

Initialization of wetland offset market under development-restoration conflicts: the role of public offset credit supply

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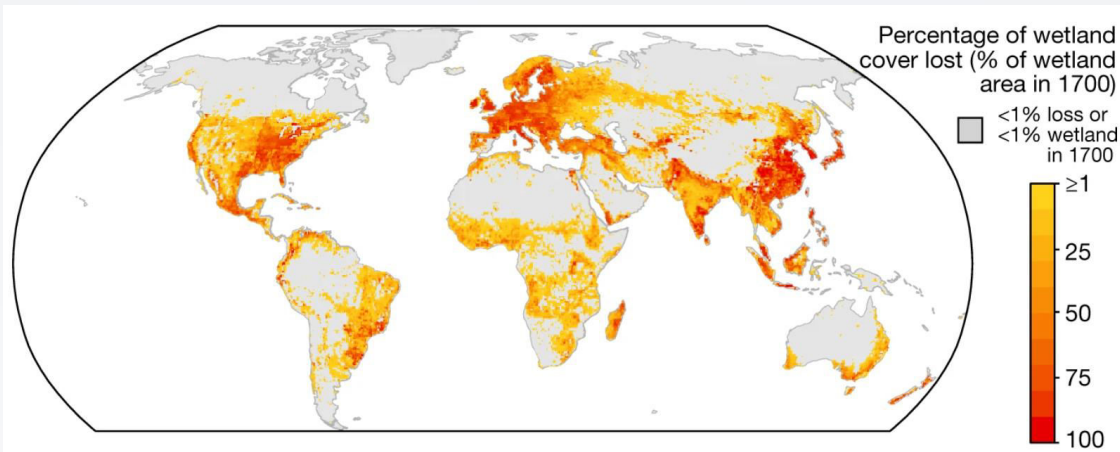
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Worldwide wetland areas notably decrease due to human activities.

"Since the year 1900, an estimated 64–71% of the natural wetland area worldwide has been lost due to human activity."

--The United Nations World Water Development Report 2018



Global wetland loss between 1700 and 2020 (Fluet-Chouinard et al., 2023. Nature 614, 281–286)

In developing countries:

Huge development needs

+

Limited investment in wetland restoration



How to coordinate increasing wetland development- restoration conflicts in developing countries?

Public good characteristics of ecological restoration



Dominating role of public sectors in ecological restoration

Limited fiscal capacity



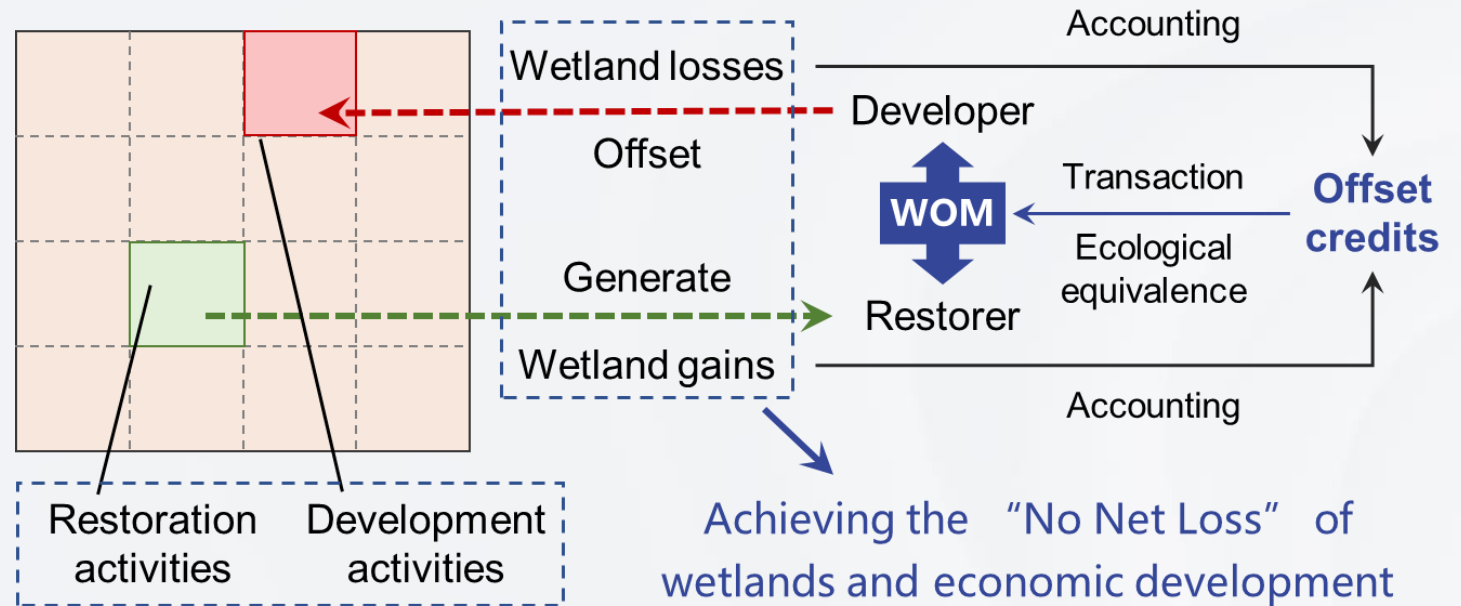
Imbalance between wetland development and restoration



How to motivate private restoration activities?

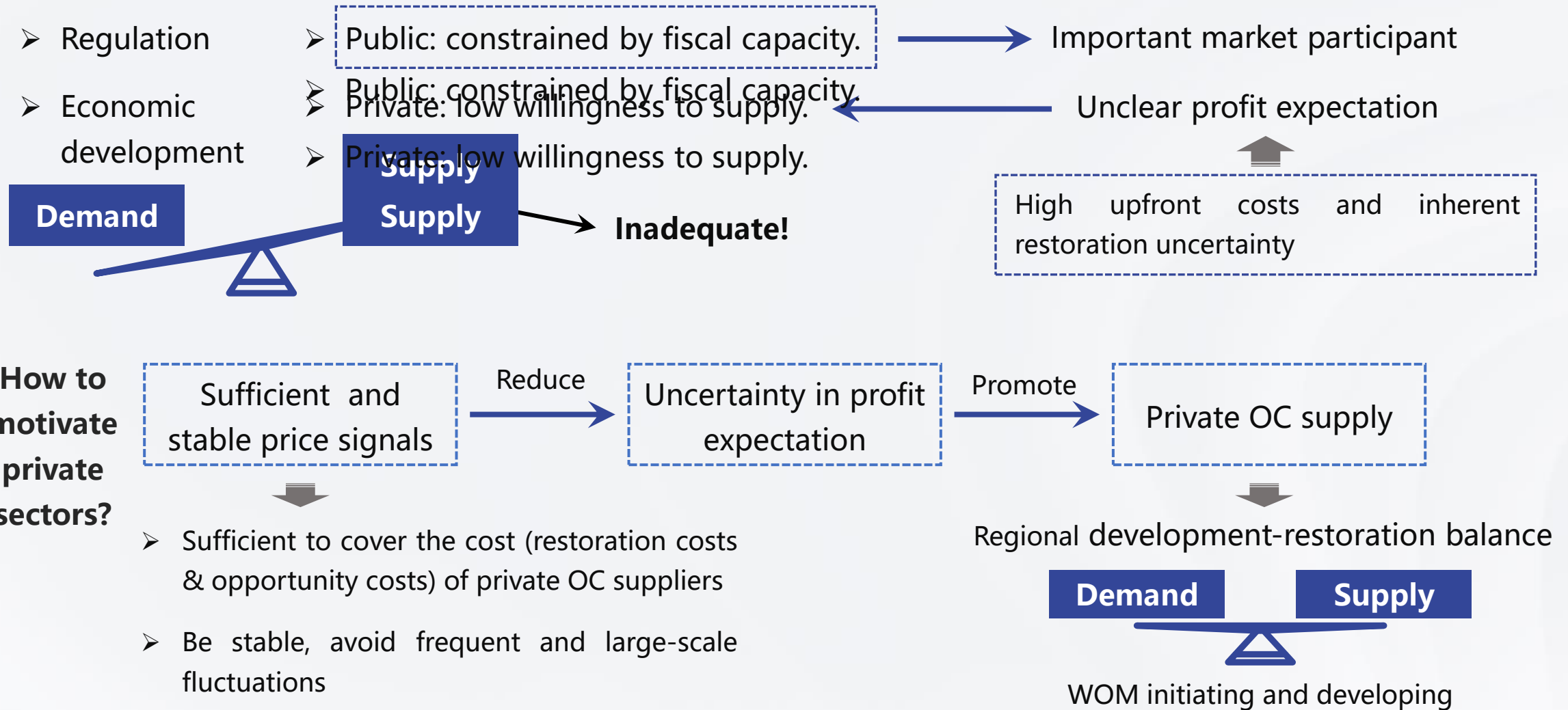
A promising tool: Wetland offset markets (WOMs)

Practices of tradable permits in the field of biodiversity offset, which are also called mitigation banking, conservation banking, biodiversity markets, et al.



Q1: How can WOMs be initialized and emerged in developing countries?

Basis for well-functioning WOMs: **sufficient supply and demand of offset credits (OCs).**



Q2: What is the role of public OC supply in providing and adjusting price signals in the early stage of WOMs?

Q3: What is the role of public OC supply in promoting WOMs development and achieving regional restoration-development balance?

General spatial agent-based WOM model



Compare WOM evolvment and wetland restoration-development dynamics

Without public
OC supply

With public
OC supply

Goal: What is the role of public OC supply in the formation of price signals and WOMs?

For simplification

Public OC supply pattern considered in the model:
same public OC supply amount each year sold at a uniform price (might be adjusted each year).

Model components

| Spatial agent | |
|--|---|
| Type | Main attribute |
| Economic parcel | <ul style="list-style-type: none"> • Location • Economic value of development • Ecological value |
| Original ecological (OE) parcel | |
| Restored ecological (RE) parcel (no redevelopment) | <ul style="list-style-type: none"> • Location • Ecological value |
| Spare parcel (no owner, only for restoration) | |
| Sea area (no owner) | <ul style="list-style-type: none"> • Location |

Affect

Government agent

Public OC price, public OC amount.

WOM agent

Matching OC transactions according to the discriminatory auction mechanism.

The amount of OC that can be generated from restoration

- RE parcels are not allowed to be redeveloped.

- Restoration uncertainty is considered

Affect

| Landowner agent | | |
|--------------------------------|--|---|
| Type | Main attribute | land use decision |
| Landowner with economic parcel | <ul style="list-style-type: none"> • Learning ability • Risk preference • Minimum profitability goal • Owned parcels | <ul style="list-style-type: none"> • Restore economic parcel • Buy and restore spare parcel |
| Landowner with OE parcel | | <ul style="list-style-type: none"> • Develop OE parcel • Buy and restore spare parcel |
| Landowner with RE parcel | | <ul style="list-style-type: none"> • Buy and restore spare parcel |

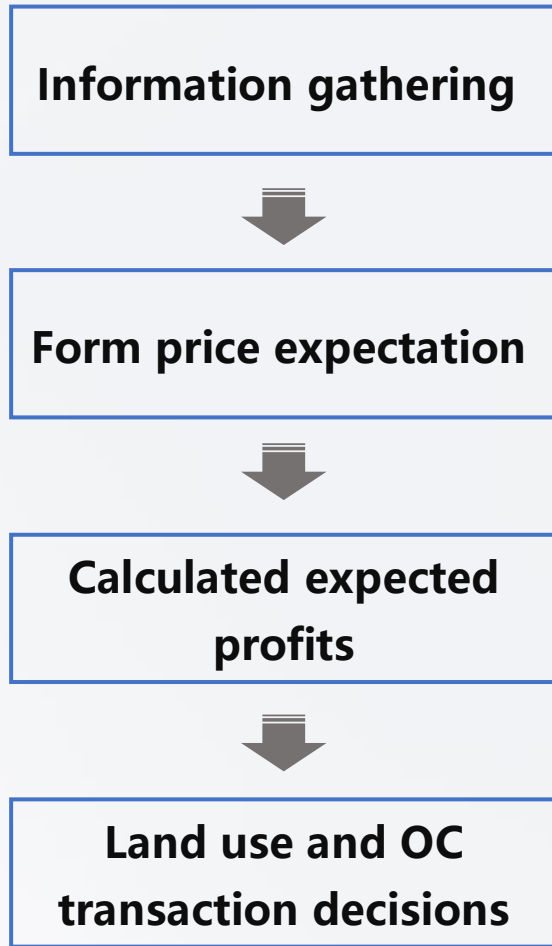
Environment

➤ Geographical:

Coastal region, ecological spatial agglomeration impacts, economic distance impacts, economic & ecological value distribution...

➤ Economic (data from Yellow River Delta):

Economic growth rate, restoration costs, ...



Three kinds of price signals:

- Individual price information
- **Market-based price expectation**
Neighbors' price information

➤ **Market developers (OE parcel owners)**, i.e., potential buyers: infer the minimum acceptable price;

Potential restorers (can be any kinds of landowner agents), i.e., potential sellers: Infer the maximum acceptable price;

➤ **OE parcel owners**
Gains from keeping OE parcel (no gains);

Adapted according to OC supply-demand ratio and previous transaction or bid price.

Gains from developing OE parcel via buying and restoring spare parcels;

Gains from developing OE parcel via buying OCs;

Gains from buying and restoring spare parcels without developing (as OC supplier).

- **Final price expectation (i.e., bid price)** is the weighted sum of the above two price.
- **Economic parcel owners**

Gains from keeping the economic parcel;

A minimum profitability goal is set according to price variation observed

by landowner agents, in which landowners' risk preference is considered.

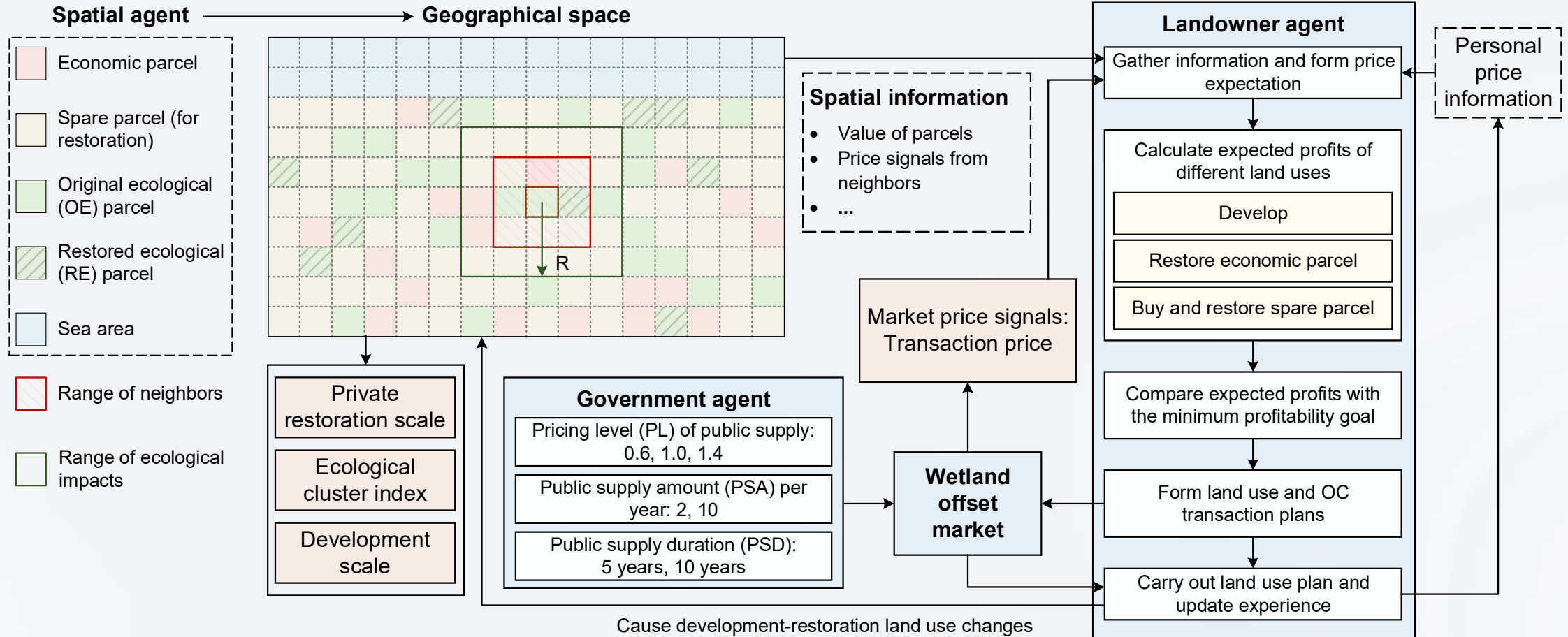
Gains from buying and restoring spare parcels while keeping own economic parcel.

Restoration plan is chosen **only if** the gains from restoration exceeds the

- **RE parcel owners**: Gains from buying and restoring spare parcels.

minimum profitability goal.

Model flowchart

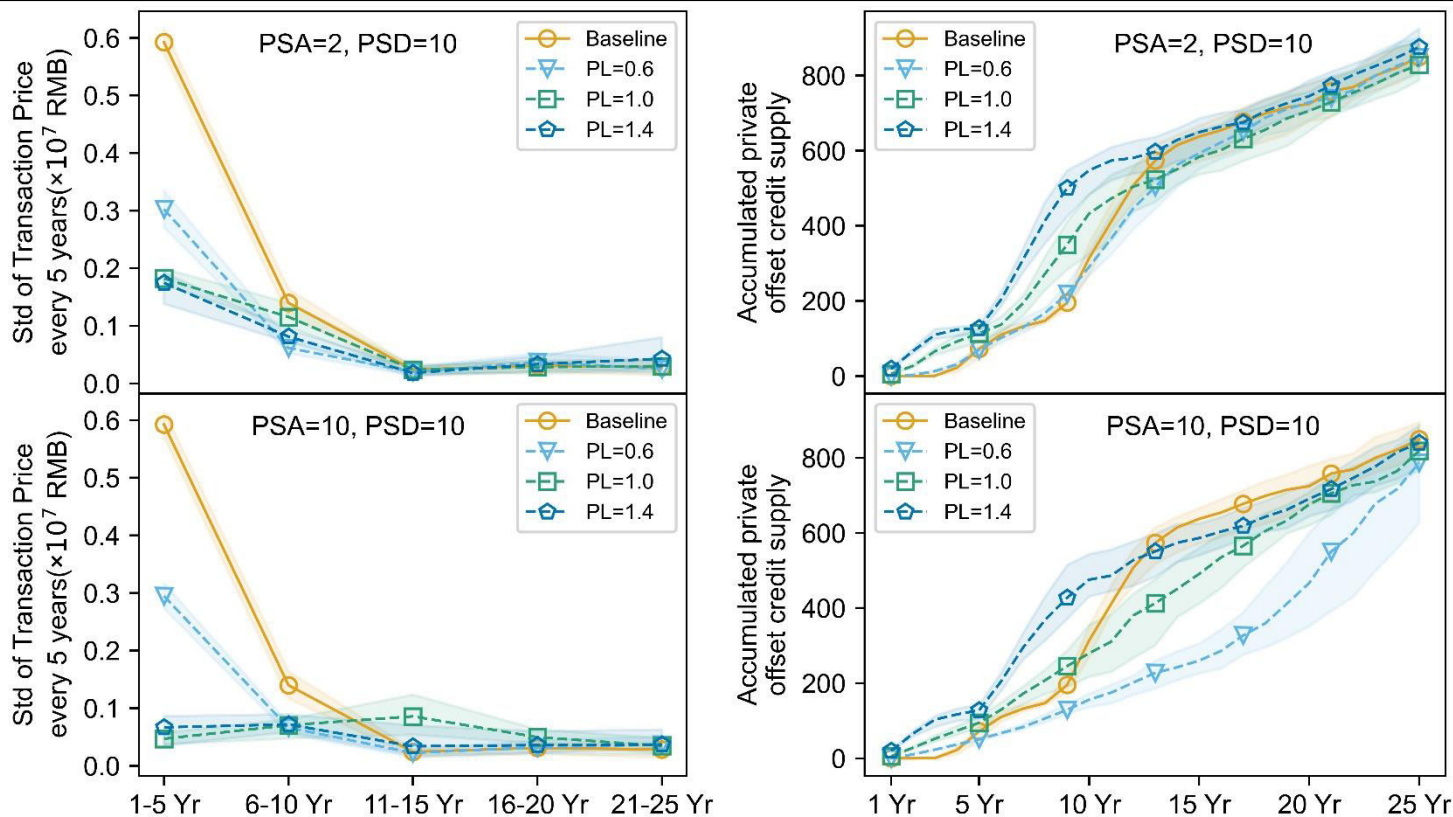


The pricing level of public OC: different ratios used to multiplied with the averaged economic value of all economic parcels.

Ecological cluster index: averaged percentage of all restored parcels' nearby ecological parcels.

Market results

| Scenario | Market appearance time (year) [median (lower quantile, upper quantile)] |
|-------------------------------------|--|
| Baseline (without public OC supply) | 2 (2, 2.25) |
| Scenarios with public OC supply | 0 (0, 0) |



Figures are plotted with the median and 25-75 quantile of 50 runs of each scenario.

In the short term, the price signal from public OC supply:

- Accelerates the formation of the WOM.
- Reduces the variation of transaction price at the early stage, especially with higher pricing level (PL) of public OC.
- Attracts more private restorers and OC supply, especially with higher PL of public OCs.

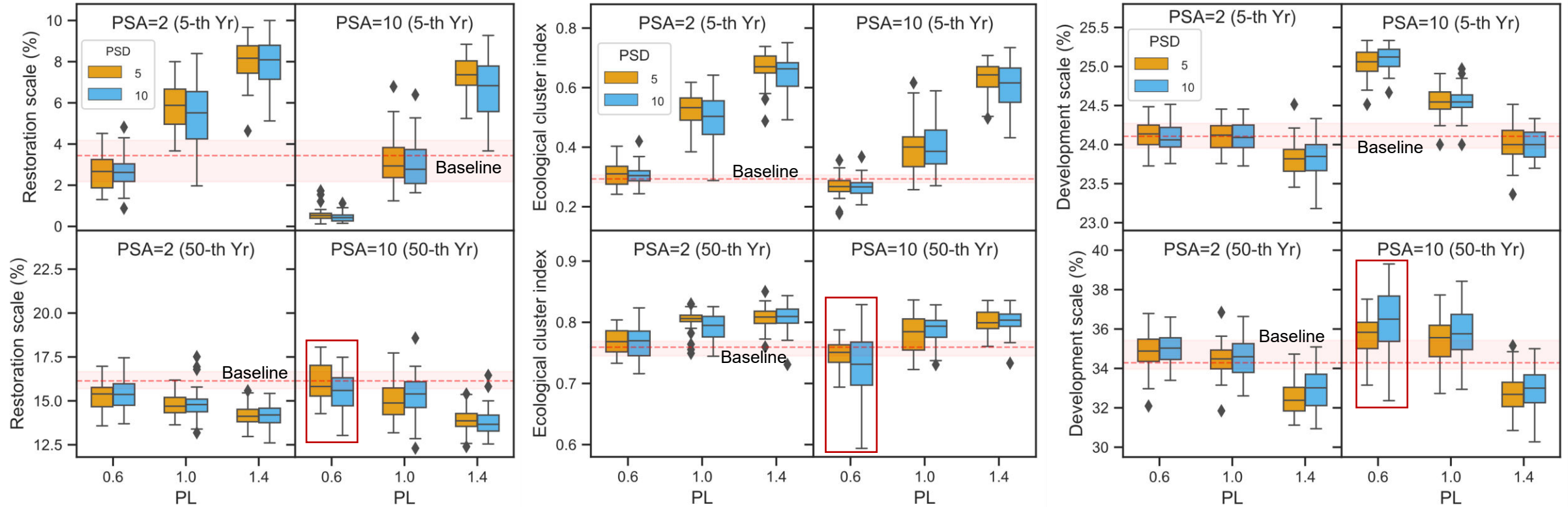
In the long term, public OC supply might extrude private OC supply, especially with higher public supply amount (PSA) and lower PL of public OC.

PL - the pricing level of public OCs

PSA - the public supply level per year

PSD - the duration of public supply

Regional Ecological & Economic results



In the short term: the promotion effect on private restoration of public OC can greatly affect regional development.

In the long term:

- Public OC supply can cause extrusion on private restoration activity especially with higher PL and lower PSA.
- Public OC supply can significantly increase the clustering of restored parcels, especially with higher PL.
- High PL can greatly reduce development scale as well as the private restoration scale.
- Both restoration scale and development scale can be increased under lower PL(=0.6), higher PSA(=10) and shorter PSD(=5 yr).

- The price of public OC **provides vital price signals** in the early stage of WOMs, which can accelerate the formation of WOMs and reduce the price variation.
- The public OC supply performs differently at different timescale, and the government needs to be cautious with the possible **extrusion impacts** of public OC supply on private restoration activity in the long term.
- The public OC supply is **an effective tool in promoting the spatial cluster of restoration activities**.
- The private restoration scale and development scale **can both be increased** with the existence of public OC, while the price, amount and duration of public OC supply need to be carefully designed.

Thank you for your kind attention!

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