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Sustainable production and consumption of CDR from tropical forestry in developing countries

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The challenge

According to the IPCC's latest report limiting warming to 1.5° Celsius translates into around 6 billion tCO2 of Carbon Dioxide Removals CDR per year by 2050. Meeting the recent pathways laid out by the IPCC will require total cumulative net CDR of 100-1000 billion tCO_2 by 2100.[1] To remove 10 billion tCO2 at US$10/$tCO_2$e or $100/$tCO_2$e, means generating between US$100 billion and US$1 trillion a year market by 2050. In short, the CDR market needs to grow very meaningfully. In the first semester of 2023, the market on CDR increased 5.6X compared to the whole 2022 and reached almost 3.4M tCO_2e which is still less than 0.04 % of 2050 goal.[2] Billions of US dollars are being raised globally to approach the trillionaire CDR market which is predicted to grow steadily up to 2050 and 2100. Tech Industry leaders, Direct Air Capture DAC developers, Investors, private sector players, registries, platforms, federal governments and Non-Governmental Organizations NGOs are aligning fast towards this new and promising avenue for fighting climate change. Agriculture, Forestry and Other Land Uses AFOLU sector accounts for a net removal of about 310 million tCO_2e in the whole European Union EU, equivalent to about 9% of emissions from the other sectors. The European Green Deal has the strategy towards a climate-neutral Europe by 2050 which includes Harvested Wood Products HWP as store of carbon (for example when used as building materials) to remove CO_2, to expand sustainable carbon removals and encourage the use of innovative solutions to capture, recycle and store CO_2 by farmers, foresters and industries.[3]

Forests cover 31 percent of the global land area, and half is relatively intact more than one-third naturally regenerated native species with no visible indications of human activities.[4] In the coming decades, there will be a global increase in demand for biomass and in advocating CDR technology and practices. In the agriculture and forestry context, intensification of land use is the most promising solution – together with processing efficiency - in balancing consumption, rated as human appropriation of net primary production (HANPP), with Net Primary Production (NPP) from atmospheric CO_2 fertilization. Human induced land use improves HANPP also in the tropics. There has been a considerable increase in net primary production (NPP) over the last century, mainly due to the CO_2 fertilization effect. Reduction of Emissions from Deforestation and Degradation REDD+ project activities are directed to increase and maintain elevate biomass stocks. There is evidence showcasing a path of native tropical forest degradation given atmospheric CO_2 fertilization, which is mainly due to favoring secondary vegetation competitiveness against trees at un-managed high biomass volume standing stocks. Following a Business As Usual BAU scenario where no intervention is performed to reduce the amount of competing secondary vegetation spreading, tropical forests would experience important dwindling in tree cover on a temporal scale,[5] as the Figure 1 portrays.

As in the Figure 2, considering a 400 years' time frame, tropical forests are going to become less and less tree covered as the CO_2 levels raise and if no management intervention is done (the data is illustrative, a proxy from previous findings on increasing of secondary vegetation in natural un-managed tropical forests). Still, the National Determined Contributions (NDCs) of tropical countries include provisions for REDD+, looking into keeping high stock levels of unmanaged forest to hold terrestrial carbon, which gives opportunities for the secondary vegetation to spread. As the image of the map of existing REDD+ project activities in the tropics shows, they are broadly spread over the equatorial line:

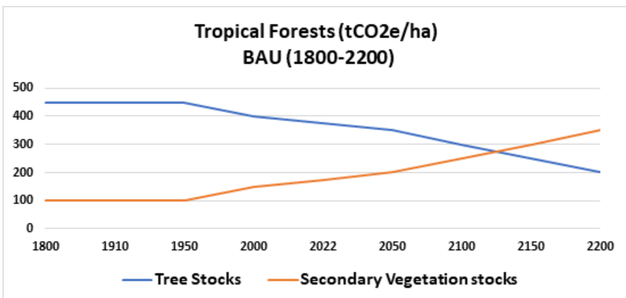

Figure 1 CO_2 fertilization and secondary vegetation competitiveness at the tropics.

Source: Zanetti et al.[5]

As the image shows, the map of areas along the equatorial line were the REDD+ project activities are located, spread over tropical forests and the goal of the NDCs at these countries is to increase the biomass stocks overtime. Within most of the countries at the region, the lack of infrastructure and lack of adequate use of biomass has shown to result on the spreading of infectious diseases, one of the main factors negatively affecting the Sustainable Forest Management results.[7] Infectious diseases such as Aedes Aegbypti are already present at all those regions and they tend to spread even to higher latitudes as the global carbon atmospheric content and temperature rises, as the Figure shows:

As the Figure 2 and Figure 3 coincide, the overall risk of losing tropical trees to secondary vegetation and gaining tropical diseases increase, making the adoption of REDD+ strategy dangerous for societies and economies in both, developing and developed countries. Areas with advancing secondary vegetation are potential reservoirs of infectious disease. Tropical forests hold the largest standing volume of trees in the planet which under CO_2 fertilization creates an environment for emerging and infectious diseases to prosper (Keesing et al, 2010).

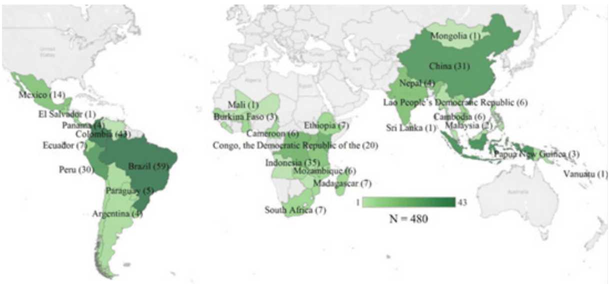

Figure 2 REDD+ at tropical countries NDCs.

Source: Shin et al.[6]

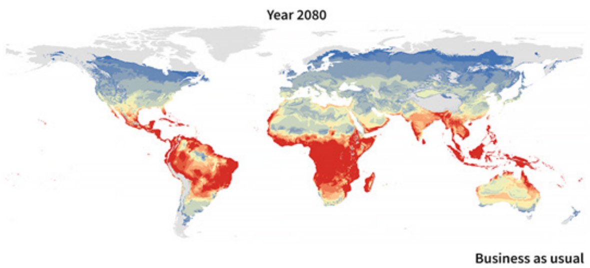

Figure 3 Predicted range of AEDES AEGYPTI IN 2080.

Source: Jordan,[8]

Our findings

Individuals' selection, seeds collection, genetic improvement, seedlings 'production, planed plantations, road and other infrastructure construction and maintenance, soil preparation, plagues and diseases prevention and fighting, fertilization, de-branching, thinning, harvesting and transportation are some elements of contemporary silviculture appliable to all forests in planet Earth. Its silviculture technology applied to forest sites in order to improve photosynthetic productivity, converting atmospheric CO_2 into fibers, oils, nuts, fruits and other carbon-based products. According to each specific individual characteristic – biodiversity of tree species – the contribution can have one or other form of carbon-based production. As an example, 1 ha of tropical forests managed under REDD+ and CDR present different results over time, when addressing their contribution to fight climate change. REDD+ involves keeping the stocks at a maximum by all means, while CDR looks into increasing productivity. The Graphic portrays the behavior over 200 years period of time, considering the starting point of a REDD+ project activity at 400 tCO_2e/ha with 0 tCO_2e/ha/year removal (maintaining stocks overtime) while the CDR project activity starts at 200 tCO_2e/ha of stocks[1] and produces 10 tCO_2e/ha/year of removals through construction timber production:

On the first 30 years the CDR management produces the same effect as REDD+ and, from this point on, increases exponentially its contribution, doubling it around 50 years and so on. The CDR brings with its silvicultural, processing and storage technology alternatives for creating jobs and incomes along the production chain far more numerous than the ones offered by REDD+ project activities. The constant use and vigilance reduce the risks of diseases to occur and spread, while keeping the forest productive means it is healthy and therefore trees less stressed and more resistant. The periodic reduction of biomass also reduces fire risks.[9]

Using the same approach, 1 ha of tropical forests managed under REDD+, CDR and CDR Plus CDR* present different results over time, when addressing their contribution to fight climate change, with CDR* representing a high intensity forest management operation, taking advantaged of productivity at a maximum. The Figure 4 portrays the behavior over 200 years period of time, considering the starting point of a REDD+ project activity at 400 tCO_2e/ha with 0 tCO_2e/ha/year removal (maintaining stocks overtime) while the CDR project activity starts at 200 tCO_2e/ha of stocks and produces 10 tCO_2e/ha/year of removals through construction timber production and CDR* starting with zero stocks and manages its plantation within a 15 years rotation period under clear cuts and reforestation, with the following results:

As both Figure 4 and Figure 5 demonstrated, the increase of productivity is directly related to the increase on Green House Gases GHG removals and therefore enhance the role of this particular land use to fight climate change. In terms of atmospheric CO_2 removals, CDR portrays a result 8.3 times better than REDD+, while the CDR* has a behavior that multiplies the effects of REDD+ by 27.6 times.

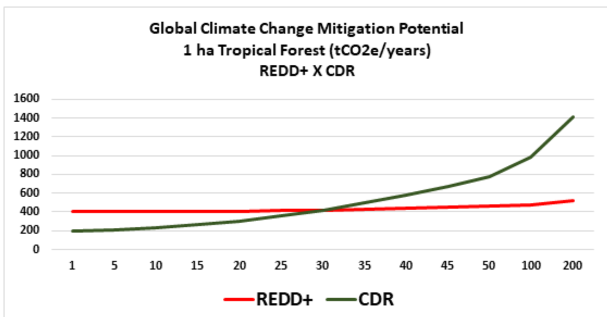

Figure 4 Comparison between REDD+ and CDR mitigation potential.

Source: Authors

For the overall sustainable management of forest site at tropics, an alternative Improved Forest Management IFM scenario is proposed, where contemporary silviculture techniques can reverse the degradation and advance of secondary vegetation process and produce instead HWP and NTFP through alternative and adapted land use intensification, as at the Figure 5.

As the Figure 6 portrays, IFM practices revert the tendency of secondary vegetation dominance and put trees back into the scene. This will contribute additional atmospheric CO_2 removals, certifiable as CDR goods – Industrial timber, biochar, biooil, which are able to generate carbon credits for financing the reduction of secondary

[1]the harvesting periods occur each 20 years when the volume is equal and are compensated in the graphic by the addition of HWP production to total removal per year

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vegetation and promoting cultivation of improved native tree species. These CDR credits can be included in tropical countries` NDC and presented at United Nations Framework Convention on Climate Change UNFCCC as an International Tradeable Mitigation Option ITMO for fighting global climate change.[10] Tropical forestry productivity is directly linked to applied silvicultural practices. In managed forests, forest biological processes react to silvicultural treatments that determine the short- and long-term productivity and stock increase or decrease. Replacing natural regeneration by human induced silviculture practices increases standing stocks and the positive effects of contemporary silvicultural techniques is improvement in harvesting volumes.

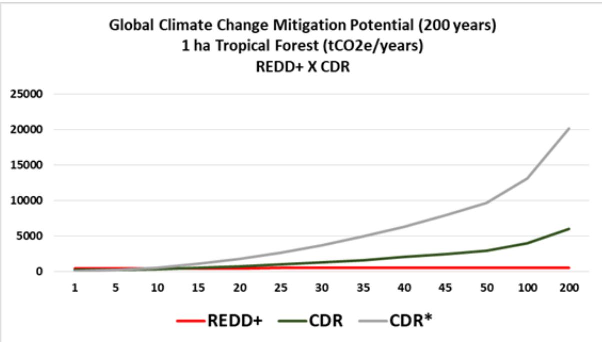

Figure 5 Comparison between REDD+, CDR and CDR* mitigation potential.

Source: Authors

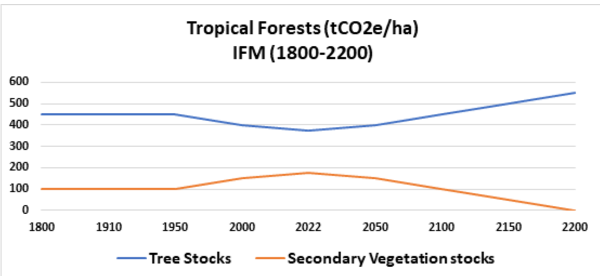

Figure 6 Effect of IFM to reduce secondary vegetation competitiveness at tropical forests.

Source: Zanetti et al.[5]

For most developing countries, estimates of GHG emissions and sinks, translated into NDCs, are mainly based on default emission factors that do not necessarily reflect country specifics in terms of forest structure and status of forest transitions. Global models and maps of GHG fluxes are based of inventory database that do not reliably represent the contexts in tropical forests with consideration of the high local or regional variability in forest structure and anthropogenic changes. Existing forest GHG flux assessment frameworks and models are unable to discriminated the contributions from anthropogenic versus non-anthropogenic effects and likewise, between managed and unmanaged land. On modeling, remote sensing procedures offer unprecedented advantages (resources, time, and cost) in large-scale biomass and GHG estimation in forests and other land uses.[2] In the context of tropical forests, the application of remote sensing procedure for biomass mapping and monitoring is receiving wide attention and progress. There is large time-lapse between the on-going deforestation actions and potential remote sensing data[3] to support the monitoring of both GHG emission and CO2 removal[4].[5]

At the tropics, there are large availability of hardwoods. Tropical hardwoods are more durable, rot and marine animals resistant, stronger and cheaper than overall global hardwoods which makes them standout when competing on the global markets. They have characteristic longer lifespans among the timbers species, which make them very attractable to consumers wishing lumber with special qualities such as durable, colorful, fragrant wood at their homes, offices and industries. By 2050, developing countries can be using 600M ha of its over 1billion ha of tropical forests as high productive ones of 6 billion m^3/year of industrial wood products. It means that by applying contemporary silviculture and CDR approach they can produce 6 billion tCO_2e/year credits, enough to comply with the 1.5o Celsius goal of Paris Agreement. This would generate millions of jobs and create a cash flow of US$ 60-600 billion /year for developing tropical countries Harvested Wood Products HWP, besides other US$ 60-600 billion /year on CDR credits sales.

Conclusion

Tropical forests in remote areas are under climate pressure resulting from global CO_2 fertilization favoring secondary vegetation and spread of infectious diseases, which makes REDD+ strategy less effective than CDR and CDR* from IFM and HWP to promote sustainable development in the tropics. CDR shows a capacity to produce a result 8.3 times better than REDD+, while the CDR* has a behavior that multiplies the effects of REDD+ by 27.6 times when it comes to fight climate change effects.

When it comes to forestry and tropics, the role of timber in removing atmospheric CO2 and their transformation into industrial and energy wood, biochar and bio oils among others might offer opportunity in accounting emission removals in developing countries. An acknowledgement of such roles might influence national policies and decision making towards including CDR as part of goals to reach carbon neutrality and in accounting NDC (National Determined Contributions). The CDR combine social inclusion, job creation and environmental quality in a unique and prosperous sustainable direction and deserves to play a part at tropical countries NDC`s.

Acknowledgments

None.

Funding

None.

[2]In the context of tropical forests, the application of remote sensing procedure for biomass mapping and monitoring is receiving wide attention and progress. Several compounding factors may be accountable for low rate of remote sensing application and technology transfer to tropical forest monitoring. Among these factors, technical capacity is increasingly a lesser hurdle compared the situation a decade prior. There are growing freely accessible archives of satellite-based remote sensing images (data) such as data provided from NASA Landsat missions and the operational mission of the European Space Agency (ESA) Copernicus program, which have jointly reduced the hurdle of access to remote sensing data.

[3]the closest being a minimum of 12 days across the tropics for ESA's Space-borne Sentinel operational satellites -

[4]Thus, in current times, most of the challenges in remote sensing monitoring of tropical forest GHG flux may center around the nature of available data for applications in tropical forest contexts - different data are needed for different contexts and as well in addressing the wide uncertainties for tropical forests in global projections and maps of GHG flux

Conflicts of interest

Author declares that there is no conflict of interest for the publication of this scientific article.

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