

Flying Rivers and Protected Territories

The role of the Amazon forest in South America's rainfall

Key Messages

- Amazonian forests drive a vast continental water cycle, recycling moisture that helps sustain rainfall from the Andes to the La Plata Basin.
- Natural Protected Areas, Indigenous Territories, and Brazil's Undesignated Public Forests generate rainfall volumes comparable to the Amazonas River's discharge.
- This rainfall supplies water to the entire South American continent, underscoring the Amazon's role as a transboundary resource.
- This service underpins food, water, and energy security across nations, making regional cooperation essential.
- Protecting and legally securing these forests through cooperation and joint action is essential to safeguarding South America's climate resilience.



The Amazonian Water Cycle: critically important, but threatened

Tropical forests like the Amazonia act as big water pumps.¹ Trees absorb moisture transported from oceanic sources through precipitation and subsequently release it into the atmosphere via evapotranspiration processes. This recycled moisture forms clouds and generates rainfall both locally and thousands of kilometers away as they are carried by winds, a process known as the “Flying Rivers”.² Through this mechanism, moisture recycled by the Amazon rainforest contributes to precipitation patterns in several neighboring countries.

This transboundary service means that the livelihoods of hundreds of millions of people depend on the health of Amazonia: what happens in one part of the forest—whether conservation or degradation has consequences far beyond national borders. This urgency was highlighted in the Belém Declaration (2023), signed by ACTO member countries, which warned about the risk of reaching a tipping point, and reinforced in the Bogotá Declaration (2025), where countries committed to advancing toward a low-carbon transition while respecting national differences.

New evidence highlights the critical role of Natural Protected Areas, Indigenous Territories and Undesignated Public Forests in the Amazon region, collectively referred to as Areas of Conservation Interest (ACIs), in generating rainfall across South America.

A state-of-the-art atmospheric moisture tracking model³ was used to quantify how water from these forested regions contributes to precipitation throughout the continent.



Figure. Flying rivers

The Amazonian forests' ability to regulate rainfall is under growing threat from deforestation, forest degradation, fires, and climate change. From 1985 to 2023, the biome lost more than 88 million hectares of forest according to the MapBiomias Amazonia initiative: this represents around 12% of its total area, or almost the area of Colombia.

In the Amazon region, these protected territories amount to roughly 415 million hectares (according to the Amazon Network of Georeferenced Socio-Environmental Information, RAISG, 2025), about the size of the entire European Union or close to 4 times the territory of Bolivia. In terms of protection within their own territories, Ecuador (77.3% or 10.2 Mha), Venezuela (75.3% or 35.4 Mha), and Colombia (69.9% or 35.3 Mha) stand out for having protected the largest shares of their Amazonian regions, with Brazil having around 45% of its Amazonian territory protected to some degree (234 Mha). Despite lower protection, Guyana and Suriname are among the most forested, meaning a large portion of their national territory remains intact despite lower formal protection coverage.

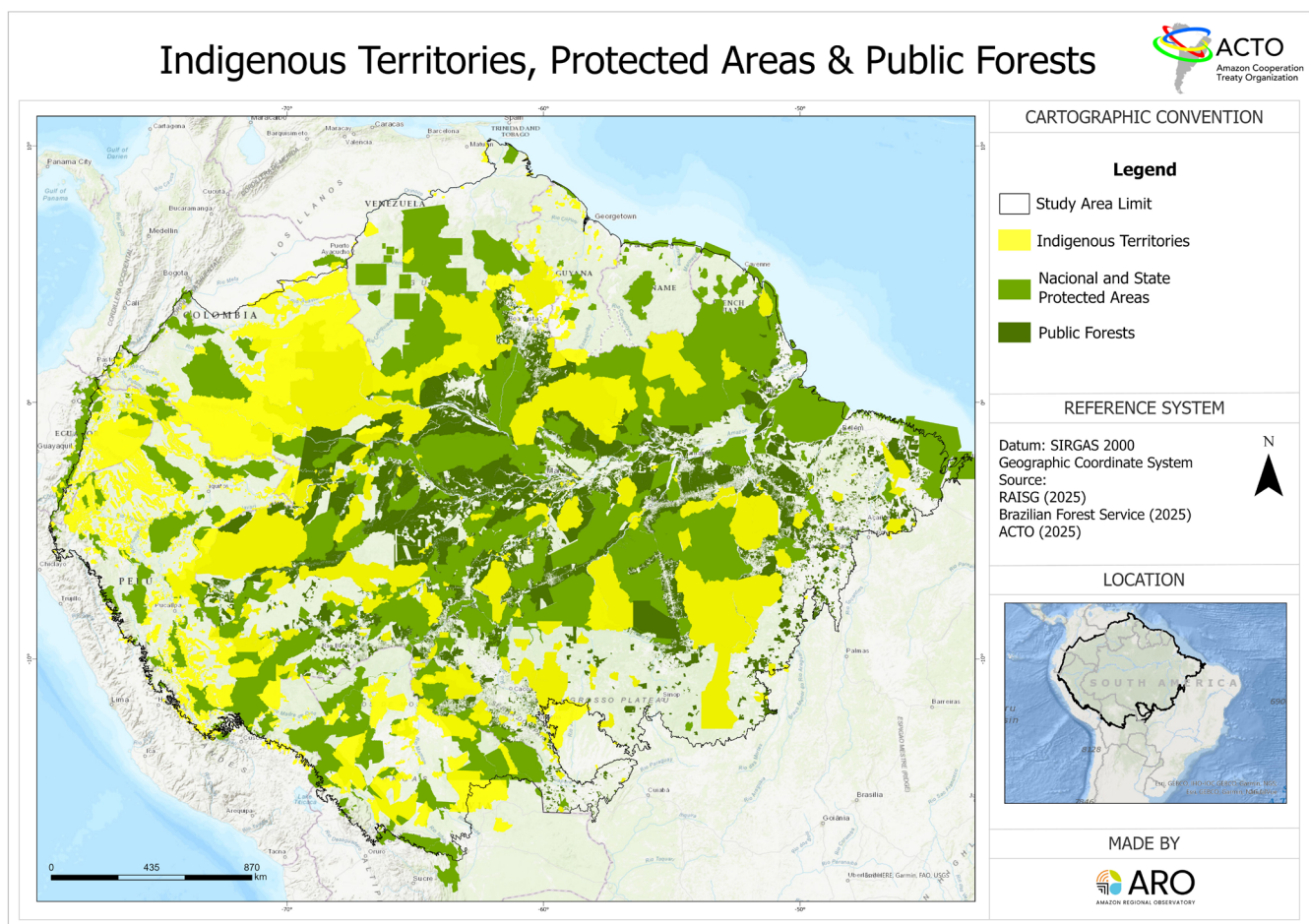
PROTECTED TERRITORIES: FIRST LINE OF DEFENSE

Natural Protected Areas and Indigenous Territories are highly effective in preserving forest cover, biodiversity, and ecosystem services.⁴ Between 1985 and 2023, only 6% of the entire loss of vegetation occurred in these protected areas.⁵ Despite their

importance, these areas are under growing pressure from economic and political interests, which seek to weaken protections to expand mining, oil extraction and logging. To counter these pressures, in the Bogotá Declaration, the Amazonian Mechanism for Indigenous Peoples (MAPI, in Spanish and Portuguese) was created, aiming to put the Indigenous Peoples at the center of the discussions regarding the protection and stewardship of the forest.

One of the big blind spots in Amazonia forest management lies in the Undesignated Public Forests (UPFs) in Brazil: vast areas of publicly owned forests that have not been legally assigned for any specific use. In Brazil, which holds around 45% of the Amazonian vegetation (~234 Mha), UPFs represent around 56 million hectares of forest.⁶ Although according to Brazil's 2006 Public Forest Management Law (*Lei de Gestão de Florestas Públicas – LGFP, Lei n 11.284/2006*) these forests should be formally designed as protection areas (in the manners of conservation units, indigenous lands, rural settlements, among others), the designation and implementation process has lagged, leaving these large forest areas exposed to illegalities. These come in the form of illegal deforestation, land grabbing, and speculative occupation. These forests are a critical frontier: protecting and designating them is one of the most effective ways to avoid further deforestation and ensure the continuity of ecosystem services.⁶

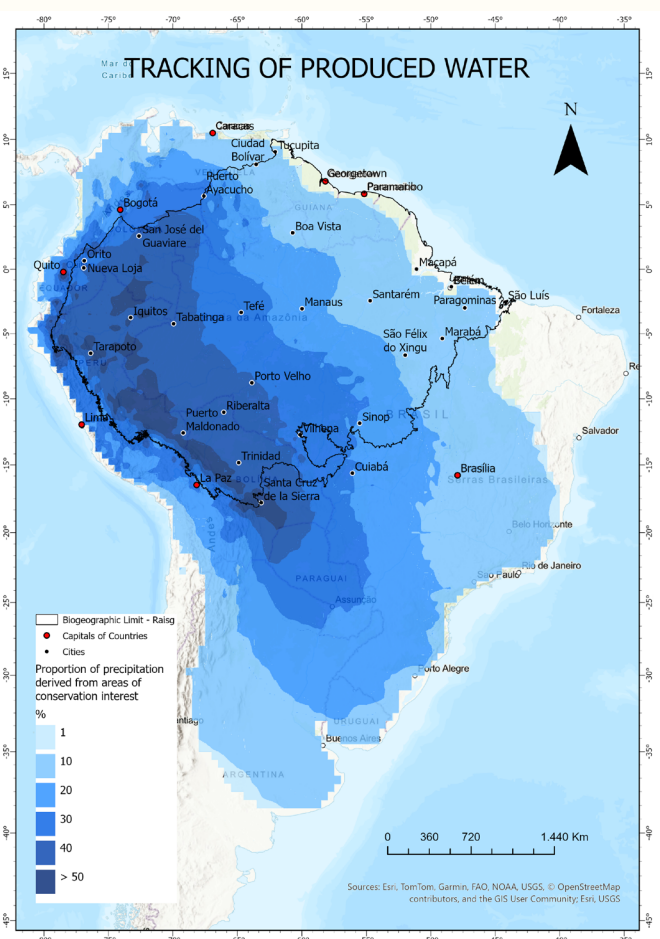
Map. Areas of Conservation Interest





TRACING THE WATER PRODUCED BY AREAS OF CONSERVATION INTEREST

All countries in South America receive rainfall that originates in Areas of Conservation Interest (ACIs). These forests are responsible for pumping an estimated 6 quadrillion liters of water into the atmosphere each year. That's roughly the same amount of water the Amazonas River discharges into the Atlantic Ocean each year.⁷ This means that the vast majority of farms, cities, hydropower plants, and ecosystems across the continent depend, to some degree, on water generated by forests in these territories. Bolivia is the country most influenced by this dynamic, with around 30% of its annual rainfall coming from protected areas in the Amazonian region. The Bogotá Declaration recognized access to water as a human right and called for stronger protection of aquatic ecosystems, echoing the finding that forest-driven rainfall is fundamental to continental water security.



Map. Proportion of rainfall derived from Areas of Conservation Interest (%)

SOUTH AMERICA: ONE CONNECTED CONTINENT

Countries in South America are deeply interconnected through the flow of water in the atmosphere. Forests in one country contribute rainfall to others, creating a web of “virtual water trade” that sustains agriculture, energy generation, and urban water supplies across borders. For example, moisture generated in the Brazilian Amazon falls as rain in Bolivia, Paraguay, and Argentina, while forests in Peru and Colombia help maintain rainfall in parts of Brazil. Quantitative analysis of these exchanges demonstrates that regional water security depends on shared management of the Amazon system. ACTO plays a vital role in enabling dialogue, data sharing, and coordinated action among the Amazonian countries. As the only intergovernmental body focused exclusively on Amazon cooperation, ACTO is uniquely positioned to strengthen cooperation and support joint strategies that protect the forest and the rainfall it generates—across borders and for the benefit of all.

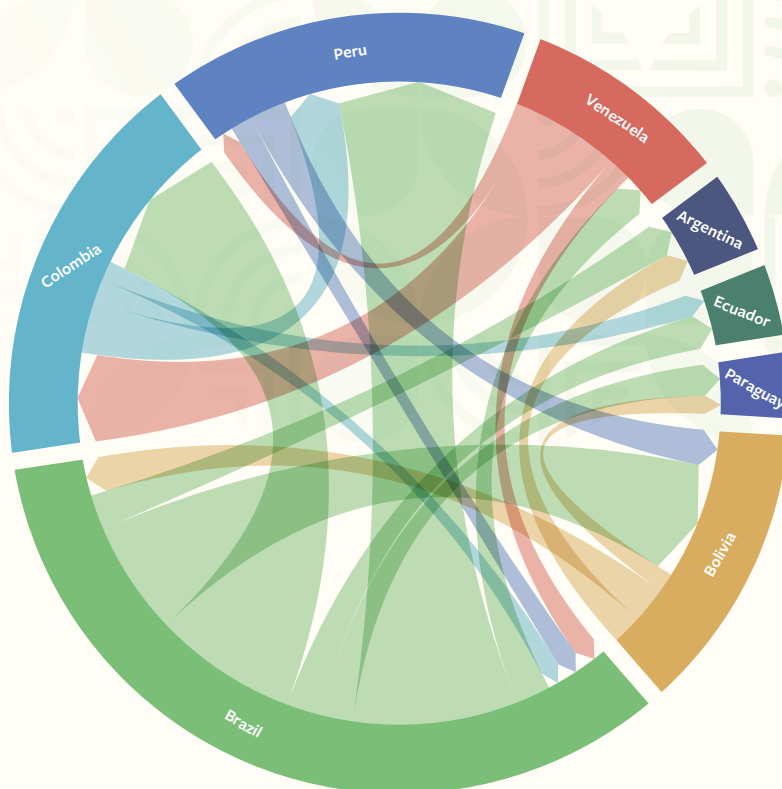


Figure. The web of connections. Arrows indicate the direction of water imports and exports among countries, while arrow size represents the magnitude of the main water fluxes between them.



BENI, BOLIVIA: WHEN THE RAIN STOPS, THE FOREST BURNS

In 2024, the Beni department faced an unprecedented drought and the worst wildfire season in Bolivia's history. Extreme dryness and high temperatures triggered fires that burned over 10 million hectares nationally,⁸ including 9% of Bolivia's remaining intact forest.⁹ Rural and Indigenous communities lost homes, crops, and access to water.¹⁰

Beni's vulnerability is linked to its dependence on forest-driven rainfall: 37% of its annual rainfall comes from evapotranspiration in ACIs, increasing to over 60% during the dry season precisely when fires are most likely. As rainfall decreases, vegetation dries out faster, making fires more severe and reducing the forest's capacity to recycle moisture.

DROUGHTS AND DEGRADATION: A WORSENING BACKDROP

Over recent decades, extreme drought events in the Amazon have become more frequent, with longer and more intense dry seasons.¹¹ Climate models project further intensification in the coming decades, which, coupled with human-induced degradation, raises the risk of ecological tipping points, where large areas of forest could shift to degraded ecosystems that no longer provide the same level of water cycling.¹² Given the importance of these forests to generating water for the rest of the continent, increasing the protection of the forest becomes paramount.

Droughts also directly affect South America's hydropower generation. Reduced rainfall lowers river flows, decreasing the generation capacity of hydropower plants and forcing greater reliance on thermoelectric plants, which are often more expensive and, in many cases, also water dependent. This shift drives up energy prices, affecting household budgets and increasing

production costs for industry. In extreme drought years, such as Brazil's 2021–2022¹³ and 2024¹⁴ crises, electricity tariffs rose sharply, illustrating the vulnerability of millions of citizens to rainfall variability.

In April 2024, Bogotá faced one of the most severe droughts in its history. The Chingaza reservoir system—which supplies about 70% of the city—fell to critical levels (~10–17% of its capacity) due to rainfall ~27% below normal and a prolonged drought.

Ecuador relies heavily on hydroelectric power for its electricity supply. In 2024, a severe drought reduced the reservoir levels of hydroelectric plants. The government implemented controlled blackouts in several provinces, including power outages for up to 9 hours in some areas. In October/November 2024, harsher blackouts were announced, with up to 14 hours of blackouts per day in some areas.

LA PLATA BASIN: FOREST WATER POWERS A CONTINENT

The La Plata Basin is a hub for South America's energy production: it is home to over 70 hydropower dams,¹⁵ including the continent's largest hydropower plant: the Itaipu Binacional Plant. It generates power from the movement of the Paraná River's waters, supplying 17% of the annual electricity needs of Brazil and 90% of Paraguay's.¹⁶ The rainfall which supplies the rivers of the basin is highly influenced by the Amazonian forests, up to 45% in some regions. Each year, the Amazonian forests deliver around 700 trillion liters of rain to the La Plata Basin: enough to fill the Itaipu Hydropower Plant's reservoir at least 24 times.

AN UNCERTAIN FUTURE

The future of the Amazon's "flying rivers" is highly uncertain. Climate models consistently project a drier future for the region, with longer and more intense dry seasons and more frequent extreme droughts.¹⁷ However, how forests will respond to these changes remains complex and difficult to predict. The interaction between deforestation, forest degradation, and climate change is still not fully understood, and the scale of future deforestation will depend on political, economic, and social choices yet to be

made. What we do know is that these three pressures working in tandem (so-called "compounding pressures"), will have a direct impact on forest stability. As forests degrade or disappear, the amount of moisture recycled into the atmosphere is reduced,¹⁸ potentially leading to less rainfall in downwind regions¹. This could set off cascading impacts¹⁹ on agriculture, energy generation, and water security across South America, making it paramount to safeguard this mechanism.

Recommendations

STRENGTHEN PROTECTION OF EXISTING FORESTS

Especially in Natural Protected Areas and Indigenous Territories, which play a central role in maintaining moisture recycling and resisting deforestation.

OFFICIALLY ALLOCATE BRAZIL'S UNDESIGNATED PUBLIC FORESTS (UPFS)

Or other forest areas without formal protection, such as Protected Areas, Indigenous Territories, or sustainable-use lands, to prevent illegal deforestation, secure land rights, and maintain hydrological functions. Between 2019 and 2021, around 30% of deforestation in the Brazilian Amazon occurred within these UPFs, underscoring the importance of safeguarding these territories to prevent further forest degradation.

PROMOTE REGIONAL COOPERATION FOR FOREST CONSERVATION AND CLIMATE STABILITY

Through organizations such as the Amazon Cooperation Treaty Organization (ACTO), this proposal focuses on strengthening data sharing, developing integrated conservation policies, and establishing regional real-time monitoring networks for weather, fires, and deforestation. These efforts build directly on the Belém Declaration's call to reactivate ACTO commissions and launch the Amazon Dialogues, as well as on the Bogotá Declaration's creation of the Indigenous Mechanism, the Amazon Forest Authorities Network, and a financial mechanism to sustain joint action.



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ARO is ACTO's reference center that integrates data, tests innovations, and disseminates information to support member countries in cooperation and decision-making.

AMAZON COOPERATION TREATY ORGANIZATION (ACTO)

ACTO is an intergovernmental organization formed by eight Amazon countries: Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname, and Venezuela, which signed the Amazon Cooperation Treaty, making it the only socio-environmental bloc in Latin America.

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