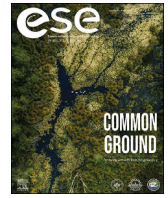




Contents lists available at ScienceDirect

Environmental Science and Ecotechnology

journal homepage: www.journals.elsevier.com/environmental-science-and-ecotechnology/

Commentary

Beyond carbon sequestration: The critical oversight of emission avoidance in restoration of wetland ecosystems



A recent study by Tölgyesi et al. [1] assessed the global potential of ecosystem restoration to mitigate climate change, concluding that restored ecosystems have very limited carbon sequestration potential (here referring to the net long-term uptake and storage of atmospheric CO₂ in biomass and soils), compared to historical human carbon emissions. While this key message of their work may be valid, we need to highlight several important limitations in commonly used assumptions when such modeling approaches are applied to anthropogenically converted wetlands and peatlands. The conclusion risks misleading policymakers because it only accounts for carbon drawn down from the atmosphere. The equally critical climate benefit of restoration—preventing ongoing greenhouse gas emissions from degraded ecosystems (i.e., the reduction of ongoing greenhouse gas emissions that would otherwise occur under continued land degradation) [2]—is overlooked. By ignoring this avoidance potential, the work offers a partial and potentially misleading picture of restoration's role in climate mitigation. This oversight may lead to incomplete assessments of restoration's climate role at a time when effective land-based strategies are urgently needed to support global net-zero targets by 2050, and the existence of climate change, as well as the need to restore ecosystems for human well-being, are increasingly challenged by parts of society [3]. We emphasize that our comment is intended to complement, rather than invalidate, global restoration assessments by highlighting an additional dimension—avoided emissions—that is particularly relevant for emission-dominated wetland systems and near-term climate policy.

Firstly, the study assigns literature values to “baseline” states [1] but largely omits evidence from anthropogenically converted mineral wetlands and peatlands. While Tölgyesi et al. [1] define net carbon gain as the difference between post-restoration and current ecosystem carbon sequestration rates, the operationalization of this baseline relies on literature-derived sequestration values that are unevenly distributed across ecosystem types and predominantly derived from low-emission systems. As a result, restoration benefits are assessed exclusively through changes in sequestration rates, while the substantial and persistent greenhouse gas emissions associated with continued degradation in high-emission wetland systems remain unaccounted for. This limitation is particularly consequential in drained peatlands, where current land use represents a persistent anthropogenic emission source rather than a stable ecological baseline. It was precisely this misconception that led to the development of the Intergovernmental Panel on Climate Change Wetland Supplement, which

demonstrated that land cover conversion of mineral wetlands and peatlands transforms sinks into substantial and persistent sources of atmospheric carbon [4]. To overlook this body of evidence in 2025—despite the stronger data collected since—represents an important gap that warrants explicit consideration. Countries with significant areas of drained wetlands and peatlands already reflect this science in their national greenhouse gas inventories and actively collaborate with researchers to refine reporting methodologies and climate policy [5,6].

Secondly, beyond this methodological issue, the publication reflects a deeper framing problem: it focuses narrowly on carbon sequestration while overlooking the equally or more important role of avoided emissions. In the original paper, restoration is framed primarily in terms of either carbon sequestration or adaptation and biodiversity gains [1]. Yet this framing does not fully capture the central climate function of restoring wetland ecosystems: preventing ongoing greenhouse gas emissions from degraded soils [2]. We understand that sequestration is politically and economically appealing because it generates a tangible, tradable commodity—the “carbon credit”—that integrates neatly into markets and policy frameworks built on exchange and growth. This framing effectively positions nature as a warehouse for storing humanity's carbon waste. Yet restoring drained wetlands, especially peatlands, may show limited long-term sequestration, but the principal climate benefit of restoring them is the immediate reduction in greenhouse gas emissions [7]. Many countries have already recognised this in their Nationally Determined Contributions to the United Nations Framework Convention on Climate Change, committing to peatland and wetland restoration as a key mitigation measure [8]. Although avoided emissions may be harder to communicate than sequestration, this does not mean they cannot be addressed. In recent years, different finance pathways have emerged, and since avoided emissions represent the dominant near-term climate benefit, they must be central to assessments of restoration potential.

Peatlands illustrate this imbalance clearly. Their annual carbon sequestration is small—less than 1% of fossil fuel emissions—but millennia of accumulation have made them the most space-efficient carbon stores of all terrestrial ecosystems [9]. Drainage, however, instantly turns them into major and persistent carbon sources. Globally, emissions from the 12% of peatlands that are drained account for about 4% of anthropogenic greenhouse gas emissions, underlining the urgency of restoring degraded peatlands and protecting the 88% that remain intact [10].

Thirdly, this framing problem is compounded by the categorical

exclusion of intensive agricultural land from the restoration potential. While intended to safeguard food security, this assumption may exclude one of the largest sources of avoidable emissions in the land sector. Most of the world's drained, high-emission peatlands are under agricultural use, much of it intensive. In the European Union, croplands and grasslands on drained peat soils produce over 25% of agricultural greenhouse gas emissions while covering only about 2% of agricultural land [11]. Excluding these areas can therefore lead to an underestimation of gigatonne-scale mitigation potential—equivalent to 0.31–3.38 Gt CO₂-eq per year from drained peatlands alone [12].

This exclusion also overlooks paludiculture, the productive use of rewetted peatlands for biomass, fodder, or *Sphagnum* farming. We recognise that incorporating paludiculture into global modelling frameworks remains challenging, but it nevertheless represents a proven land-use option with substantial mitigation potential. Paludiculture demonstrates that avoided emissions can be reconciled with agricultural production, providing both climate and economic benefits [13]. Leaving agricultural peatlands out of assessments not only underestimates restoration's mitigation potential but also obscures innovative pathways that could align climate goals with rural livelihoods. While including these areas in a global modelling framework may not alter the main result, it is crucial because these stakeholders risk being misrepresented, potentially misleading policy development.

The urgency of climate stabilisation lies in the next two to three decades [9]. Carbon sequestration in peatlands unfolds slowly over centuries and is vulnerable to reversal through drainage, clearance, fire, or drought. In contrast, avoided emissions deliver mitigation on timescales directly relevant to bending the global emissions curve, with their cooling effect maturing within two decades [14]. This front-loaded benefit is indispensable for limiting near-term warming, yet it is not always fully represented by models that focus on the total carbon sequestered by 2100. If taken at face value, Tölgyesi et al.'s conclusions risk diverting restoration funding away from wetlands toward ecosystems with higher sequestration rates but lower net mitigation value and higher permanence risks. This would be a profound mistake. Peatland restoration is a quintessential “no-regrets” strategy: it reduces emissions, enhances biodiversity, improves water quality, and reduces land subsidence and flood risks [15].

Sequestration is not irrelevant, and the analysis by Tölgyesi et al. contributes to quantifying one part of the restoration puzzle. However, a complete assessment of climate mitigation potential must integrate both sequestration and emission avoidance. For carbon-rich ecosystems—particularly peatlands—emission avoidance often dominates climate-mitigation benefits in the short to medium term [7]. In mangrove and other wetland systems, the contribution of avoided emissions is more context-dependent and cannot be generalized across sites [16,17]. Models must therefore appropriately represent carbon source behaviour at baseline, reconsider outdated assumptions that exclude agricultural land, and develop robust approaches to quantify avoided emissions alongside net sequestration potentials.

Conclusion

Tölgyesi et al. rightly highlight that restoration benefits biodiversity and ecosystem services. But its role in climate mitigation is also profound—it simply operates through a mechanism their model omits: emission avoidance. Nowhere is this clearer than in wetlands, where the central question is not “How much carbon can we sink?” but “What emissions can we stop?”

The finding that the drawdown of legacy carbon (carbon stored over long timescales and released following land-use conversion)

is limited must not be misinterpreted as evidence that the prevention of new emissions is similarly limited. By focusing on the former, we risk overlooking restoration's most powerful climate function, at least for wetlands and peatlands. To extend a metaphor: the climate crisis is a cardiac arrest, and degraded peatland ecosystems are bleeding carbon. Generating a healthy patient is a long-term necessity, but the immediate priority—the one that saves the patient—is to stop the bleeding.

CRedit authorship contribution statement

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This work was supported by the Horizon Europe project Wet Horizons (Grant Agreement No. 101056848). We thank our colleagues in the project consortium for valuable discussions that informed this contribution.

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8 December 2025