

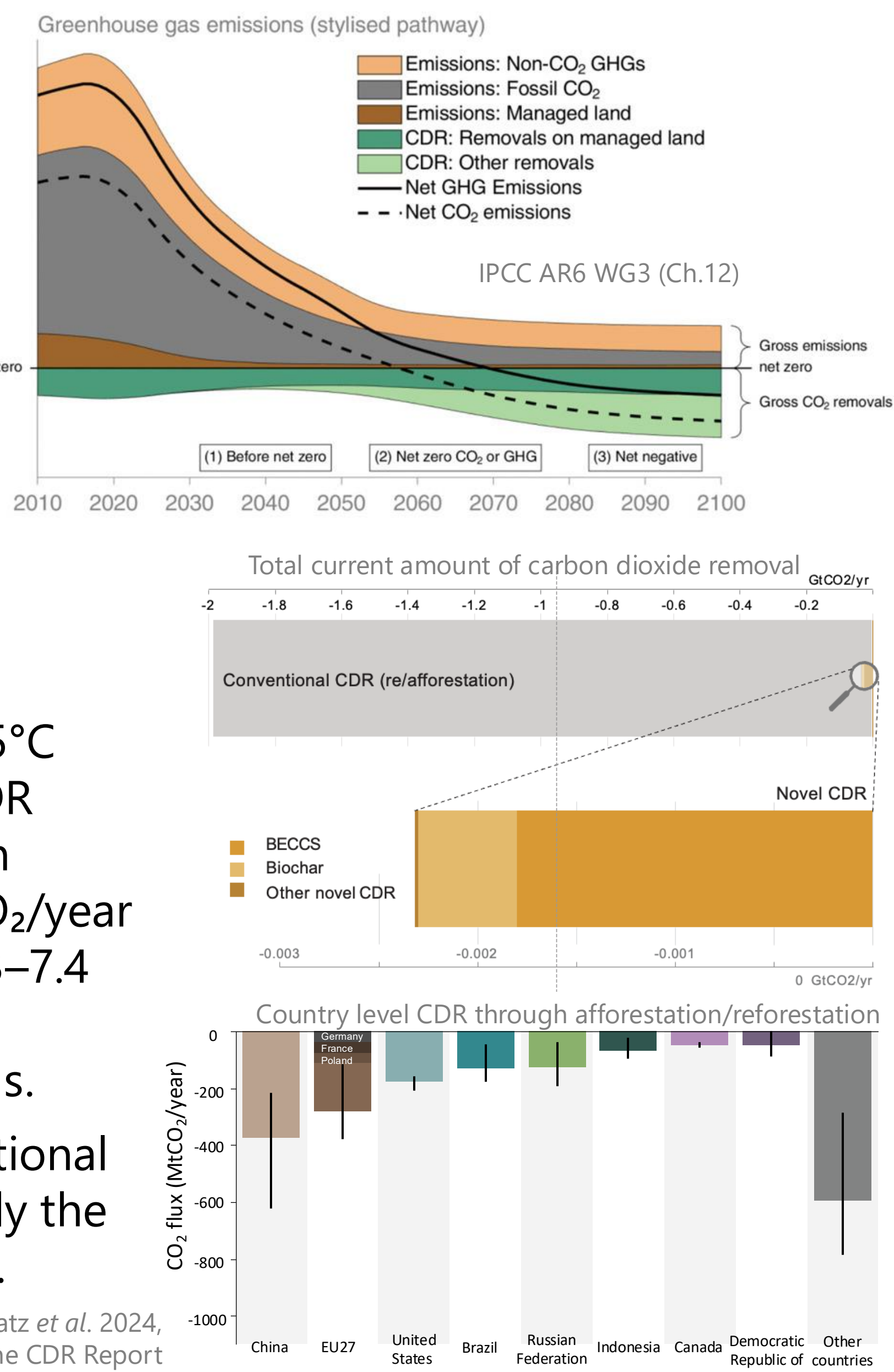
Scaling Carbon Dioxide Removal Effectively: Insights from Earth System Modelling, Interdisciplinary Assessment, and Global Tracking

Shraddha Gupta^{a,b}, Yiannis Moustakis^a, Sabine Egerer^a, Tobias Nuetzel^a, Clemens Schwingshackl^a, Felix Havermann^a, Julia Pongratz^{a,c}

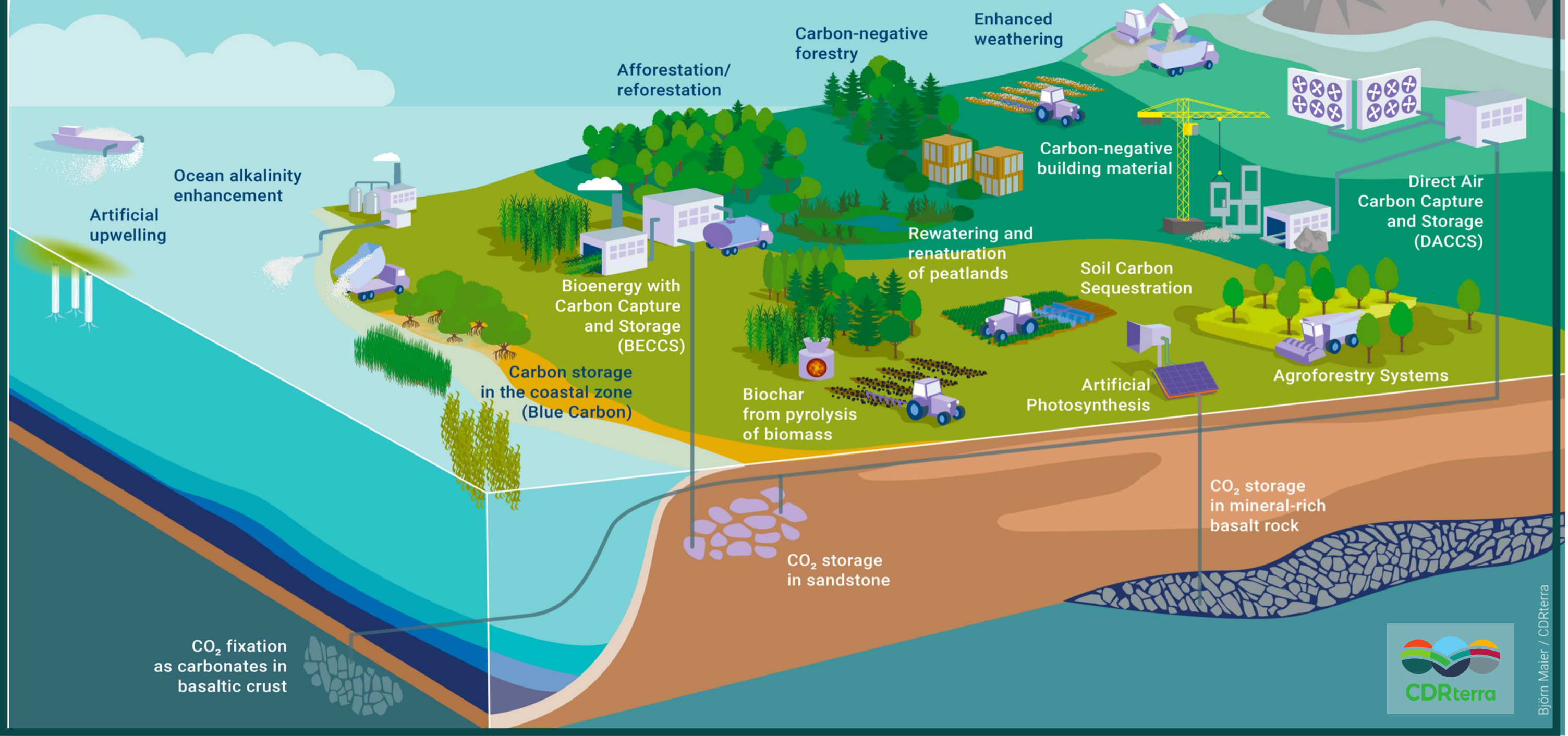
A **diverse CDR portfolio** enables **scalable deployment** while reducing risks and minimizing unintended side effects.

Scaling up CDR is essential to meet climate goals

- All 1.5°C scenarios consistent with the Paris Agreement combine deep near-term emission cuts with CDR in multiple roles.
- However, emission reductions continue to lag behind what is needed, and a clear CDR gap exists between current national proposals and most 1.5°C-consistent pathways.
- Currently, more than 99.9 % of all CDR is through A/R.
- Limiting warming to 1.5°C through sustainable CDR deployment requires an additional 1.0–2.9 GtCO₂/year of CDR by 2030 and 2.3–7.4 GtCO₂/year by 2050, compared to 2020 levels.
- The most ambitious national proposals approach only the lower end of this range.



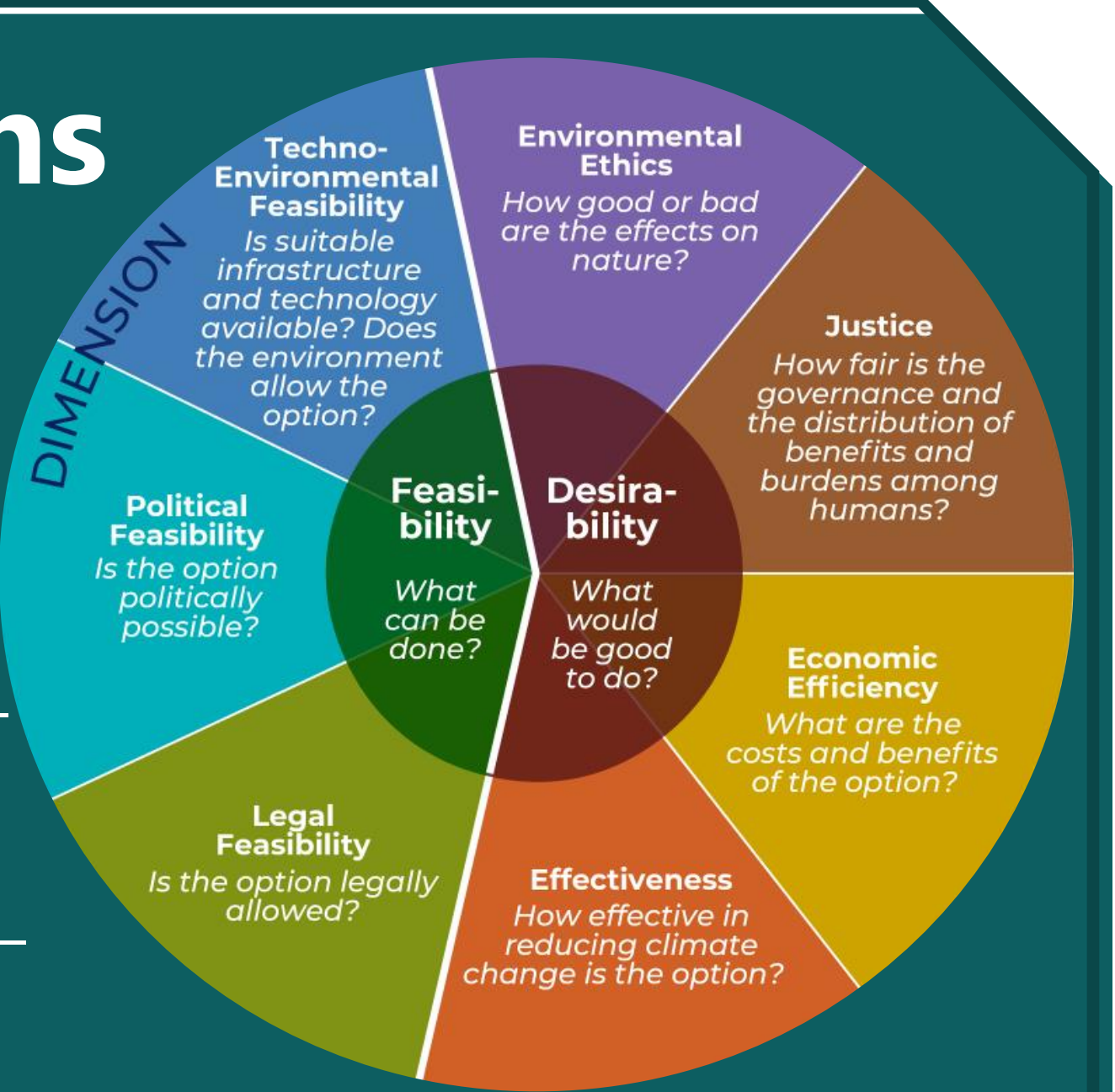
Methods of CO₂ Removal (CDR)



Assessing CDR options

Robust planning requires assessing both **how feasible** and **how desirable** a CDR method is. This includes technical, legal, and political readiness, as well as social, ethical, and environmental impacts.

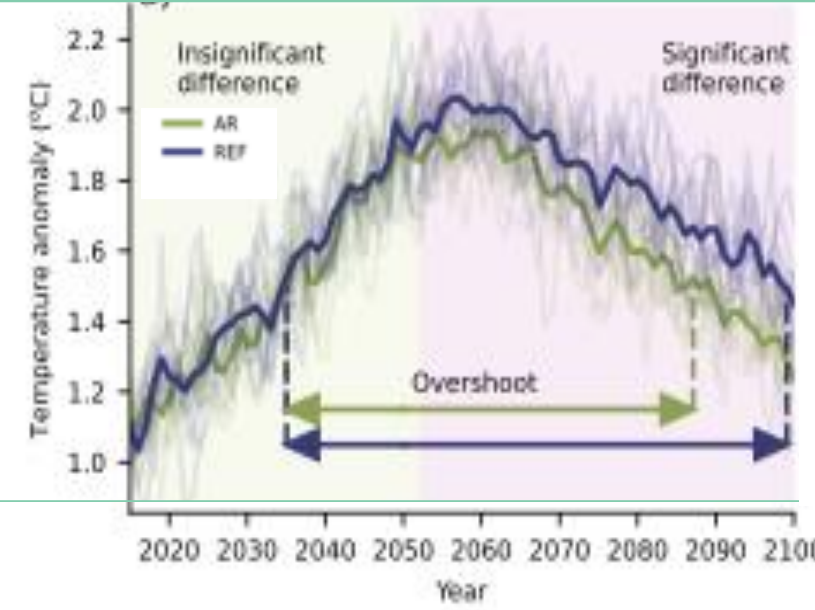
This framework supports transparent, evidence-based comparisons by considering not only whether a marine CDR method **can be implemented**, but also whether **it should be** — based on its impacts on people, biodiversity, ecosystems, and long-term sustainability.



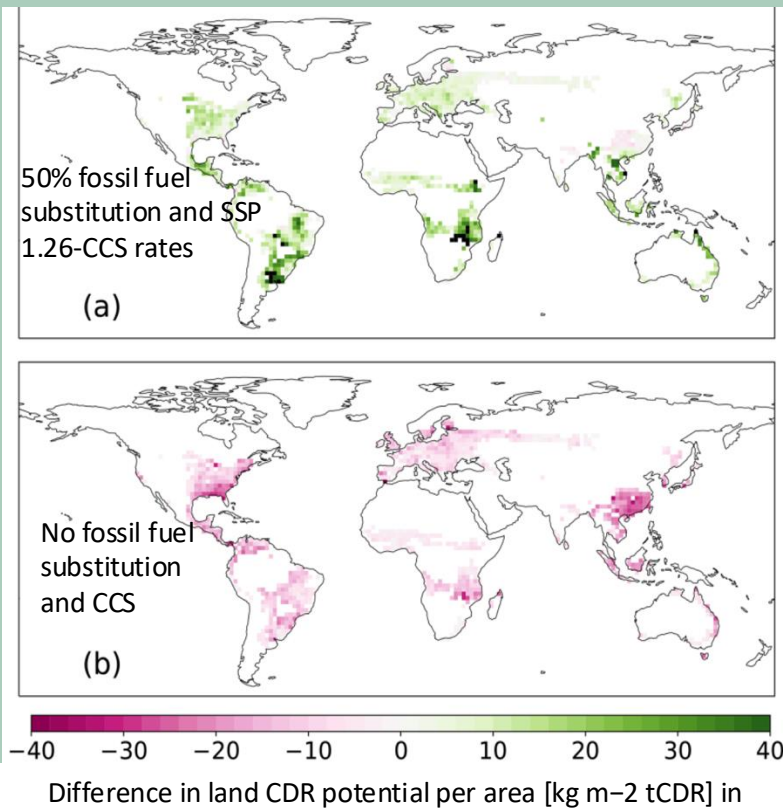
Adapted from Baatz et al. 2025, Graphic: Rita Erven, CDRmare and the ASMASYS team

What do Earth System Models reveal about CDR effectiveness?

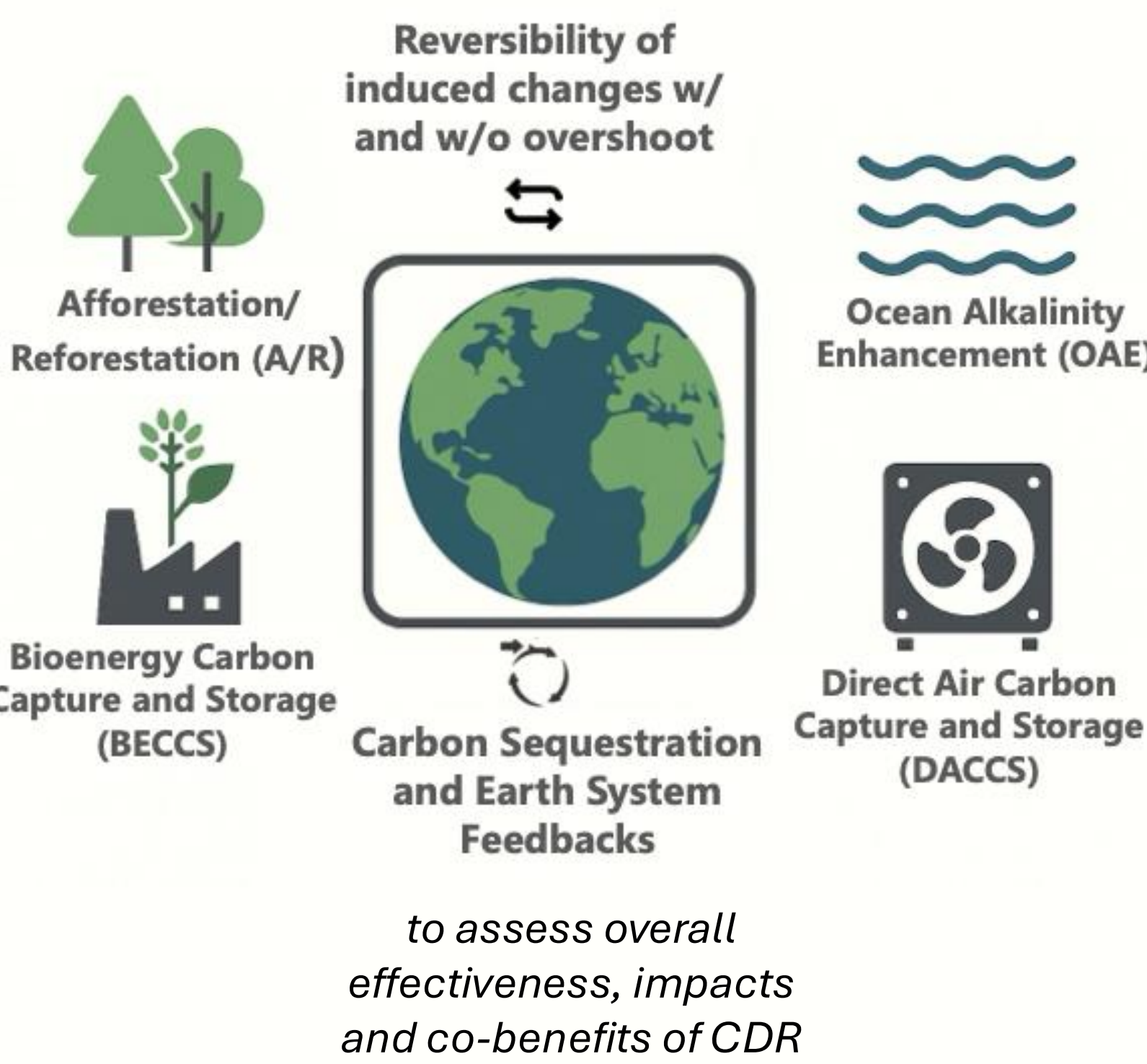
Ambitious re/afforestation aligned with ambitious country pledges (595 Mha A/R in 2060, 935 Mha by 2100) reduces overshoot (by 0.08°C) and speeds up temperature recovery (~13 yrs) but delivers only modest global cooling (0.2°C by 2100)—highlighting its role as a valuable complement to, not a substitute for, rapid emissions cuts. Moustakis et al. 2024



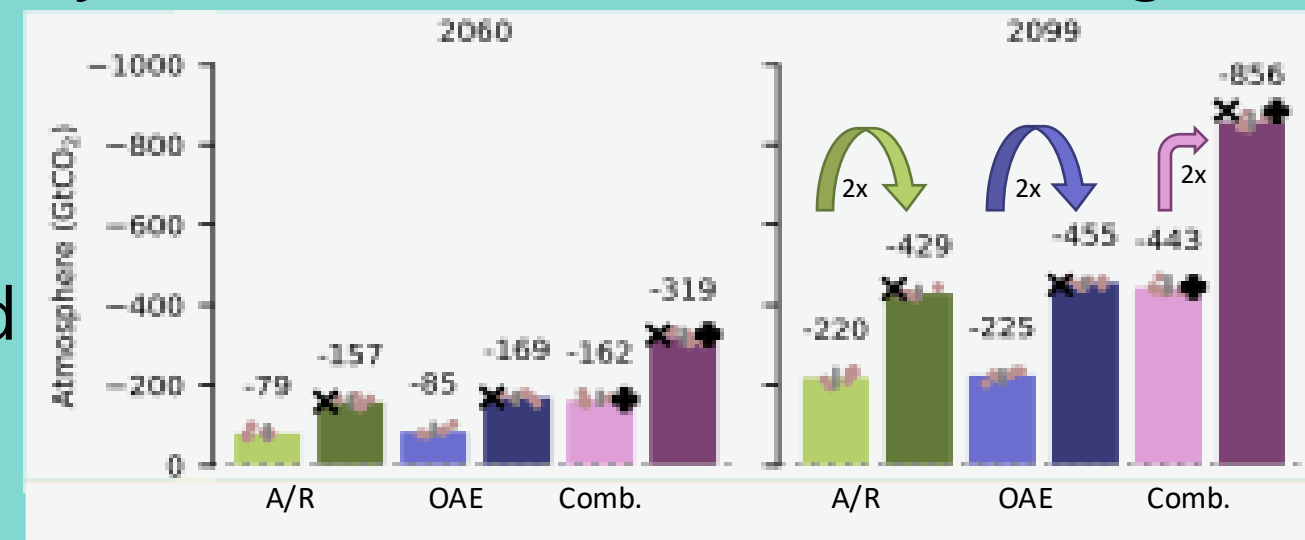
Bioenergy crops vs A/R. The CDR potential of A/R is greater than that of BECCS for short- and medium-term climate targets. On long term, bioenergy plantations may be more efficient — but only upscaling of CCS facilities and with high fossil fuel substitution. Egerer et al. 2024



Planned Multi-Model Simulation Framework to Evaluate Diverse CDR portfolios



Combining terrestrial (A/R) and marine (OAE) CDR methods yields nearly additive carbon removal with no efficiency trade-off observed from scaling or method mixing — global carbon fluxes respond linearly.



CDR timing, location, and method combination matter — support for diversified CDR portfolios. Removals can be scaled more effectively by combining methods while diversifying risks and remaining below ecologically and socially acceptable limits.

References

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