

CORAL BLEACHING AND CLIMATE CHANGE





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Executive Summary

2025



Coral bleaching and climate change

Question

Brazil is home to the only shallow coral reefs in the South Atlantic Ocean - vital ecosystems for marine biodiversity, food security and the economy of coastal areas. With an estimated value of more than R\$ 160 billion a year, these reefs support artisanal fishing, tourism and provide natural protection against extreme weather events for millions of Brazilians.

Today, these ecosystems are facing an unprecedented crisis. The Fourth Global Coral Bleaching Event (2023-2024) - declared by the US National Oceanic and Atmospheric Administration (NOAA) - is the most severe ever recorded, with **90% bleaching in some Brazilian regions** and record levels of thermal stress, exceeding **18 degrees Celsius accumulated per week (degree-weeks of warming)**. Globally, **75% of the planet's total reef area has already been impacted**, with Brazil among the most critical hotspots.

The combination of marine heatwaves, acidification, loss of oxygen in the oceans, local pollution and the lack of ecological planning for emerging activities is pushing Brazilian reefs towards **a climate tipping point**. Climate models from the Intergovernmental Panel on Climate Change (IPCC) indicate that at the current rate of global warming (already **1.1 degrees Celsius above the pre-industrial average**), **70% to 90% of the world's coral reefs could collapse by 2050**. In Brazil, this projection is already manifesting itself in **severe mortality of endemic species** and loss of ecological functionality in various regions.

This executive summary, aimed at formulating national public policies, presents an analysis based on scientific evidence and up-to-date data on the collapse of Brazilian reefs. At the same time, it proposes strategic and viable solutions to avoid irreversible losses and guarantee the continuity of the multiple ecological, economic and social benefits that these ecosystems offer to Brazilian society.

Problem

Coral reefs are strategic ecosystems for Brazil and the world. Globally, they generate around **US\$ 2.7 trillion a year**, especially for tourism, fishing and coastal protection. In Brazil, their contribution exceeds **R\$ 160 billion a year**, supporting artisanal fishing, food security and tourism in various coastal regions.

However, these ecosystems are rapidly collapsing due to **climate change**, especially rising sea temperatures, which are causing **mass coral bleaching**. The global event of 2023-2024 is the most severe ever recorded, with extensive impacts on Brazilian reefs. Without urgent action, it is estimated that **up to 90% of reefs could disappear in the coming decades**.

Brazil is home to the only shallow reefs in the South Atlantic, with **high levels of endemism and unique formations**. Protecting and restoring these ecosystems is essential for the climate, biodiversity and the well-being of millions of people in coastal zones. Their loss



represents a real and growing risk to the economy, security and culture of traditional communities.

Global warming has already reached **1.1 °C above pre-industrial levels**, and the IPCC confirms that this increase is caused by human activities. The oceans have absorbed **more than 90% of this excess heat**, suffering profound and lasting impacts: rising sea levels, **acidification, deoxygenation** and an accelerated increase in **marine heat waves**.

Since the 1980s, the frequency of these extreme thermal events has increased by almost **300%**, and could grow up to **16 times** even with warming limited to 1.5 °C – or **23 times** in a 2 °C scenario. Acidification has already reduced **the average pH of the oceans by 0.1 units**, and dissolved oxygen in the waters has fallen by around **2% since 1960**, expanding marine dead zones.

These effects affect biodiversity and the base of the food chain. Projections point to a sharp decline in the **diversity and productivity of tropical phytoplankton**, jeopardizing the natural sequestration of CO₂. The global cost of these impacts could exceed **US\$ 1 trillion by 2100** if the Paris Agreement targets are not met.

Seven factors are accelerating the collapse of Brazilian coral reefs by combining global stresses and local pressures that compromise their ecological and functional resilience.

- **Marine heat waves (MHWs):** Since 1982, the frequency of these events has increased by more than **100%**. With 1.5 °C of global warming, they could become **16 times more common**. In 2023–2024, the South Atlantic recorded **500 consecutive days with temperatures above 1 °C of the average**, contributing to the largest bleaching ever documented.
 - **Ocean acidification:** The absorption of CO₂ has reduced the pH of the ocean surface by up to **0.027 units per decade**, affecting the formation of coral carbonate skeletons. Projections indicate an **extreme state of almost permanent acidity from 2030 onwards**, even in moderate emissions scenarios.
 - **Deoxygenation:** Since 1960, the total dissolved oxygen content has fallen by **2%**, with low oxygen events lasting **more than 200 days in tropical areas**. This threatens fish, invertebrates and reef regeneration.
 - **Pollution and local overload:** Untreated sewage, dredging, overfishing and disorderly tourism increase turbidity, spread disease and reduce the corals' ability to recover.
 - **Lack of regulation on new activities:** The expansion of offshore wind energy is taking place without clear guidelines for ecological planning, generating risks in sensitive areas without integrated assessment.
 - **Fragmentation of public policies:** Plans such as the National Climate Change Adaptation Plan (PNA) and the National Action Plan for Coral Reef Environments (PAN) Corais exist, but their implementation is limited and disjointed, hindering integrated responses between climate, biodiversity and coastal zones.
 - **Underfunding and institutional inequalities:** Tropical marine science lacks investment. Continuous monitoring is fragmented, with **large gaps in the North and Northeast**, compromising the ability to respond on a national scale.
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Combined, these factors are pushing reefs towards **ecological tipping points**, with the risk of irreversible collapse. The loss of biodiversity and services such as fishing and coastal protection could be permanent, with high social and economic costs.

Implications

The degradation of coral reefs is not just an environmental emergency. It is a **multidimensional systemic risk** that directly threatens the Brazilian economy, social cohesion in coastal areas, the food security of vulnerable populations and Brazil's international position in multilateral climate and biodiversity forums.

Social and economic impacts

The loss of reefs jeopardizes critical production chains:

- **More than 1 million people** depend directly on artisanal fishing in Brazil's coastal regions – an activity that is strongly supported by the biodiversity of the reefs.
- Tourism associated with reefs, including destinations such as **Fernando de Noronha, Costa dos Corais and Abrolhos**, accounts for a **significant part of the R\$160 billion** that reefs generate annually in Brazil. The degradation of these ecosystems represents a real risk of economic collapse in several coastal locations.
- Reefs act as natural barriers, absorbing up to **97% of wave energy** in tropical areas. Their loss increases vulnerability to flooding, coastal erosion and extreme weather events – risks already exacerbated by rising sea levels and the intensification of cyclones.

Ecological impacts

Brazil's reefs, unique in the South Atlantic, are already showing signs of collapse:

- They are among the **first global ecosystems to cross the climate tipping point**, with recent episodes of bleaching of more than **90% in the Northeast Region and the Ocean Islands**, and **mortality of more than 60%** in endemic species such as *Mussismilia harttii*.
- The collapse compromises **essential ecological functions** such as nutrient cycling, reef fish reproduction and algae regulation – functions that are fundamental to marine balance and food security.
- Modeling projects that **70% to 90% of global reefs** could disappear even under warming scenarios of **1.5 °C**. For Brazil, recent data show that **there are no longer any fully resilient areas** – all reefs are at high risk.

Geopolitical and institutional impacts

Reef collapse also weakens Brazil's ability to fulfill its international commitments:



- Reef degradation directly undermines the climate and biodiversity targets set out in the **Paris Agreement**, the **Kunming-Montreal Goals (CBD)** and the **Sustainable Development Goals (Agenda 2030)**.
- Brazil runs the risk of **losing credibility and international prominence** at strategic events such as **COP30**, the **Third UN Conference on Oceans (UNOC3)** and in the negotiations of the **Convention on Biological Diversity**.
- Legal setbacks, such as **PEC 03/2022**, which allows for the privatization of coastal areas, could further weaken legal certainty and marine governance, exacerbating pressures on already vulnerable ecosystems.

Solutions

Protecting Brazil's coral reefs requires coordinated, multi-scalar actions involving robust legal frameworks, funding, cutting-edge science and active social participation. The solutions below are already underway or planned, and should be strengthened:

- **Multilateral instruments already ratified:** Brazil is a signatory to **more than 35 international agreements**, including the Convention on Biological Diversity (CBD), the Paris Agreement and the United Nations Convention on the Law of the Sea (UNCLOS). It has recently joined leading initiatives such as the **Biodiversity Beyond National Jurisdiction Agreement (BBNJ)** and has taken a leading role in the G20 and **COP29**, including ocean-based measures in its Nationally Determined Contribution (NDC).
- **Historical and recent national milestones:** Since 1979, Brazil has created **emblematic marine conservation units**, such as Atol das Rocas, Abrolhos and Fernando de Noronha, as well as Extractive Reserves such as Corumbau. In 2024, the **ProManguezal Program** was launched and calls for **R\$ 30 million** were opened via BNDES for coral reef conservation projects.
- **Policies under construction:** The new **National Plan on Climate Change (PNMC)**, **which** is in the final stages of public consultation, provides for a **National Strategy for the Conservation of Coral Reefs by 2025**, articulated with sectoral plans and climate adaptation actions.
- **Applied and participatory science:** Brazil has **20 years of participatory monitoring via Reef Check**, and networks such as GCRMN and MapBiomass. In addition, new scientific fronts are prioritizing **restoration, modeling extreme events, citizen science and engaging traditional communities**.
- **Education and multi-level governance:** **Climate education is** being integrated into **school curricula**, in line with SDGs 4 and 13. The country is also making progress in **including young people and artisanal fishermen** in conservation actions, combining traditional knowledge and science.



Benefits

The full implementation of the above solutions will bring multiple dividends that transcend environmental conservation:

- **Protecting production chains and livelihoods:** Artisanal fishing supports **more than 1 million people** in Brazil. Reef tourism generates **R\$ 160 billion/year**. Protecting reefs means **guaranteeing food and economic security** for coastal populations, especially in the Northeast.
- **Reducing climate risks and increasing resilience:** The reefs absorb up to **97% of wave energy**, protecting coastlines from flooding and erosion. Their loss can increase natural disasters and public damage to infrastructure, displacement and health.
- **Fulfilling international commitments:** Investing in reef conservation reinforces Brazil's role as a leader at **COP30**, strengthens its role at **UNOC3 (Nice, 2025)** and contributes to the goals of the **2030 Agenda**, the **CBD** and the **Paris Agreement**.
- **Preservation of the South Atlantic's unique biodiversity:** Brazil is home to the **only shallow reefs in the South Atlantic hemisphere** with high endemism. Losing these ecosystems means eliminating species that **exist nowhere else on the planet**.
- **Prevents irreversible collapse:** The IPCC projects that with warming of **1.5°C, 70–90% of reefs could disappear**; with **2°C, up to 99% will be lost**. Immediate action can contain this scenario and preserve the regenerative potential of ecosystems.

Protecting Brazil's coral reefs is a strategic measure to ensure the country's **economic, social and ecological sustainability**. These ecosystems support millions of people through fishing and tourism, provide natural barriers against climate disasters and are home to a unique biodiversity on the planet. Faced with a scenario of imminent collapse, aggravated by marine heat waves, acidification and loss of oxygen, this study shows that investing in their conservation is not only an environmental obligation, but an urgent action of national security, climate justice and commitment to the future.



About the Report “Coral Bleaching and Climate Change”

This executive summary presents the main discussions contained in the Synthesis Report “*Coral Bleaching and Climate Change*”, produced and made available by the Center for Synthesis on Environmental and Climate Change – SIMACLIM (<https://simaclim.com.br/>). SIMACLIM’s main mission is to integrate accumulated and ongoing research from various national and international networks and research groups, organizing information and supporting the planning of the Brazilian State to achieve the goals established in Climate Change agreements. SIMACLIM is funded by the Ministry of Science, Technology and Innovation (MCTI) through the National Fund for Scientific and Technological Development (FNDCT), FINEP Process 01.22.0584.00. The Synthesis Report “*Coral Bleaching and Climate Change*” involved the participation of the following researchers:

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Use of Artificial Intelligence:

This summary was prepared with the assistance of Large Language Model (LLM) tools, also known as Artificial Intelligence (AI). To learn how these tools were used, please refer to the methodological annex available at this link: <https://simaclim.com.br/relatorios-de-sintese/>

About SIMACLIM

Scientific literature shows that synthesis centers are unique environments that combine culture, infrastructure, leadership and support, facilitating the creative discovery of important issues for science and society. In Brazil, we have a high-level scientific environment that offers a unique opportunity to address urgent and relevant problems for society.

The Environmental and Climate Change Synthesis Center project is aligned with this mission, having a close relationship with state policies and strong independence. It will integrate accumulated and ongoing research from various national and international networks and research groups, organizing information and assisting state planning to achieve goals set out in Climate Change agreements. In addition, he/she will assist in the processes of drafting and revising documents and treaties related to the topic.

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The complexity of the effects of global environmental and climate change, including their future projections, requires interdisciplinary and transdisciplinary approaches. These approaches are essential for understanding the interactions between social, biophysical, and ecological systems, characterizing the risks of impact, vulnerability, possibilities for mitigating their causes, and adaptation solutions. The Synthesis Center on Environmental and Climate Change (SIMACLIM) has as its main mission to integrate accumulated and ongoing research from various national and international research networks and groups, organizing information and assisting in Brazilian government planning to achieve goals established in agreements on climate change. SIMACLIM is funded by the Ministry of Science, Technology and Innovation (MCTI) through the National Fund for Scientific and Technological Development (FNDCT), FINEP Process 01.22.0584.00.

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