✗ the larger area, the better
- ✗ the faster speed, the better
- ✗ the more investment, the better

- NbS is not using natural materials
  —it is restoring natural processes.
- NbS is not a greening project
  —it is functional recovery.
- NbS is not a short-term target
  —it is a long-term, multi-objective commitment.

Our Definition

They are designed to address various environmental challenges in a resource efficient and adaptable manner and to provide simultaneously economic, social and environmental benefits.

（IUCN,2022 & EU,2022）

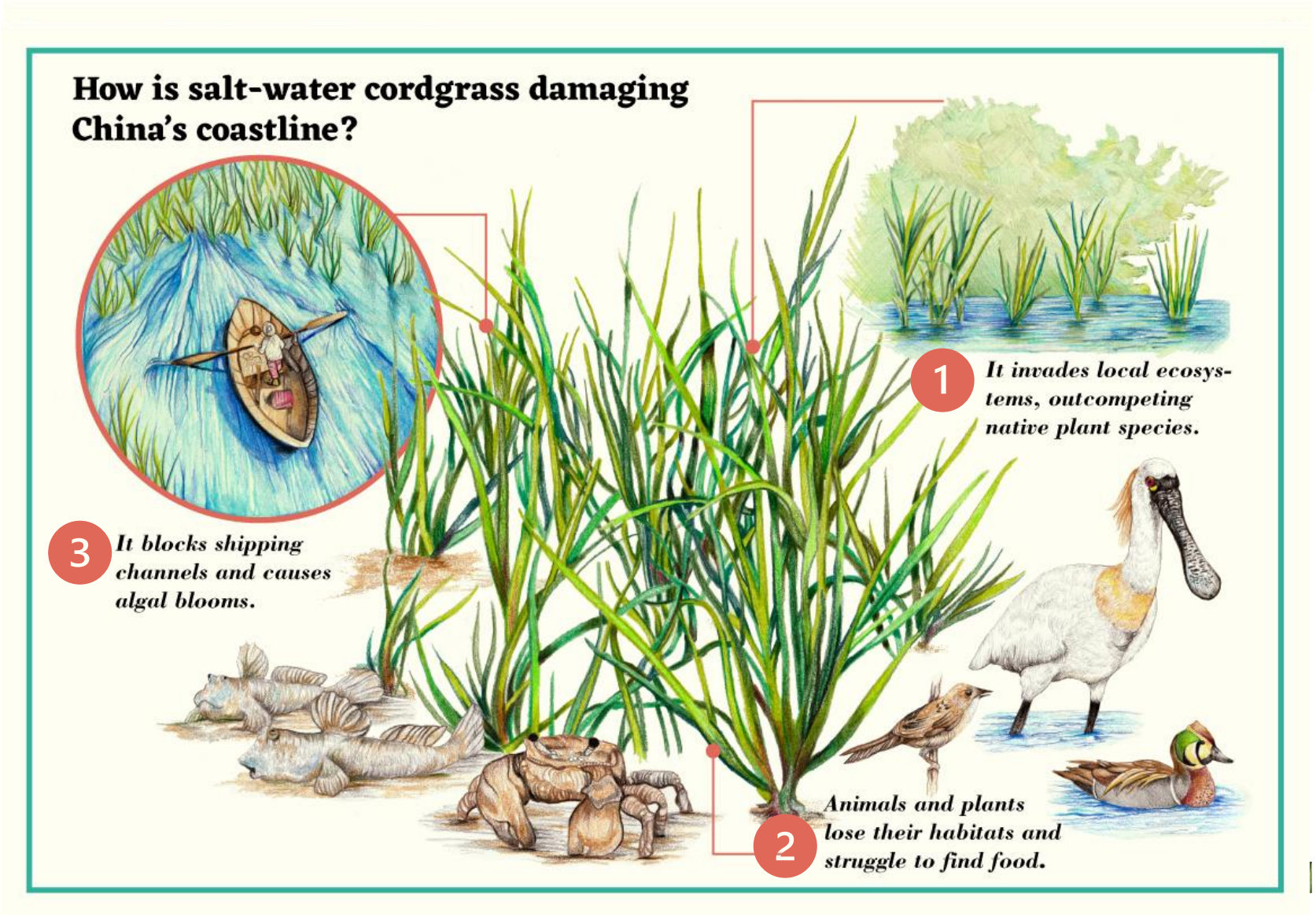
Addressing multiple societal challenges at the same time in a sustainable manner.

To achieve a triple-win of "society", "economy" and "environment".

Nature based Solutions

The nature of progress

Background



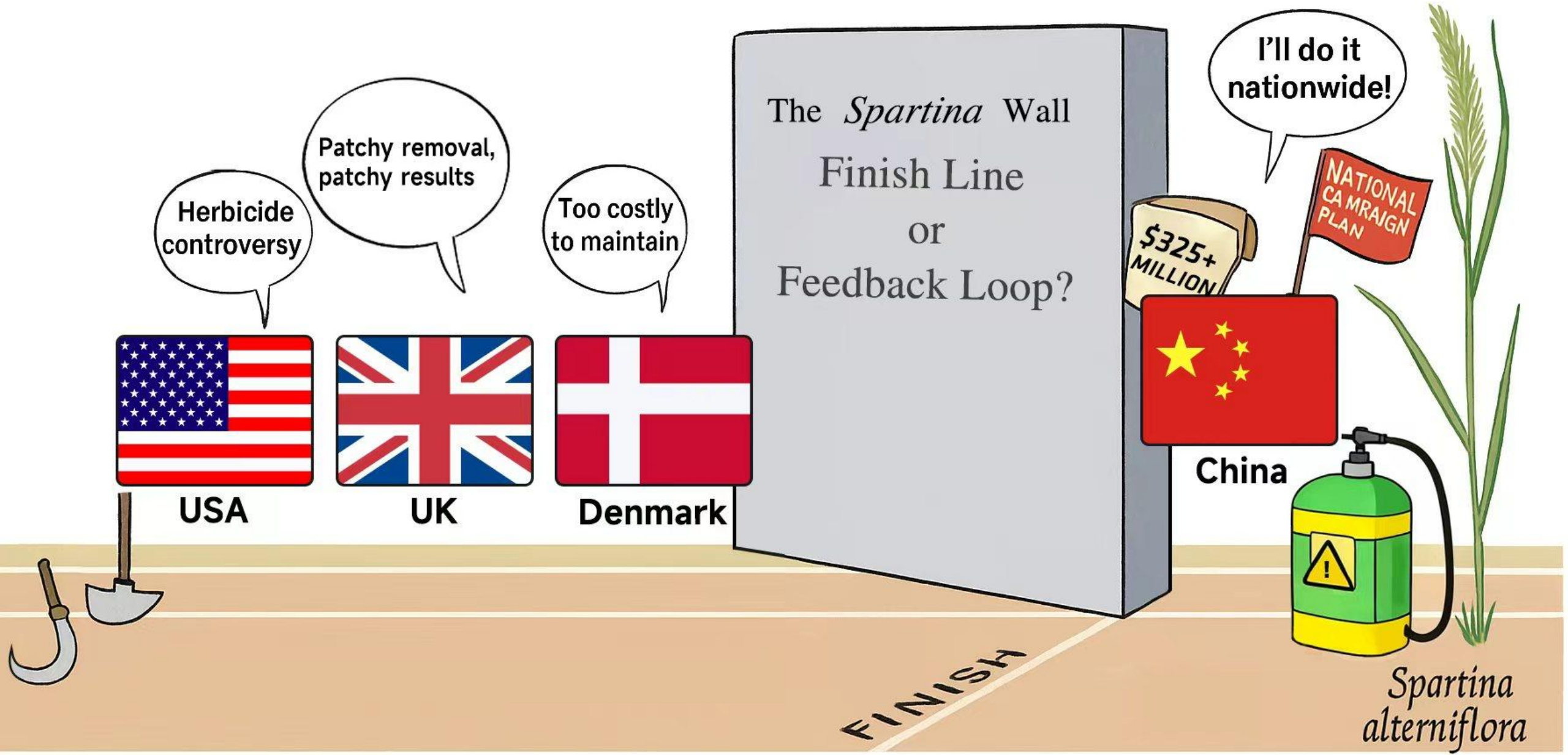
Reducing **biodiversity** and causing **socio-economic harm**:

- Crowding out native vegetation.
- Causing the extinction of benthic animal.
- Reducing habitat for birds.
- Blocking shipping channels.

Policy

- Eradicate **all** *Spartina alterniflora* in three years.
- Already invested **USD 325 million (~250 million GBP)**.

Same Game, Same Grass, Same Outcome?



Approaches

Although there are 8 mainstream methods, but what is pursued is "**efficiency**".

This is likely to lead to long-term failure.

Field Survey

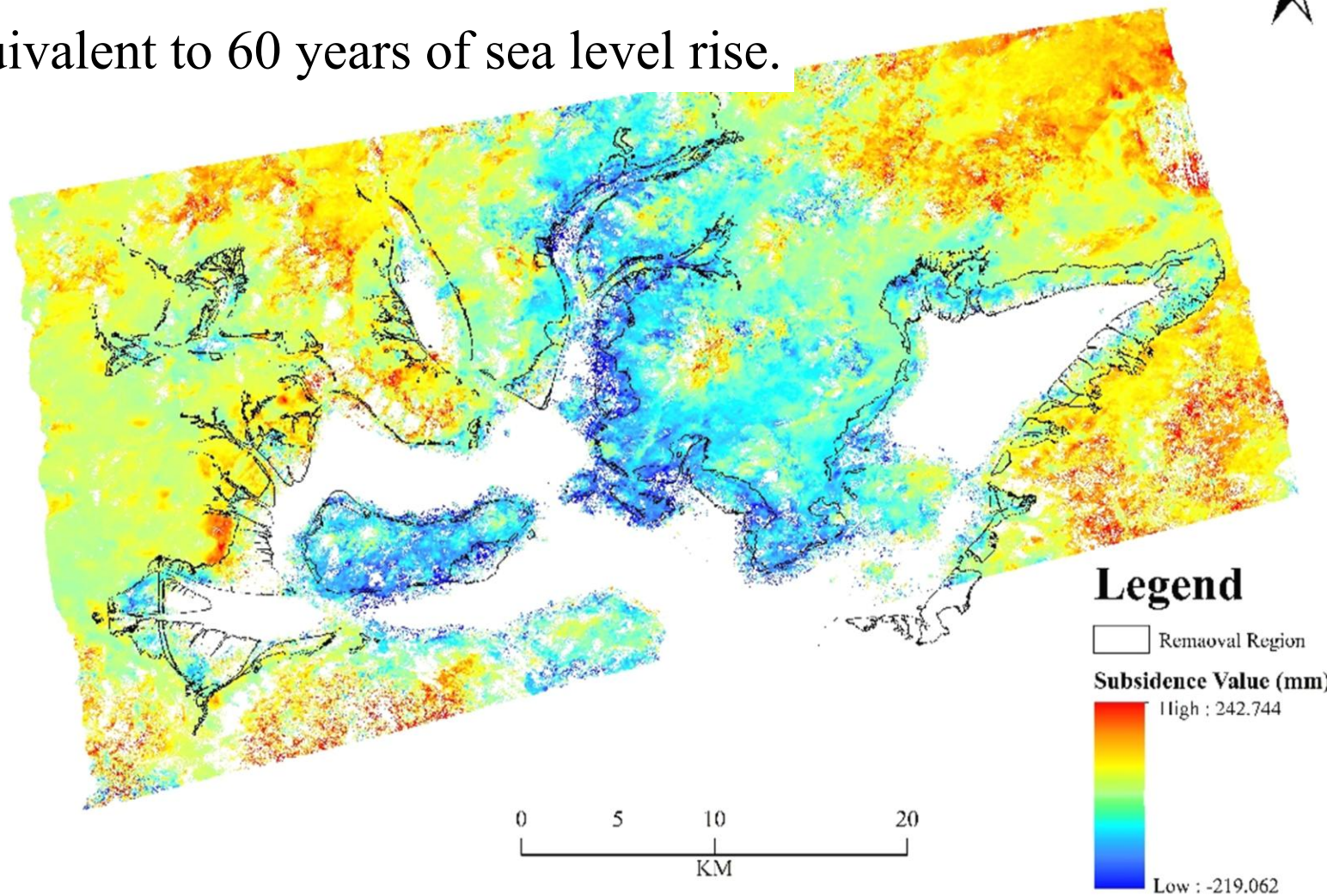
China’s coastal region is

Turning bald!

Vegetation salt marsh is transformed into bare mudflat.

Field Survey

If this were in Wales, 18 cm is equivalent to 60 years of sea level rise.



Perspective – we argue:

Avoid national – scale eradication – destructive
Instead: concentrate resources on National Reserves, using NbS

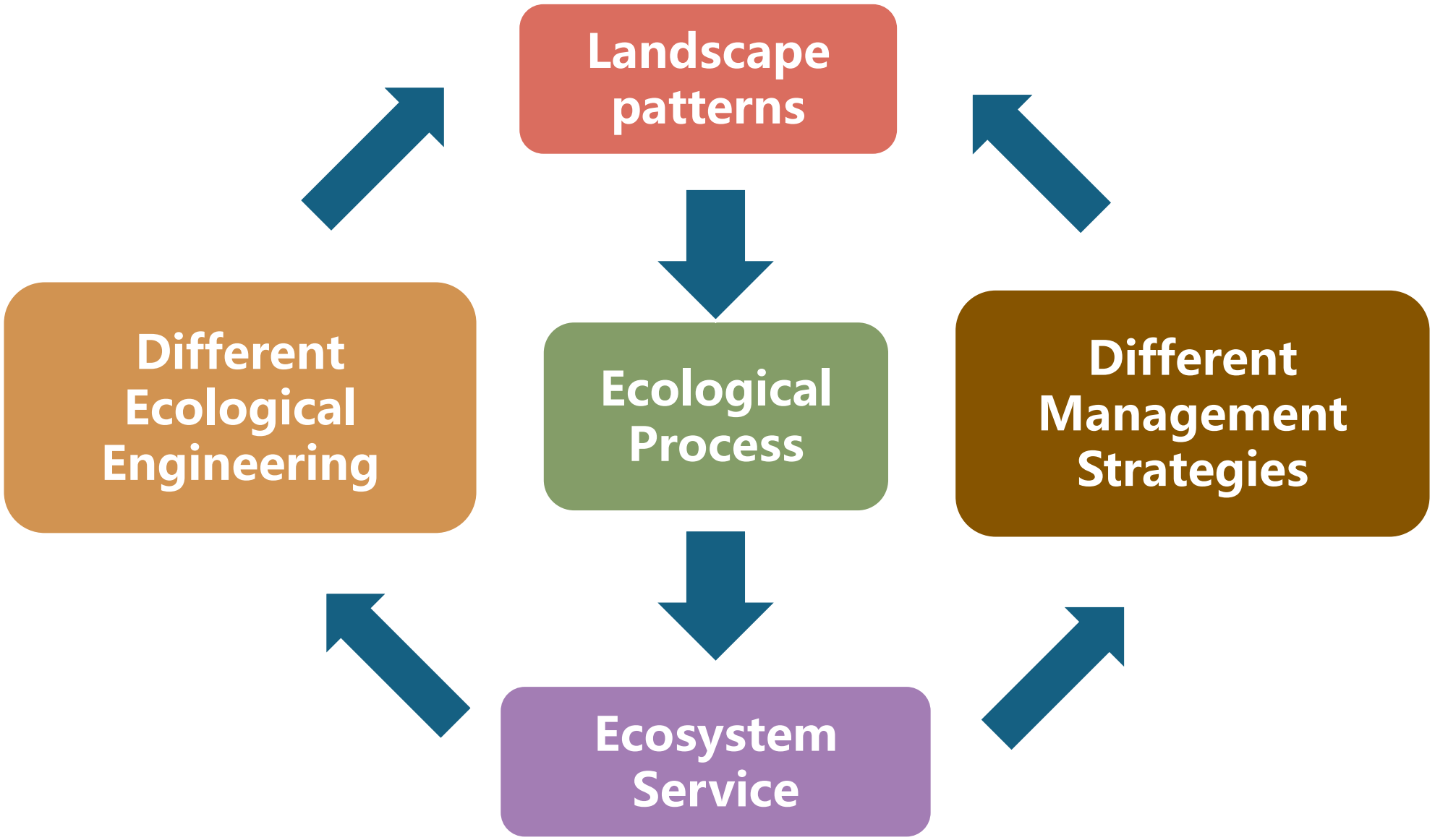
Current drawbacks:

- Huge financial expenditures;
- Unmanageable recurrence rate;
- Biodiversity has not been effectively enhanced;
- Salt marsh is eroding and dying out.
- …… ……

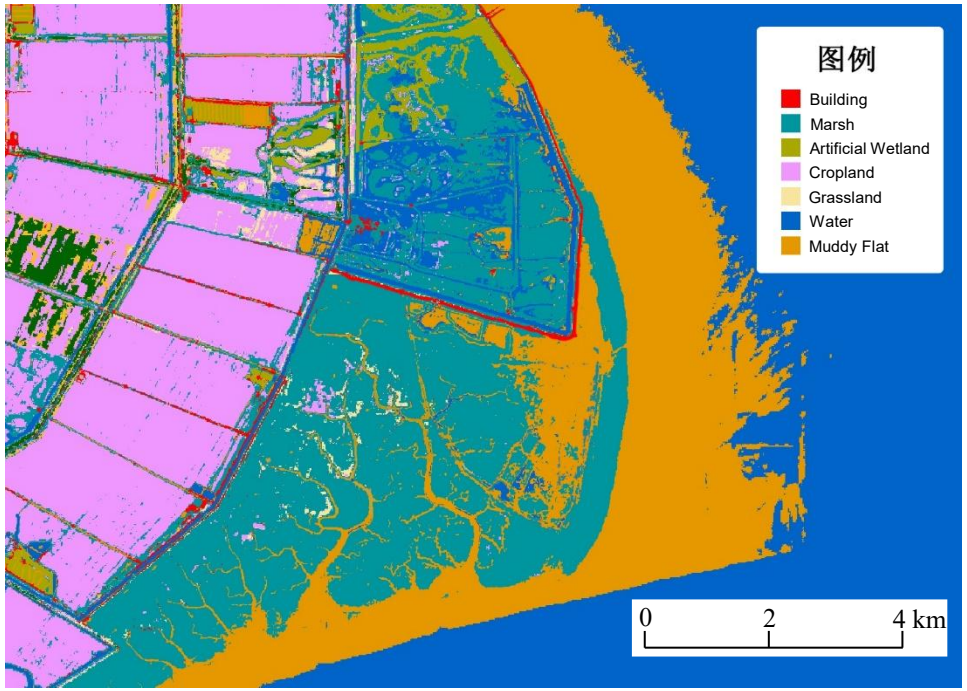
Our opinion:

Spartina alterniflora should not be eradicated entirely but should be selectively removed within coastal reserves and considered as part of regular management activities.

Framework Overview



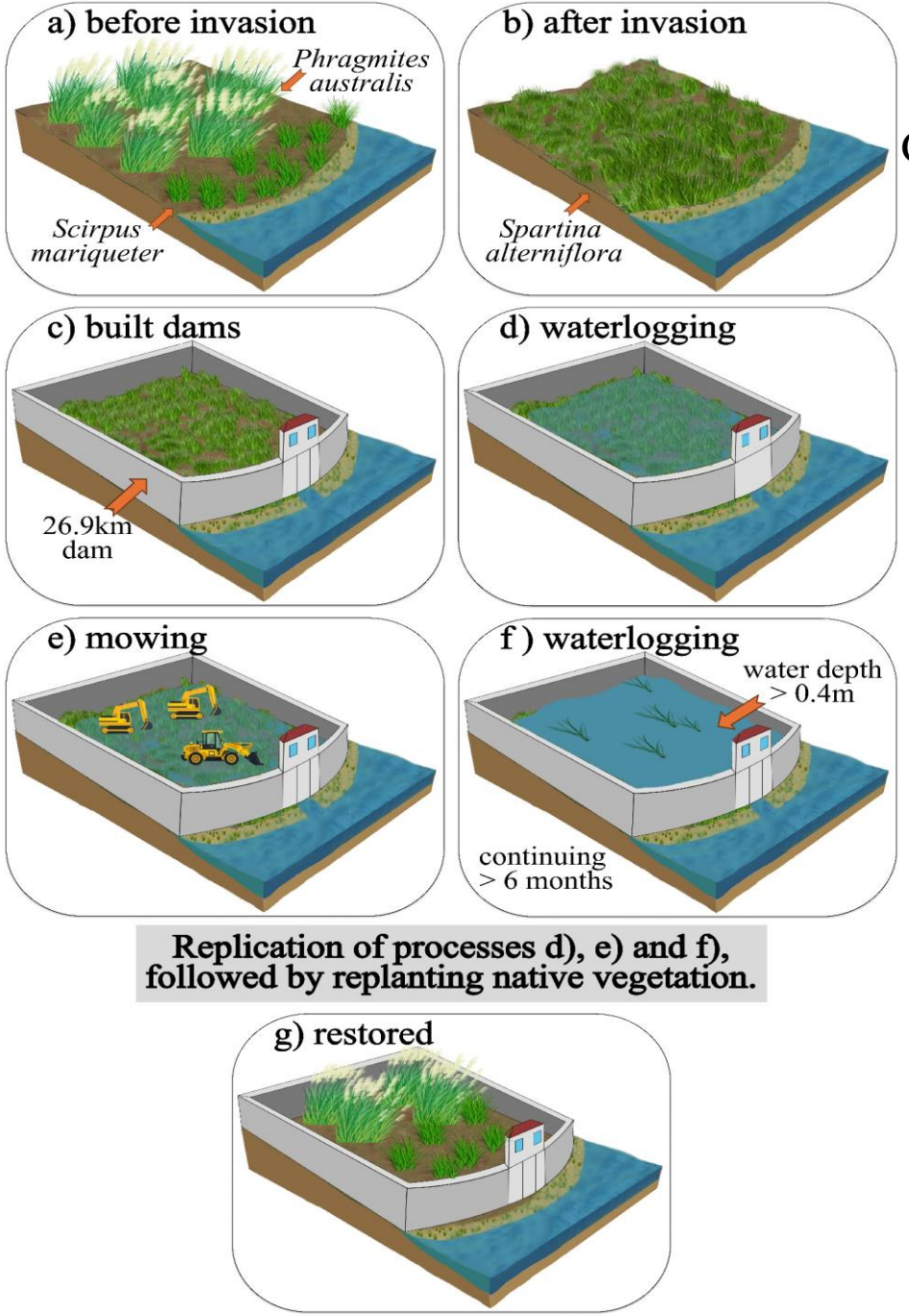
NbS self - assessment



-
-
-

Machine mowing

Mowing with wate



Replication of processes d), e) and f), followed by replanting native vegetation.

Cofferdam 围

Cut 割

Flooding 淹

Exposure 晒

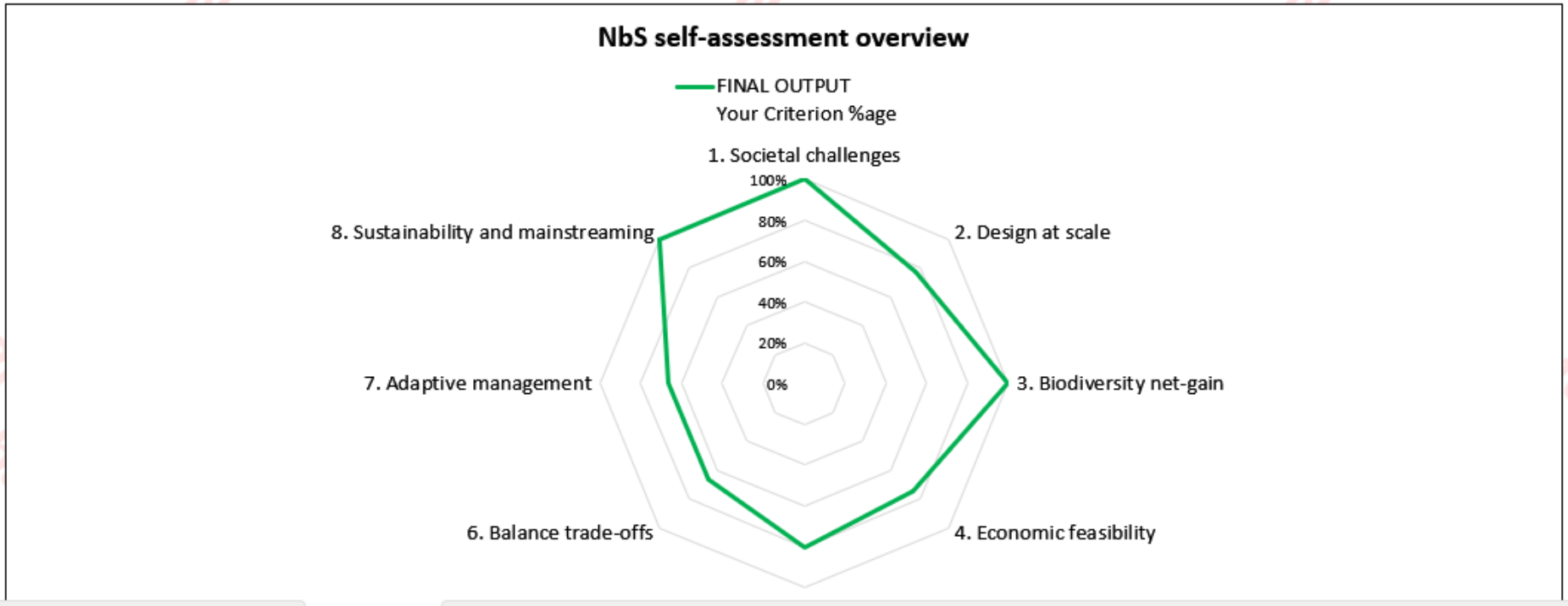
Plant 种

Regulate 调

NbS self - assessment

NbS self-assessment overview

Criterion	Your Criterion Score	Maximum Criterion Score	Normalised criterion	FINAL OUTPUT Your Criterion %age
1. Societal challenges	9	9	1.00	100%
2. Design at scale	7	9	0.78	78%
3. Biodiversity net-gain	12	12	1.00	100%
4. Economic feasibility	9	12	0.75	75%
5. Inclusive governance	12	15	0.80	80%
6. Balance trade-offs	6	9	0.67	67%
7. Adaptive management	6	9	0.67	67%
8. Sustainability and mainstreaming	9	9	1.00	100%
Total Percentage match				83%
Is this in adherance with the IUCN Global Standard for NbS?			In adherance	

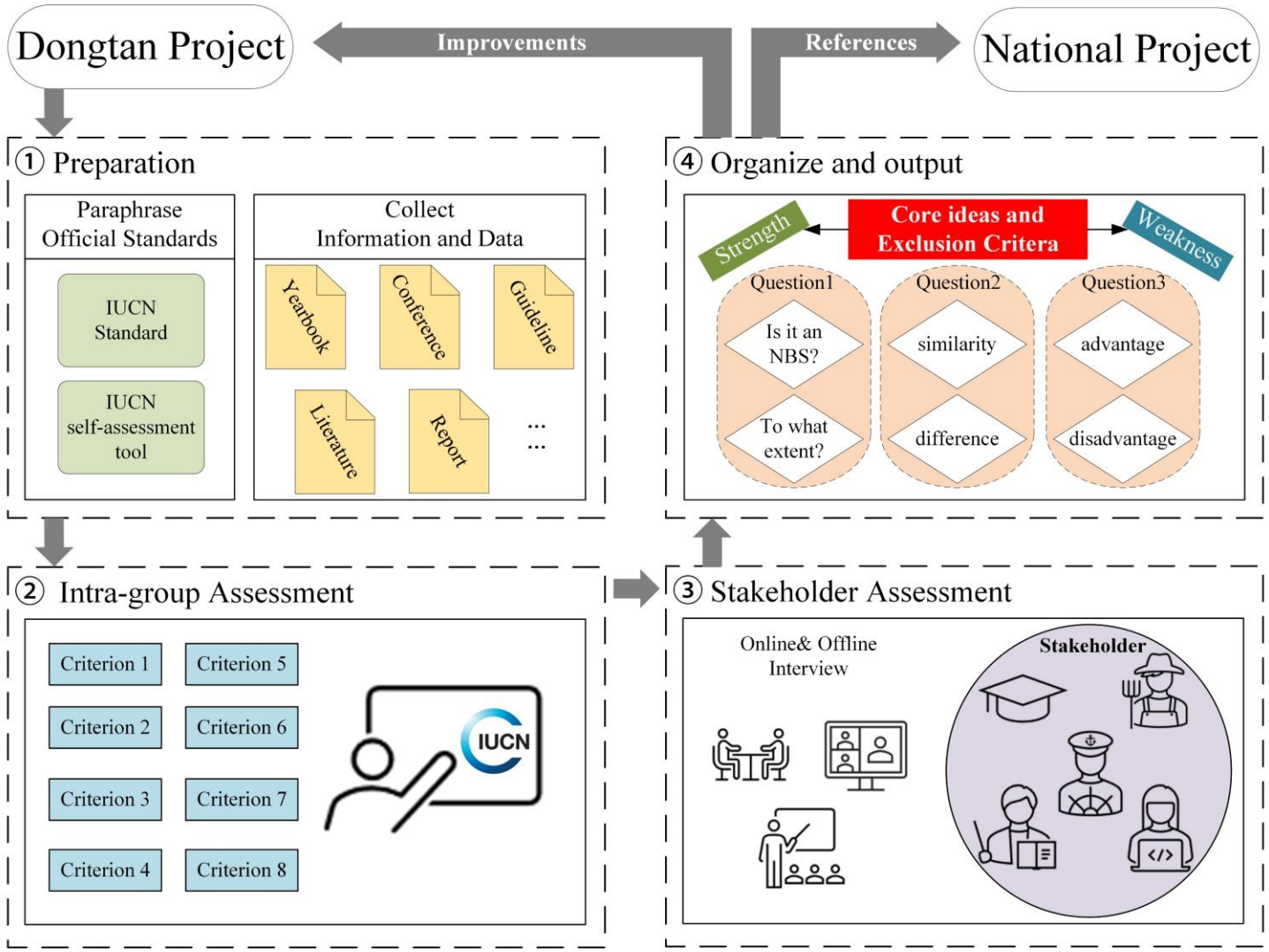


- Score<70, not a NbS
- 70<Score<80, Partial
- 80<Score<90, Adequate
- 90<Score, Strong

Case Explanation:

- Handle/address social challenges;
- Enhance biodiversity;
- Poor performance in adaptive management and multi-benefit trade-offs;

NbS self - assessment



Workflow of Whole Research

Material Preparation

↓

Intra-group Assessment

↓

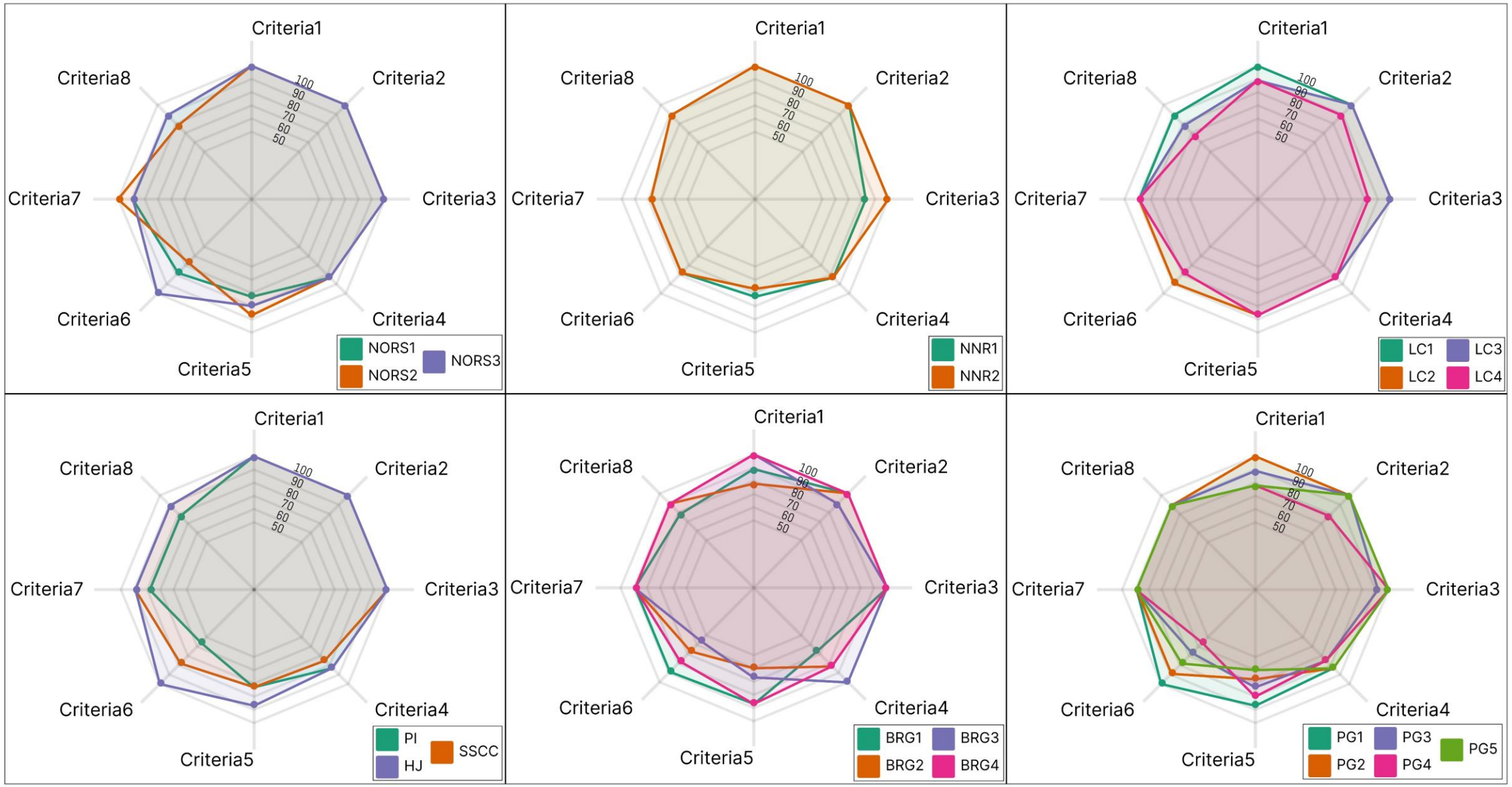
Stakeholder Assessment

↓

Organize and output

Is the Dongtan *Spartina* eradication project a Nature-based Solution?

NbS self - assessment



NbS self - assessment

Conclusion:

- Dongtan Project is an NbS (**88%**);
- Criteria4 ("Economic feasibility"), Criteria5 ("Inclusive governance") and Criteria6 ("Balance trade-offs) needs improvement;
- Criteria1 ("Societal challenges"), Criteria3 ("Biodiversity net-gain") and Criteria8 ("Main-streaming") are advantages;

Highlights:

- Need to conduct NbS assessment at the design stage;
- *Spartina alterniflora* eradiction project need **adapative management**;
- "Blance trade-offs" needs to be take into account.

Adaptive Management

Nature based Solutions

1 Societal challenges

2 Design at scale

3 Biodiversity net-gain

4 Economic feasibility

5 Inclusive governance

6 Balance trade-offs

7 Adaptive management

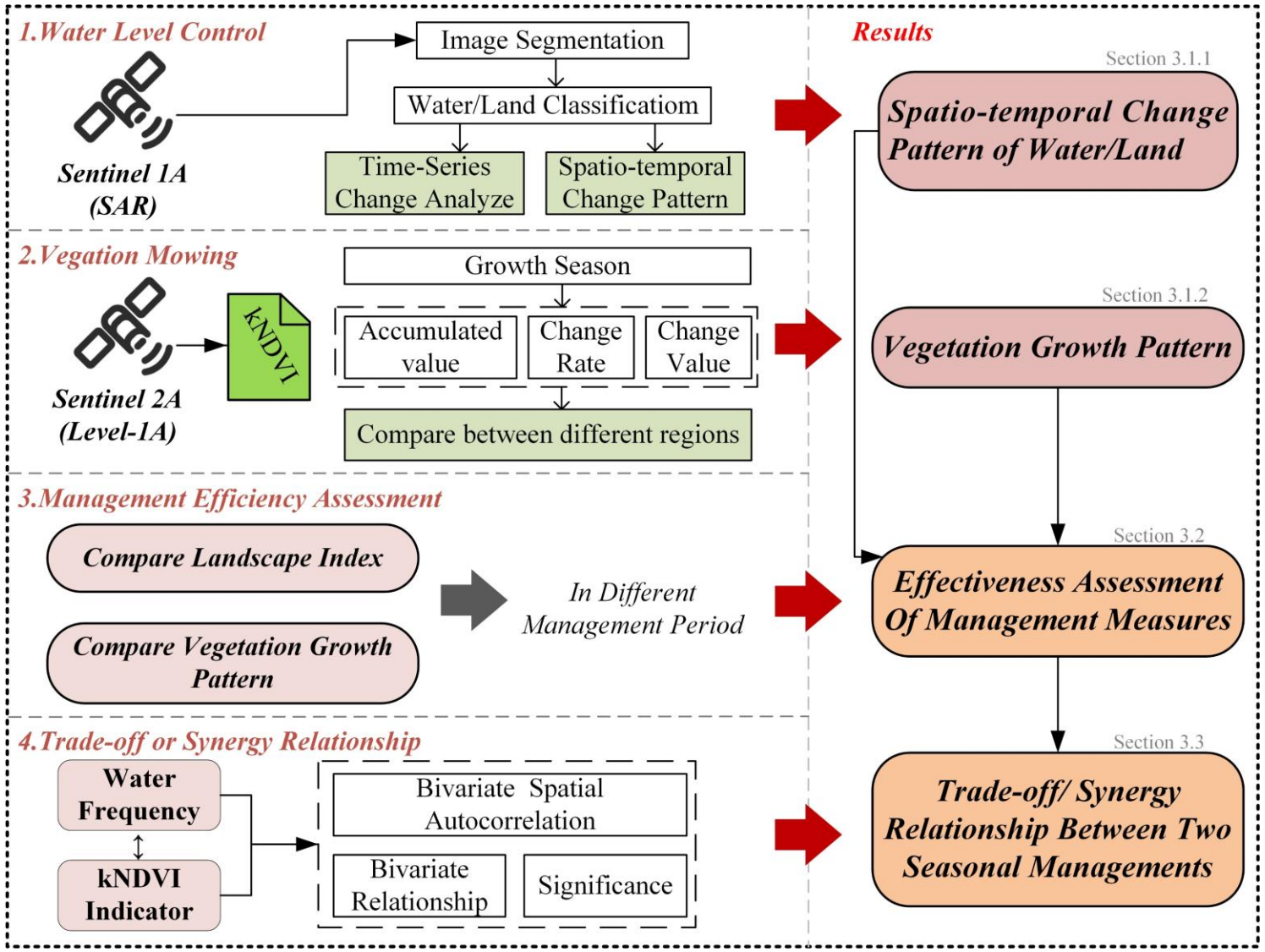
8 Mainstreaming &sustainability

Adaptive Management

Vegetation Mowing

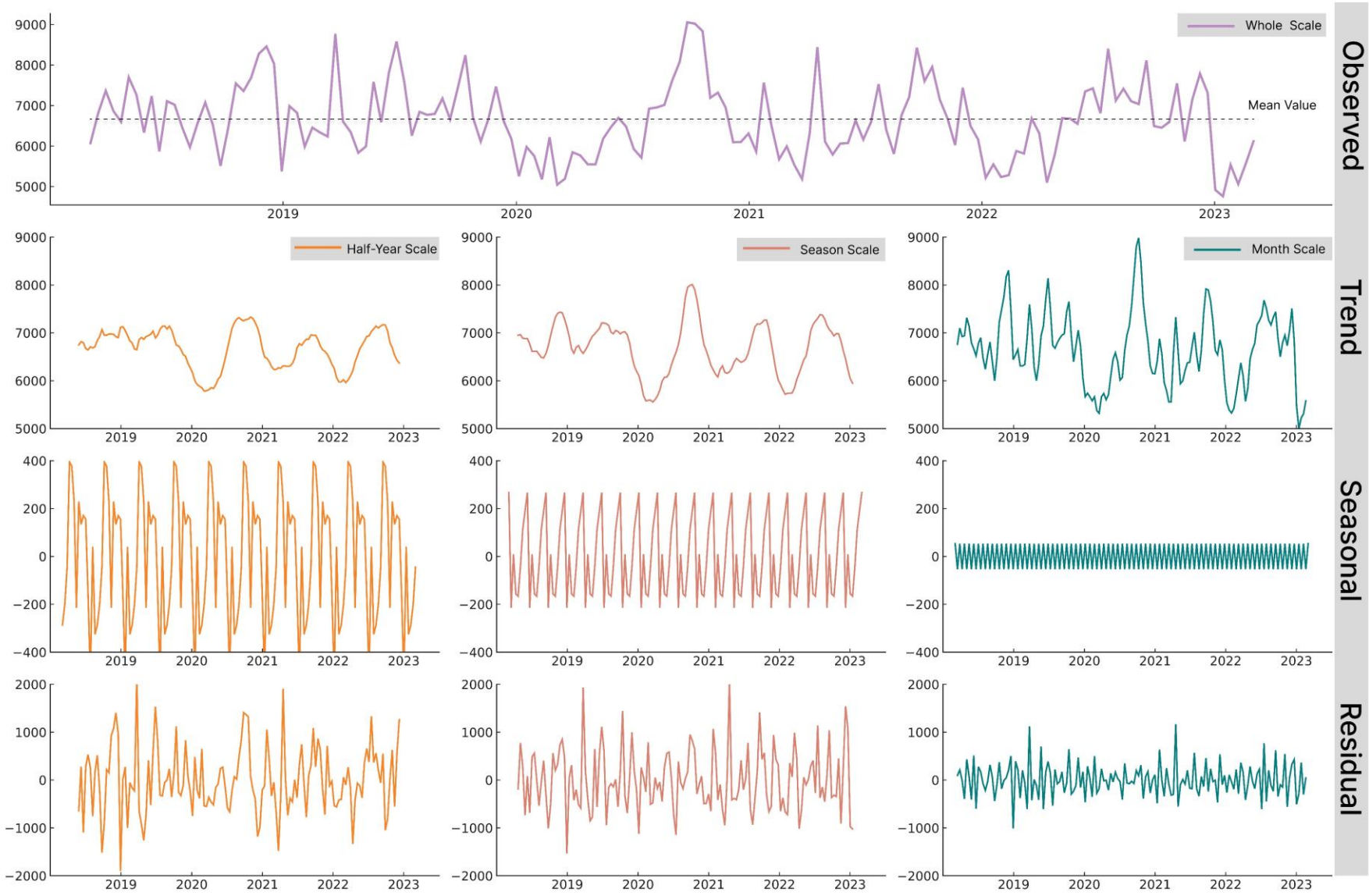
Water-level Regulation

Adaptive Management



- Whether the two seasonal management measures in Dongtan Reserve were Synergy?
- Is it an adaptive management strategy?

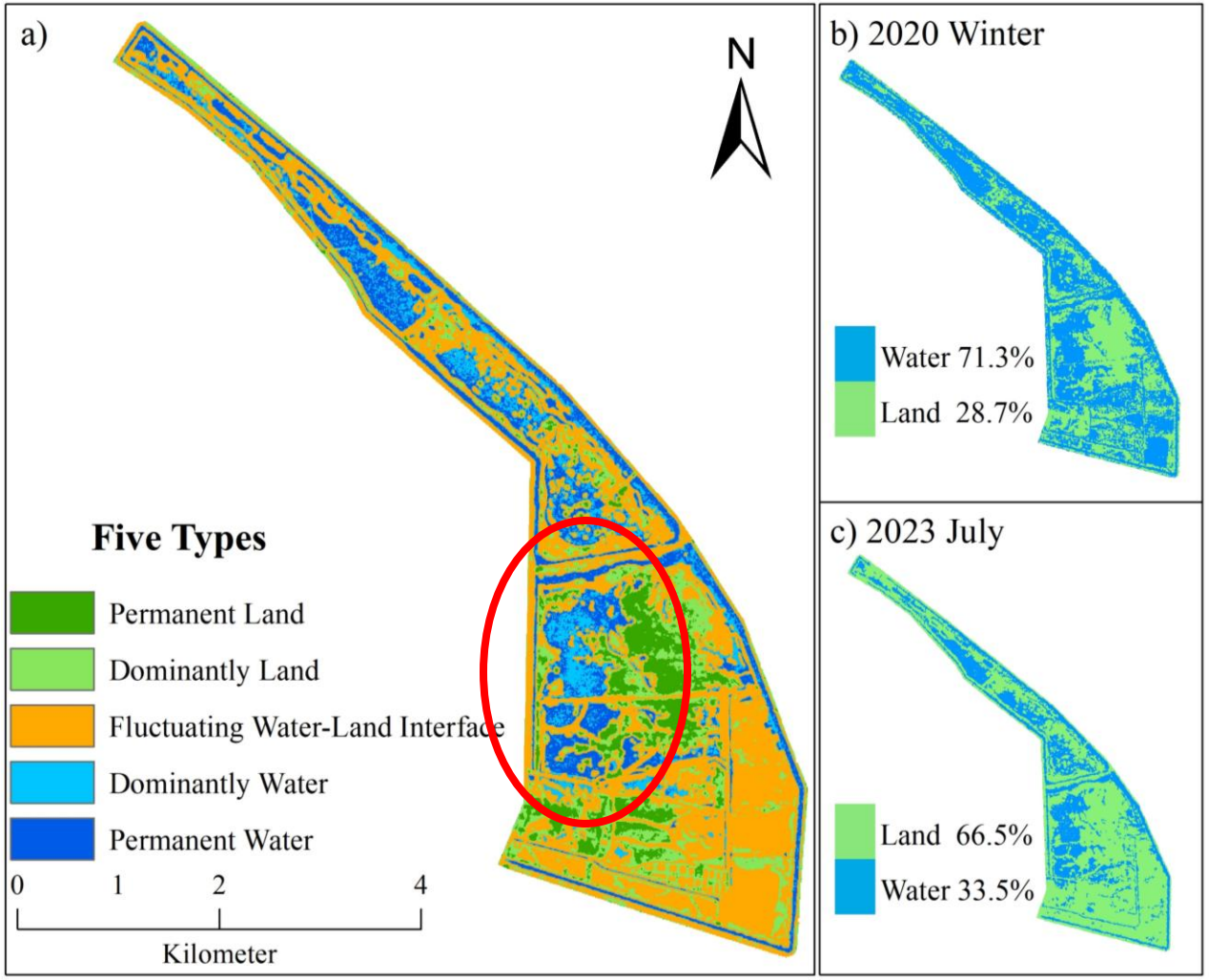
Water Level Trend



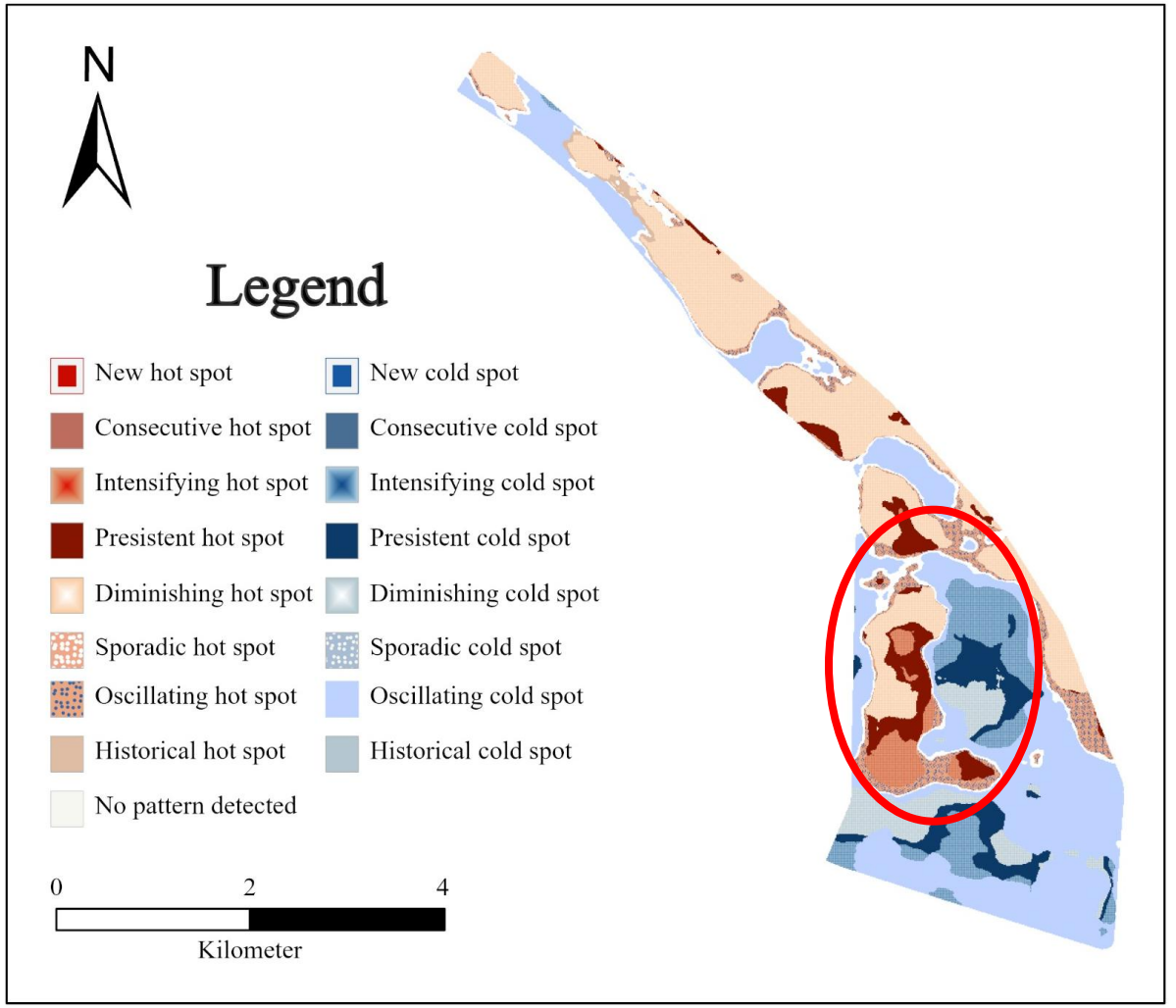
STL Analyze Result:

- Half-year, Season, and Month scales, all with significant cycles of change.
- Water Frequency here consist a clear **seasonal trend**.
- **Half-year** and **Season** **(3 months)** scales are the most significant.

Water Frequency

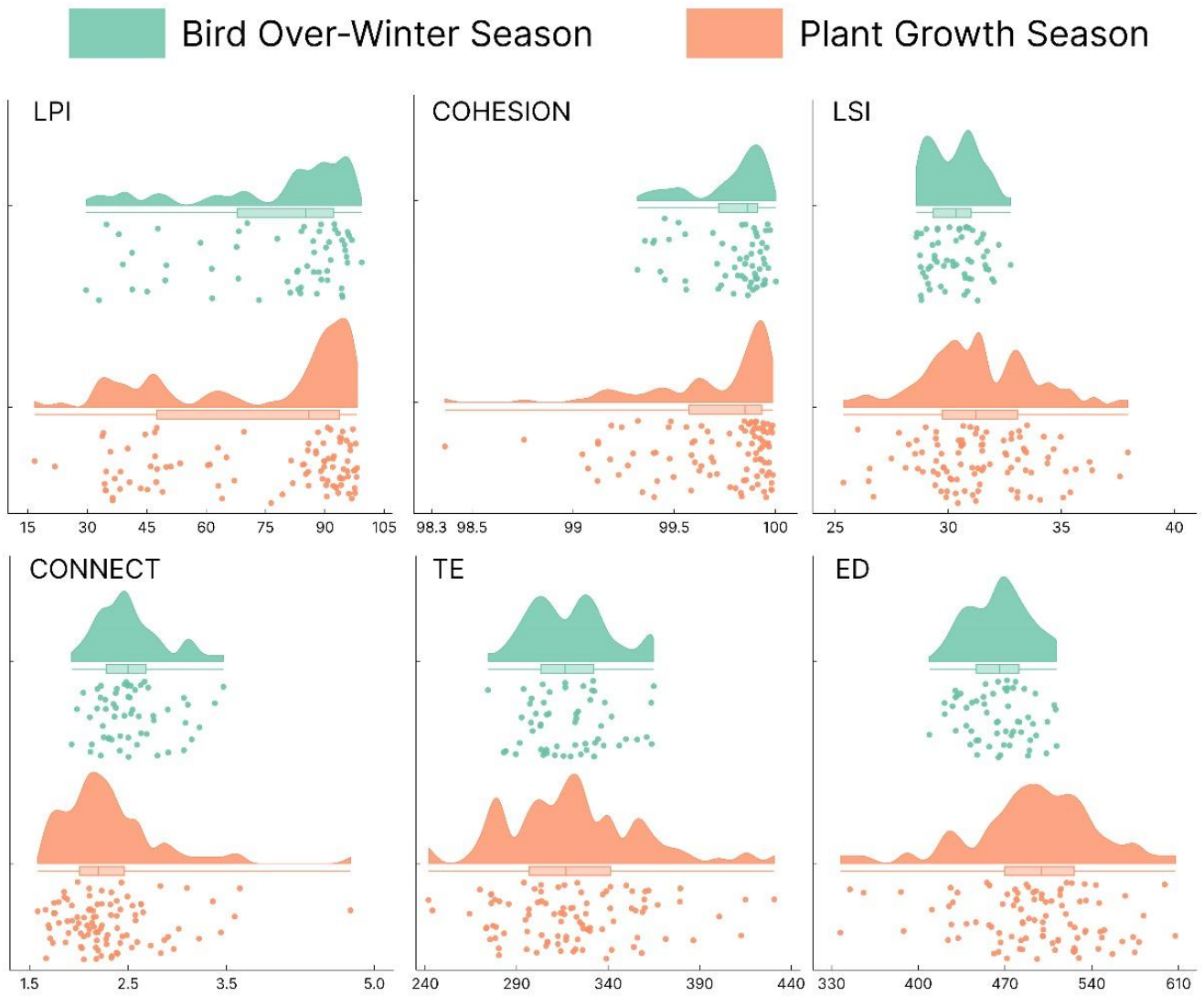


Water Frequency Classification



Water Frequency Space Time Cube

Create Bird Shelter



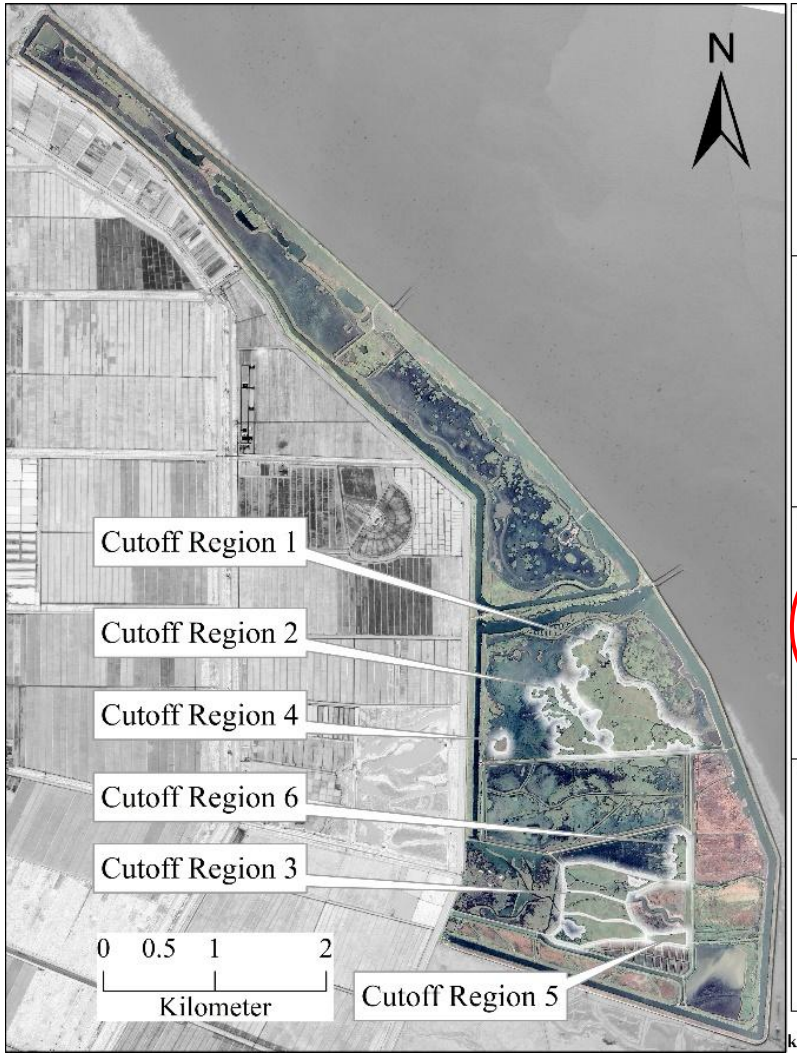
Landscape Index:

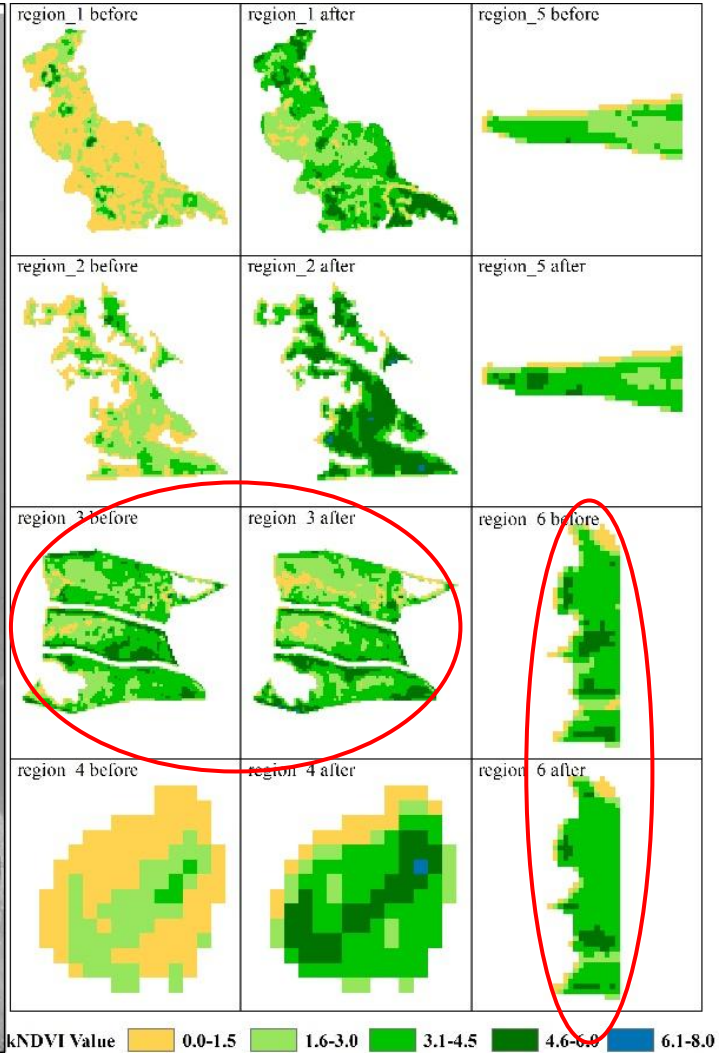
- The CONNECT and ED indices here reflect the effectiveness to create open water and increase the length of the edge of the land-water interface.
- All indices are reflected more **compactly** during the overwintering period compared to the vegetative growth period, which suggests that the regulation is considered to be effective.

Conclusion:

Water level control is effective in creating suitable habitat for birds.

Mowing Help Plant Restore

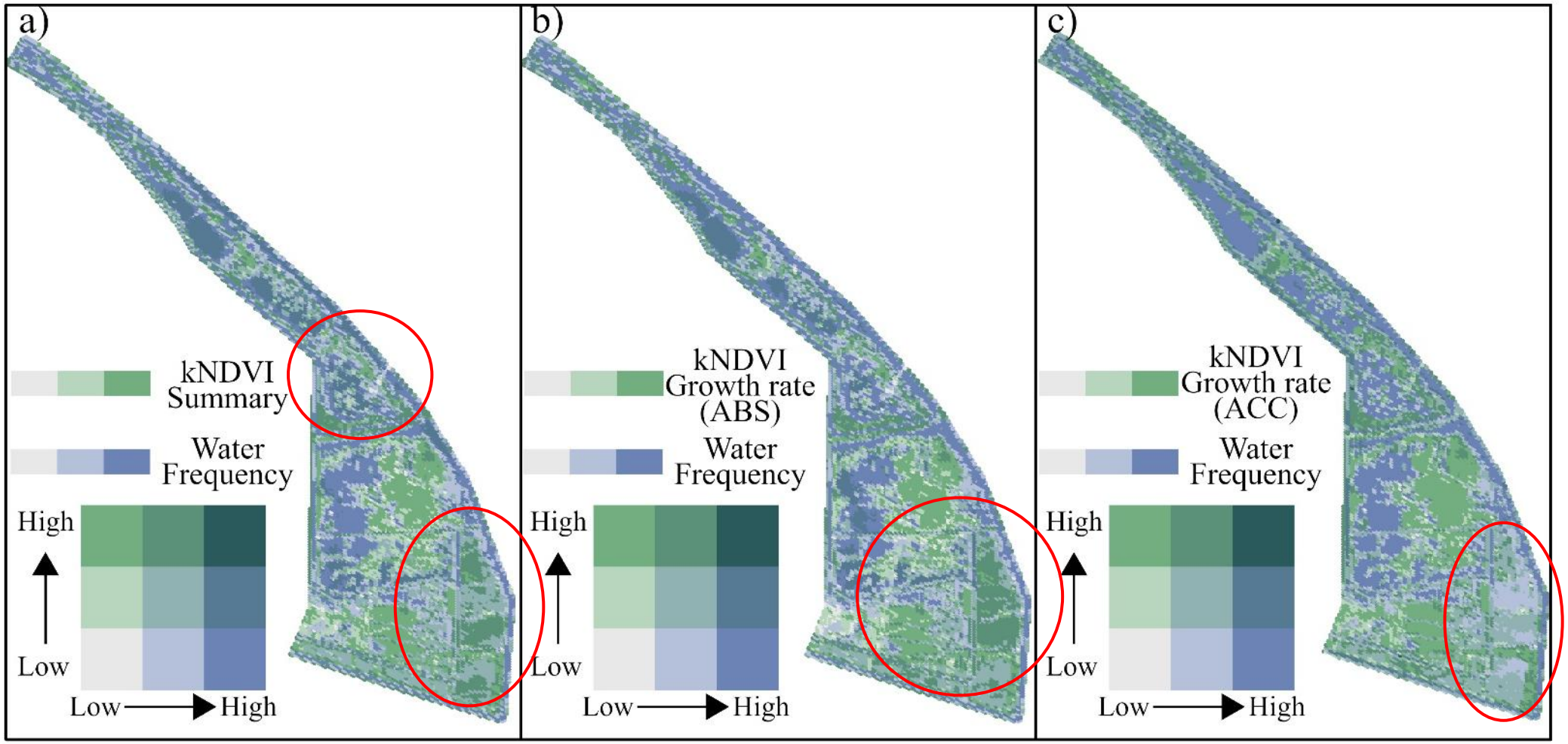




Conclusion:

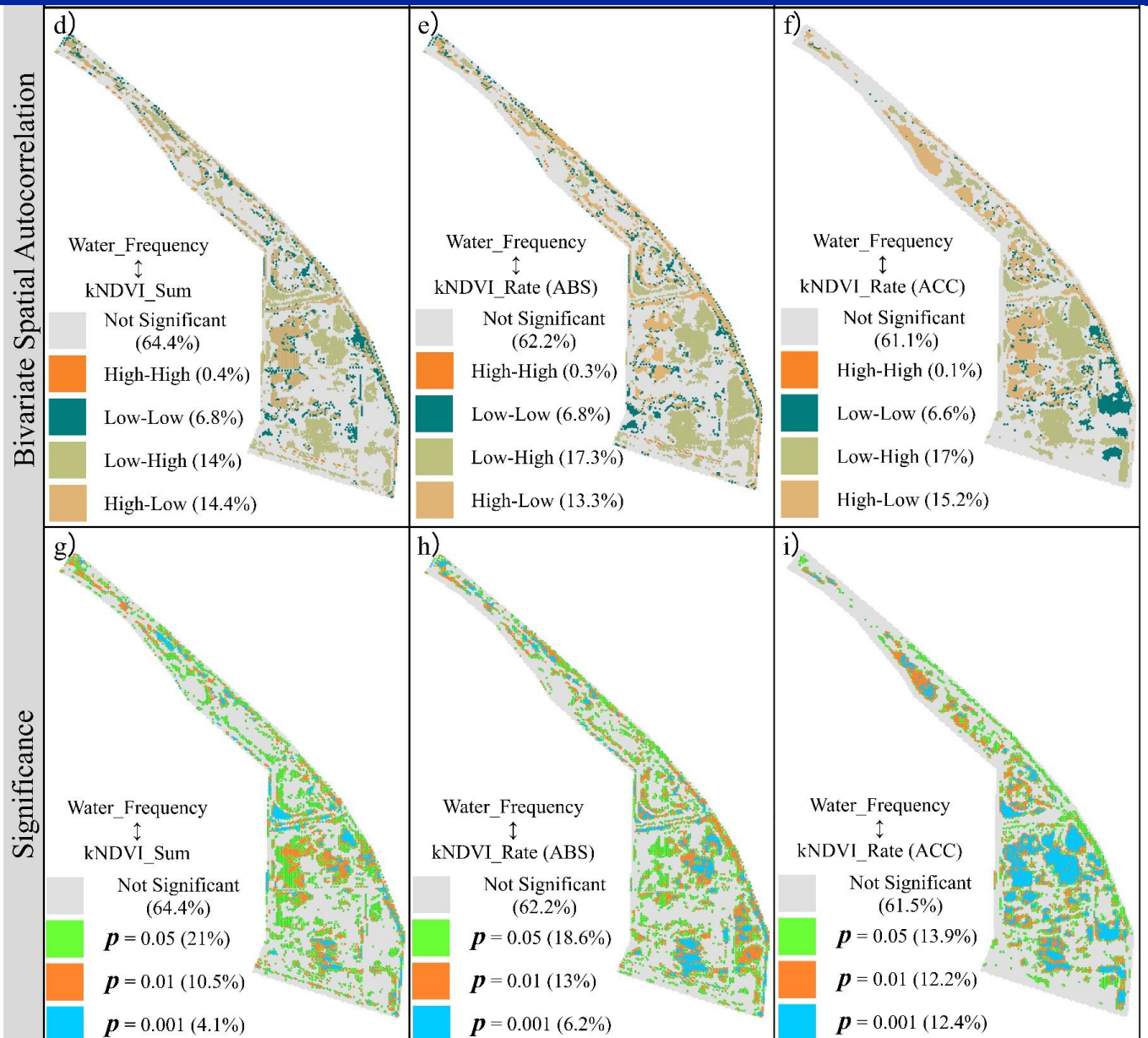
- The mowing is good and favors the restoration of native vegetation in the project area.
- However, it is still not regular enough and it is needed to be more regular in the mowing.

Spatiotemporal Relationship



The binary variable plot shows that the two measures, **which conflict only in a small part of the region**, but not much.

Trade-off or Synergy?



Lisa Result:

High-High: the most ideal state of ***synergy***, almost none;

Low-Low: a ***trade-off*** state, only a little in the east;

Low-High: this zone is mainly vegetation growth areas, where vegetation growth is less affected by inundation, judged to be ***synergistic***;

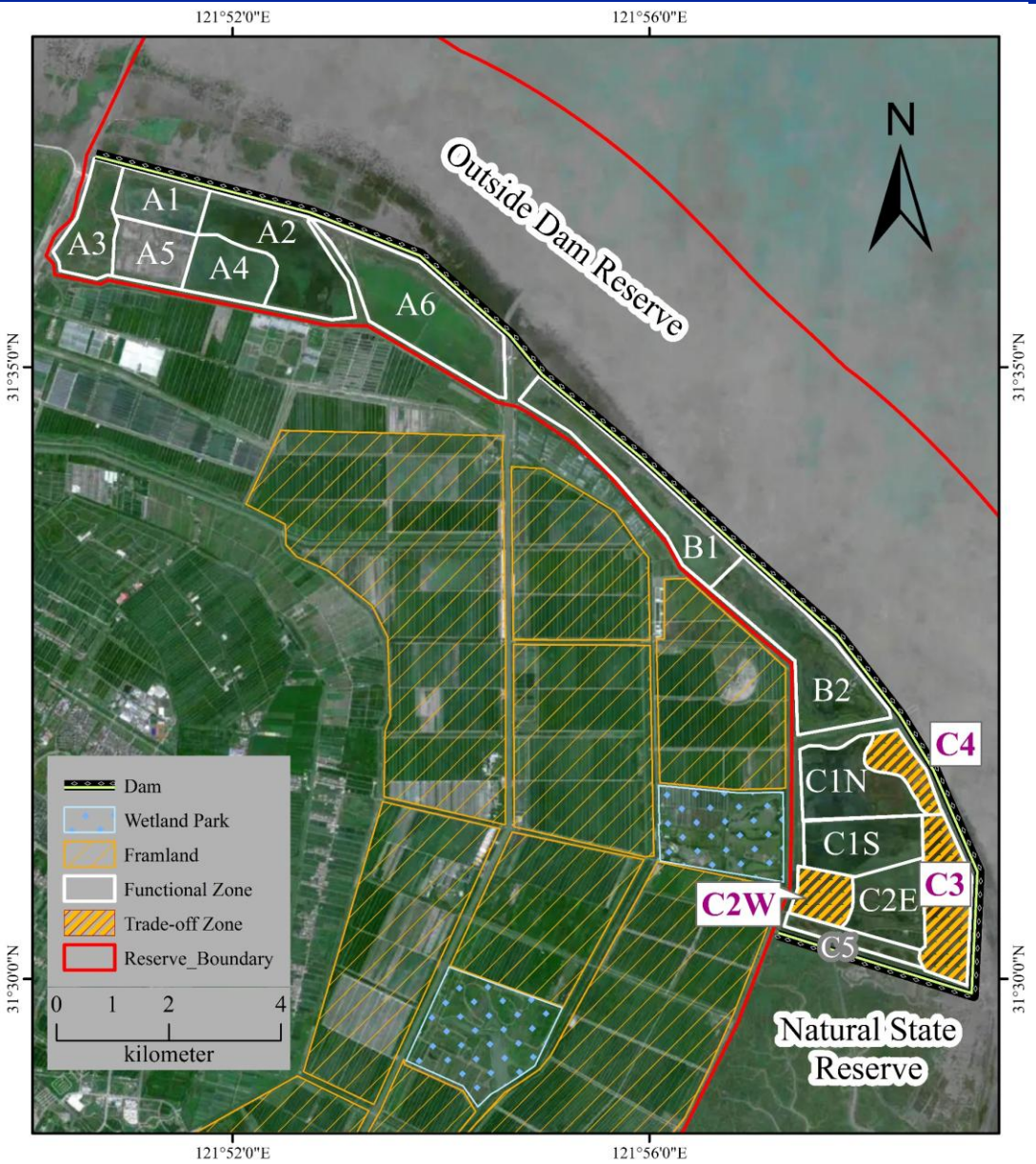
High-Low: this zone is mainly a permanent water distribution area and is judged to be ***synergistic***;

Non-Significant: the largest area, but based on the design of the functional area, it can be interpreted as ***synergistic*** because the two measures are not in conflict.

Conclusion:

Seasonal water level control and vegetation restoration, although they have **shown conflict on each other at some zone**, but **are generally in synergy with each other**.

Adaptive Management



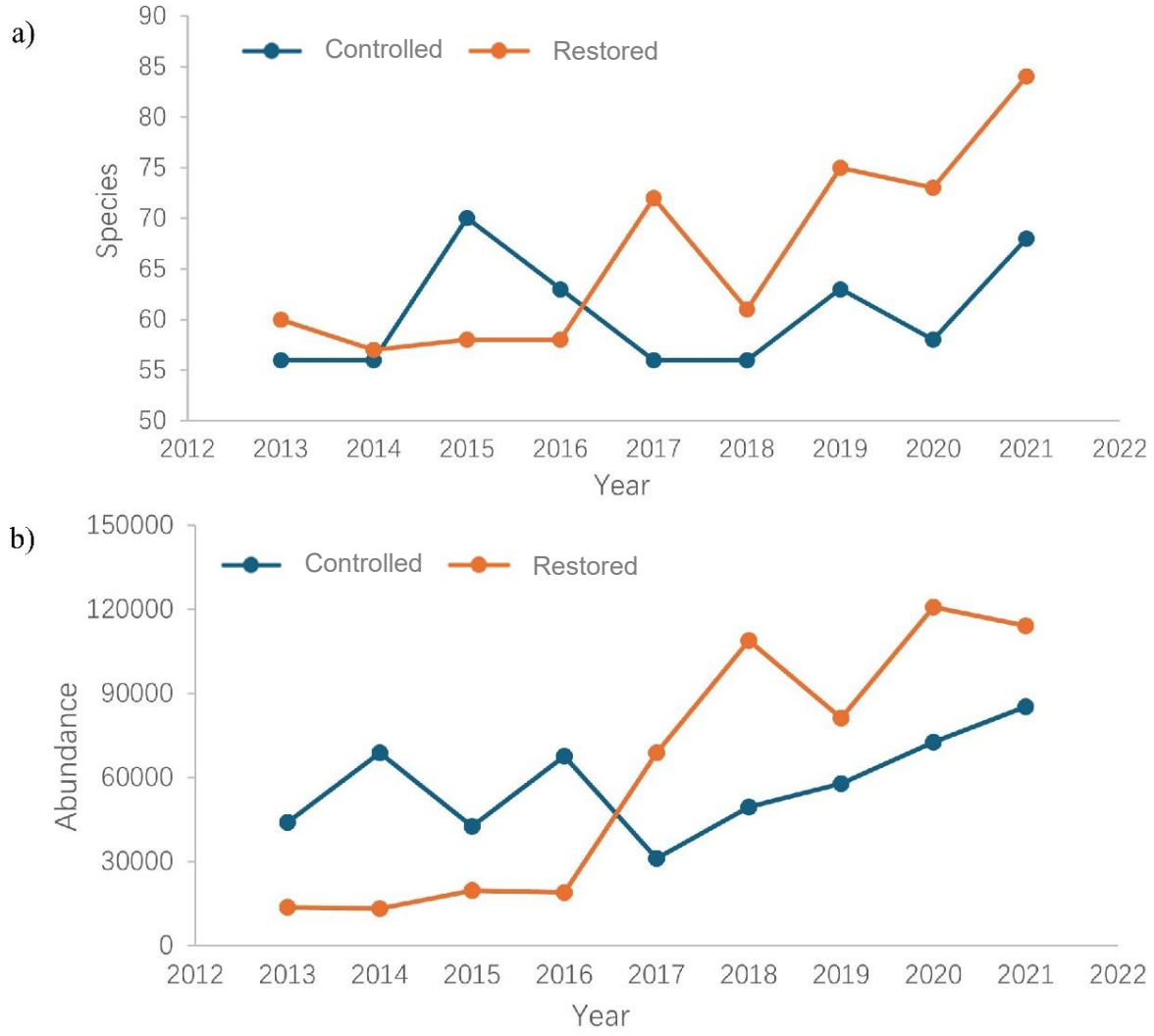


Fig S2 Changes of waterbirds in natural tidal flats and ecological restoration wetlands in Dongtan Reserve from 2013 to 2021: (a) Species; (b)Abundance.

Adaptive Management

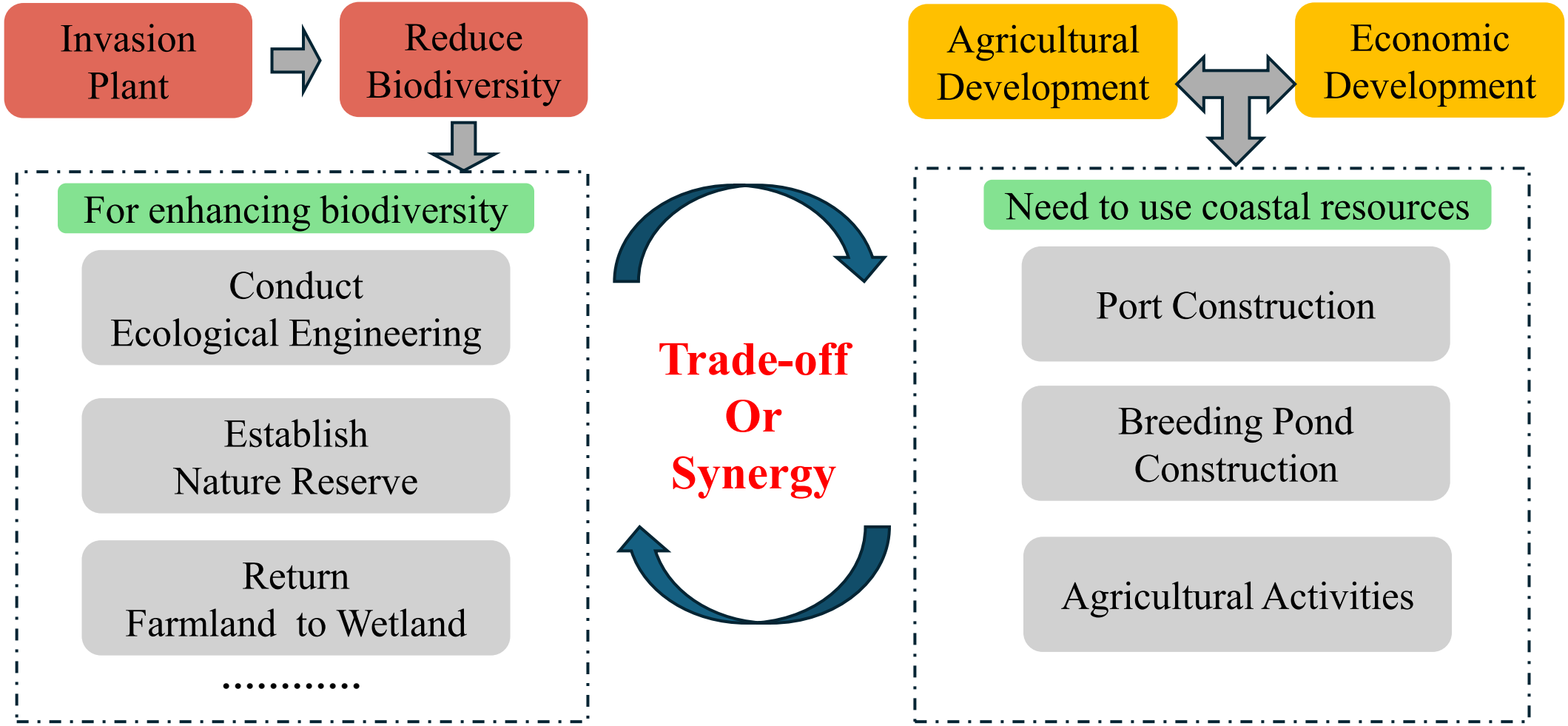
Conclusion:

- The two seasonal management measures are generally **synergistic** (~93%).
- The management measures considered different seasons and functional areas, is an **adaptive management** (Criteria7) measure that complies with the NbS.

Highlights:

- Need to be further moderated to make them more regular.
- For the regions after the *Spartina alterniflora* eradication, adaptative management measures are effective strategies.

Coastal Reserves' ESs



Coastal Reserves' ESs

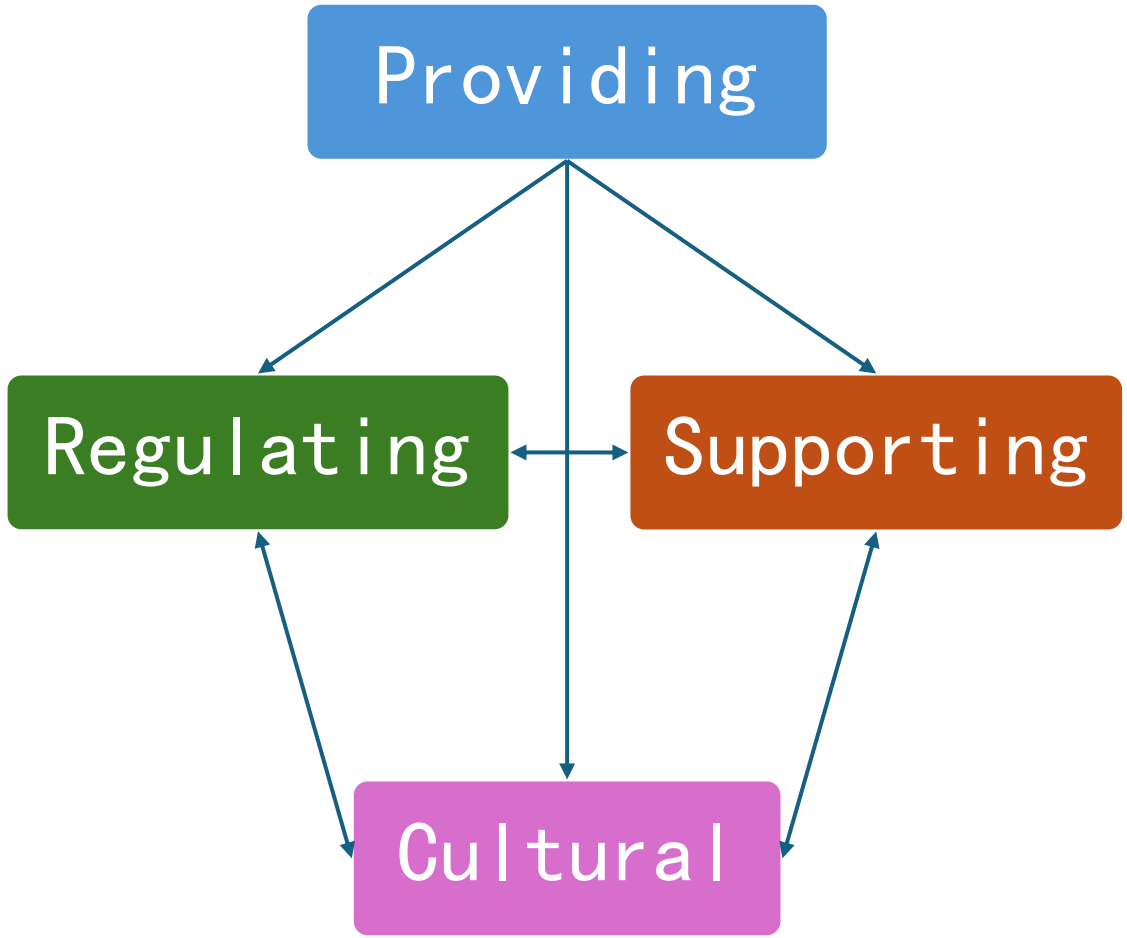
Science Issue：

Can coastal reserves both safeguard core ESs and generate measurable spillover benefits for adjacent landscapes?

Objectives：

- Quantify the spatial distribution of ecosystem services and their relationships;
- Identify spatial clustering patterns of ecosystem services;
- Assess the spatial influence of reserves on ecosystem services;
- Explore the effects of landscape diversity on the trade-offs and synergies of ESs.

Coastal Reserves' ESs



Eight Major Ecosystem Services in Coastal Zone

Providing Service:

Food Production, Water Yielding

Regulating Service:

Carbon Sequestration, Water Purification,

Water Conservation

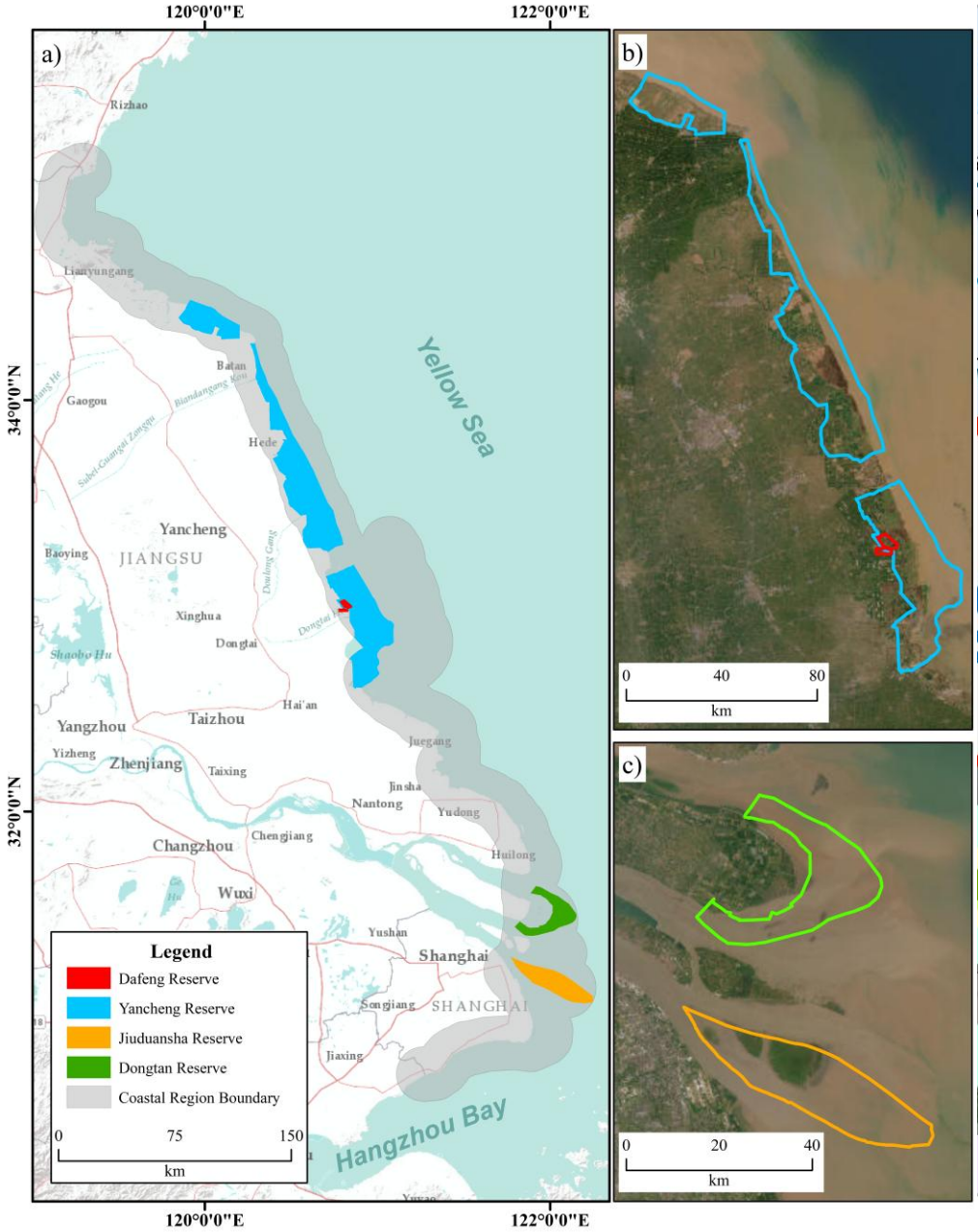
Cultural Service:

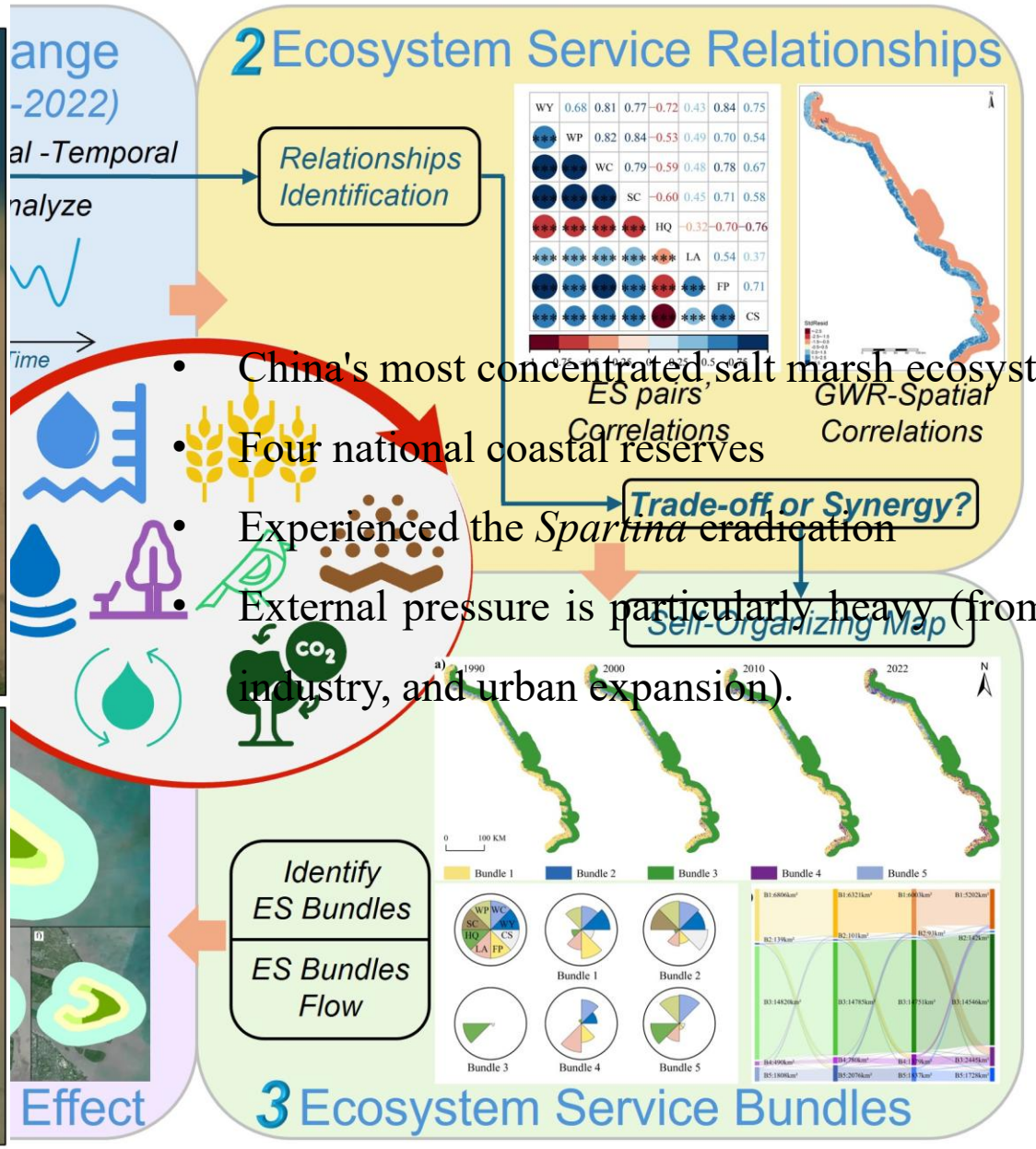
Landscape Aesthetic

Supporting Service:

Soil Conservation, Habit Quality

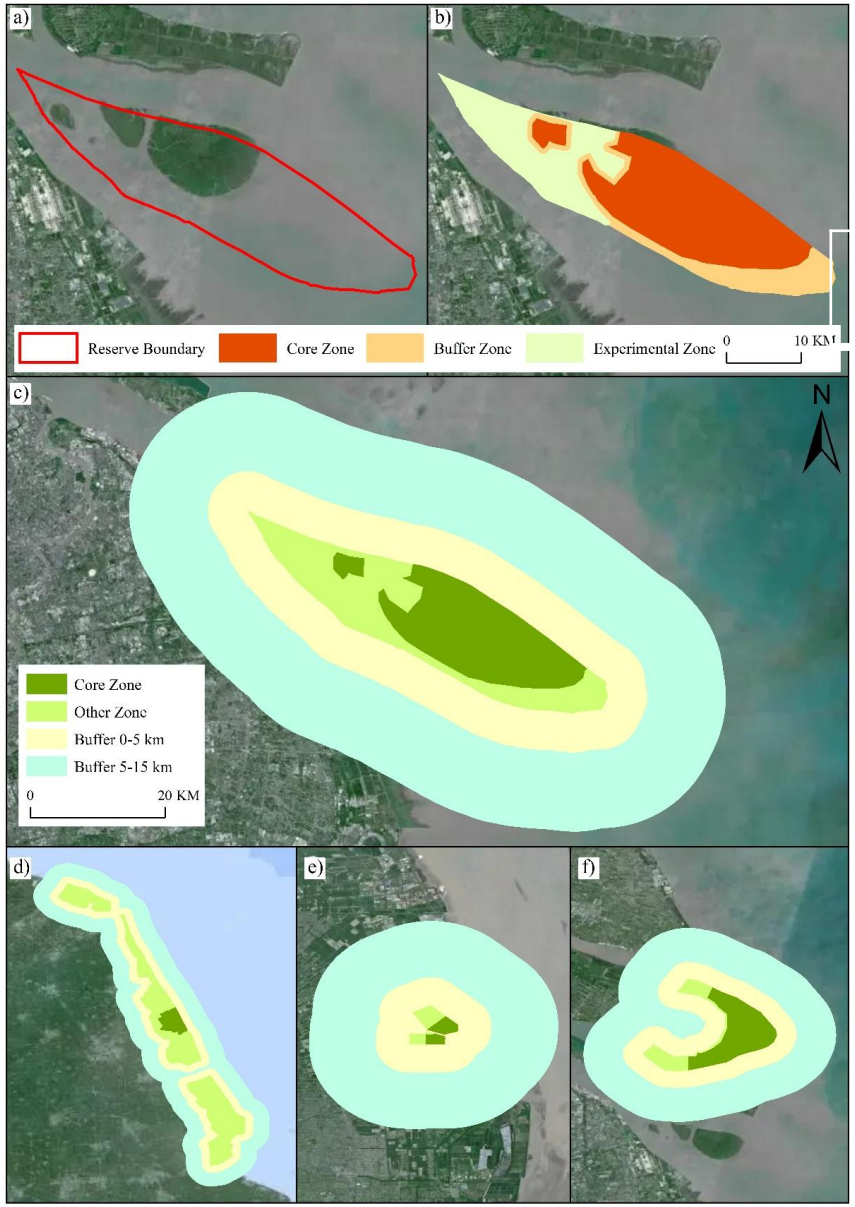
Coastal Reserves' ESs





- China's most concentrated salt marsh ecosystems (43%)
- Four national coastal reserves
- Experienced the *Spartina* eradication
- External pressure is particularly heavy (from agriculture, industry, and urban expansion).

Coastal Reserves' ESs

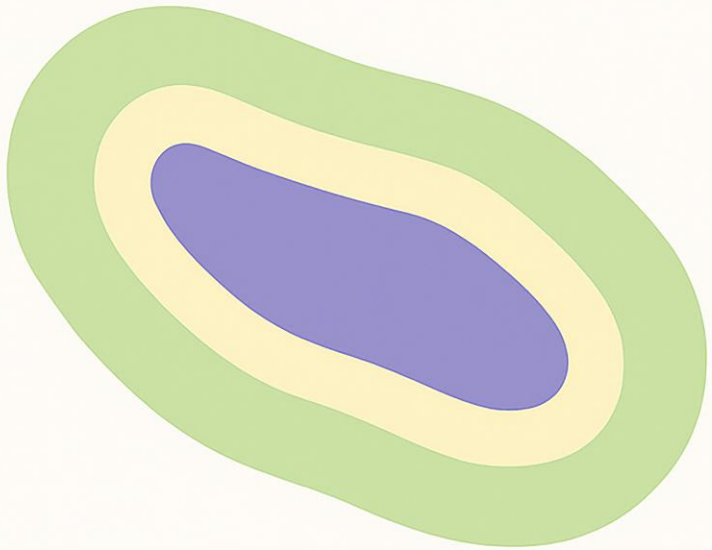


$$ATT = \bar{Y}_{Treatment} - \bar{Y}_{Control}$$

$$DID\_ATT=[(Y_{Core,Post}-Y_{Core,Pre})-(Y_{Out,Post}-Y_{Out,Pre})]$$

Reserve	Period	Carbon Sequestration	Habit Quality	Landscape Athestic	Ecological Land Use
Dafeng	1990↔2022	-0.037	0.096	0.055	0.108
Yancheng	1990↔2022	0.021	0.032	-0.029	0.067
Dongtan	2000↔2022	-0.001	0.021	0.017	-0.002
Jiuduansha	2000↔2022	0.019	0.088	-0.061	0.081

Coastal Reserves' ESs



Improvements in Ecosystem Services(1990-2022)

Habit Quality	+0.1179
Ecological Land Use	+0.1759
Carbon Sequestration	+0.0031
Landscape Aesthetics	-0.0356

Reserves generate positive spillover effects extending 15 km beyond boundaries.

Perspective

Confirmation - NbS approach in Reserves work best!

Current drawbacks:

- Huge financial expenditures;
- Unmanageable recurrence rate;
- Biodiversity has not been effectively enhanced;
- Salt marsh is eroding and dying out.
- …… ……

Our opinion:

Spartina alterniflora should not be eradicated entirely but should be selectively removed within coastal reserves and considered as part of regular management activities.

Thanks for your listening !

E-mail: dfxu22@m.fudan.edu.cn

17/12/2025