BRAZIL'S OPEN ECOSYSTEMS: CARBON STOCKS OVERLOOKED BY CLIMATE FINANCE

AIMS

This document presents science-based information and practical recommendations for public managers, legislators, and civil society organizations. Its goal is to guide the formulation and implementation of policies, plans, programs, and projects that promote the recognition of **Brazil's open ecosystems** as providers of essential ecosystem services, ensuring their inclusion in climate finance mechanisms. It highlights the crucial role of these ecosystems in CO_2 absorption and for the maintenance **of carbon stocks**, **water security**, and **biodiversity**, demonstrating how their conservation and sustainable use are fundamental to **strengthening the integration between the UN conventions on climate change (UNFCCC), combating desertification (UNCCD), and biological diversity (CBD).**

KEY MESSAGES

- Brazil's open ecosystems are under threat and continue to be neglected by climate policies that focus exclusively on trees, inadvertently encouraging the afforestation of these naturally non-forested landscapes.
- Open ecosystems store large amounts of carbon in their soil and host high levels of unique and endemic biodiversity. They contribute significantly to the stable provision of ecosystem services that support climate adaptation, including water security, soil stabilization, and control of desertification.
- The multiple benefits that open ecosystems provide for both climate change mitigation and adaptation remain unrecognized and excluded from climate finance. Recognizing and valuing these contributions is essential for ensuring climate security, water availability, and the well-being of people across Brazil.

A. What are Brazil's open ecosystems, and where are they found?

Open ecosystems are comprised **of non-forest vegetation**, usually associated with specific soil features and characterized by a continuous herbaceous-shrubby layer. **They occur across all Brazilian biomes and in all states of the country,** including different types of grassland and savanna, with predominance in the Caatinga, Cerrado, Pantanal, and Pampa regions, but with important enclaves within the Atlantic Forest and Amazon forest biomes. For most of these ecosystems, disturbances such as fire and grazing are intrinsic to their dynamics and evolution, and are essential for maintaining their biodiversity (Overbeck et al., 2022).

A1. Why are these ecosystems important, and why are they threatened?

Brazil's open ecosystems are highly biodiverse ecosystems that provide multiple ecosystem services. However, they have been historically neglected, which compromises both water (Item B) and climate security (Item C), resulting in significant biodiversity loss (Box 1) and increased desertification. This historical neglect is reflected in: a lack of awareness, on the part of society, about their real ecological and socioeconomic value; technical and scientific gaps, as well as the scarcity of technologies for protection, management, restoration, and monitoring; and the absence of legal instruments, public policies and specific programs aimed at the conservation and sustainable use of these areas **(items detailed in the complete document available in the QR Code below)**, including their **limited** access to climate finance (Item D).

For more information, access the full document (in Portuguese) via the QR code.

Box 1. Biodiversity of Brazil's Open Ecosystems

CAATINGA	Herbaceous plants contribute significantly to the species–area relationship — nearly twice that observed in the Amazon.
CERRADO	A global biodiversity hotspot: for every 1 tree species, there are 6 species of small plants (herbs, grasses, and shrubs)
CAMPO RUPESTRE	Harbors about 15% of all Brazilian flora, with 41% of its species being endemic
CAMPO SULINO (Southern Grasslands)	Hosts more than 50 plant species within just 1 m^2

For more information on biodiversity in these ecosystems, consult the full document available via the QR Code.

Possible lines of action for the conservation of open ecosystems at the national level:

1. Invest in environmental education and public communication to raise awareness among Brazilian society about the essential role of open ecosystems for human well-being — emphasizing their contributions to biodiversity, climate regulation, and water security.

2. Integrate open ecosystems into the specific strategies and goals of National (NBSAPs) and subnational (BSAPs) biodiversity, climate change, and sustainable land-use policies.

3. Strengthen the technical and scientific basis by supporting research and institutional partnerships aimed at improving remote-sensing and restoration techniques, as well as producing technical materials and training programs that enhance the capacity to identify and properly manage these ecosystems in monitoring, licensing, and restoration processes.

4. Update, create, and strengthen federal and state legislation and technical standards that establish ecological and practical parameters for monitoring, licensing, and restoration of open ecosystems, recognizing their specific floristic and functional characteristics.

B. Open ecosystems are essential for Brazil's water supply

Open ecosystems, with sparse tree cover, retain less rainwater in their canopies. This allows more water to infiltrate directly into the soil, replenishing aquifers and groundwater. As a result, they are **more efficient** than forests **in providing the ecosystem service of groundwater recharge** (Jackson et al., 2005; Honda & Durigan, 2016). The Cerrado region, for instance, contains thousands of springs that feed perennial rivers across eight of the country's hydrographic regions. The perennial nature of these rivers is a remarkable advantage compared to other major savannas around the world, where rivers often dry up for extended periods, hindering **irrigation and hydroelectric generation.** This is mainly due to the Cerrado's predominance of open ecosystems—such as grasslands and savannas—which ensures high efficiency in water recharge. If current rates of native vegetation loss continue, the Cerrado is projected to experience a decline of over 30% in watercourse flow by 2050 (Salmona et al., 2023).

C. Open ecosystems store large amounts of carbon

Open ecosystems store approximately one-third of the planet's terrestrial carbon, with the majority of this stock concentrated in belowground structures and soil organic carbon (SOC) (Bai & Cotrufo, 2022). Likewise, Brazil's open ecosystems hold substantial amounts of carbon in their soils and roots, reinforcing their strategic role in the national greenhouse gas balance (Andrade et al., 2025). The soils of **wet grasslands and palm swamps (veredas) of the Cerrado** – waterlogged areas with soils rich in organic matter – **can store more carbon than upland forests in the Amazon region** (Wantzen et al., 2012; Verona, 2024). These ecosystems have peat soils that store **up to 1100 tons of carbon per hectare, a concentration approximately eight times greater than that found in Amazonian biomass** (Verona, 2024). **The Pampa region has the second highest value of carbon stocks per hectare among all Brazilian natural regions** (Mapbiomas, 2023), and cattle grazing – a critical process for maintaining biodiversity and the ecological characteristics of grasslands – can, when properly managed, contribute to the role of these grasslands as a carbon sink, offsetting methane emissions from cattle (Conant et al., 2017). Additionally, recent studies suggest that the Caatinga can serve as a significant CO_2 sink, particularly during periods of rainfall (Da Costa et al., 2025). Nonetheless, these ecosystems, their ecological characteristics, and the strategies to maintain or enhance their carbon storage potential **remain invisible to climate policy.**

D. Why are open ecosystems not included in climate finance?

Despite their ecological relevance, open ecosystems remain underrepresented in the main climate finance mechanisms, including REDD+ and voluntary carbon standards (Verra/VCS, Gold Standard). These instruments were initially designed to address forest deforestation and thus adopted definitions with a forest bias (e.g., based on minimum tree cover thresholds) (UNFCCC, 2001). **Therefore, predominantly herbaceous ecosystems, even those rich in belowground carbon, such as the Cerrado wetlands, do not fit into current measurement and certification methodologies.** Without this recognition, projects in open ecosystems cannot issue credits or access resources from climate funds.

D1. What is needed for open ecosystems to be recognized and considered in climate finance?

Ideally, **open ecosystems should be valued** primarily for the multiple benefits they provide, contributing to both climate change mitigation and adaptation (including carbon, biodiversity, water, and social benefits). In particular, **their role in water security is critical.** The water sources that originate in these environments are crucial for national water security and, consequently, for the stability of forest ecosystems and tropical peatlands (Lima & Silva, 2008). However, in the current context, **it is necessary to revise international carbon credit methodologies, creating specific parameters for the inclusion and measurement of belowground carbon storage,** including in deep soils and roots. It is **also essential that the natural regeneration of secondary savannas be recognized as a valid restoration practice, allowing these areas to maintain their carbon stocks** and avoid being subjected to afforestation (Honda & Durigan, 2016).

D2. Are there other strategies to access climate finance beyond carbon?

Even before the full recognition of open ecosystems within climate finance mechanisms, there are pathways that enable their inclusion in both mitigation and adaptation strategies. Two possible approaches are:

Ecosystem-Based Approach (EbA): adaptation to climate change

Major international agreements recognize the Ecosystem-Based Approach (EbA) as a legitimate strategy for climate change adaptation. Unlike mechanisms focused exclusively on mitigation, **EbA allows conservation, sustainable management, and ecosystem restoration actions to be framed as adaptation measures.** EbA actions can be incorporated into a country's Nationally Determined Contributions (NDCs), even if they are not counted as emission reductions, but rather as adaptation measures (Brazil, 2018). However, their implementation still depends on the national capacity to gather scientific evidence and design technically robust projects that demonstrate the benefits of using biodiversity and ecosystem services in non-forest ecosystems to help people adapt to climate change.

Ecosystem-Based Approach

Focus: Climate adaptation.
Origin of resources: Public and multilateral funds (such as GCF, GEF, Adaptation Fund, and Global EbA Fund).
Access mechanism: Projects that demonstrate adaptation benefits (e.g., water regulation, vulnerability reduction).
Example: Conserving natural grasslands in headwater regions to ensure water recharge and reduce the vulnerability of rural communities to drought.

Nature Finance: Integration of multiple credits and hybrid mechanisms

Nature Finance is an investment and revenue generation approach that creates financial products, recognizing the aggregated value of ecosystem services. It represents a transition from the traditional "carbon market" to a broader "nature market," exploring hybrid financing models (public + private) (Nature Finance, 2023). Recent experiences in South Africa (Grasslands Carbon) and Namibia (Kunene Elephant Highlands), incubated by the Sustainable Finance Coalition (2025), estimate outcomes of 18.7 million tons of CO_2 sequestered in 30 years, a 66% increase in species abundance, and a 136% increase in water availability. Sustainable land management in these areas, combined with soil carbon measurement methodologies (such as VM0032 - Verra, 2024) and the creation of complementary credits (including biodiversity, water, and social benefits), has yielded consistent environmental and economic benefits.

Nature Finance

Focus: Integrated valuation of multiple ecosystem services.
Origin of resources: Voluntary carbon markets + private funds + corporate partnerships.
Access mechanism: Sale of multiple credits or "stacked" credits (carbon, biodiversity, water, social inclusion).
Example: A project that combines carbon credits in the soil with biodiversity and social inclusion indicators, attracting companies or ESG funds (investment funds that invest in projects, companies, or assets that meet sustainability standards).

Recommendations in the context of climate finance

1. Promote international cooperation among megadiverse countries to advocate for the recognition of open ecosystems within UNFCCC climate mechanisms and voluntary standards, by gathering scientific evidence and developing/standardizing specific carbon measurement methodologies.

2. Develop an integrated national strategy to enable climate finance for open ecosystems, through the application of standardized carbon measurement metrics and the integration of these environments into national carbon quantification and verification systems.

3. Adopt the Ecosystem-Based Approach (EbA) as an immediate pathway for conserving and sustainably managing open ecosystems as adaptation actions, enabling their inclusion in Brazil's NDCs and access to climate funds focused on adaptation and water resilience.

4. Create hybrid and multi-benefit financial instruments to integrate carbon, biodiversity, and water credits into Nature Finance models, recognizing and valuing the multiple ecosystem services provided by these environments.

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REFERENCES

ANDRADE, B. O. et al. The GrassSyn dataset: Soil organic carbon stocks in Brazilian grassy ecosystems. Journal of Environmental Quality, v. 54, n. 2, p. 335–348, 2025.

BAI, Y.; COTRUFO, M. F. Grassland soil carbon sequestration: Current understanding, challenges and solutions. Science, v. 377, p. 603–608, 2022.

BRASIL. Ministério do Meio Ambiente. Adaptação baseada em Ecossistemas (AbE) frente à Mudança do Clima: Apostila do Curso. Brasília: MMA, 2018.

CONANT, R. et al. Grassland management impacts on soil carbon stocks: a new synthesis. Ecological Applications 27(2): 662–668, 2017.

DA COSTA, L. M. et al. A comparative analysis of GHG inventories and ecosystems carbon absorption in Brazil. Science of the Total Environment, v. 958, p. 177932, 2025.

HONDA, E. A.; DURIGAN, G. Woody encroachment and its consequences on hydrological processes in the savannah. Philosophical Transactions of the Royal Society B: Biological Sciences, v. 371, n. 1703, 2016.

JACKSON, R. B. et al. Trading water for carbon with biological carbon sequestration. Science, v. 310, p. 1944–1947, 2005.

LIMA, J. E. F. W.; SILVA, E. D. Recursos hídricos do bioma Cerrado: importância e situação. In: SANO, S. M.; ALMEIDA, S. P.; RIBEIRO, J. F. (Orgs.). Cerrado: ecologia e flora. v. 1. Brasília: Embrapa Cerrados, 2008. p. 87–106.

MAPBIOMAS. Mapeamento anual do estoque de carbono orgânico do solo no Brasil 1985–2021 (coleção beta). MapBiomas Data, v. 1, 2023. Available at: https://mapbiomas.org. Accessed on: November 06, 2025.

NATURE FINANCE. The Future of Biodiversity Credit Markets. Taskforce on Nature Markets, 2023.

OVERBECK, G. E. et al. Placing Brazil's grasslands and savannas on the map of science and conservation. Perspectives in Plant Ecology, Evolution and Systematics, v. 56, p. 125687, 2022.

SALMONA, Y. B. et al. A Worrying Future for River Flows in the Brazilian Cerrado Provoked by Land Use and Climate Changes. Sustainability, v. 15, n. 5, p. 4251, 2023.

SUSTAINABLE FINANCE COALITION. Sustainable Finance Coalition – Official Website. Available at: https://sustainablefinancecoalition.org/. Accessed on: September 06, 2025.

UNFCCC. Decision 11/CP.7: Land use, land-use change and forestry (Marrakesh Accords). 2001. Available at: https://unfccc.int/files/meetings/workshops/other_meetings/application/pdf/11cp7.pdf. Accessed on: November 6, 2025.

VERONA, L. Carbon dynamics and stability in an endangered Cerrado wetland. 2024. Dissertação (Mestrado em Biologia Vegetal) – Universidade Estadual de Campinas, Campinas, 2024.

VERRA. Verra consolidates sustainable grassland methodologies. 2024. Available at: https://verra.org/verra-consolidates-sustainable-grassland-methodologies/. Accessed on: November 6, 2025.

WANTZEN, K. M. et al. Soil carbon stocks in stream-valley-ecosystems in the Brazilian Cerrado agroscape. Agriculture, Ecosystems & Environment, v. 151, p. 70–79, 2012.