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Five-year satellite monitoring of *Suaeda japonica* aboveground biomass in a Korean salt marsh using a parsimonious model

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Introduction

- Salt marshes store carbon far out of proportion to their area and are central to blue carbon climate mitigation.
- *Suaeda japonica*, an annual pioneer halophyte of the western Korean coast, grows in small fragmented stands. Biomass and carbon baselines remain scarce because intertidal field sampling is difficult.
- Its canopy flushes deep red with betacyanin, a spectral signature distinct from the bare tidal flat.
- A reproducible way to record its biomass and carbon stock is needed for blue carbon accounting and conservation.



Suaeda japonica: stand (top) and plant (bottom)

AIM Test whether a deliberately parsimonious satellite model, calibrated from only **30 field quadrats**, can map *S. japonica* aboveground biomass (AGB) and carbon across Garorim Bay, Republic of Korea.

Materials and Methods

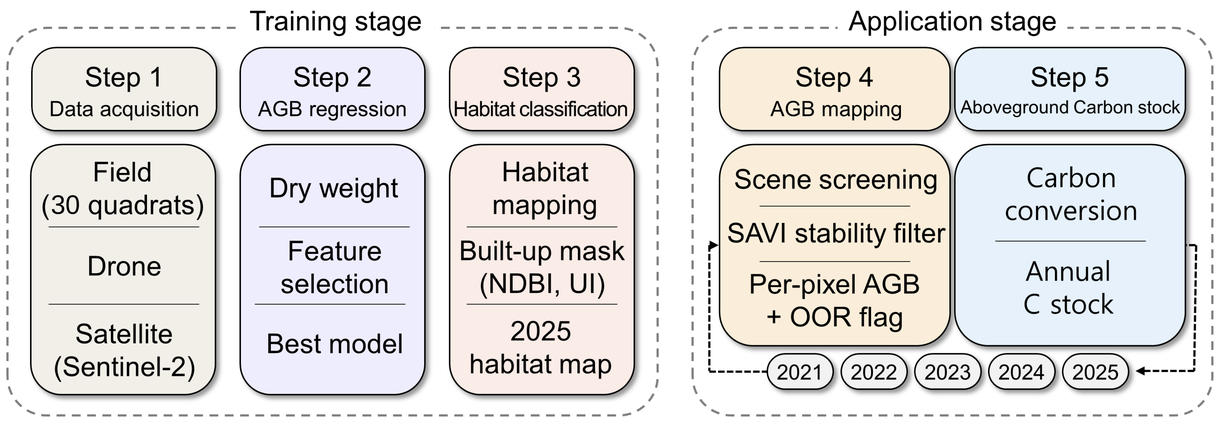

Fig. 1. Workflow: models are calibrated for 2025 (training), then applied to screened 2021–2025 scenes (application).

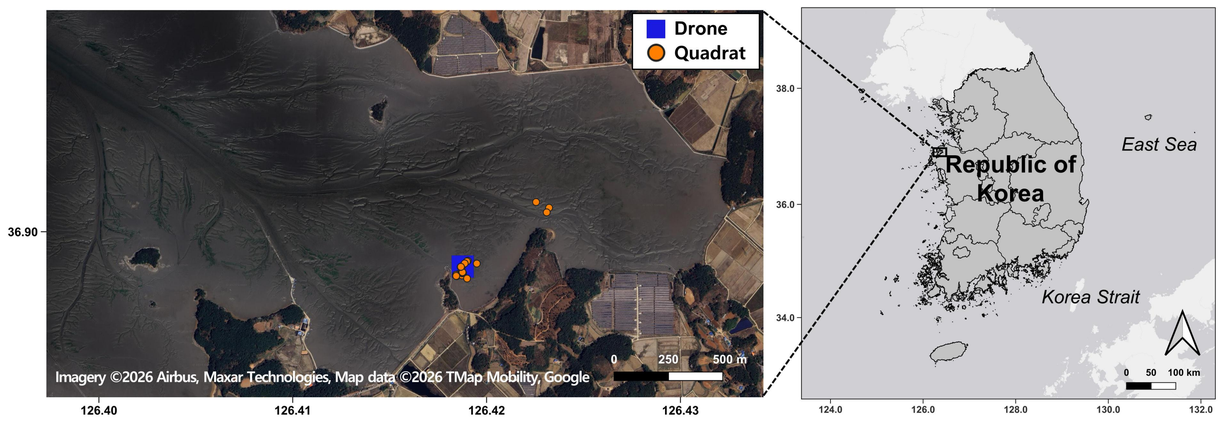

Fig. 2. Study area in Garorim Bay, west coast of the Republic of Korea: 30 field quadrats (orange) and UAV mapped *S. japonica* patches (blue, 390 m²).

Field and UAV

30 quadrats (1 m²) harvested on 11 Aug 2025, dried at 60 °C for 48 h. UAV orthomosaic (DJI Mavic 3M); patches digitized.

Satellite

Sentinel-2 L2A in Google Earth Engine; reference scene 25 Jul 2025. 10 bands and 21 spectral indices as candidate predictors.

Model selection

AGB: 5 regression algorithms × 1-5 predictors, leave one out CV (LOOCV). Habitat: 3 classifiers, leave one polygon out CV.

Application, 2021-2025

One screened growing season scene per year, no recalibration. SAVI stability filter; out of range (OOR) flag; carbon = AGB × 0.47.

Results

1 A single band model matches complex models

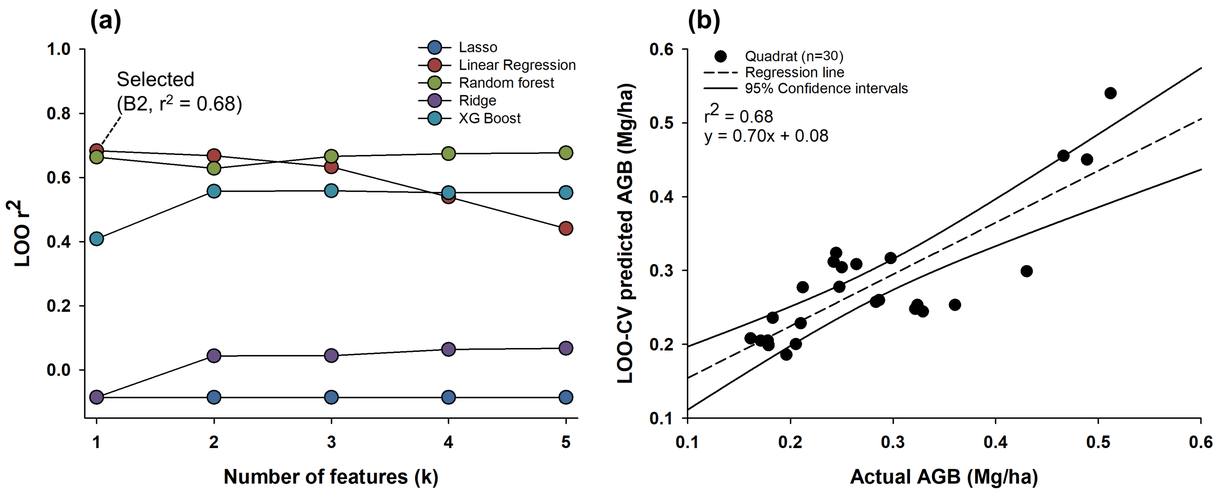

Fig. 3. (a) LOOCV r^2 by number of predictors for five algorithms. (b) Predicted versus measured AGB (n = 30).

- Linear regression on blue reflectance (**B2**) alone gave the best LOOCV skill: **r^2 = 0.684**, RMSE = 0.056 and MAE = 0.047 Mg·ha^{-1}.
- A random forest with five features was comparable (r^2 = 0.677): XGBoost reached 0.562, while ridge and lasso failed ($r^2 \leq 0.07$).
- B2 had the strongest correlation with AGB (|r| = 0.85): blue reflectance drops as the sparse canopy covers bright sediment.

2 Classifier choice needs a spatial plausibility check

Table 1. Habitat classifiers with one predictor (RVI).

Classifier	Accuracy	F1	Pixels
Logistic regression	1.000	1.000	31,160
Random forest (selected)	**0.941**	**0.970**	**7,404**
Gradient boosting	0.941	0.970	7,404

- Logistic regression scored a perfect F1 but mapped about **four times more pixels**, absorbing bare mudflat.
- Random forest with RVI alone: **94.12% accuracy**, F1 = 0.970, stable extent.
- After masking: 3,291 pixels (41.09 ha).

3 2025 baseline: biomass and carbon stock

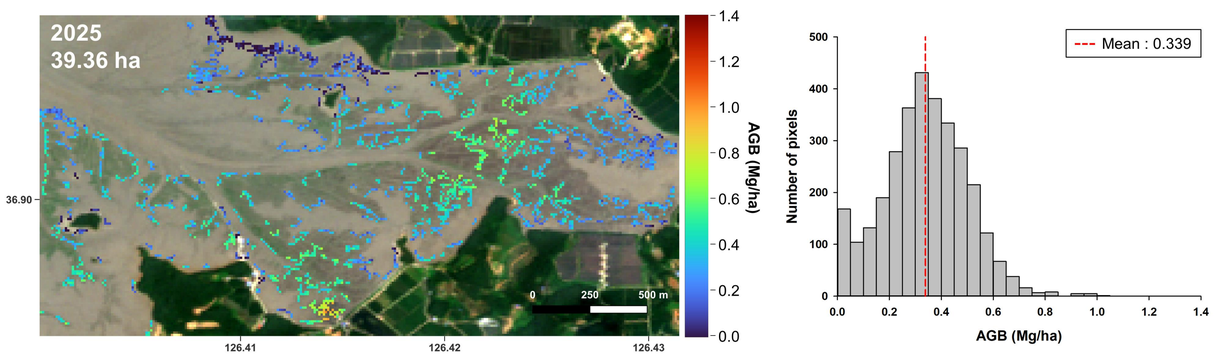

Fig. 4. *S. japonica* AGB over the stable habitat in 2025 and its pixel frequency distribution. Contains modified Copernicus Sentinel data [2025].

39.36 ha stable habitat

0.339 ± 0.162 mean AGB ± SD (Mg·ha^{-1})

13.34 Mg total AGB

6.27 Mg C carbon stock (95% CI 4.13-8.41)

- Biomass concentrates along **broad tidal channel banks**; pixels above 0.5 Mg·ha^{-1} cover 15.4% of the habitat, above 0.7 Mg·ha^{-1} only 1.3%.
- The habitat is highly fragmented: narrow elongated patches, the largest only 1.42 ha (3.6% of the area).

4 2021-2025: exploratory reconstruction of AGB and carbon stock without recalibration

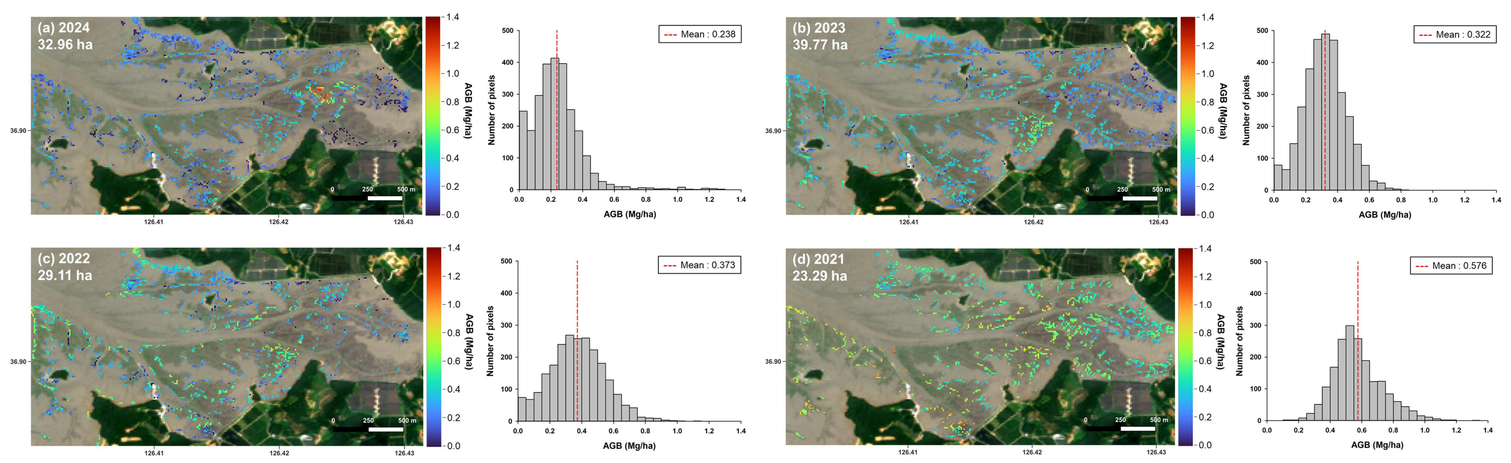

Fig. 5. *S. japonica* AGB over the stable habitat for (a) 2024, (b) 2023, (c) 2022 and (d) 2021, with pixel frequency distributions. Contains modified Copernicus Sentinel data [2021–2024].

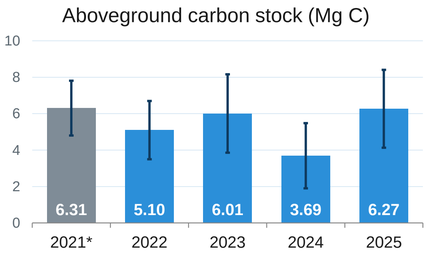

Fig. 6. Annual carbon stock; whiskers show the 95% CI. *2021 lies outside the applicability domain.

Table 2. Stable habitat, AGB and OOR.

Year	Area (ha)	Mean AGB	OOR (%)
*2021**	*23.29*	*0.576*	*63.3*
2022	29.11	0.373	31.1
2023	39.77	0.322	18.2
2024	32.96	0.238	34.6
2025	**39.36**	**0.339**	**27.2**

Mean AGB in Mg·ha^{-1}. OOR: share of habitat pixels outside the calibration AGB range (0.16–0.51 Mg·ha^{-1}).

- Carbon stock ranged **3.69-6.27 Mg C in 2022-2025** with no directional trend, as expected for an annual rebuilt from seed each year.
- 2021 is dominated by extrapolation: 63.3% of pixels fall outside the calibration range and the scene failed the bare flat screening.
- No field data exist for 2021-2024: an exploratory reconstruction, not a validated record.

Conclusions

1 Simple can be enough

From only 30 quadrats, one predictor for regression (B2) and one for classification (RVI) performed as well as complex models.

2 First baseline for *S. japonica*

Garorim Bay held 6.27 Mg C aboveground (95% CI 4.13-8.41) across 39.36 ha of stable habitat in 2025.

3 Protect channel margins

The highest AGB sits on broad tidal channel banks, a priority for conservation and blue carbon management.

4 Recalibrate before transfer

Coefficients are site specific. Next: calibrate across seasons and sites; add belowground biomass and sediment organic carbon.

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