

Sierra leone energy conservation

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Voluntary carbon offset markets from projects in the tropics are expected to contribute to meeting net-zero climate change objectives in the Global North. In voluntary markets, certified third-party agencies sell carbon credits to buyers who aim to reduce their carbon footprint beyond levels legally required either by national domestic legislation or international commitments1.

Recently, there has been a surge in voluntary carbon credits, with the market value rising from US\$473 million (all \$ values in US dollars henceforth) in 2020 to edging close to \$2 billion at the end of 20222. The value of these offsets is expected to increase at least 100-fold by 2050, as industries and governments aim to meet the 1.5 ?C Paris target3. In response to this surging demand, a new offset industry has emerged in which numerous entities develop carbon offset projects and seek their certification from private organizations through verification processes, after which myriad consultancy companies rate their quality and sell the offsets to buyers.

Within the overall voluntary carbon credit market scene, REDD+ offsets have become the leading category, constituting 40% of the market. More importantly, in 2021 the market showed a 166% annual increase in the volume of traded carbon credits coming specifically from REDD+ projects that avoid unplanned deforestation and a 972% increase in programmes that avoid planned (legal) deforestation8, signalling the dynamism of forestry-based credits.

Despite this context of "REDD+ project-euphoria", the scientific literature assessing the impacts of voluntary REDD+ offsets remains notably scant9. Carbon credit verification agencies do include monitoring and evaluation as part of their processes to renew voluntary carbon credits. However, the objectivity, transparency and robustness of these assessments have been called into question, undermining the credibility and viability of the voluntary offset market10. This controversy11 has increased the calls within the scientific and policy communities for more independent and rigorous assessments of REDD+ projects9,12,13,14,15.

Supplementary Information A and Supplementary Table 1 summarize published work that uses BACI approaches to assess the environmental effectiveness and livelihood impacts of REDD+ initiatives. The



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majority of studies focus on non-certified sub-national REDD+ initiatives, or projects that were in the early stages of development (pilot schemes)18,20,21,22,23,24,25,26. The overall picture that emerges from this work on mostly non-certified REDD+ initiatives is that they have had a rather muted impact on deforestation.

Remarkably, just four studies in our review, focus exclusively on actually certified REDD+ projects10,27,28,29. These studies focus on assessing deforestation impacts only and do not assess the livelihood impacts or behavioural mechanisms that could explain any changes in deforestation. They tend to rely on remote sensing data rather than field survey data. Where survey data are included, they tend to be "ex-post" rather than collected "before and after" in recipient/non-recipient control (that is, comparable) groups. A few studies find mildly positive or at least no negative impacts on welfare and livelihood indicators21,23,30.

In sum, the available body of evidence still leaves many under-researched issues concerning the environmental and economic impacts of voluntary carbon offset schemes. In this paper, we contribute to the need to build the evidence base by reporting on a study that evaluates the impacts of an actual certified voluntary REDD+ project. In particular, we contribute a BACI assessment of the impacts of such a project 5 yr after its commencement and consider the causal pathways through which REDD+ operates. Notably, we also add a cost-to-carbon analysis.

Each pixel shows whether any deforestation took place from 2001 until 2018. The dashed line shows the 4 km buffer zone in which the REDD+ programme took place. Source: ref. 42.

a, Total forest loss from 2001 to 2018 in 8 PAs of Sierra Leone and the average for Sierra Leone. b, Total forest loss from 2001 to 2018 in the 4-km buffer zones of these PAs. The PAs shown are the GRNP, Outamba, Loma Mountains, Western Area Peninsula, Kangari Hills, Tingi Hills, Kambui Hills and Tiwai Island (see Supplementary Fig. 1 for separate graphs for each PA). The break in the lines in 2013 denotes the launch of a new satellite (Landsat 8) resulting in more precise measures of forest loss. Source: ref. 42/UMD/Google/USGS/NASA.

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