



OPEN ACCESS

EDITED AND REVIEWED BY
Seyed Mohammad Moein Sadeghi,
Northern Arizona University,
United States

*CORRESPONDENCE
Yashwant S. Rawat
✉ yasrawat@gmail.com

RECEIVED 05 January 2026
REVISED 01 February 2026
ACCEPTED 03 February 2026
PUBLISHED 17 February 2026

CITATION

Rawat YS, Kala CP and Tekleyohannes AT
(2026) Editorial: Forest landscape
restoration and carbon storage
dynamics.
Front. For. Glob. Change 9:1780993.
doi: 10.3389/ffgc.2026.1780993

COPYRIGHT

© 2026 Rawat, Kala and Tekleyohannes.
This is an open-access article distributed
under the terms of the [Creative
Commons Attribution License \(CC BY\)](#).
The use, distribution or reproduction in
other forums is permitted, provided the
original author(s) and the copyright
owner(s) are credited and that the
original publication in this journal is
cited, in accordance with accepted
academic practice. No use, distribution
or reproduction is permitted which does
not comply with these terms.

Editorial: Forest landscape restoration and carbon storage dynamics

Yashwant S. Rawat^{1*}, Chandra Prakash Kala² and
Anteneh T. Tekleyohannes^{1,3}

¹Department of Wood Technology Management, Faculty of Civil Technology, Federal Technical and Vocational Training Institute (TVTI), Addis Ababa, Ethiopia, ²Indian Institute of Forest Management, Bhopal, Madhya Pradesh, India, ³Innovation Consultant, Whole-value Forest Products (WFP) Innovation Hub (PI), Addis Ababa, Ethiopia

KEYWORDS

carbon sequestration, climate change, ecosystem services, forest landscape restoration, livelihoods, management strategies

Editorial on the Research Topic

Forest landscape restoration (FLR) and carbon storage dynamics

1 Introduction

Forests play a vital role in global carbon sinks, sequestering 15.6 billion tons of atmospheric carbon, annually (FAO, 2024). As a result, they offer myriad ecosystem services, notably climate change mitigation, and promoting ecological sustainability (Wu et al., 2020; Forest Declaration Assessment Partners, 2024). Approximately 45% of the organic carbon present in biomass and soil is stored within forests (Kafy et al., 2023; Gorain et al., 2025), which is essential from both ecological and environmental perspectives (Forest Declaration Assessment Partners, 2024; Gorain et al., 2025). Unfortunately, terrestrial forests currently face significant threats due to human activities such as agricultural expansion, land use and land cover change, over-exploitation, and infrastructure development (Williams et al., 2021; Forest Declaration Assessment Partners, 2024), which subsequently lead to changes in forests, carbon storage dynamics, and ecological functionality (Kafy et al., 2023; Qasha et al., 2024; Gorain et al., 2025). In order to restore the ecological functionality of degraded forests and lands, it is essential to embrace the Forest Landscape Restoration (FLR). FLR determines the carbon storage dynamics and so that the climate change mitigation and human wellbeing (Garrett et al., 2022; FAO, 2024; Gorain et al., 2025).

The carbon sequestration in forests is not merely achieved by following forest management practices (e.g., enrichment planting, regeneration, silviculture management, agroforestry systems, afforestation, reforestation, and selective logging assessments), but also by managing the balance between biomass accumulation, mortality, decomposition,

soil carbon stabilization, and disturbance regimes (Gorain et al., 2025). It is, therefore, suggested to shift carbon into more stable pools (e.g., large, long-lived trees, and protected soil carbon) and to reduce vulnerability to disturbances that cause large carbon losses. The effectiveness of sustainable forest management practices is contingent on local ecological conditions, climate, and its long-term impact on forest structure, species composition, and soil carbon dynamics (Qasha et al., 2024). Therefore, it is essential not only to conserve the forests but also to expand them to enhance carbon stock through FLR and sustainable forest management practices those are in harmony with the UN Decades on Ecosystem Restoration aiming mitigating climate change impacts and conserving biodiversity (FAO, 2024). Fortunately, the global imperative to mitigate climate change has positioned forest ecosystems as the primary terrestrial carbon sink, necessitating a scientific understanding of how management, restoration, and economic frameworks interact with forest growth (Gorain et al., 2025).

FLR is no longer merely a biological endeavor but a complex socio-ecological strategy that seeks to regain ecological functionality and enhance human wellbeing across deforested or degraded landscapes (FAO, 2024). In this backdrop, this Research Topic on the FLR and Carbon Storage Dynamics addresses various emerging gaps and priorities that are essential for climate change mitigation, biodiversity conservation, sustainable land use, and the enhancement of human wellbeing. It further presents diverse strategies from high-precision spatial modeling and long-term agroforestry trials to innovative green productivity metrics that aim to optimize carbon sequestration while ensuring economic and ecological stability. By examining forest dynamics across various biomes and governance structures, this Research Topic provides a comprehensive foundation for leveraging forest growth as a natural climate solution by integrating diverse considerations, including socio-cultural factors, silviculture, scientific advancements in carbon monitoring, ecological functionality, and climate change impacts into the implementation of sustainable forest management. This Research Topic has further sought to assess and enhance the carbon sequestration capabilities of forests and refine management practices to support broader climate change mitigation and biodiversity conservation efforts along with quantification of carbon sequestration rates across various restoration methods (Burru et al., 2025).

Each article published in this Research Topic is focused to bridge the existing knowledge gaps and contributes to the development of effective, sustainable forest management strategies, thereby supporting global efforts under the UN Decades on Ecosystem Restoration. This Research Topic presents ten contemporary valuable contributions from dedicated scholars that provide empirical investigations and findings on FLR and carbon storage dynamics with regard to climate change mitigation, sustainable forest management, ecosystem services, and biodiversity conservation in the context of global environmental change focusing on: advanced modeling and productivity metrics in forest growth; silvicultural interventions and ecosystem disturbance; landscape restoration and afforestation strategies as well as socio-economic frameworks and industrial integration. The articles are summarized below under the four important categories.

2 Advanced modeling and productivity metrics in forest growth

Kuang and Chen, address the spatial heterogeneity of forest carbon stocks in the Xiangjiang River Basin urban agglomeration by applying a multiscale geographically weighted regression (MGWR) model. Their research identifies five key variables (average diameter at breast height, stand density, average age, tree height, and annual precipitation) to estimate the spatial distribution of large-scale carbon stocks with high precision. The findings demonstrate that the MGWR (Gaussian) model provides superior estimation accuracy compared to traditional global regression models, identifying an overall distribution pattern characterized by high central and low peripheral carbon values, with an estimated unit area carbon stock of 31.162 t/hm². This spatial non-stationarity approach allows for a more nuanced understanding of how urbanization and industrial activities in areas like the Changsha-Zhuzhou-Xiangtan core impact forest carbon sink functions.

Jiang and Li, explain in detail a multidimensional analysis of China's forestry green total factor productivity (GTFP) from 2000 to 2020, revealing how traditional metrics often overestimate performance by omitting environmental costs. Utilizing the Slacks-Based Measure (SBM) and Non-radial Directional Distance Function (NDDF), they identify forest carbon stock (FCS) as a structural determinant of efficiency, noting that while traditional productivity grew significantly (11% annually), GTFP increased by only 1% due to the gradual nature of forest growth. Their study reveals a pronounced regional heterogeneity; in which the Eastern region defines the national meta-frontier through green innovation, while the Western and Northeastern regions face challenges in balancing rapid economic expansion with the inherent biological rigidity of carbon sequestration. This framework suggests that the true level of forestry productivity lies between the overestimation of market-only total factor productivity (TFP) and the current underestimation of green productivity that may still omit non-market services like biodiversity.

3 Silvicultural interventions and ecosystem disturbance

Forestry management practices play a crucial role in regulating biomass accumulation and carbon sequestration, with important implications for climate change mitigation (FAO, 2024; Burru et al., 2025; Gorain et al., 2025). Ali et al., examine the impact of thinning and pruning on 50-year-old *Larix principis-rupprechtii* plantations in Northern China, providing critical evidence that management intensity shapes biomass partitioning. Their research reveals that while intensive management promotes individual tree growth (increasing DBH and height), it significantly compromises cumulative stand-level carbon stocks. Specifically, heavy thinning reduces aboveground and belowground biomass by up to 42.9% and 42.6%, respectively in comparison to control treatments. Their study concludes that light to moderate thinning integrated with light pruning offers the most sustainable balance, maintaining

forest health and productivity without substantially depleting the plantation's ecological role as a carbon sink.

Ono et al., explore the effects of prescribed burning frequency on the annual soil carbon balance of loblolly-shortleaf pine forests in East Texas over a 20-year period. They observed that frequent burns (annual or intermittent) reduced fine root biomass and soil autotrophic respiration (Ra), likely due to lower investment in root maintenance and reduced mycorrhizal colonization compared to unburned stands. However, as a result of mutually offsetting ecological responses including reduced heterotrophic respiration (Rh) stemming from lower fine root detritus the net soil carbon balance remained statistically similar across all fire regimes, losing between 71 and 167 g C m⁻² year⁻¹. This suggests that while fire management alters the fundamental processes of belowground carbon allocation, low-intensity prescribed burns can be utilized for habitat restoration and wildfire risk reduction without causing a significant net loss of mineral soil carbon.

4 Landscape restoration and afforestation strategies

FLR is a cost-effective and nature-based climate mitigation strategy that aims to regain ecological functionality and enhance human wellbeing across degraded and deforested landscapes (Kafy et al., 2023; Qasha et al., 2024; FAO, 2024; Burru et al., 2025). Restoring forests through natural regeneration, assisted planting, and sustainable land-use practices, FLR increases carbon sequestration in biomass and soils, thereby reducing net greenhouse gas concentrations in the atmosphere (Kafy et al., 2023; Gorain et al., 2025). Focusing soil protection, carbon sequestration potential, resilience, and adaptability, Tudor et al., provide a global bibliometric review of pine afforestation on degraded lands, synthesizing research on 38 pine species utilized for soil protection and carbon sequestration. Their analysis reveals resilience and adaptability of pines (such as *Pinus sylvestris* and *Pinus nigra*) across various harsh conditions, including mined lands and semi-arid regions. The study demonstrates that while pine monocultures offer economic productivity, mixed pine forests with deciduous species often provide a superior balance for long-term ecosystem restoration and atmospheric CO₂ sequestration. Furthermore, they identify and discuss significant research trend shift after 2015 toward broader environmental concerns like biodiversity recovery and climate change adaptation in the context of reforestation.

Barman et al., present evidence from a 15-year study in the Indian Himalayas, demonstrating that mulberry-based agroforestry systems significantly enhance soil organic carbon (SOC) pools in both surface and deep soil layers. Their results indicate that the integration of *Morus alba* with cowpea-toria cropping (T7) results in a higher carbon accumulation rate of 0.99 Mg C ha⁻¹ yr⁻¹, which is 160% higher than traditional farmers' practices. Their study further reveals that these systems attribute 44.82% of their carbon sequestration to the deep soil layer (30–60 cm), proving that tree-based systems are a vital strategy for the long-term stabilization of SOC and the restoration of degraded mountain landscapes.

5 Socio-economic frameworks and industrial integration

Greenhouse Gas (GHG) emissions have accelerated climate change, leading to substantial environmental and socio-economic impacts, including sea-level rise and an increased frequency of extreme weather events (FAO, 2024; Gorain et al., 2025). The growing urgency to mitigate these effects has prompted governments and industries to pursue innovative strategies aimed at reducing carbon footprints and advancing sustainability. Sustainable forest management practices, which enhance carbon storage in both forest ecosystems and harvested wood products, represent a promising approach for reducing atmospheric CO₂ concentrations (Burru et al., 2025). Climate change mitigation strategies increasingly emphasize carbon trading, with forestry and agroforestry management systems offering significant potential for carbon sequestration while supporting sustainable livelihoods. Jaisridhar et al., explain the findings of a systematic review of carbon sequestration potential in the North Western Ghats of India, identifying agro-horticulture systems as the most effective configuration for the region. Their analysis suggests that agroforestry is approximately four times more profitable than monoculture agriculture, even without accounting for carbon revenues, although high transaction costs and methodological complexities remain significant barriers for participation by smallholder and marginalized communities. The research proposes a methodological framework that links carbon storage with livelihood benefits, advocating for simplified monitoring and verification protocols to make carbon trading more accessible to resource-poor farmers.

Yu et al., develop a scientific framework for forest horizontal ecological compensation in Chongqing, China, utilizing a carbon budget approach to define responsible entities. By measuring carbon emissions and forest sequestration across 38 districts, they establish a spatial pattern of “southwest compensating the east,” where economically developed urban areas provide financial support to resource-rich ecological protection zones. Their study advocates for differentiated regional compensation standards that reflect local economic development levels and resource endowments, aiming to achieve a synergistic symbiosis between forest ecology and economic growth under China's “dual-carbon” goals.

Zhang et al., assessed the coupling coordination relationship between forestry industry development and the ecological environment in Northeast China from 2011 to 2022. Using the Pressure-State-Response (PSR) model, they found that while the industry and the environment generally promote one another, a specific gap remains between current levels and the ideal state of coordination. Their findings suggest that provinces like Heilongjiang and Jilin must restructure their transformation models by advocating for clean production projects and low-carbon economic development to resolve the contradiction between the consumption of forest resources and environmental preservation.

Pullalarevu et al., provide a qualitative assessment of corporate timberland companies' participation in carbon programs, identifying financial returns as the primary motivator for entities like Timber Investment Management Organizations (TIMOs)

and Real Estate Investment Trusts (REITs). The study reveals that regulatory uncertainty, high transaction costs, and administrative complexity are major deterrents, with timber markets often remaining more attractive than carbon offset initiatives. To scale up corporate involvement, they emphasize the need for stable policy frameworks, standardized carbon accounting, and the potential integration of carbon-storing wood products into market strategies.

6 Synthesis and future outlook

Finally, these studies suggest that forest growth is not merely a biological process but a managed ecological asset that requires precise spatial modeling, strategic silvicultural interventions, and robust policy integration (Chazdon et al., 2017; Besseau et al., 2018; Li and Zhou, 2022; Pretzsch, 2022; Gorain et al., 2025). Whether through the deep root systems of Himalayan agroforestry or the high-tech spatial monitoring of urban agglomerations, FLR must balance immediate economic needs with long-term carbon stability (Nitoslowski et al., 2019; Bishowo, 2020; Dhyani et al., 2021; Barman et al.; Jiang et al., 2025). To comprehend this balance, one might view forest carbon storage as a biological engine, whereas silvicultural management serves as the fuel and tuning necessary to enhance tree growth. The engine's long-term sustainability, or carbon sequestration, relies on the structural integrity of the soil and the legislative framework that underpins it. Future research must continue to refine these dynamics, ensuring that the global expansion of forest landscapes provides a resilient and verifiable sink for the world's carbon (Ontl et al., 2020; Gorain et al., 2025).

The ten research and review articles included in this Research Topic provide a comprehensive synthesis of FLR and carbon storage dynamics, with clear relevance to biodiversity conservation, climate change mitigation, and sustainable forest management. We sincerely acknowledge the dedicated efforts of the authors, reviewers, and handling editors whose contributions were instrumental in bringing this Research Topic to fruition. Their commitment in addressing existing knowledge gaps and ascertaining future research directions has significantly advanced understanding in the fields of FLR and carbon dynamics, while strengthening the scientific basis for ecosystem service enhancement and sustainable forest management (FAO, 2024; Gorain et al., 2025). Collectively, these studies represent a valuable contribution to the literature and are expected to stimulate further research on FLR and carbon storage dynamics in the context of global environmental change.

Author contributions

YSR: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources,

Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. CPK: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. ATT: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Acknowledgments

We express our gratitude to all the authors, reviewers, and handling editors for their valuable contributions, and also to the Frontiers Editorial Office for their assistance in both the creation and management of this Research Topic.

Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author YSR declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

Generative AI statement

The author(s) declared that generative AI was not used in the creation of this manuscript.

Any alternative text (alt text) provided alongside figures in this article has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

- Besseau, P., Graham, S., and Christophersen, T. (2018). *Restoring Forests and Landscapes: The Key to a Sustainable Future*. Vienna, Austria: Global Partnership on Forest and Landscape Restoration.
- Burru, D. Y., Durai, J., Chinke, M. A., Sileshi, G. W., Rawat, Y. S., Gizachew, B., et al. (2025). Allometric models for estimating biomass and carbon stocks in natural and homestead highland bamboo stands in the sidama region, Ethiopia. *Forests* 16:701. doi: 10.3390/f16040701
- Chazdon, R. L., Brancalion, P. H., Lamb, D., Laestadius, L., Wiedmann, M., and Hosseini, R. (2017). A guiding framework for integrated local and regional priorities of forest landscape restoration. *Conserv. Lett.* 10, 700–708. doi: 10.1111/conl.12220
- Dhyani, S., Kadaverugu, R., Pandey, B. W., and Dasgupta, R. (2021). “Agroforestry for climate resilience and food security in the Indian Himalayas,” in *Nature-Based Solutions for Climate Change Adaptation* (Springer), 315–334.
- FAO. (2024). *The State of the World's Forests 2024-Forest-Sector Innovations Towards a More Sustainable Future*. Rome, FAO.
- Forest Declaration Assessment Partners (2024). *Forests under fire: Tracking progress on 2030 forest goals*. Climate Focus (coordinator and editor). Available online at: <http://www.forestdeclaration.org> (Accessed January 30, 2026).
- Garrett, L., Lévite, H., Besacier, C., Alekseeva, N., and Duchelle, M. (2022). *The Key Role of Forest and Landscape Restoration in Climate Action*. Rome, Italy: Food and Agriculture Organization of the United Nations.
- Gorain, S., Dutta, S., Balo, S., Malakar, A., Choudhury, M. R., and Das, S. (2025). Harnessing green wealth: a two-decade global assessment of forest carbon sequestration and credits and the economic implications of sustainable forest management practices. *J. Environ. Manag.* 393:126987. doi: 10.1016/j.jenvman.2025.126987
- Jiang, X., Li, L., and Yu, H. (2025). Spatial heterogeneity of forest carbon stocks in the Xiangjiang river Basin urban agglomeration: analysis and assessment based on the multiscale geographically weighted regression (MGWR) model. *Front. Environ. Sci.* 13:1604533. doi: 10.3389/fenvs.2025.1573438
- Kafy, A.-A., Saha, M., Fattah, M. A., Rahman, M. T., Dutti, B. M., Rahaman, Z. A., et al. (2023). Integrating forest cover change and carbon storage dynamics: leveraging Google Earth Engine and InVEST model to inform conservation in hilly regions. *Ecol. Indic.* 152:110374. doi: 10.1016/j.ecolind.2023.110374
- Li, H., and Zhou, Y. (2022). Progress and prospects of forest ecological asset research. *Sustainability* 14:395. doi: 10.3390/su14010395
- Nitoslawski, S. A., Galle, N. J., Van Den Bosch, C. K., and Steenberg, J. W. (2019). Smarter cities for trees: a systematic review of technologies for urban stock management. *Sustain. Cities Soc.* 51:101703. doi: 10.1016/j.scs.2019.101770
- Ontl, T. A., Janowiak, M. K., Swanston, C. W., Daley, J., Handler, S., Cornett, M., et al. (2020). Forest management for carbon sequestration and climate adaptation. *J. Forestry* 118, 86–101. doi: 10.1093/jofore/fvz062
- Pretzsch, H. (2022). *Forest Dynamics, Growth, and Yield: From Measurement to Model*. Cham: Springer Nature.
- Qasha, V., Manyevere, A., Flynn, T., and Mashamaite, C. V. (2024). Assessing the impact of ecological forest restoration on soil carbon stocks in Sub-Saharan Africa: a systematic review. *Carbon Manag.* 15:2404409. doi: 10.1080/17583004.2024.2404409
- Williams, D. R., Clark, M., Buchanan, G. M., Ficetola, G. F., Rondinini, C., and Tilman, D. (2021). Proactive conservation to prevent habitat losses to agricultural expansion. *Nature Sustain.* 4, 314–322. doi: 10.1038/s41893-020-00656-5
- Wu, Y., Wang, D., Qiao, X., Jiang, M., Li, Q., Gu, Z., et al. (2020). Forest dynamics and carbon storage under climate change in a subtropical mountainous region in central China. *Ecosphere* 11:e03072. doi: 10.1002/ecs2.3072