SCIENCE PANEL FOR THE AMAZON

POLICY BRIEF

THE AMAZON WE WANT

Science Panel for the Amazon

HUMAN IMPACTS ON CARBON EMISSIONS & LOSSES IN ECOSYSTEMS SERVICES: THE NEED FOR RESTORATION AND INNOVATIVE CLIMATE FINANCE FOR THE AMAZON

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KEY MESSAGES

(i) Over the last decade (2010-2020), the Amazon carbon budget, integrating all absorption and emission processes, indicates that the region has become a carbon source – primarily due to land-use changes, representing an annual CO_2 emission of 1.1 billion tonnes per year.

(ii) Deforestation and forest degradation spur regional climate change by inducing climate disturbances that severely compromise the remaining forests, reducing forest carbon uptake and storage, and affecting regional microclimates, provoking lower rainfall and higher surface temperatures, particularly during droughts, leading regions with >20% deforestation to approach their tipping point.

(iii) Extreme climate events in the Amazon, such as the super El Niño 2023-24, in combination with high temperature anomalies in the North Atlantic Ocean, exacerbate human-driven changes in the Amazon (i, ii), especially with the occurrence of mega-fires, threatening the wellbeing of Indigenous peoples and local communities (IPLCs) as well as those who live in its cities and towns. In 2023, Amazonian municipalities showed some of the worst air quality in the world due to regional fires[1], including Manaus, Santarém, and Santa Cruz de la Sierra.

(iv) Primary and secondary forests remove 0.7 billion tonnes of CO_2 per year combined, which represents about 14% of all global sources associated with land-use change. The Amazonian forests act not only as carbon sinks, but also provide multiple ecosystem services, including: regulating the regional climate by recycling water to the atmosphere and reducing regional and local air temperatures, supporting hydrological systems, conserving biodiversity, and supporting the livelihoods of IPLCs as well as urban populations.

(v) Ending all deforestation (legal and illegal) and preventing forest degradation can restore the Amazonian carbon sink, even in the face of global climate change. Implementing large-scale forest protection measures would maintain the existing carbon stocks, while an advancing and ambitious program of forest restoration would capture and store an additional 15-30 billion tonnes of CO_2 in Amazonian forests by 2050.

(vi) Carbon markets (i.e., transactions of carbon credits in exchange for carbon removals or storage) can provide part of the finance needed for forest protection and restoration in the Amazon, but most current models of carbon finance restrict the ability to grow to scale because the needs to ensure additionality, prevent leakage and promote permanence of carbon stocks at the individual level of projects or programs. There is a need for innovation and alternative approaches in financing forest protection and restoration, focusing on a wider definition of climate and environmental finance that can be deployed at the landscape level and avoid the challenges of project or program-based approaches.

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RECOMMENDATIONS

(i) Act now to end all deforestation and avoid forest degradation.. There is a need to initiate immediate actions to combat regional deforestation, forest degradation, fires, and global warming, to safeguard the Amazonian carbon sink and sustain the livelihood of the Amazon's inhabitants. These actions should include, among others,

1. Environmental monitoring, land tenure and territorial planning to combat illegal practices and prioritize low-carbon economies,
2. Regulation of economic and fiscal incentives (e.g., funds, access to credits benefiting responsible producers),
3. Promotion of sustainable productive activities (e.g., the sociobioeconomy of healthy standing forests and flowing rivers[2]).

The success of these actions depends on political will and public-private policy partnerships, motivated by corporate social responsibility in supply chain initiatives. Delaying such climate actions only increases the ecological, social, and economic damage that is impacting the Amazon forest and its peoples.

(ii) Build 'Arcs of Forest Restoration' by 2030. Redouble efforts to restore deforested areas and degraded forests, and also reforest degraded pastures. Give priority to regions near the tipping point such as in the southern (e.g., Madre de Dios) and eastern Amazon (e.g., Mato Grosso and center-south of Pará states) and then follow with the other regions of the Arcs of Reforestation[3].

(iii) Restoration needs to implemented using appropriate and diverse native species for each sub-region of the Amazon, considering current and future climate changes, and informed by Indigenous and local knowledge systems as to provide more diverse environmental services, and enhance livelihoods of IPLCs. Increasingly, the response to forest recovery has focused on plant monocultures that do not address broader issues of landscape recovery and resilience, such as soil nutrient recovery, long-term carbon uptake, and the reconstruction of ecological diversity. This approach could potentially reduce pollinators and soil water recharge[2].

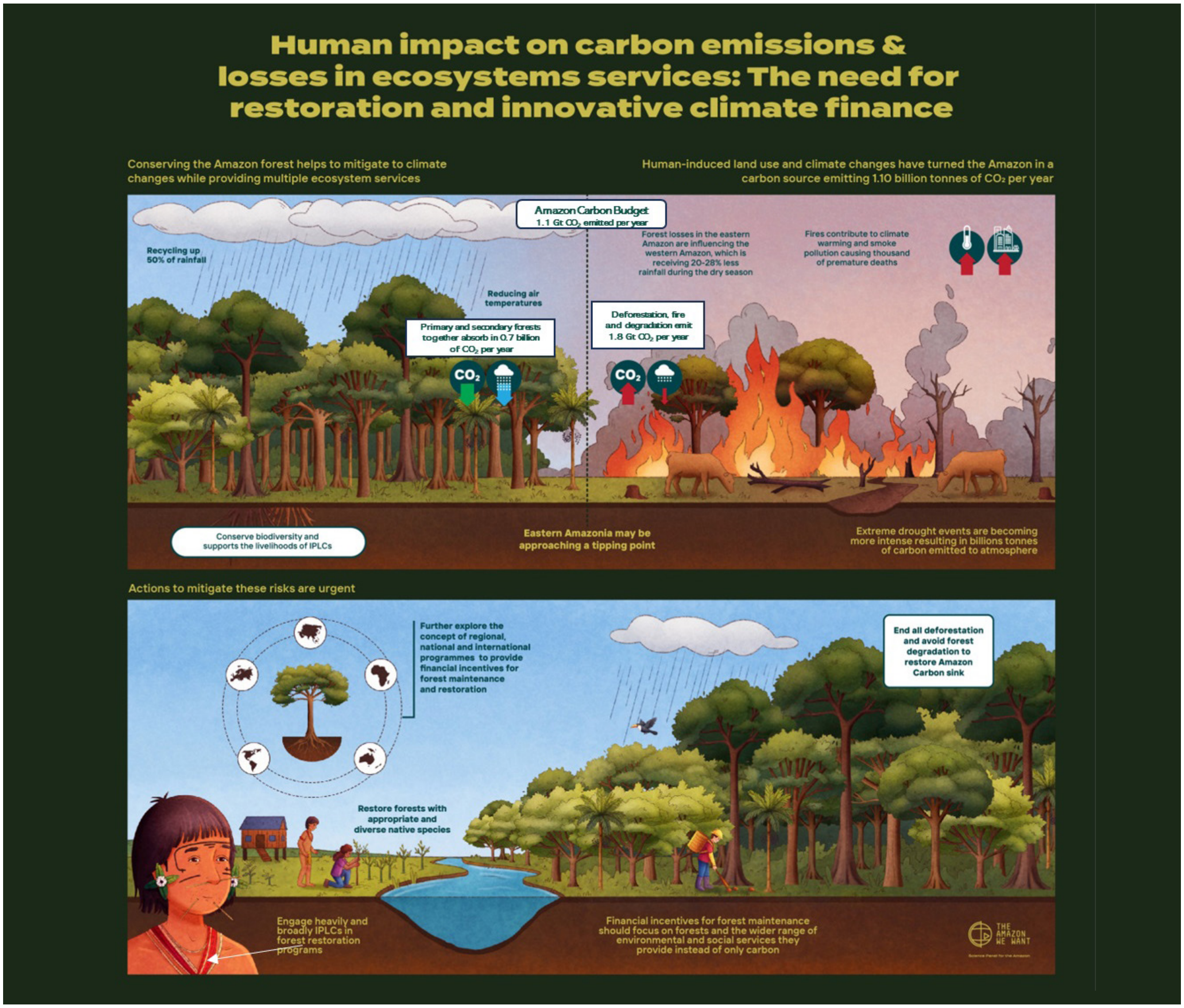
(iv) Finance for forest restoration and conservation must be inclusive and equitable for all stakeholders involved in the area, using a framework that strengthens the enforcement of environmental laws and recognizes the land rights of IPLCs.

(v) Explore innovations in current frameworks for climate finance, including but not limited to carbon markets, such as sovereign climate bonds, biodiversity markets, conversion of environmental fines, and other modalities of payment for environmental services (i.e., carbon stocks, water, etc.).

(vi) Further explore the concept of regional or national programs to coordinate the flow of financial incentives for forest maintenance, moving away from a focus on carbon to a focus on forests and the wider range of environmental and social goods and services they provide, e.g., water recycling and provision, biodiversity, prevention of soil erosion, soil nutrient recovery, ecotourism, and provision of forest resources and subsistence.

A. LEVERAGING THE AMAZONIAN CARBON SINK FOR CLIMATE CHANGE MITIGATION, ADAPTATION AND ECOSYSTEM SERVICES

Amazonian forests are among the most productive natural ecosystems in the world, storing carbon in the order of 150-200 billion tonnes (Gt) in soil and vegetation[4] – a stock equivalent to 14-18 years of global carbon emissions. As they grow, these forests also help remove carbon dioxide from the atmosphere, taking in up to 0.7 Gt of CO_2 per year in primary and secondary forests[5,6]. This contribution to the reduction of atmospheric CO_2 may seem modest when compared to all human emissions (40 Gt CO_2 per year over the last 10 years[7v]), but it represents 14% of all global sources associated with land-use change (5 Gt CO_2 per year[7]). Sustaining this carbon sink is critical if we wish to reduce net carbon emissions to keep global warming below the Paris Agreement target of 1.5°C, and to reduce the risk of a tipping-point collapse of the Amazon forest, which would bring long-term regional and global impacts[8].



GRAPHICAL ABSTRACT: Human impact on carbon emissions and losses in ecosystem services: The need for restoration and innovative climate finance.

Beyond sequestering carbon, forests help regulate the water cycle in the Amazon region and beyond. As the humid air from the Atlantic Ocean enters the Amazon, it is transported towards the Andes and then redistributed to other regions of South America, including major agricultural regions in the Cerrado and southern cone as well as population centers[9]. This humidity and the water vapor produced by evapotranspiration are responsible for cloud formation, modulating regional temperatures and water availability in streams and rivers throughout the year. Evapotranspiration by forests actively maintains atmospheric rivers that bring essential precipitation to the continent. This process involves the active role of vegetation, in general, and forests, in particular, which recycle rainfall through evapotranspiration and by accessing soil water via roots, including few trees with very deep rooting systems[10] – a process first described in the early 1980s[11]. For the western Amazon, this recycling becomes especially important towards the end of the dry season[12], which is a critical time for maintaining forest ecosystems.

The loss of forests can reduce rainfall and increase land surface temperatures, particularly during the dry season, reinforcing a feedback loop in which reduced transpiration leads to reduced atmospheric water content and further reductions in precipitation. This has already been observed in the southern and southeastern Amazon, where the dry season is 4-5 weeks longer[13]. These processes accelerate regional warming and increase the likelihood of extreme climate events, which contribute to forest degradation and impoverishment over time[14]. The cumulative impacts of these compounding disturbances amplify the threat of irreversible forest degradation, undermining carbon sinks and making the long-term burden of cutting emissions even greater[15]. Ultimately, these processes could push rainforest regions closer to a critical threshold (tipping point) and eventual ecological collapse[16], barring effective management interventions to mitigate these impacts.

Given these potential impacts, it is imperative to align social, economic, and political factors to preserve Amazon forests – and with them regional climate stability (and global stability) and the long-term capacity to sequester carbon at levels required to achieve global targets (15-30 Gt of CO_2 land sink, contributing to the overarching target of 100, 367 Gt CO_2 by 2050). Amazon forest conservation can offer a sustainable, long-term strategy for emissions reduction[15].

B. THE AMAZON REGION EMERGING AS A CARBON SOURCE (NATURAL + ANTHROPOGENIC)

Warning signs from remotely sensed data on vegetation dynamics indicate that, due to the accelerating synergies among deforestation, forest degradation, fire, and climate change, over three-quarters of the Amazon forest is losing resilience, particularly in the drier regions most impacted by human activity[17]. Without intervention, the progressive expansion of deforested areas (e.g., 850,000 ha yr^{-1} of forest loss in the Brazilian Amazon alone from 2013 to 2022), could add 6 million - 7.5 million ha (Mha) of newly cleared areas by 2030. The growing extent of degraded regions within the Brazilian Amazon (33.7 Mha from 1992 to 2014)[18], combined with a heightened frequency of climatic anomalies, such as droughts and forest fires, has forged a self-reinforcing feedback connections among these factors.

Estimates of the Amazon's carbon balance over the last decade indicate that the Amazon as a whole is now a carbon source (i.e., C losses to the atmosphere) on the order of 1.1 Gt CO_2 yr^{-1} (Total Carbon Flux) (Figure 1). In addition, the emission by biomass burning is responsible for 1.5 Gt CO_2 yr^{-1}[19-21]. These results include all processes in the Amazon, including sinks in mature and secondary forests, in rivers and floodplains, recovery from disturbed forests, and carbon emissions from deforestation, degradation, logging, decomposition, fires, fossil fuels, and agriculture (pasture and crops).

Recent studies have documented a notable increase in the net Amazon carbon balance during 2019 and 2020[20], with an 80% increase in deforestation, and a 40% increase in biomass burning compared to 2010-2018. Carbon emissions more than doubled over this period, jumping from 0.9 to 1.9 Gt CO_2 yr^{-1}. Consequently, the Amazon transitioned from being a carbon sink to a discernible carbon source, largely due to the dismantling of measures to control deforestation, forest degradation, fires and lack of law enforcement in the Brazilian Amazon during this period.

Carbon emissions exhibit regional variation, influenced by different climatic conditions due to the magnitude of deforestation and forest degradation[5]. After declining by 83% from 2004 to 2012, Amazon deforestation rates have been increasing, especially in the "arc of deforestation", contributing to substantial warming in this region[21]. While the enforcement of environmental protection policies in Brazil were responsible for reducing deforestation by 83% from 2004 to 2012, more recently (since 2016, and more intensified since 2019) the dismantling of these policies caused a 76% increase in deforestation associated with fire events, alarming the national and international community and causing worldwide protests[22].

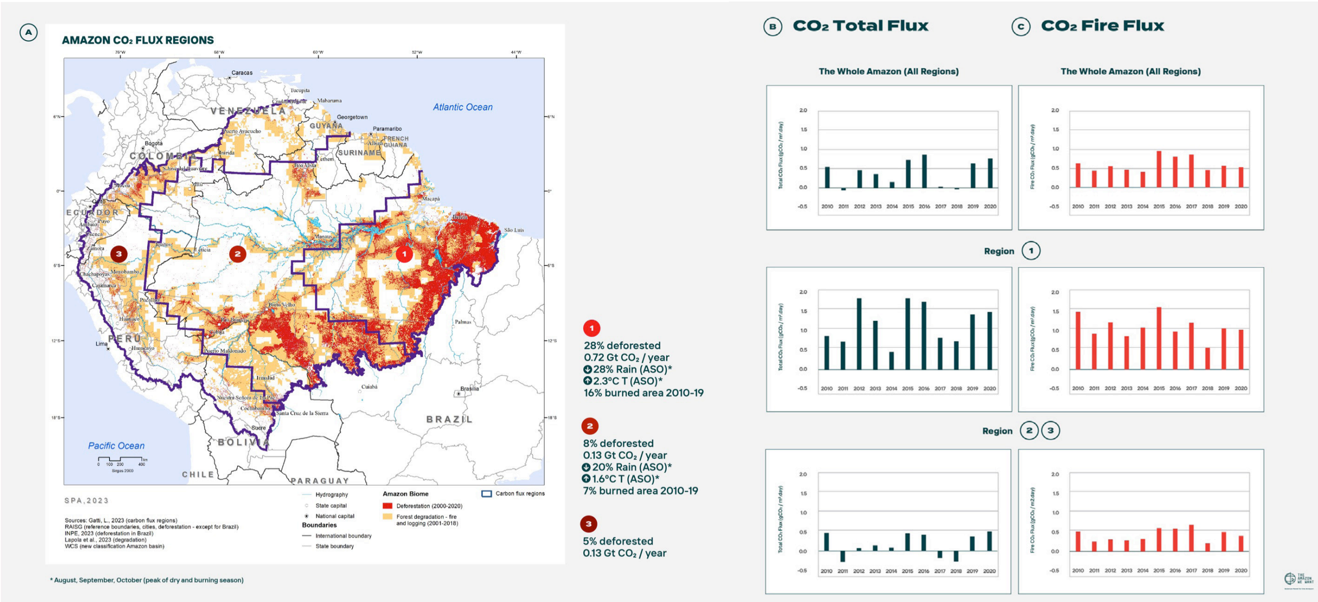


FIGURE 1. Amazon Carbon Flux (2010-2020). A. Regions of influence for the Amazon CO_2 flux connect to deforestation, forest fires, and regional climate change trends, B. CO_2 total flux and fire fluxes for the whole Amazon biome and for the three regions of influence (see [20,21]).

An extreme Amazon drought occurred in 2015-2016, impacting over 40% of the Amazon forest biome and increased fire occurrence in the Brazilian Amazon by 36%, with active fires observed across 80 million ha of forest (19% of the Brazilian Amazon)[23]. The Amazon has warmed an average of 1.0°C since 1978, which includes an increase of 1.4°C during the peak of the dry season (August-October). In highly deforested regions, the effects are particularly acute. In the southeastern Amazon, where deforestation has affected over 28% of the land area, during August and September (dry season months) temperatures have increased by 3.1°C. In the northeastern Amazon (38% deforested), annual accumulated precipitation has declined by 11%, including dry season losses of 35%, showing that the impacts of forest loss on water cycling can be as significant as the contribution to carbon emissions [20,21]. Moreover, the intensification and increase in the length of the dry season represent an increase in forest stress, which will likely amplify carbon losses, especially by fire, as forests become drier and more flammable[24] (Figure 2). With the El Niño event of 2023-2024, the Amazon region is again at risk of large fires due to the intense drought and increased air temperatures[25]. Associated with high rates of deforestation and the use of fire to manage pastures and agricultural areas – the scenario has been proving catastrophic for local peoples and biodiversity[26]. Events like this have previously affected the Amazon[27], causing yearly degradation of millions of hectares.

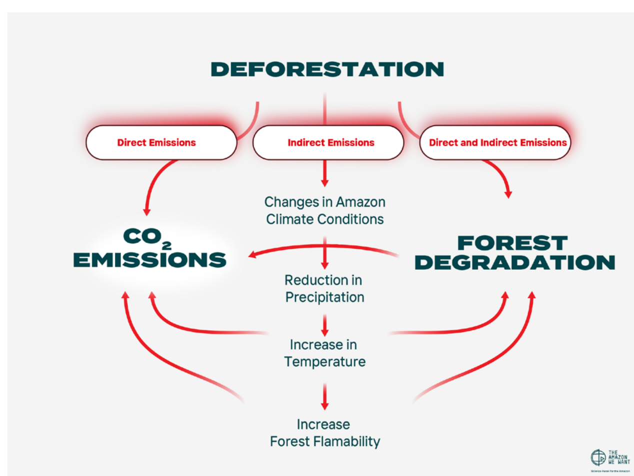


FIGURE 2. Deforestation represents direct and indirect CO_2 emissions. Deforestation promotes changes in the climate of the remaining forest, leaving it more degraded and flammable, promoting additional forest losses.

C. THE POTENTIAL OF CLIMATE CHANGE MITIGATION INITIATIVES TO PROTECT AMAZON FORESTS, BIODIVERSITY, AND LIVELIHOODS

(i) Urgent need to stop all deforestation, degradation, and fires

To prevent the Amazon from becoming a persistent source of carbon emissions[20,21], jeopardizing the success of climate mitigation and adaptation efforts, it is imperative to implement globally and nationally coordinated urgent actions aiming at achieving zero deforestation, forest degradation, and fires in the Amazon. Achieving this goal by 2030 may be too late. There is a need for urgent actions, such as an immediate moratorium on deforestation[28] and specific policies to prevent the movement of agribusiness from climatologically affected regions (southern Brazil) towards the Amazon regions, inducing worsening of severe drought conditions[29].

From 2004 to 2012, Brazilian policies and forest law enforcement approaches were important instruments related to the reduction of deforestation supporting natural forest regeneration[30,31]. In recent years (2019 and 2020, compared to 2010-2018), an increase in deforestation was observed associated with a 13% increase in cattle herds, a 70% increase in the area planted with grains (soybeans and corn), and a 700% in wood exports in the Amazon[19]. The increase in the deforestation rates since 2013 has led to the failure of the targets stipulated by the National Climate Change Policy (Law nº 12,187/2009) to reduce deforestation to 3,925 km^2 by 2020[31].

National and global policies, law enforcement and control of economic incentives for the agricultural commodities market in the Amazon contribute significantly to combating deforestation and forest degradation[32]. Administrative, criminal and civil sanctions related to environmental violations act as disincentives to practices of illegal deforestation[33,34]. Public–private policy partnerships are crucial for enhancing supply-chain initiatives to eliminate deforestation from company operations or supply chains, motivated by corporate social responsibility and growth strategies as well as international boycotts such as the recent EU initiatives [35,36].

In the Brazilian Amazon biome, the officially released deforestation rate in November 2023 revealed a 40% reduction from August 2022 to July 2023 compared to the period from August 2021 to July 2022[37]. From January through October 2023, deforestation in the Legal Brazilian Amazon reduced close to 50% compared to the same period of 2022[38]. Similarly, the Colombian Amazon exhibited a noteworthy reduction of 36% in deforestation during 2022 compared to the preceding year. In Brazil and in Colombia, this success in combating deforestation can be attributed to the return the implementation of renewed national plans to curb deforestation[39,40], and political will, with action strategies aimed at environmental monitoring, regulation of land tenure and territorial planning, collection of environmental fines, interventions and confiscation of equipment, and others. The economic regulation and fiscal incentives to reduce deforestation is expected to increase the success in promoting sustainable activities.

Resolving these fundamental issues requires strong and coordinated commitments from the Amazonian countries at national and sub-national levels to deal with the deep roots of deforestation. The deforestation land-market in the Amazon has fueled it with illegal activities being reinforced by deterioration of democracy in recent years [41]. The Amazon land market has converted millions of hectares of public land into private properties contributing to create an ecosystem of crime involving: violence, illegal land acquisition, illegal logging, mining, fraud, money laundering, and other illegal practices. The Belém Declaration, signed by the eight Amazonian countries during the Amazon Summit on August 9, 2023, represents an advance in the future perspective. However, its commitments are still insufficient considering the urgency of climate change currently observed. Challenges remain surrounding Amazonian states' willingness and capability to implement and maintain effective regulatory policies over time[42]. Collective commitments under the New York Declaration on Forests and initiatives like the Tropical Forest Alliance 2020 highlight global efforts in catalyzing deforestation-free commodities supply chains.

In the Amazon fire is already a major source for forest degradation. The best means for controlling forest fires is prevention, which will require an extensive and intensive educational effort, not only in the formal school systems, but also with rural producers and decision-makers. An additional incentive will be that by controlling fires, the impact of smoke pollution in the Amazon will diminish, a factor that currently is contributing tens of thousands of premature deaths[43] and reducing years of life expectancy[44]. The potential for fire increases in a hotter Amazon with a longer dry season. The recovery rates decrease one fourth (25%) in the most water-deficient regions of the Amazon, a potential reduction in the carbon sink of these forests as a response to future changes in hot and dry climate extremes[45].

Despite global calls for a low-carbon economy, fossil fuel exploitation still persists and increase in the Amazon, without adequate attention to its climate, ecological, and cultural impacts. 10.5% (62 Mha) of the Amazon biome is currently involved in oil and gas activities, being 68% and 16% of all wells, respectively, overlapping with Indigenous territories and protected areas. Oil blocks overlap significantly in the Andean-Amazonian countries, specifically the Ecuadorian (59%), Bolivian (34%), and Colombian (36%) Amazon. Adopting a territorial suitability approach for infrastructure expansion in the Amazon, in which cultural and ecological diversity take precedence, is essential [46,47].

(ii) Build 'Arcs of Forest Restoration'

Forest restoration is critical as a component to address carbon emissions regionally and to contribute to the global effort to reducing carbon emissions and increasing carbon absorption. On local and regional scales, forest restoration provides multiple ecosystem services, such as maintaining water flows, conserving biodiversity, and reducing heat stress[48,49].

The Amazon has around 50 million ha under different land tenure categories, including untitled public and private lands and collective properties with potential to be restored[3]. Priorities for restoration should be given to regions with substantial accumulations of deforestation and degradation, as well as those undergoing more stressful conditions by climate changes: (i) primarily, within the Arc of Deforestation spanning southern and eastern Amazon, and then (ii) across the Andean-Amazonian Arc of Deforestation, which traverses Colombia, Ecuador, and Peru (Figure 3)[3].

These tens of millions of hectares with potential for restoration include degraded forests and forests under different stages of regrowing after deforestation (i.e., secondary forest (SF)). Forests degraded through logging, forest fires and edge effect covered 36 million ha of the Amazon biome between 2001 and 2018[50]. In the Amazon, SF covers 14 million ha only in the Brazilian Amazon biome[6] and can recover slightly more than one-third (37%) of its previous above-ground carbon within 20 years[45], sequestering between 4.8 $tCO_2\ ha^{-1}\ year^{-1}$ (eastern Amazon) to 11.0 tCO_2

ha^{-1} yr^{-1} (western Amazon)[43]. Maintaining SF can contribute to reducing Brazil's net emissions by 5.5% by 2030 considering its Nationally Determined Contribution[6]. Logged over forests have a carbon sink of approximately 4.9 tCO_2 ha^{-1} year^{-1} [51]. While it may require several decades for above-ground biomass and species diversity to fully restore to levels seen in old-growth tropical forests (90% recovery in 12 and 6 decades, respectively), the restoration of forest functioning, which encompasses forest carbon cycling and recovery capability after disturbance —take place at a much swifter rate (90% recovery in 3 to 27 years)[52]. The restoration of secondary forests and degraded forest by selective logging represents lower opportunity cost compared to other alternatives for forest restoration[53] (e.g., planting of agroforestry and silvicultural systems) and can be encouraged through the provision of certification and accreditation of these initiatives and the development of a viable credit market[54,55]. The combined efforts to protect old growth forest, while regenerating degraded and secondary forests have the potential to accumulate an average of 62 Mt C yr^{-1} [45].

The restoration of deforested or degraded lands musr also encompass agroforestry systems (AFS) aimed at atmospheric carbon removal, as well as delivering a diverse array of ecological and socio-economic benefits[2]. This includes the cultivation of native species such as cacau (*Theobroma cacao*), cupuaçu (*Theobroma grandiflorum*), açai (*Euterpe oleraceae*), and babassu (*Attalea speciosa*)[56]. Agroforestry systems can also be implemented in deforested Legal Reserves converted to pastures or crop cultivation, in accordance with the Brazilian Forest Code (Law 12,651/2012), to make significant contributions to climate change mitigation and adaptation. AFS have the potential to uptake carbon, with estimates ranging from 29 Mt CO_2 ha^{-1} over 10 years to as much as 202 Mt CO_2 ha^{-1} over a period exceeding 30 years[56].

While arborization in urban areas in the Amazon, where much of the region´s population lives, could be a modest carbon sink, it can have a tremendous social benefit for reducing the heat island effect and improve human well-being in a warming climate[57] while enhancing the array of ecological services provided within urban ecosystems. Ecosystem restoration should be reconsidered in its relation to urban areas as part of holistic landscape recovery strategies with high potential for local participation[58]. The urban Amazon now comprises more than 50% of the population of 48 million, and up to 70% in the Brazilian Amazon. Urban centers typically have higher solar absorption, lower solar reflectivity (albedo) and greater thermal capacity/conductivity, more impermeable surfaces, higher pollution levels compared to the surrounding areas. All these characteristics produces intense heat island effects in the tropical cities. The Amazonian cities of Belém and Manaus have the highest urban heat island indices in Brazil, with Manaus coming in at 4.2 °C UHI (Urban Heat Island) differential from surrounding areas [59,60]. While the more general CO_2 uptake in urban areas remains understudied, the few studies that exist on CO_2 uptake show much higher rates of absorption compared to temperate zone sites in the very small sites that have been studied [61]. Environmental impacts of urban vegetation (massive increase in trees plantation, green roofs, green facades, vertical greeneries, and green pavements) can significantly mitigate the UHI intensity, both directly and indirectly, resulting in the decrease of urban air temperature and mean radiant temperature. The impact of greenery on the urban ecosystem from a physical point of view include a partial compensation of greenhouse gas (GHG) emissions by carbon fixation, decrease temperature, thermal comfort, energy-use reduction, flood protection and improved runoff-water quality. In addition, the widespread use of dooryard agroforestry as well as relatively diverse public plantings provide habitats and food security[62].

To ensure the success of restoration projects in terms of long-term ecosystem service recovery and reduced carbon emissions, justifying the associated costs, restoration efforts may demand a combination of native regeneration and replanting native species[3,63] considering choices of plant species adapted to current and future climate change impacts[64]. Focusing on "how and where to restore," contribute to more realistic spatial prioritization[65]. For instance, species-rich forests demonstrate greater temporal stability in carbon (C) capture and are more resistant to drought compared to monodominant plantation (e.g., eucalyptus), enhancing climate change mitigation efforts while providing additional benefits for biodiversity conservation and other ecosystem services[66].

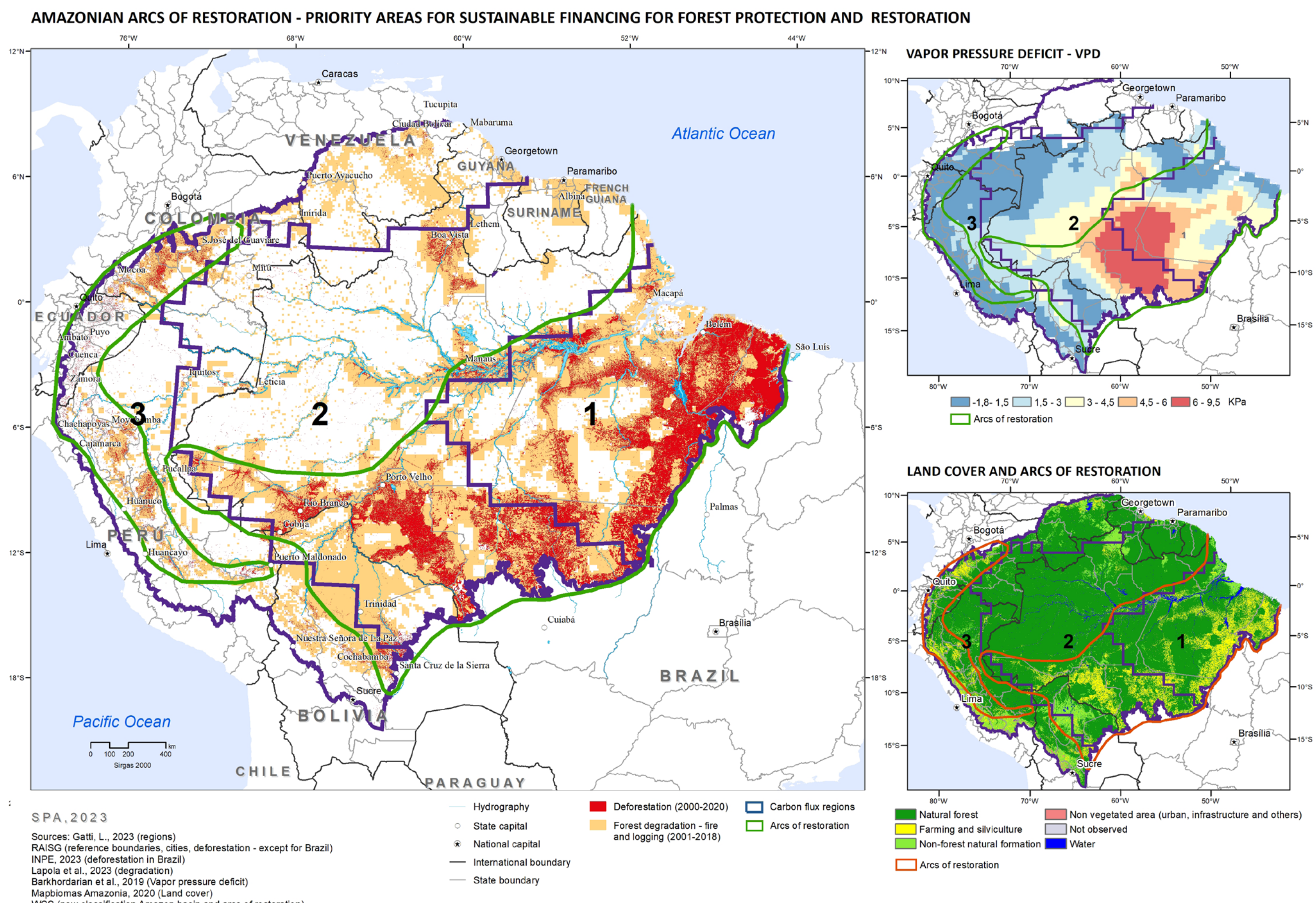


FIGURE 3. Priorities areas for sustainable financing for Amazon forest restoration and protection. Prioritizing areas marked by significant deforestation and forest degradation, as well as those experiencing hotter and drier environments. Land use and land-cover types underscores the political and financing challenges associated with landscape restoration.

(iii) The knowledge of Indigenous peoples and local communities, contributing to forest restoration strategies, biodiversity and forest management

Indigenous territories (ITs) store approximately 10%–20% of global forest carbon stocks[67], and are a critical component of national and international climate mitigation efforts. Forests in ITs in all eight Amazonian countries and French Guiana acted as net carbon sinks from 2001 to 2021, but the amount of sequestration varied significantly between countries[68]. Forests outside ITs in the Amazon biome were a net carbon source during the same period, emphasizing the crucial role of Indigenous territories in protecting the forests and mitigating climate change. In 2016, ITs of all-Amazon countries stored 24,641 M tC, Venezuela (85%), Ecuador (81%), and Colombia (73%) having the largest proportion of their carbon within ITs[69].

While to a lesser extent, Indigenous territories and protected areas in the Amazon also face pressure from deforestation and degradation. Over the past 37 years, 10% of the remaining forest and 17% of its diverse natural vegetation have been lost [67,70]. Illegal mining has become a major threat in Brazilian ITs, causing deforestation rates to rise 195% in 2019-2020[71] and almost doubling CO_2 emissions in these areas. This destruction weakens the resilience of the forest[72], and forest-dependent people, to adapt to climate change, address food insecurity, and avert water crises[73]. These circumstances highlight the persistent pressure faced by ITs and other protected areas, as well as the concerning fact that deforestation rates in the vicinity of protected areas are significantly higher than rates within them[74]. Consequently, this situation serves as a crucial test of the commitment of governments in the region to effectively conserve the forest and sustain the well-being of its original inhabitants. A significant challenge lies in the form of insufficient financial resources. This presents a major hurdle in achieving the ambitious global restoration goals set forth in climate agreements[75,76].

In spite of the threats and pressure on IPLCs territories, they have used their ancestral knowledge systems to deal with natural and anthropogenic external disturbances in order to resist and survive[77]. The relationship of IPLCs with natural resources (e.g., forests and rivers) are based on ancient empirical management practices which ethnobiological sciences corroborated help keep integrity of forest and river ecosystems and support local species, guaranteeing their food security[78]. They are great landscape managers via slash-and-burn secondary forest rotation strategies, and decentralized forest management[79–83]. Complex fire management is also part of the management repertoire inside their territories to manage fuel material, promote better food for grazing animals, and improve hunting[84–86]. Their knowledge on management which includes the right time to burn (e.g., early in the dry season) which reduces the potential of an intense and uncontrolled fire[85], or the knowledge on when and how to use secondary forests in agriculture production and the management of secondary forests for an array of goods. In addition, Indigenous peoples also have been active forest recuperators, managing the landscape for centuries restoring and enriching forest areas with species that are important for their livelihoods (e.g., fruits, plants used for utensils or housing)[87].

In sum, in a situation where forests and rivers inside IPLCs' territories are becoming more degraded due to external pressures of land use change and climate change, their knowledge on how to manage disturbances and create a sustainable/resilient landscape is ever more needed. For example, ancient knowledge on how to manage "cultural fires" have been acknowledged as important assets for modern prescribed burns as well as for creating Amazon Dark Earths, the highly productive anthropogenic soil found widely in the Amazon[88]. Following IPLC strategies to address disturbances that cause degradation is a way to incorporate centuries of learning through viable and tested adaptation strategies integrated with current scientific approaches to generate better tactics for large scale restoration, biodiversity, and forest management.

(iv) Nature-based Solutions (NbS) through forest conservation and restoration can be achieved if climate finance can be attracted and deployed at the scale needed to tackle this environmental challenge

The challenges mentioned above require the deployment of funding at scale to counteract the processes and trends that are affecting the Amazon region (Figure 4).

The importance of native vegetation and nature-based solutions to climate change mitigation has been widely recognized at both the UN level and in voluntary agreements. Carbon markets have existed since the 1990s and over the last years have given more importance to Nature-based Solution, with financial pledges worth tens of billions of dollars[89]. These new sources of capital have been directed to a variety of NbS activities, including REDD+ (Reducing Emissions from Deforestation and Forest Degradation), forest protection, restoration, blue carbon, sustainable

Overview of climate finance options for the Amazon

	Voluntary Carbon Markets	International Compliance Markets (Article 6)	National or sectoral compliance schemes	New Innovative Strategies
EXAMPLES	• Verra Verified Carbon Standard • Gold Standard • ART's Trees	• Internationally Transferred Mitigation Outcomes (ITMOs)	• National or jurisdictional emissions trading system schemes • EU Emissions Trading Scheme • Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) • Amazon Fund	• Payment for forest stocks Examples: Green or Climate Bonds, payment for forest stocks, payment for wider range of environmental services, conversion of environmental fines.
ADVANTAGES	• Existing frameworks, already in operation • Carbon credits can be bought by anyone • Can be used for small projects	• Aligned with UNFCCC and Paris Agreement • Allows for international cooperation in implementing the Nationally Determined Contributions (NDCs)	• Can involve the private sector in the reduction of emissions at the domestic level • Can create demand for carbon credits through requirements to offset company CO_2 emissions • Can allow countries to assist other countries in CO_2 reduction activities without incurring Corresponding Adjustments	• Potential to scale up to national scale • Domestic fund distribution rules defined by host country and alligned with national priorities and circumstances • Focus on all environmental services of the forest, as well as on stakeholder needs
DISADVANTAGES	• Complexity of process • Restrictive rules • Not scaleable • Focused on a single environ-mental service: carbon • Some standards don't include avoided deforestation activities (e.g. Gold Standard)	• Complexity of process • Restrictive rules • Corresponding Adjustments may create liabilities for host countries • Focused on a single environ-mental servicee: carbon • Not yet operational	• Restrictive rules • Focused on a single environme-nal service: carbon	• A new mechanism, yet to be defined, agreed and negotiated

FIGURE 4. Overview of climate finance options for the Amazon.

agriculture, soil management, and grazing land management[90].

Internationally, there is a recognition that carbon markets are not a panacea to attract and deploy climate finance and that new environmental finance approaches need to be developed and deployed to fight carbon emissions and losses of ecosystem services. This is because the rules and architecture of carbon credit creation and sales create limitations to scaling up. Carbon markets are based on the trading of carbon credits or mitigation outcomes that represent a tonne of CO_2 reduced or removed from the atmosphere. Carbon credits are created according to the modalities, rules and requirements of different standards, depending on the markets where they will be sold and the intended final use of these instruments.

Carbon trading today can be broadly divided into three main categories depending on the end use of the carbon instrument: international compliance markets under the Paris Agreement, domestic or regional carbon markets, and voluntary carbon markets (VCM). Each of them has different rules, and requirements that could be applicable or not to different project types, including NbS.

INTERNATIONAL COMPLIANCE MARKETS

International compliance markets refer to transactions involving parties with commitments of emission reductions adopted with the UNFCCC, originally under the Kyoto Protocol and now the Paris Agreement, signed in 2015[91]. Article 6 of the Paris Agreement creates the basis for international cooperation in implementing the Nationally Determined Contributions (NDCs) adopted by parties via a new international carbon market aiming at reaching a net-zero greenhouse gas (GHG) emissions scenario. Its Article 6.2 recognizes 'cooperative approaches' between Parties that provide financial assistance to one another in exchange for an amount of 'Internationally Transferred Mitigation Outcomes' (ITMOs), and its Article 6.4 refers to emission reductions and removals from mitigation activities developed by the public and private sectors. Transactions using some sections of Article 6 require the use of corresponding adjustments, an accounting mechanism that subtracts the GHG mitigation outcomes occurring from the host country's account and adds it to the importing country's account so that there is no double-counting of the mitigation unit and the emission reduction or removal outcomes only contribute to the NDC of a single country. The requirement for corresponding adjustments, however, can have a negative impact on host countries. If they export their low-cost mitigation outcomes, host countries would still need to invest in additional mitigation outcomes to reach their NDCs[92]. Depending on the costs of the mitigation outcomes exported, and the costs of the remaining mitigation options available to the host country, such transfers could result in negative economic impacts for the host country (Box 1). On the other hand, voluntary transactions without corresponding adjustments (under the VCM and some modalities of Article 6[93]), can assist countries in meeting their NDC targets as these do not need to be debited from the host country's account and added to the national account of the buyer.

BOX 1: Corresponding adjustments and their impact on host countries

In order to ensure the integrity of the international GHG accounting system, cross-boundary transfers of mitigation outcomes must be accounted for by a system of Corresponding Adjustments. This mechanism subtracts the GHG mitigation outcomes occurring from the host country's account and adds it to the importing country's account so that the outcomes contribute to the NDC of a single country.

The requirement for corresponding adjustments, however, can have a negative impact on host countries. By exporting their mitigation outcomes, the host country still needs to invest in additional mitigation outcomes to reach their NDCs. Depending on the costs of the mitigation outcomes exported, and the costs of the mitigation options still available to the host country, such transfers could result in negative economic impacts for the host county. The exact costs to host countries vary depending on the marginal abatement cost curve (MACCs) of each country.

Given that investors usually look for low-cost mitigation options, the host country may be left with higher mitigation outputs to meet their NDCs. The result is that the overall cost of meeting NDCs will increase at the national economy level. A recent study for the World Bank Climate Market Club[i] estimates that the opportunity costs to developing countries ranges from \$20 to \$78 /tCO_2e. Consequently, programs that purchase and export credits at, e.g., \$10/tCO_2e, result in an additional abatement cost of \$10-68 to the host country. In order to avoid this environmental liability, host countries would need to impose levies on these transactions, charging the residual cost of abatement available to the country after exporting carbon credits.

Alternatively, voluntary carbon markets could provide the basis for international climate cooperation without being detrimental to host countries' targets. The emission reductions created by voluntary projects do not need to be reflected in any official accounts: the seller's credits are not debited from the host country's account, and not added to the national account of the buyer[ii]. Voluntary transactions without corresponding adjustments, instead, can assist countries in meeting their NDC targets and result in emission reductions that either contribute to, or that are additional to the targets of the Paris Agreement, a truly positive outcome.

[i] Climate Market Club. Article 6 Approach Paper Corresponding Adjustment and Pricing of Mitigation Outcomes. DRAFT May 2022.

[ii] Of course, this would not be the case for "mitigation outcomes authorized for use towards achievement of NDCs and/or Other International mitigation purposes" (e.g., CORSIA and the VCM). In this case, the emission reductions should be subjected to corresponding adjustments.

NATIONAL OR SECTORAL SCHEMES

While UNFCCC targets were adopted only by parties of the convention (i.e., countries), many countries have introduced measures to involve the private sector in the effort to reduce emissions at the domestic level, both voluntarily and for compliance purposes. These include the European Union Emissions Trading System (EU ETS), the United Kingdom Emissions Trading System (UK ETS), the Regional Greenhouse Gas Initiative (RGGI) in the US, and emissions trading system schemes in China, California, and Quebec, among others. Additionally, the sectoral Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) also creates demand for carbon credits through a requirement to offset international aviation CO_2 emissions. In Amazon countries, Colombia has implemented a number of schemes including a carbon tax on fossil fuels, and a portion of revenues from the tax has been earmarked for forest conservation projects in the Amazon[94]. Guyana and Suriname entered into contractual agreements with oil and gas companies to acquire emission reduction credits from its land use sector. And Brazil has had the Amazon Fund since 2006 and is now creating new models of public incentives for carbon management including forest concessions for carbon management, BNDES's Floresta Viva funding line for forest restoration, and the low carbon agriculture credit line (Fundo ABC) of the Federal Government. It is expected that additional domestic schemes will be created as a result of commitments from countries in the region to the Paris Agreement.

VOLUNTARY CARBON MARKETS

The Voluntary Carbon Market (VCM) refers to transactions of carbon credits purchased by companies, individuals, or governments on a voluntary basis. While this was previously a relatively small market, it has grown to around USD 2 billion in 2023 and is expected to grow significantly more[95]. While, theoretically, voluntary transactions can purchase credits created by any mitigation activities, buyers are concerned about the reputational risk of buying credits that are not certified according to internationally recognized standards (e.g., Verra, Gold Standard, ART's TREES, ART's HFLD High Forest-Low Deforestation standard, etc.). The main driver of demand for the VCMs is corporate commitments to reduce their GHG footprints to align with guidance from industry advisory bodies such as the Science-Based Targets Initiative (SBTi), the Carbon Disclosure Project (CDP), and the Accountability Framework Initiative. In order to support the growth of the voluntary carbon market, the Integrity Council for the Voluntary Carbon Market (ICVCM) was created in 2021 to set threshold guidance governing integrity of high-quality carbon credits representing the supply side of the market, and the Voluntary Carbon Markets Integrity Initiative (VCMI) was created in 2021 to guide companies on how to use carbon credits in a credible and transparent way, representing the demand side of the market. Over the last three decades, thousands of voluntary carbon projects and programs that generate carbon credits were developed worldwide, including REDD+ and forest conservation activities. Some of these mitigation interventions were developed and implemented with Indigenous peoples and local communities, as for instance the REDD-Suruí project (Box 2) or the German Development Bank's REDD Early Movers program in Acre and Mato Grosso, which illustrates how Indigenous peoples participated in jurisdictional emission reduction efforts[96].

BOX 2. Forest Carbon Surui: Indigenous-Led Carbon Forest Project

Emerging markets for carbon credits have at times been called misleading, with some companies not delivering the promised environmental benefits. Land and socio-environmental conflicts have also been attributed to companies developing REDD+ projects that have "seized" carbon from areas belonging to Indigenous peoples and local communities. Indigenous-led REDD+ projects are still few and far between, with the Suruí REDD+ project on Sete de Setembro Indigenous Land being the first project to comply with a REDD+ validation process [97].

The "Projeto Carbono Florestal Paiter Suruí," was an initiative undertaken by the Suruí Indigenous people in Brazil. By harnessing the potential of their forested land to generate financial income, the project aimed to enable the Suruí to implement and manage sustainable activities across various domains such as education, culture, health, and the environment. The project's overarching goal was to achieve these objectives independently, eliminating the need for external intermediaries.

The project's origins were deeply intertwined with the Suruí people's historical role as guardians of the forest. Indigenous communities, including the Suruí, have traditionally served as protectors of their territories, preserving the rich biodiversity and cultural heritage present within their lands. In the 21st century, this role has taken on renewed significance as environmental challenges such as deforestation, degradation, and resource exploitation persist. By capitalizing on their expertise and knowledge, the Suruí championed a proactive approach to sustainable development while safeguarding the intricate balance of their ecosystem.

The project provided financial benefits relating to forest restoration and monitoring, but was also threatened through illegal invasions by loggers and miners which resulted in the deforestation of 10,000 hectares of forest. Ultimately, the project was discontinued due to implementation challenges, but it remains an important example of the potentials and challenges faced by IPLC-led projects. Among them, the difficulties in aligning the objectives of all members of IPLC communities to avoid conflicting views on land use that could lead to disputes – for example, on whether to allow mining or timber extraction in areas that other members of these communities committed to forest protection and REDD+[98].

CHALLENGES AND LIMITATIONS OF CARBON FINANCE

To ensure climate impact, carbon standards introduce a series of requirements to ensure the environmental integrity of emission reduction or removal results that are represented by issued carbon credits. The exact rules of these standards differ, especially amongst methodologies for projects or jurisdictional programs, but all carbon-crediting programs are focused on three main requirements: ensure additionality (i.e., that projects would not have happened without carbon finance), avoid leakage (i.e., that project interventions do not result in emissions or deforestation elsewhere), and guarantee permanence of carbon impact (i.e., that carbon stocks created by carbon-funded projects are maintained for the long term).

Demonstration of compliance with these requirements poses significant challenges to project development and approval. Doubtful additionality is the main reason for project reviews and rejections, leakage is still seen as a major risk related to land use projects, and the possible reversibility of the GHG benefits from forestry projects has raised questions about the environmental integrity of land-use based mitigation interventions[99,100]. In order to deal with some of the challenges of project-based accounting, jurisdictional REDD+ standards were developed, including Verra's Jurisdictional & Nested REDD+ (JNR) and ART's TREES, a standard for government-led jurisdictional programs. Given the recent introduction of TREES in 2021 and the complexity of meeting all the requirements, only one jurisdiction has successfully completed the registration, validation, and verification processes and been issued carbon credits[99,100] to date, while other Amazon countries and jurisdictions have started the process, including Colombia, Peru, and the states of Amapá, Maranhão, and Tocantins in Brazil. Similar to project-based activities, jurisdictional approaches are also exposed to criticisms from market stakeholders[101].

Another barrier of VCM carbon finance that is specific to project-based approaches relates to the requirement of "regulatory surplus" – i.e., that the activities receiving carbon finance are over and above the requirements of any law or regulatory framework. In the case of countries with very low levels of law enforcement, this requirement creates a serious impediment to project-based carbon finance. It is clear that most forest conservation projects in the Brazilian Amazon, for instance, will not occur in the absence of financial incentives but these rules limit the role of project-based methodologies to support them[102]. Regulatory surplus would also prevent climate finance from funding forest restoration of legal reserve areas in Brazil, given that in theory these areas should be restored to comply with the Brazilian Native Vegetation Protection Law (NVPL). Project-based methodologies could instead adopt the "common practice" approach used by the UNFCCC to analyze whether compliance with laws requires financial incentives. Challenges around proving regulatory additionality, which is required by many project-based standards, can be addressed by jurisdictional-scale implementation of programs such ART, or through new innovative forms of climate finance at the landscape level (see next section).

Innovative strategies in the realm of environmental finance: moving towards climate finance at a landscape scale

As discussed in the previous section, project-based carbon trading has limitations that prevent the deployment of finance at the scale needed for the Amazon. Furthermore, its focus on the single objective of carbon storage or sequestration, rather than addressing the drivers and impacts of climate change, limits the wider impacts needed to maintain the ecological function of the region. Proposed new systems of payments for specific environmental services (e.g., biodiversity credits), are likely to suffer from similar constraints and challenges as carbon credits. A new approach is needed to address the scale of the challenge and provide the multiplicity of environmental services desired.

A possible approach is to develop inclusive programs at the landscape level, covering whole regions or states, including all stakeholders involved with the regions, from private landowners and IPLCs to municipal, state and government agencies. Program participants would receive financial incentives for adopting, monitoring, and enforcing environmentally positive land use practices selected to optimize the provision of a whole range of environmental services, including protection and sequestration of carbon stocks, water storage and flows, temperature regulation, biodiversity conservation, reduction of fires and air pollution, as well as new sources of financial support for IPLCs.

This can be achieved through activities promoting forest protection, ecosystem restauration, and sustainable agriculture. Such prioritization should also take into account the UNFCCC Cancun safeguards, and implementation of activities should incorporate IPLC knowledge. Given the wider range of objectives, the basic metrics and key performance indicators for the programs could move from "tonnes of carbon" to "hectares of forests", especially if the sources of finance are not related to carbon markets[103]. Forest cover and other environmental benefits could be measured adopting existing methodologies and using remote sensing platforms such as those of INPE37 and MapBiomas[70]. Climate benefits could be reported using the Forest Reference Levels (FRELs) prepared for the UNFCCC or whatever requirement of the providers of finance[104].

Funding for the programs could come from a combination of approaches, including climate bonds (e.g., Uruguay[105] and Brazil[106]), carbon and biodiversity markets (both compliance and voluntary), conversion of environmental fines, payments for carbon stocks[107,108], REDD+ Results Units, levies on fossil fuel production, or Payments for Performance of projects under Article 5 of the Paris Agreement.

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