Synthesis of national carbon fluxes of African rainforest countries

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African tropical ecosystems possess great potential for nature-based solutions in mitigating anthropogenic greenhouse gas emissions and biodiversity loss. However, past studies mostly focused on pan-continental carbon balance quantification, often ignoring regional differences. Remarkably, few science-informed attempts have been made to refine national-level carbon flux estimates within African rainforest countries. Yet, such refined estimates are essential to improving the quantification of Nationally Determined Contributions for the United Nations Framework Convention on Climate Change.

Here, we present preliminary results on quantifying national carbon budgets for African rainforest countries, disentangling four major carbon fluxes for 2003-2019: (1) the net carbon uptake in intact tropical terrestrial ecosystems, (2) land-use change fluxes, 3) CO_2 outgassing in inland waters, and (4) fossil fuel emissions. The net carbon uptake in intact terrestrial ecosystems is based on Dynamic Global Vegetation Models TRENDY v11[1,2] (DGVMs), ground-based data (AfriTRON[3]), CARDAMOM[4], and remote sensing data products of Net Primary Productivity[5] and soil heterotrophic respiration[6-7]. Land-use change emissions are calculated using bookkeeping models (BLUE[8], H&N2017[9], OSCAR[10]), DVGMs[1,2], and CARDAMOM[4]. Additionally, we estimate carbon emissions from land-use change by analyzing various satellite images and related products providing data on land-use change[11–12], soil and tree carbon stocks[13–18], fire emissions[19–20], and carbon recovery in regrowing forests[21–22] in tropical Africa. We also quantify carbon emissions from CO_2 outgassing in estuaries[23] and inland waters[24-25]. National carbon balances are completed by using data on fossil fuel emissions from the Global Carbon Project[2]. Besides calculating national-level net carbon fluxes using a bottom-up approach by summing individual carbon fluxes, we quantify the net carbon flux using a top-down approach based on atmospheric inversion models (GCP-GridFED[26], CAMS[27], Jena CarboScope[28], MIROC4-ACTM[29], NISMON-CO_2[30]).

We reveal that carbon balances of African rainforest countries remain highly uncertain. Our bottom-up estimates show that Congo Basin countries are net carbon sinks, while most West-African countries are net carbon sources. In contrast, our top-down estimates of net carbon fluxes indicate that African rainforest countries are net carbon sources. Overall, tropical terrestrial ecosystems have played an important role in mitigating anthropogenic carbon emissions in African rainforest countries. Our insights into nation-level carbon fluxes will be crucial for informing African rainforest countries, guiding climate policies to help stay on track to keep global warming well below 2°C.

Keywords

Nature-based Solutions, African Tropical Terrestrial Ecosystems, National-level Net Carbon Flux, Anthropogenic Carbon Emissions, African Rainforest Countries

References

1. Sitch *et al.* (2015).
2. Friedlingstein *et al.* (2022).
3. Hubau *et al.* (2020).
4. Bloom *et al.* (2020).
5. Zhao *et al.* (2005).
6. Huang *et al.* (2020).
7. Konings *et al.* (2019).
8. Hartung *et al.* (2021).
9. Houghton *et al.* (2017).
10. Gasser *et al.* (2017).
11. Hansen *et al.* (2013).
12. Vancutsem *et al.* (2021).
13. Simard *et al.* (2019).
14. Avitabile *et al.* (2016).
15. Zarin *et al.* (2016).
16. Saatchi *et al.* (2011).

17. Baccini *et al.* (2012).
18. Poggio *et al.* (2021).
19. Van Wees *et al.* (2022).
20. Di Giuseppe *et al.* (2018).
21. Heinrich *et al.* (2023).
22. Cook-Patton *et al.* (2020).
23. Laruelle *et al.* (2013).
24. Raymond *et al.* (2013).
25. Lauerwald *et al.* (2015).
26. Jones *et al.* (2021).
27. Agusti-Panareda *et al.* (2023).
28. Rödenbeck *et al.* (2018).
29. Chandra *et al.* (2022).
30. Niwa *et al.* (2022).