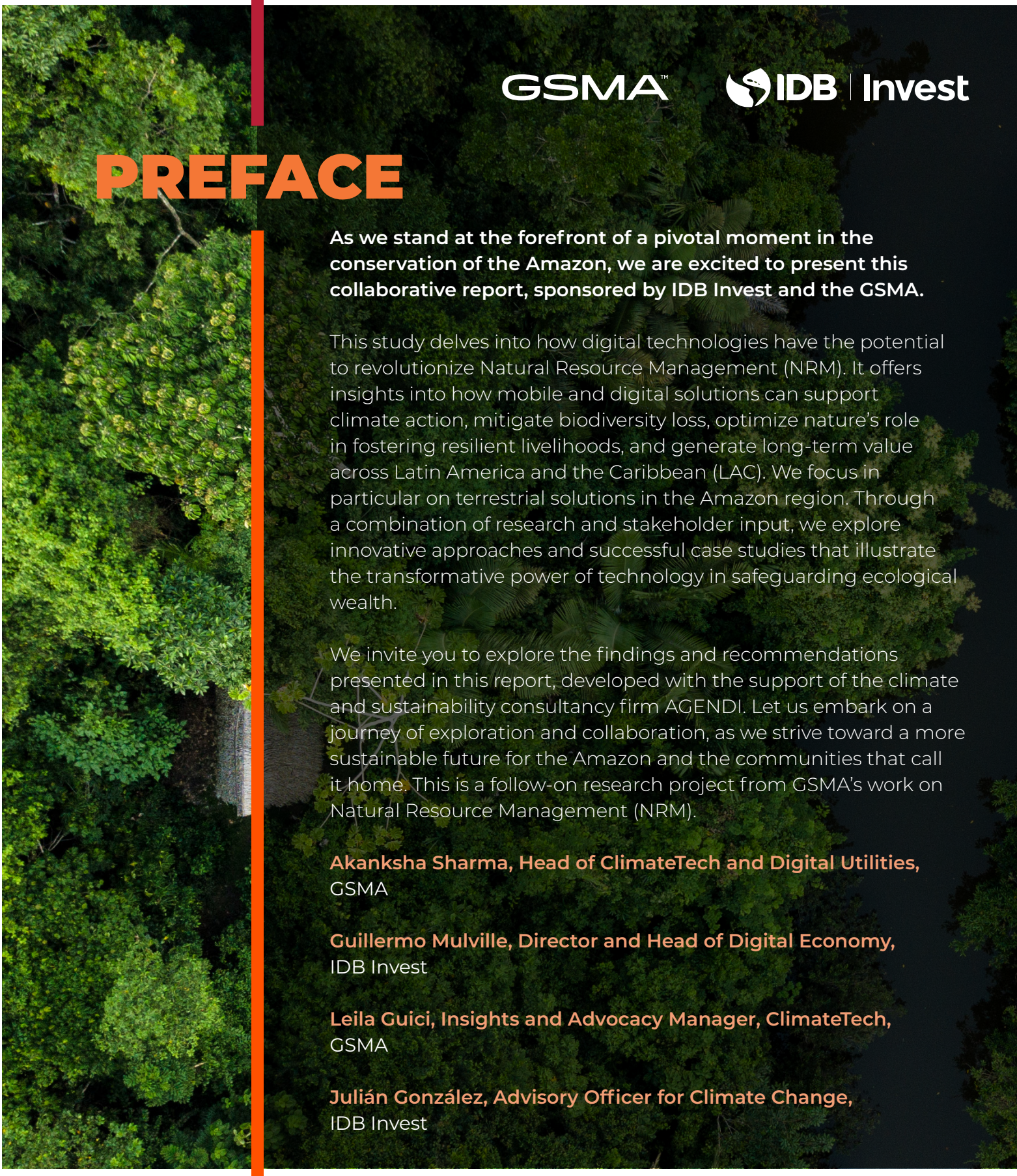
EXPLORING THE CASE FOR DIGITALIZING NATURAL RESOURCE MANAGEMENT IN THE AMAZON

GSMA™ IDB | Invest

IDB Invest, a member of the Inter-American Development Bank Group, is a multilateral development bank committed to promoting the economic development of its member countries in Latin America and the Caribbean through the private sector. IDB Invest finances sustainable companies and projects to achieve financial results and maximize economic, social, and environmental development in the region. With a portfolio of $21 billion in assets under management and 394 clients in 25 countries, IDB Invest provides innovative financial solutions and advisory services that meet the needs of its clients in a variety of industries.

The GSMA is a global organization unifying the mobile ecosystem to discover, develop and deliver innovation foundational to positive business environments and societal change. Our vision is to unlock the full power of connectivity so that people, industry, and society thrive. Representing mobile operators and organizations across the mobile ecosystem and adjacent industries, the GSMA delivers for its members across three broad pillars: Connectivity for Good, Industry Services and Solutions, and Outreach. This activity includes advancing policy, tackling today's biggest societal challenges, underpinning the technology and interoperability that make mobile work, and providing the world's largest platform to convene the mobile ecosystem at the MWC and M360 series of events. Find out more at www.gsma.com.



PREFACE

As we stand at the forefront of a pivotal moment in the conservation of the Amazon, we are excited to present this collaborative report, sponsored by IDB Invest and the GSMA.

This study delves into how digital technologies have the potential to revolutionize Natural Resource Management (NRM). It offers insights into how mobile and digital solutions can support climate action, mitigate biodiversity loss, optimize nature's role in fostering resilient livelihoods, and generate long-term value across Latin America and the Caribbean (LAC). We focus in particular on terrestrial solutions in the Amazon region. Through a combination of research and stakeholder input, we explore innovative approaches and successful case studies that illustrate the transformative power of technology in safeguarding ecological wealth.

We invite you to explore the findings and recommendations presented in this report, developed with the support of the climate and sustainability consultancy firm AGENDI. Let us embark on a journey of exploration and collaboration, as we strive toward a more sustainable future for the Amazon and the communities that call it home. This is a follow-on research project from GSMA's work on Natural Resource Management (NRM).

Akanksha Sharma, Head of ClimateTech and Digital Utilities, GSMA

Guillermo Mulville, Director and Head of Digital Economy, IDB Invest

Leila Guici, Insights and Advocacy Manager, ClimateTech, GSMA

Julián González, Advisory Officer for Climate Change, IDB Invest

Executive Summary

The Amazon region is complex, both from a geographical and social perspective. It consists of rural and urban areas and includes several biomes from the rainforest to savannas and cloud forests. Current economic models have accelerated the rate of deforestation through forest conversion for intensive agriculture and the exploitation of natural resources. **According to research, more than half of Amazonia (52%) has been adversely affected by anthropogenic activity, as evidenced by carbon loss, areas burned, deforestation, and the transformation of natural areas[1].** Global warming and changing weather patterns have also impacted the region, which has suffered from deforestation and degradation, even in isolated areas or those not directly affected by forest conversion. This has negatively impacted indigenous peoples who reside in remote areas and whose livelihoods and way of life depend on the sustainable use of the rainforest.

Digital and mobile technologies are increasingly being designed and adapted for use in NRM, including for the preservation and restoration of the Amazon region. GSMA has produced global reports exploring this topic,[2] highlighting projects that leverage technology to better manage natural resources, engage with indigenous people and local communities (IP&LC), and help coordinate efforts across multiple stakeholders.

Recent advances in the satellite industry, the application of artificial intelligence (AI) and blockchain, combined with monitoring by local communities make it possible to feed robust databases and build expert systems that zero in on the main challenges faced by the Amazon region. Data capture via smartphones, metadata and the ability to measure the results of different actions efficiently and in real time provide traceability and increased transparency across the value chain.

[1] *"Amazonia Under Pressure", Amazonian Network of Georeferenced Socio-Environmental Information (RAISG), 2021*
[2] *-https://www.gsma.com/solutions-and-impact/connectivity-for-good/mobile-for-development/gsma_resources/digital-dividends-in-natural-resource-management/*

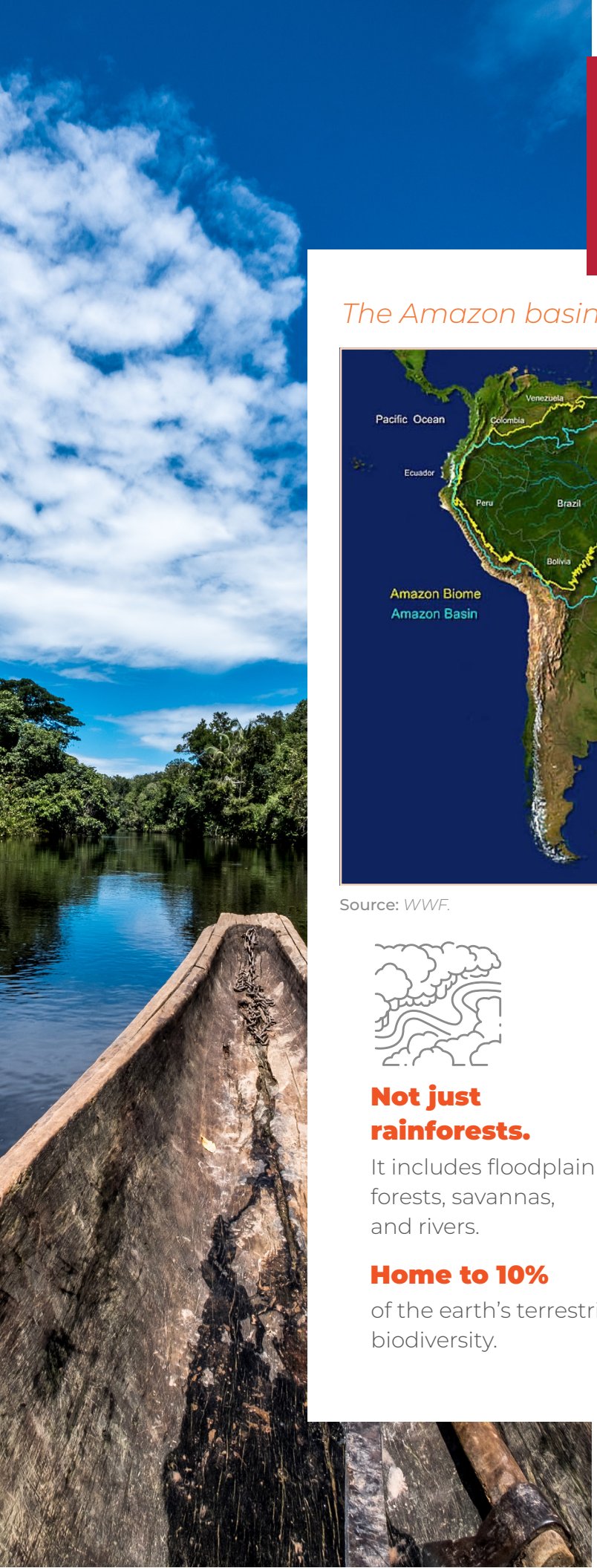
Some of these technologies facilitate short-term actions, including the control of illegal logging, and fire mitigation, as well as long-term actions, such as the financing and supervision of natural resource protection initiatives.

Solutions that combine local and indigenous knowledge, technology for data collection and monitoring, access to market information, and fortified government services can inspire new, scalable solutions for forest conservation and the bioeconomy.

This report combines desk research with stakeholder interviews. We surveyed development banks, NGOs, entrepreneurs, telecom companies and satellite services providers. We sought to understand the current initiatives, key learnings, opportunities, and barriers to using digital technology for NRM. Successful projects share several common themes: Localization and co-creation with IP&LC, public-private partnerships and integration within existing organizations and structures, and easy-to-use, accessible technology and interfaces.

Given the socioeconomic, structural, and geographical complexity of the region, providing mobile internet connectivity requires high capital and operating expenditure (CapEx and OpEx) costs. However, mobile network operators (MNOs) can harness these challenges as opportunities to create new business models providing a platform for service delivery while working with IP&LC to find solutions for conservation and a sustainable bioeconomy.

The continued success of these projects depends on several factors: Country level commitments combined with on-the-ground local action, and nature-related guidance and regulations at the global level to encourage businesses to disclose their nature-related impacts and dependencies. Businesses will continue to assess their operational and value chain impact on nature and biodiversity and their participation in projects that align with these biodiversity commitments.



A snapshot of the Amazon – challenges and transformation

The Amazon basin and biome

Source: *WWF.*

6.7 million km²
in area - Twice the size of India

Shared by 8 countries

- Brazil (61.9%)
- Peru (11.4%)
- Bolivia (8.4%)
- Colombia (6%)
- Venezuela (5.6%)
- Guyana (2.5%)
- Suriname (1.7%)
- Ecuador(1.6%)
- French Guinea (1%)

Not just rainforests.
It includes floodplain forests, savannas, and rivers.

Home to 10%
of the earth's terrestrial biodiversity.

Contains approximately 150–200 billion tons of carbon
equivalent to 15–20 years' global CO_2 emissions.

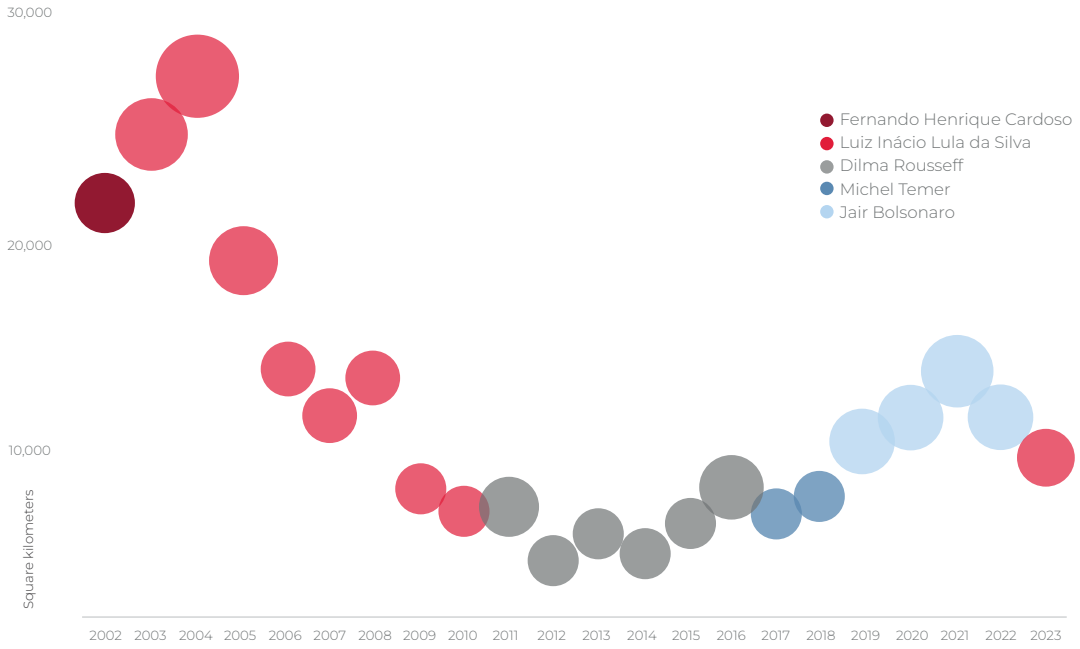
Contributes up to 50% of rainfall
in the region and is crucial for moisture supply across South America.

Home to more than 400 different indigenous people,
speaking around 300 indigenous languages.

Source: *WWF, Statista, Nature.com.*

Deforestation in the Amazon

Deforestation in the Brazilian Amazon since 2002, according to INPE



Annual deforestation in the Brazilian Amazon since 2002 under each presidential administration, according to the PRODES system of Brazil's National Institute for Space Research (INPE).
Note: *Temer took office on August 31 2016, replacing Rouseff, while other presidents started their terms January 1. The data for 2023 is preliminary.*
Source: *Mongabay.*

- **11.6 thousand km² deforested area** in Legal Amazon Region in 2022.

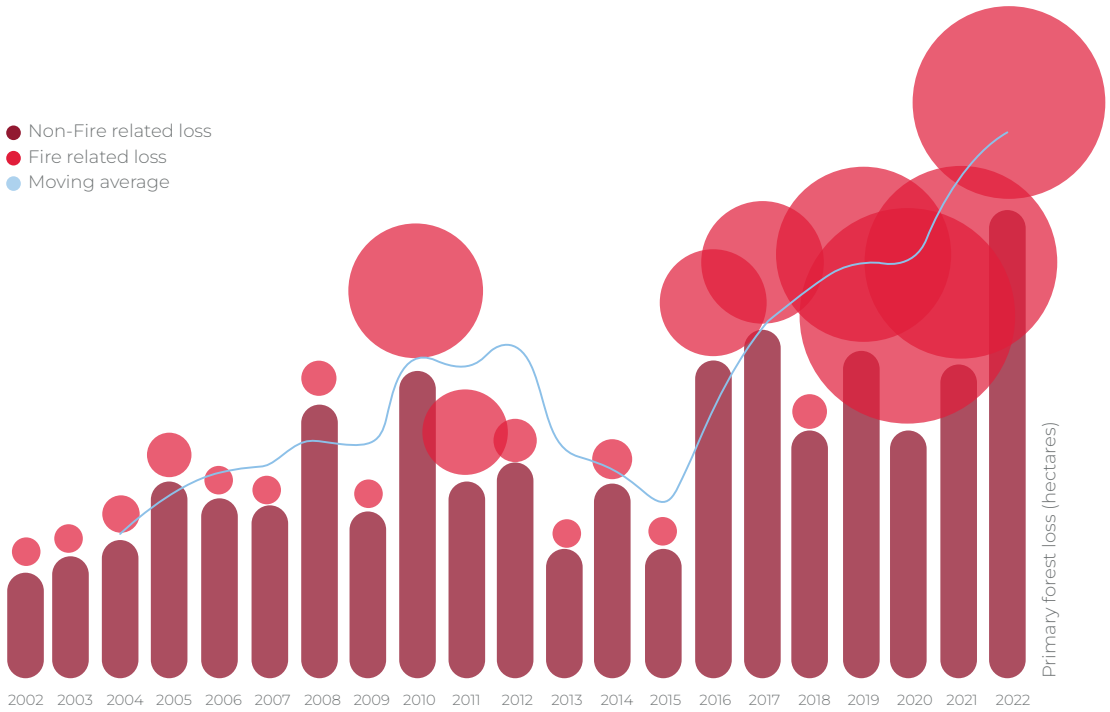
- **Reasons for deforestation:** Cattle ranching, small-scale agriculture, fires, illegal logging, mining, etc.

- According to data released by Brazil's National Space Research Institute, **deforestation in the Legal Amazon decreased by 22% by July 2023.**

- The Colombian government also reported a **70% annual reduction in deforestation by September 2023.**

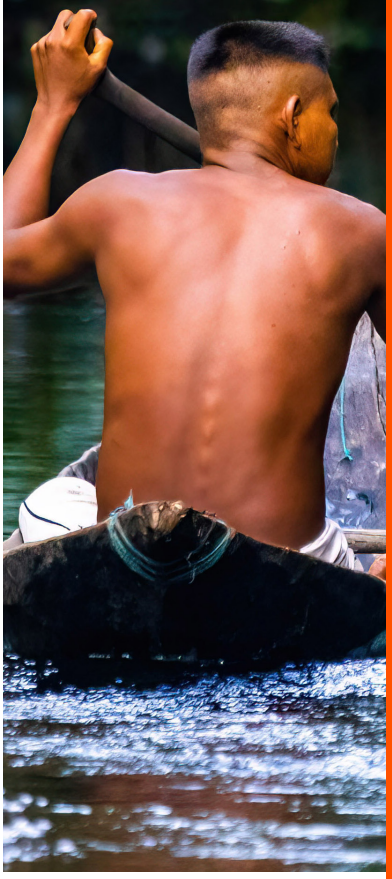
• **Bolivia saw a record-high level of primary forest loss in 2022,** with a 32% increase from 2021 levels, driven primarily by commodity (soybean) agriculture.

Bolivia primary forest loss, **2002-2022**



Non-fire-related loss can occur from mechanical clearing for agricultural and logging, as well as natural causes such as wind damage and river meandering. The three-year moving average may represent a more accurate picture of the data trends due to uncertainty in year-to-year comparisons. All figures calculated with a 30% minimum tree cover canopy density.
Source: *Mongabay, World Rainforests, Global Forest Review-WRI.*
World Resources Institute.

INTRODUCTION



Representing over half the remaining tropical rainforests on earth, the Amazon covers 2.8 million m². It is estimated to hold over 10% of the planet's terrestrial biodiversity and contains approximately 123 billion tons of carbon, making it one of the earth's largest stores of carbon[3]. However, large parts of this ecosystem are increasingly exposed to unprecedented stress from rising temperatures, extreme droughts, deforestation, and fires[4]. Deforestation and habitat destruction are known to be the main drivers behind the devastation of the Amazon rainforests, particularly in Brazil, Bolivia, Colombia, and Peru.

A study published by Nature.com concluded that **significant deforestation in the Amazon region has directly contributed to decreased rainfall and increased temperatures during the dry season[5].** This changing regional climate has turned the southern portion of the Amazon from one of the earth's greatest carbon sinks into a large source of carbon emissions[6]. Between 2010 and 2019, the southeastern Brazilian Amazon released nearly 20% more carbon dioxide into the atmosphere than it absorbed, mostly driven by fires and rising global temperatures[7]. Research has shown that deforested and degraded landscapes are more vulnerable to fires, which in turn trigger the release of carbon into the atmosphere, causing negative health consequences. Human activities have strained the Amazon's resources, which has led to a decline in biodiversity and ecosystems.

[3] "Deforestation, Warming Flip Part of Amazon Forest from Carbon Sink To Source", research.noaa.gov/2021/07/14/deforestation-warming-flip-part-of-amazon-forest-from-carbon-sink-to-source/. Accessed 14 Dec. 2023
[4] Graduate Program in Ecology, Federal University of Santa Catarina, Florianopolis, Brazil
[5] Gatti, L.V., Basso, L.S., Miller, J.B. et al., "Amazonia as a carbon source linked to deforestation and climate change." Nature 595, 388–393 (2021).
[6] Ibid
[7] "Brazilian Amazon Released More Carbon than It Absorbed over Past 10 Years." The Guardian, Guardian News and Media, 30 Apr. 2021

Degraded landscapes can no longer store carbon via plant life and soil, thereby decreasing arable land for agriculture and pushing farming operations into less suitable land. We must address this inextricable **link between climate change, overpopulation, and nature as we look for solutions.**

Tipping point for Amazon?

A "tipping point" is the threshold value of an environmental stressor at which a small disturbance becomes significant enough to cause an important change in the ecosystem. According to a study by Nature.com published in February 2024, it is estimated that by 2050, 10–47% of Amazonian forests will be exposed to increased disturbances that may trigger unexpected ecosystem-wide transitions, adversely impacting regional climate change[8].

Historically, **Amazon IP&LC have helped manage forests and associated critical ecosystem services.** The conservation of Amazon indigenous territories (Its) and protected natural areas (PNAs) has been key to maintaining the biodiversity of the Amazon's tropical forests, while avoiding carbon emissions from forest degradation[9]. A recent study on the carbon dynamics of Its and PNAs found that carbon loss was twice as high outside of IPLC lands than within them[10]. In Bolivia, Brazil, and Colombia, IP&LC have managed land and successfully reduced deforestation and their associated carbon emissions.

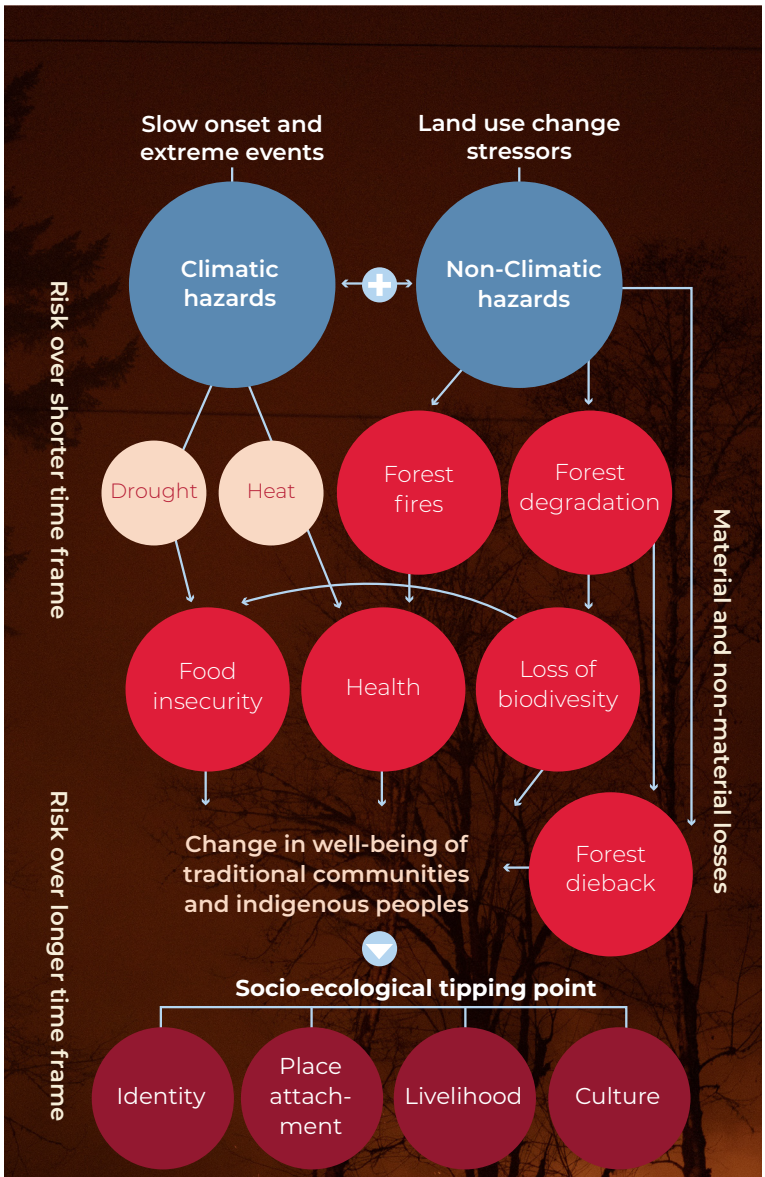


Figure 1: *Socio-Ecological risks to the Amazonia ecosystem Source: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.*

[8] *Iores, B.M.; Montoya, E.; Sakschewski, B. et al., "Critical transitions in the Amazon forest system." Nature 626, 555–564 (2024)*

[9] *Walker W.S.; Gorelik S.R.; Baccini A.; Aragon-Osejo J.L.; Josse C.; Meyer C.; Macedo M.N.; Augusto C.; Rios S.; Katan T.; de Souza A.A.; Cuellar S.; Llanos A.; Zager I.; Mirabal G.D.; Solvik K.K.; Farina M.K.; Moutinho P.; and Schwartzman S., "The role of forest conversion, degradation, and disturbance in the carbon dynamics of Amazon indigenous territories and protected areas." Proc Natl Acad Sci U S A. 2020 Feb 11;117(6):3015-3025. doi: 10.1073/pnas.1913321117. Epub 2020 Jan 27. PMID: 31988116; PMCID: PMC7022157*

[10] *Walker, W. et al. "The role of forest conversion, degradation, and disturbance in the carbon dynamics of Amazon indigenous territories and protected areas." Proceedings of the National Academy of Sciences, January 2020*

Three categories of digital technology usage

Real-time monitoring and data collection	Connected devices (IoT) and other technologies are used to support data collection and the monitoring of species, people and assets, often in real time or in near real time.. **Common techonologies used:** Sensors, satellite, drones, camera, traps and mobile devices.
Engaging and informing communities	A broad range of technologies and approaches are used to influence positive behaviors or to provide communities with the tools they need to actively participate in NRM projects, to access information or support, or to receive payments for ecosystem services. **Common techologies used:** Call centers, interactive content, peer-to-peer content, push and pull content, mobile payments and mobile devices.
Data management and analysis	AI and other data management tools are used to provide real-time analysis, support decision making, predict trends and promote efficiencies. **Common technologies used:** Inventory management tools, blockchain, AI, data visualization software.

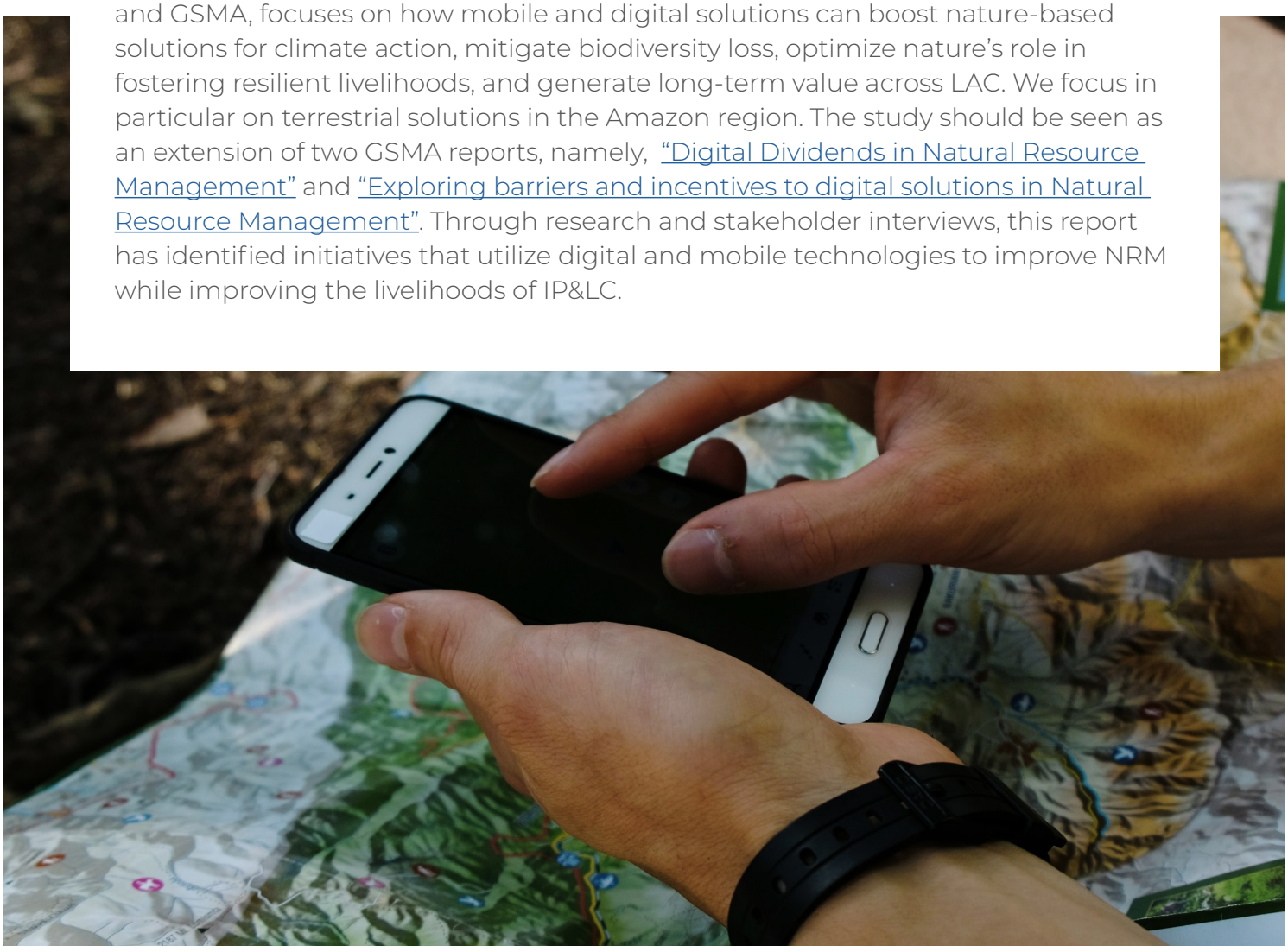
Source: *GSMA.*

Digital technologies have transformed human lives over the past decade. A growing body of evidence has emerged indicating that digital technologies can bring incremental, and sometimes transformational, benefits to **the sustainable use and management of the planet's natural resources and ecosystems[11].** The most common uses of digital technology in NRM include: a) enabling real-time monitoring and data collection; b) supporting community engagement in NRM activities; and c) allowing organizations to store, analyze and visualize data. Research by GSMA[12] found that when developed and applied in a customizable and scalable way, digital solutions can enhance the quality and efficiency of data collection, engage local and global communities in conservation efforts, and aid real-time decision-making. **In the Amazon basin, digital NRM could be instrumental to forest and wildlife preservation and management, while simultaneously providing opportunities for indigenous communities to improve their livelihoods and resilience.**

[11] *GSMA, Digital Dividends in Natural Resource Management, 2020*
[12] *GSMA, Exploring barriers and incentives to digital solutions in Natural Resource Management, 2023*

Although technology has already transformed other sectors, NRM has not yet leveraged these tools on a large scale. There is a **need to co-create projects with IP&LC,** empower stakeholders, and help sustain efforts to preserve local territories and ecosystems. As local communities get involved with bioeconomy projects, their participation in local decision-making is strengthened, which puts them in control of NRM. Global commitments, including the Paris Agreement, the KunmingMontreal Global Biodiversity Framework, and recommendations such as the Taskforce on Nature-related Financial Disclosures (TNFD) are expected to increase the number of nature-related impact disclosures by businesses, encouraging them to assess their own suppliers' impact on nature and biodiversity. There is **an opportunity to create services that focus on nature conservation, monitoring, and bioeconomy as a different layer of services, leveraging public-private partnerships and collaboration with local communities.**

Scope and focus of this report: This study, sponsored by IDB Invest and GSMA, focuses on how mobile and digital solutions can boost nature-based solutions for climate action, mitigate biodiversity loss, optimize nature's role in fostering resilient livelihoods, and generate long-term value across LAC. We focus in particular on terrestrial solutions in the Amazon region. The study should be seen as an extension of two GSMA reports, namely, "Digital Dividends in Natural Resource Management" and "Exploring barriers and incentives to digital solutions in Natural Resource Management". Through research and stakeholder interviews, this report has identified initiatives that utilize digital and mobile technologies to improve NRM while improving the livelihoods of IP&LC.



DIGITAL TECHNOLOGY FOR IMPROVED NRM IN THE AMAZON

In LAC, mobile connectivity remains the main form of internet connectivity, particularly as for many it is the only form of connectivity[13].

At the end of **2023**

the number of mobile internet users in LAC exceeded

418 millon

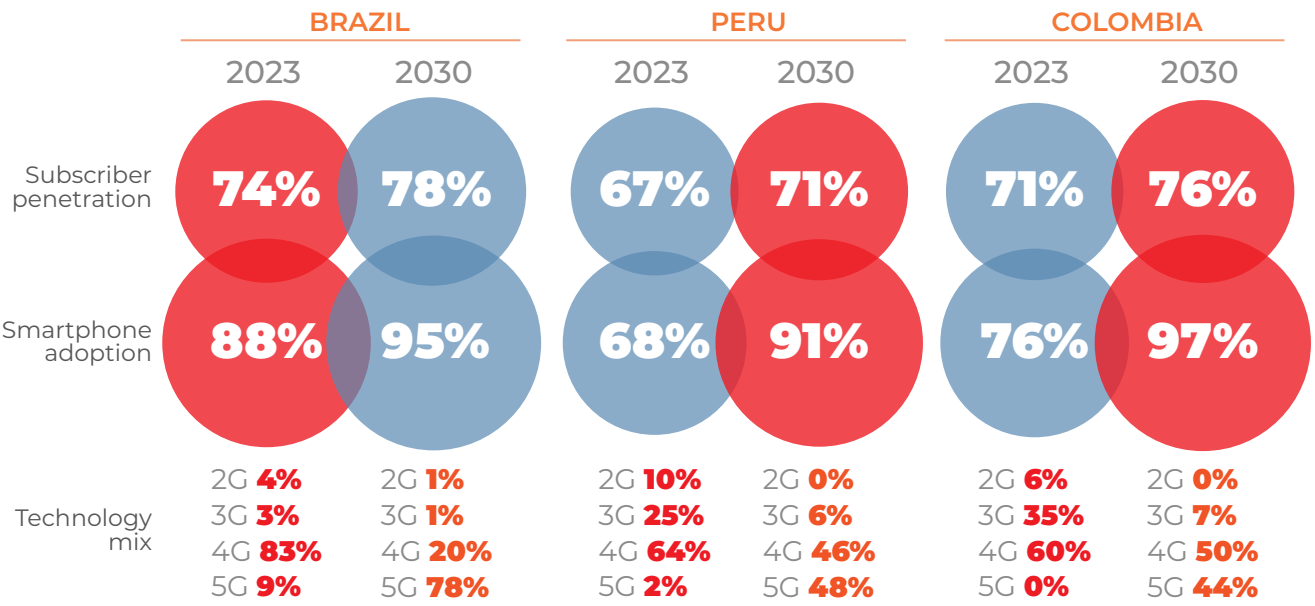
equating to **65%** of the population.

In Brazil, which constitutes majority of the Amazon region

74% of the population are mobile subscribers

and **88%** of whom use smartphones.

[13] https://www.gsma.com/solutions-and-impact/connectivity-for-good/mobile-economy/wp-content/uploads/2022/11/GSMA_LATAM_ME2022_R_Web.pdf



Technology type	Level of adoption for NRM applications in the Amazon region	Description	Example
Mobile technologies, 4G smartphones	High	Mobile technologies, including smartphone-based apps and 4G can be accessible and affordable to global communities for real-time communication and data tracking.	Money-based platforms can be used to gamify participation in NRM efforts via a rewards system.
Blockchain	High	Blockchain stores data in a distributed database across large networks at various locations. Blockchain's structure ensures secure and auditable transactions, thereby replacing the financial intermediary role.	Blockchain technology provides a more secure and transparent platform. Storing large amounts of granular data can improve resource management, credibility and data access.
Artificial intelligence (AI)	Low, increasing	AI and other data management tools are used to provide real-time analysis, support decision-making, predict trends, and promote efficiencies.	Used to interpret a wide variety of data, such as images.
Satellites	Medium	Satellites have a variety of potential uses, including communication, weather forecasting, location services, imagery, and observation.	Satellites are a critical tool for monitoring natural resources. This technology has been used to detect changes in land cover and track vegetation growth. Satellites are increasingly being used to improve NRM strategies.
Internet of Things (IoT)	Low, increasing	IoT connects numerous devices and sensors to a network to continuously share and collect data. IoT data can enable network devices to function autonomously based on real-time information.	Within agricultural systems, IoT has been used to monitor needs and coordinate the delivery of essential nutrients to crops.

Source: *GSMA Intelligence.*

Emerging, disruptive digital technology and innovation have the potential to be part of the solution to the Amazon rainforest's degradation. Technologies such as blockchain, IoT, AI, and satellite imaging and communication can assist in solving significant NRM challenges, enabling governments, local communities, and entrepreneurs to better protect, preserve, and restore natural lands while building resilience for IP&LC. The increased affordability and accessibility of these technologies, including the extension of 4G coverage, flexible satellite access, and low-cost IoT sensors, make them suitable for projects in the Amazon region.

IDB: Enhancing the market for biodiversity credits through the implementation of digital tokens under an integrity protocol.

Goal: The IDB Group and its partners are developing a protocol for the financing of biodiversity conservation projects using digital tokens. This project leverages the protocol Colombian company, Terrasos, developed to issue voluntary biodiversity credits (VBC), or creditos de biodiversidad voluntarios (CBV) in Spanish. The project focuses on developing technology to facilitate the conversion of VBC to biodiversity tokens, including its validation and commercialization.

Technology: The use of biodiversity tokens dynamizes VBC markets. For example, Terrasos, the implementing partner, has eight Habitat Banks registered but uptake has been slow because of the low number of infrastructure, mining and energy projects in that specific region. Tokens improve the traceability and transparency of transactions by using the distributed ledger technology (DLT) enabling businesses and donors to purchase VBC.

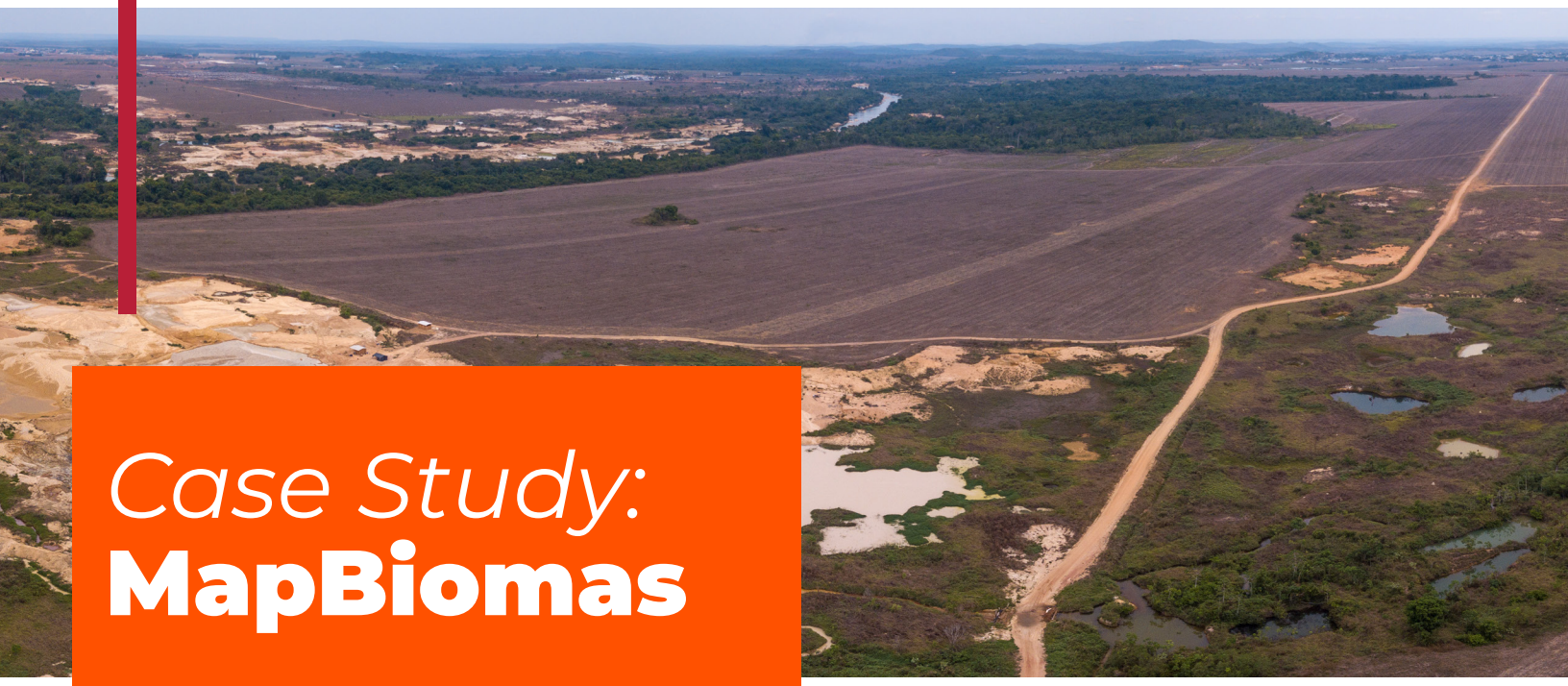
Expected Impact: This project is expected to benefit the communities or organizations that own the land where the tokens are issued. The new climate-finance income model will help conserve 1,000 hectares of Colombian territory that has been under threat for 30 years. Beyond the project's initial implementation, it will be scaled and replicated throughout the Amazon basin countries, including Brazil, Peru, Bolivia, Ecuador, Colombia, Venezuela, Guyana, and Surinam. Voluntary biodiversity credits and the tokenization of VBC, together with the integrity protocol, which guarantees quantifiable biodiversity gains as well as financial and legal guarantees, are an improvement on the traditional payment for ecosystem services (PES), which had been demonstrated to be ineffective after payments had stopped[14].

[14] Cauê D. Carrilho; Gabriela Demarchi; Amy E. Duchelle; Sven Wunder; and Carla Morsello, "Permanence of avoided deforestation in a Transamazon REDD+ project (Pará, Brazil)", Ecological Economics, Volume 201, 2022

CASE STUDIES

In this section, we highlight three examples of digital technology being used successfully for NRM in the Amazon region.

We identified solutions from a long list of ongoing NRM initiatives, with projects scored on the availability of impact data, technology relevance and replicability, the potential for public-private partnerships, and the inclusion of local stakeholders, among other factors. We interviewed several representatives as a second layer of research into case applicability. We selected the final case studies based on their high replicability, demonstrated success, and the ability to self-sustain and scale impacts.



Case Study: **MapBiomas**

Location
Multiple countries within the Amazon basin (Bolivia, Brazil, Colombia, Ecuador, Peru, Venezuela, and other regions)

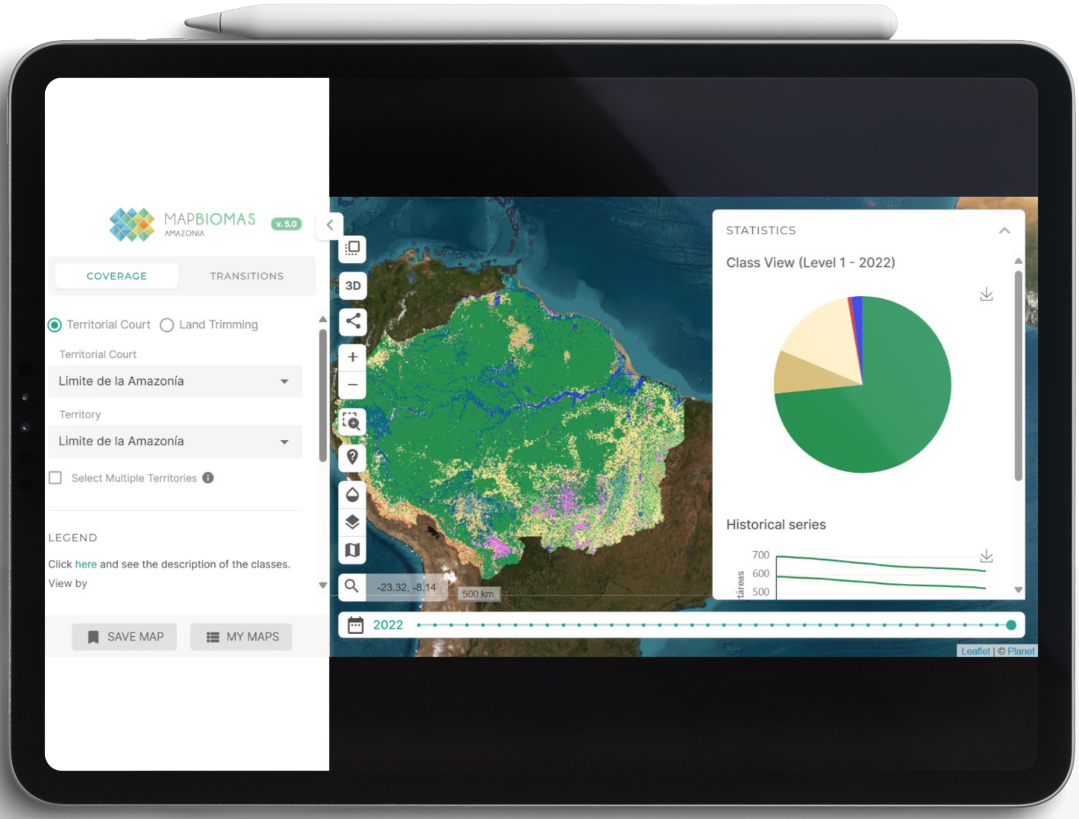
Technology
Satellite imagery and mapping, machine learning, Cloud

NRM Sector
Forest management, land use

Implemented by
RAISG (Amazon Network of Georeferenced Socio-Environmental Information), a collective of civil society organizations from Amazon countries: Bolivia: Fundación Amigos de la Naturaleza (FAN); Brazil: Instituto Socioambiental (ISA), Instituto do Homem e Meio Ambiente da Amazônia (Imazon); Colombia: Gaia Amazona Foundation (FGA); Ecuador: EcoCiencia; Peru: Institute for the Common Good (IBC); Venezuela: Provita, Wataniba

The Problem

The Amazon region is densely forested and deforestation activities occur daily; accurate, up-to-date, location-specific data can be hard to come by. Issues of thick canopy coverage and remote, dispersed populations complicate the process of data collection. Moreover, the existing data is often unconsolidated or inaccessible.



The Solution

The MapBiomas initiative generates annual land use and land cover maps for the Amazon region, with the aim of supporting biodiversity and forest conservation. These low-cost, comprehensive maps support users in calculating and monitoring land use and cover transitions, forest losses and gains, regeneration, water resources, the impact of urban and agricultural expansion into previously forested lands, and the management of protected areas.

These terrestrial maps are developed using 30 by 30 meter resolution satellite images. The images are put together in a mosaic form annually, creating a historical series. The mosaic contains over 100 layers of information, generated by the Landsat satellite image itself or by the local partner in each country, who will add indices and other details. The images are subsequently reassembled to include the additional information and are accessible for further data processing or instant download using Google Earth Engine.

The project's core offering is an open-source, online platform that allows for the processing of large amounts of spatial data stored in the cloud using algorithms hosted on Google Earth Engine. Local partner organizations with location-specific data collection expertise can feed the platform with additional data.

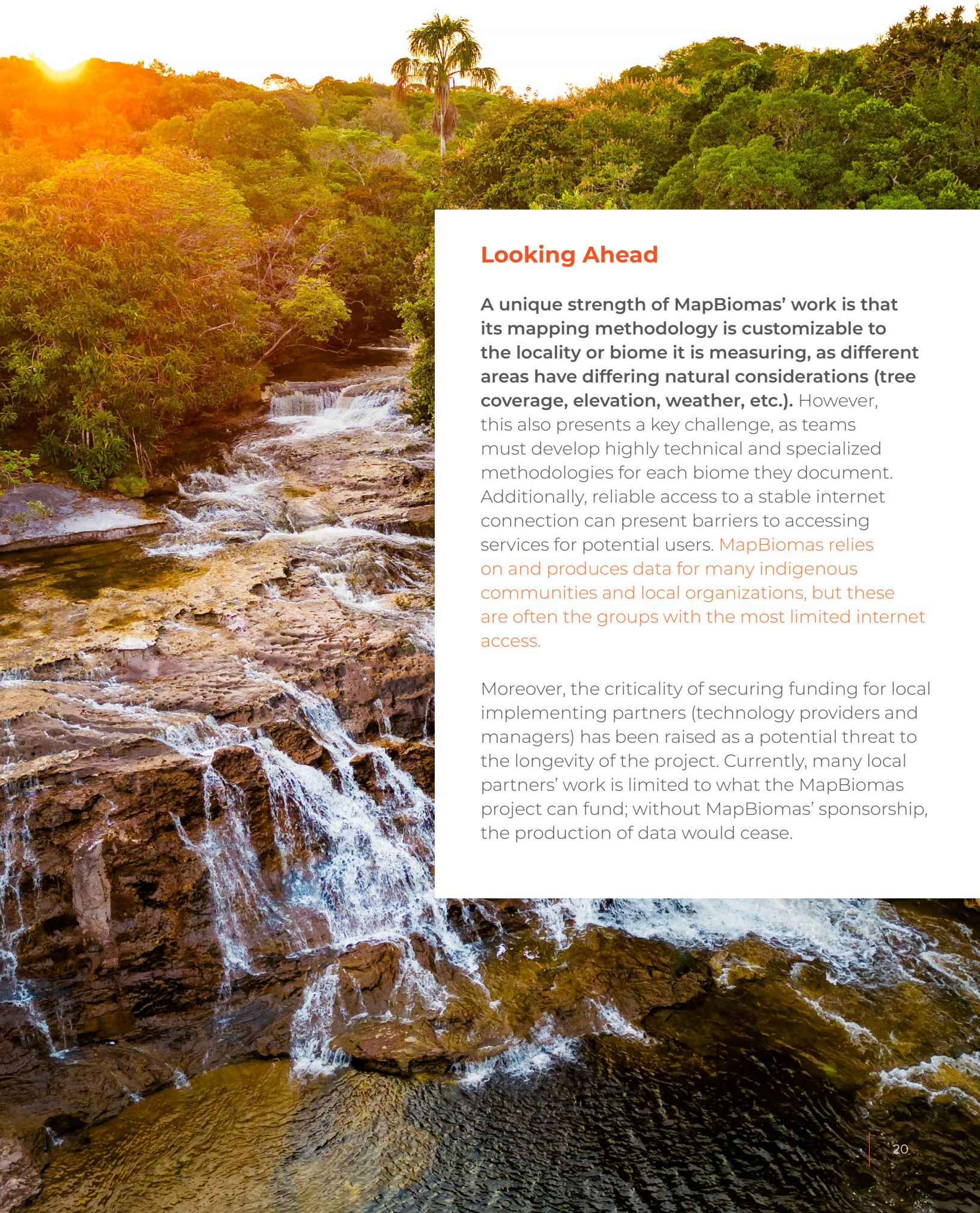
Impact

MapBiomas data has been used successfully across the Amazon region to understand land use dynamics and make evidence-based decisions on land use and forest management. In Peru, the Environment Ministry's (MINAM) program uses MapBiomas maps to document ecosystem degradation in the Andean region and coastal desert. The Argentinian initiative La Red de Áreas Protegidas de Argentina uses MapBiomas data to create its land management plans. While in Brazil, MapBiomas data has been used for multiple initiatives, most notably to generate emissions inventories related to land coverage changes. In 2022, MapBiomas data was used to demonstrate significant natural vegetation loss in the Amazon to an audience at the Brazilian embassy in Lima, Peru.

Drivers of Success

Implementers of the MapBiomas project work with local community leaders and organizations, including indigenous representatives, to scale project coverage and data usage. Data generated through MapBiomas' mapping systems is used by indigenous and land use advocates to support their conservation initiatives. MapBiomas leverages existing community structures and federations to proliferate and scale its work across dozens of communities. While communities are not directly involved in the design and creation of new MapBiomas initiatives, they are involved as direct stakeholders and beneficiaries of the solution. **This is key, because MapBiomas relies on its local partnerships for both the implementation and uptake of its products. Its implementing partners, the groups collecting the raw map data, are organizations with specific local and regional knowledge.** As the maps are produced at a more granular level than previously possible, MapBiomas data and products are highly localized and relevant to local stakeholders. Local groups are able to use the data to monitor land use and deforestation more effectively in their communities.

MapBiomas also prioritizes public, open-access use of its data. The results of its data collection are readily available on the project's website and sub-websites of its national initiatives. Its platform is interactive, free, and intentionally easy-to-use. It takes advantage of existing hosting technologies (Google) that are user friendly and scalable for stakeholders, who can use the data as evidence for conservation initiatives when, for example, presenting to regulatory, policymaking and funding bodies.



Looking Ahead

A unique strength of MapBiomas' work is that its mapping methodology is customizable to the locality or biome it is measuring, as different areas have differing natural considerations (tree coverage, elevation, weather, etc.). However, this also presents a key challenge, as teams must develop highly technical and specialized methodologies for each biome they document. Additionally, reliable access to a stable internet connection can present barriers to accessing services for potential users. MapBiomas relies on and produces data for many indigenous communities and local organizations, but these are often the groups with the most limited internet access.

Moreover, the criticality of securing funding for local implementing partners (technology providers and managers) has been raised as a potential threat to the longevity of the project. Currently, many local partners' work is limited to what the MapBiomas project can fund; without MapBiomas' sponsorship, the production of data would cease.

Case Study: **Umgrauemeio (Pantera Platform)**

Location
Brazil

Technology
Radio, satellite sensors, monitoring towers, AI

NRM Sector
Protected area conservation/wildlife preservation and habitat protection

Founders/Implementers
Embrace the Forest Initiative

Strategic Partners
Land Innovation Fund; Sitawi; UNESCO; Bureau Veritas; UN Global Compact; IPE

Beneficiaries
Local NGOs; Brazilian Federal Administration; NOS Telecom; JBS S.A.

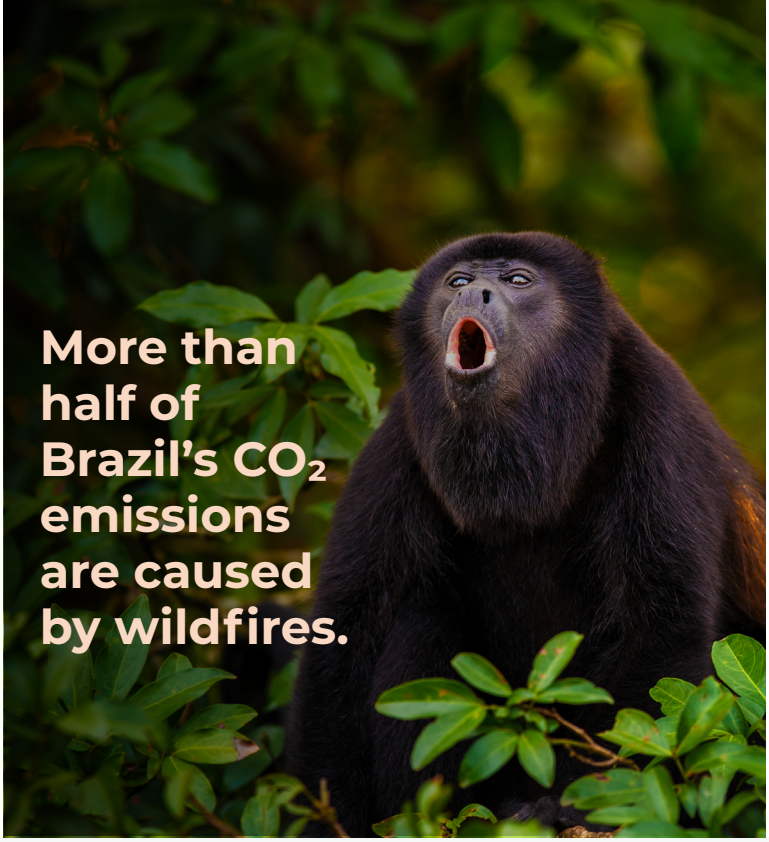
The Problem

Wildfires have seriously affected the world's forests and wetlands. The Amazon and the Pantanal, the world's largest tropical wetland areas, are both great, unique biomes characterized by unparalleled biodiversity. These two regions have been particularly hard hit by fires in the twenty-first century. **In 2020, 26% of the Pantanal was consumed by fire. The fires left more than 4 million hectares of wetland compromised, killing around 17 million vertebrates and emitting 150 million tons of CO^2 into the atmosphere.**[15] Since the 1970s, the duration of fire seasons has increased by an average of 19% globally, according to a report by the World Wide Fund for Nature (WWF)[16].

[15] *Mataveli, G.A.V.; Pereira, G.; de Oliveira, G. et al. "2020 Pantanal's widespread fire: short- and long-term implications for biodiversity and conservation." Biodivers Conserv 30, 3299–3303 (2021). https://doi.org/10.1007/s10531-021-02243-2*

[16] *"Press Release: Global Fires Analysis." WWF, www.wwf.org.uk/press-release/press-release-global-fires-analysis. Accessed 12 Dec. 2023*

The impact of wildfires on local communities has been severe, with approximately 1.1 million people living in regions affected by the fires. The city of Corumbá, known as the gateway to the Pantanal, has seen an increase in hospitalizations due to respiratory issues. In a recent fire, Corumbá experienced a 25% increase in searches for medical attention as a direct result of exposure to smoke. In response to the increased severity and frequency of megafires, the founders of a technology-based platform have sought to revolutionize Brazil's approach to fire management and allow the biome to regenerate.



The Solution

The Pantera Platform software addresses several challenges related to fire management and environmental impact assessment. The platform hosts a risk map, which is updated daily with weather forecasts, occurrence history, and combustible material analysis[18]. **The solution uses satellites to reach remote areas, with alerts and continuous tracking of potential hotspots.** Additionally, high resolution cameras have been installed on monitoring towers covering a radius of 15 kilometers. These cameras are used to spot smoke or fires using an AI algorithm. The towers are also equipped with solar panels and a radio connection to provide instant detection and alerts.

With these resources, the Pantera Platform software enables the detection of forest fires in less than three minutes, significantly reducing the response time and, subsequently, the size and amount of burned areas. The system then generates an alert containing crucial information about the fire's location, size, and potential direction of spread.

[17] *Sant'Anna, Emilio, and e Leonardo Cabral., "Tempo Seco e Queimadas Fazem Queixas de Problemas Respiratórios Subirem 25% EM Corumbá." Estadão, Estadão, 26 Aug. 2021, www.estadao.com.br/sustentabilidade/tempo-seco-e-queimadas-aumentam-em-25-busca-por-atendimento-de-problemas-respiratorios-em-corumba/*

[18] *https://restor.eco/*

This information is transmitted in real-time to relevant stakeholders responsible for managing the fire, such as local or national government authorities. **The Pantera Platform monitors 13.5 million hectares of land in Brazil, including forests, agricultural land, and native areas[19].**

This comprehensive and innovative solution to the wildfire problem in the Pantanal helps protect the region's biodiversity, local communities, and the environment. It reduces the risks of forest fires damaging the rainforest and harmful greenhouse gas emissions being released into the atmosphere.

In the project's first six months, the Pantera Platform detected and swiftly responded to 323 fire outbreaks, saving an estimated five million tons of CO^2 from being released into the atmosphere.

Why is it successful?

Establishing partnerships and relationships of trust with producers in this region can be difficult and hinder the ability to fight fires and protect lands. By working side-by-side with local communities is therefore central to umgrauemeio.

The development process is dynamic and continuously evolving to suit diverse needs and adapt solutions to meet those needs. For example, continuous feedback from communities directly influences cycles of improvement.

[19] *Embrace Pantanal (umgrauemeio.com)*

Given local residents' deep understanding of their environment, they can often quickly identify signs of fire, which is why umgrauemeio is now developing a mobile app for real-time, on-the-ground fire surveillance to complement the more extensive monitoring conducted via towers.

The app will encourage residents to actively participate in fire monitoring efforts. However, a lack of digital skills among the local communities can be a barrier given the sophisticated technologies required for the platform. Umgrauemeio has offered training and education programs to communities, businesses, and government agencies to equip them with the knowledge and tools needed for anticipatory fire management and to use the technology provided by the organization.

Looking Ahead

The Pantera Platform solution benefits local biodiversity and the economy while preventing the release of harmful polluting gases into the atmosphere. However, many stakeholders, including governments and corporations, tend to allocate resources and attention to wildfires only after they have caused significant damage. The focus on short-term solutions and immediate firefighting efforts often overshadows the importance of long-term planning and preventive measures. This shortsightedness can result in increased damage and higher costs in the long run.

There is a tendency to overlook the potential return on investment from proactive fire prevention and sustainable land management practices. Investments in these areas are sometimes costly up front but often lead to substantial cost savings in the long term. Umgrauemeio aims to shift the narrative from reactive to anticipatory approaches by emphasizing the importance of proactive fire prevention, advocating for policy changes, and fostering public-private collaboration.

This shift may ultimately contribute to a more sustainable and resilient future where environmental crises are mitigated before they escalate into disasters.

Case Study: Camino Verde RealTrees

Location
Madre de Dios and Loreto, Peru

Technology
Blockchain, AI, mobile app, inventory management tools, interactive content

NRM Sector
Payment for ecosystem services/forest management/bioeconomy

Implementers
Camino Verde (non-profit, US)
Tambopata (non-profit, Peru)

Strategic Partners
Bext360
Indigenous communities (tree planting partners)

Beneficiaries
Non-profits (tree planting projects)
Companies managing NTFP supply chains

The Problem

Peru holds the worlds' 10th-most-forested area[20]. Yet, Peru's forests are among the most deforested in the world. **Between 2001 and 2022, Peru lost 3.86 million hectares of tree cover (or 4.9%) to deforestation, resulting in 2.44 gigatons of CO_2 emissions[21].** Despite reports of an encouraging reduction in primary forest loss during 2023 compared to previous years, there was still a clearing of almost a million hectares that year[22].

[20] https://www.worldwildlife.org
[21] https://rainforestfoundation.org/our-work/where-we-work/peru/
[22] https://www.maaproject.org/2023/amazon-deforestation-carbon/

The Solution

Launched in 2022, RealTrees is a proprietary technology designed by Camino Verde and created with tech-partner Bext360. RealTrees registers and monitors reforestation and forest management on a tree-by-tree basis.

Tree data is collected in-field via the RealTrees mobile app using image captures and simple data collection tools. Further, GPS and compass data fed into the app is analyzed using machine learning algorithms to provide the most precise location possible for each individual tree registered.

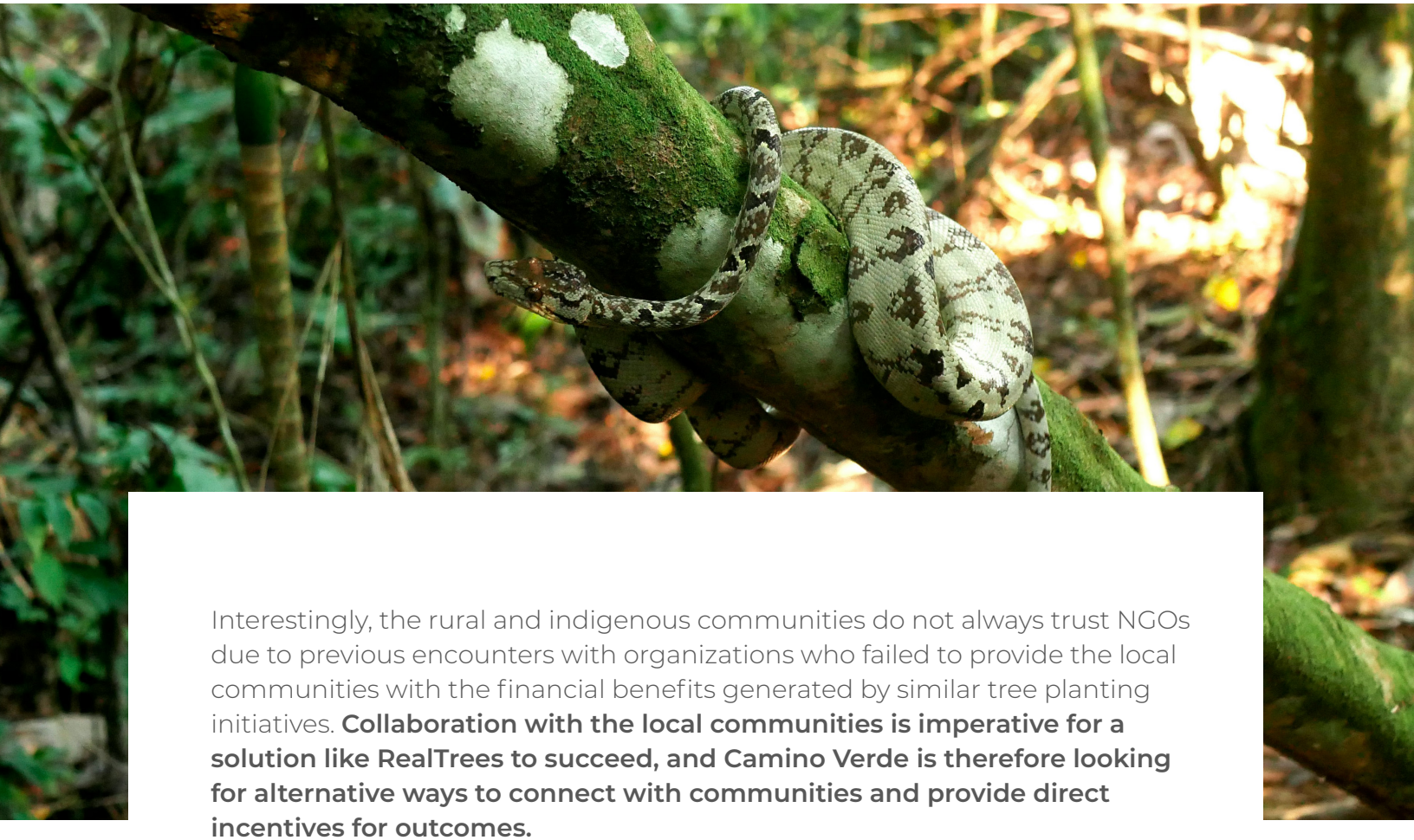
This allows for future data captures of the trees to be automatically matched to previously registered data without having to manage manual recordkeeping or cumbersome code systems. All tree capture data is stored in a blockchain, rendering it permanent. Tree size and carbon capture are calculated on a tree-by-tree basis, and individual tree profiles are available to donors on a public-facing tree adoption platform.

Camino Verde aims to make RealTrees a plug-and-play solution at the granular level of individual trees for reforestation projects to track and share progress, and for non-timber forest product supply chains to communicate their products' sourcing with transparency.

Looking Ahead

Camino Verde works closely with the local communities; it has registered trees on the agroforestry parcels of over one hundred families in five indigenous communities to date. The reforested trees help farmers produce non-timber forest products, such as essential oils, aromatics, soaps, and honey, among others, helping the local communities improve their livelihoods while regenerating the forest.

Launched in 2022, RealTrees is still in its infancy and has room to grow as a solution. Due to an increased awareness of climate risks combined with private sector investment in, for example, the carbon market, we are seeing a rise in demand for tree planting activities worldwide. However, as Camino Verde works with smallholders with parcels of only one or two hectares, carbon credit generation is not yet viable at such a small scale. Camino Verde currently owns 200 hectares of land and has the capability to involve a larger area through collaboration with local smallholders and communities. By allowing small-scale tree planting initiatives to be combined and bundled while having access to similarly powerful monitoring tools as large for-profit projects, the process of entering the voluntary carbon market seems more achievable.



Interestingly, the rural and indigenous communities do not always trust NGOs due to previous encounters with organizations who failed to provide the local communities with the financial benefits generated by similar tree planting initiatives. **Collaboration with the local communities is imperative for a solution like RealTrees to succeed, and Camino Verde is therefore looking for alternative ways to connect with communities and provide direct incentives for outcomes.**

Grassroots initiatives, including Camino Verde's RealTrees, which leverage technology, have the potential to scale and grow with the right financial and infrastructure support. **Camino Verde's primary reforestation center is based in Madre de Dios, a sparsely populated region in southeastern Peru, which faces several connectivity challenges, especially during the rainy season. Camino Verde currently uses HughesNet as their satellite dish provider, as the local mobile network is unable to reach the area.** The existing internet speed is slow, so registering a large amount of newly planted trees and uploading the data from the app to the cloud takes time. The data occasionally has to be stored off-line and uploaded once the farmer reaches a connected area. There is an opportunity for MNOs to provide innovative connectivity pilots and platform services that could alleviate the technology challenges faced by these initiatives. These startups need reliable internet connections with a low-energy cost, and alternative forms of connection and power sources should be explored.

New approach for land rights – Fit-For-Purpose

Approximately 75% of the world's population does not have access to formal systems to register and safeguard their land rights[23]. In 2014, the International Federation of Surveyors (FIG) and the World Bank created Fit-For-Purpose Land Administration (FFPLA) solutions.

These solutions were built to be flexible, inclusive, participatory, affordable, reliable, attainable, and upgradable.

FFPLA initiatives leverage new technologies, including the use of mobile phones, to capture land parcel boundaries and other legal information to record and adjudicate land rights.

More recently, drone and street level imagery has been enhanced with machine learning (ML) to either automatically or semi-automatically extract objects from the captured imagery. FFPLA has been used in the Amazon region, specifically in projects in Brazil and Colombia. In Brazil's Tangará da Serra, FFPLA has helped determine areas under threat of deforestation using satellite technology to identify unregistered communities and formalize them[24]. For the Land in Peace project, a land administration project in rural Colombia, FFPLA was used to alleviate conflict between two groups, defining land boundaries between indigenous Sikuani and neighboring settler farmers. **The program helped develop and propose an efficient land administration system using satellite and mobile app technologies[25].**

[23] *Kelm, K.; Antos, S.; and McLaren, R., "Applying the FFP Approach to Wider Land Management Functions." Land 2021*
[24] *Reydon, B.; Molendijk, M.; Porras, N.; and Siqueira, G., "The Amazon Forest Preservation by Clarifying Property Rights and Potential Conflicts: How Experiments Using Fit-for-Purpose Can Help." Land 2021*
[25] *Becerra, L.; Molendijk, M.; Porras, N.; Spijkers, P.; Reydon, B.; and Morales, J,. "Fit-For-Purpose Applications in Colombia: Defining Land Boundary Conflicts between Indigenous Sikuani and Neighbouring Settler Farmers." Land 2021*

BEST PRACTICES FOR NRM IN THE AMAZON

The GSMA report on “Exploring barriers and incentives to digital solutions in Natural Resource Management” identified four core approaches to inclusive and scalable NRM globally.

These include:

a) Co-creation of solutions,
b) Localizing the design and application of digital solutions,
c) Providing clear and direct rewards for using the solution and
d) Prioritising simple and intuitive user interfaces.

As part of this research, we validated the relevance of these solutions in the context of the Amazon by consulting multiple stakeholders (see stakeholder list) and reviewing the impact and uptake of dozens of NRM projects in the region. Below is a summary of best practices to help implement scalable digital NRM solutions in the Amazon region.

Best practices for driving uptake of digital NRM solutioes

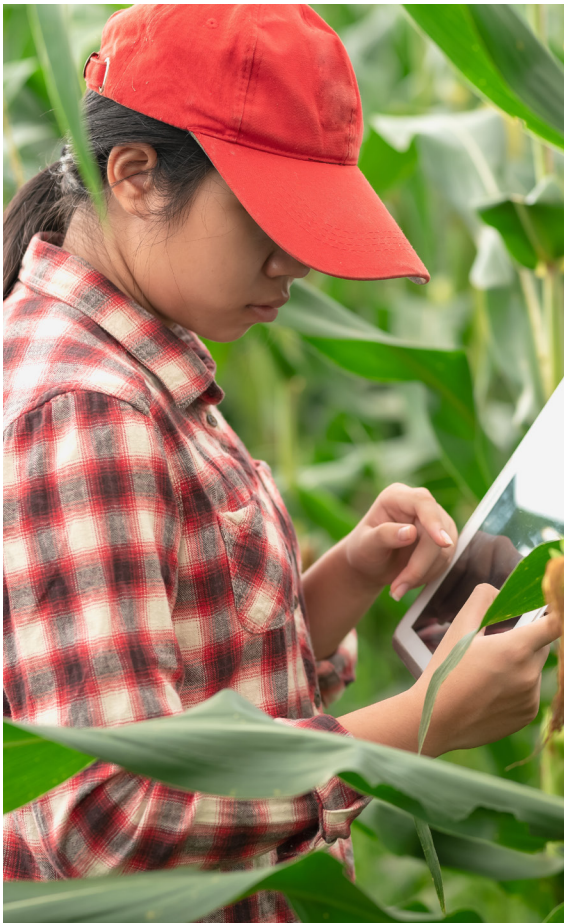
Source: *GSMA, Exploring barriers and incentives to digital solutions in Natural Resource Management, 2023.*

1. *Provide solutions that complement existing NRM practices in the Amazon*

It is important to understand that IP&LC have long been stewards of natural resources across the globe; the same holds true for the Amazon. When digital solutions complement IP&LC existing practices and help achieve efficiencies, we see higher chances of their adoption and impact. Data collection and management is a laborious task; digital solutions offer the ability to collect, share, and measure data efficiently, sometimes in real time. Our research found that almost all successful digital solutions in the region include a data collection element. Precise and up-to-date data also provides decision-makers with reliable information for reaching evidence-based decisions. The RealTrees app, created by Camino Verde (see case study above), uses blockchain and AI to facilitate the registration and tracking of reforested trees sponsored by donors. Each tree planted becomes its own data point when it is registered as a unique entity using blockchain technology.

The RealTrees data management system captures and provides real-time data on each tree's growth and associated carbon capture. This data collection and monitoring allows for unparalleled precision in impact reporting, providing donors and other stakeholders with a level of transparency that incentivizes further participation and program scalability.

2. *Ensure consistent local engagement*



Local communities are key stakeholders in adding value to and benefiting from NRM interventions. They bring highly relevant contextual knowledge and are critical in establishing the legitimacy of the project, helping to ensure its sustainability and future scalability. Indigenous and rural populations across the Amazon region are often already working sustainably within their local ecosystems, or eager to begin doing so, indicating clear co-benefits for both local populations and project implementers. Most of the projects we reviewed considered and integrated the needs and knowledge of the local communities in which they were implemented. However, we observed that **successful projects ensured that local engagement was done consistently and iteratively in project design, launch, implementation, and future planning.** Further, the projects that not only consulted the locals but also involved them in co-creation were better accepted in the communities and showed a higher uptake of the solution.

3. *Collaborate with existing frameworks and structures*

Along the lines of engaging local populations, successful projects also often tap into existing networks and institutions. These include civil society organizations and networks, local government and public sector bodies, or other community organizations. By collaborating with and within existing structures, projects are legitimized with local stakeholders and increase their connectivity within local contexts. These existing institutions and structures can also be powerful in helping to implement projects. For example, the MapBiomas project is implemented across multiple countries by integrating existing organizations into its implementer network to scale up its map coverage. The project collaborates with and sponsors a network of non-profit and civil society organizations dispersed throughout its coverage area to customize its data collection approach to the local context.

4. *Prioritize ease of use*

To ensure a successful uptake, projects utilizing digital technologies should ensure their technology is accessible and, ideally, easy to use or learn. Simplifying user interfaces, whether app- or web-based, or training stakeholders to use the technology, facilitates uptake and generation of the intended results.

While the MapBiomas initiative (highlighted in the case studies section) collects its data through a highly technical collection of satellite imagery equipment, the resulting maps are presented through a publicly available, easy-to-access online platform. **This accessibility allows diverse groups of users—community members, indigenous organizations, policy makers, etc.—to access MapBiomas data and make easy use of it.**

ENABLING DIGITAL INCLUSION FOR SUCCESSFUL NRM IN THE AMAZON

Digital technologies offer a plethora of use cases for NRM in the Amazon. There is increasing awareness, political will, finances, and commitment to save the Amazon. But the **cornerstone of successful digital NRM implementation is ensuring digital inclusion,** which relies on equitable digital access, affordability, knowledge and skills, relevant content and services, and safety and security. In the introductory chapters, we discussed high mobile connectivity and smartphone adoption rates in LAC.

But the region, particularly in remote parts of the Amazon forests, struggles with two issues:

a) the **connectivity gap**
b) the **usage gap,** which refers to the population living within mobile broadband coverage but not using it.

Expanding connectivity in the Amazon

Largely, owing to the remote and unreachable nature of the Amazon forests that cover 60% of the country, Brazil accounts for 40% of those in LAC without mobile broadband coverage[26].

According to GSMA's Mobile Connectivity Index (MCI)[27], Brazil has seen improvements across the four key connectivity enablers, with Infrastructure and Affordability (meaning the total cost of mobile ownership, including mobile tariffs, handset prices, inequality, and taxation) recording the strongest growth. Several structural challenges persist, however, preventing the Amazon from fully exploiting its digital potential. Remote and sparsely populated areas of the Amazon provide negative returns on investment for MNOs.

There are further structural challenges, including a lack of reliable electricity services and transportation to the remote parts of the region. For example, the Internet Para Todos (IPT) initiative in Peru—funded by Telefónica, Meta, IDB Invest and CAF development bank (see the box below)—has worked to extend services to rural populations of nearly 600 people (a typical mobile network investment usually targets population sizes of 5,000+). But it struggles to reach settlements of between 100 and 200 people, which are common in the Amazon.

Similarly, satellite providers, including Hispasat, which have participated in projects that provide connectivity to rural regions have achieved low returns on investment. These projects are costly and complex, generally in areas

[26] *https://www.gsma.com/r/wp-content/uploads/2023/10/State-of-Mobile-Internet-Connectivity-2023-Latin-America-and-Caribbean.pdf*
[27] *https://www.mobileconnectivityindex.com/index.html*

that are difficult to access, with some requiring two to three days of travel, which increases logistics and costs. Once operational, the services are not as profitable as desired due to low local incomes. The number of new subscribers—residents who can afford these services—is less than anticipated. **This highlights the need for public investment to complement private financing and alternative means of connection to reach the last mile.**

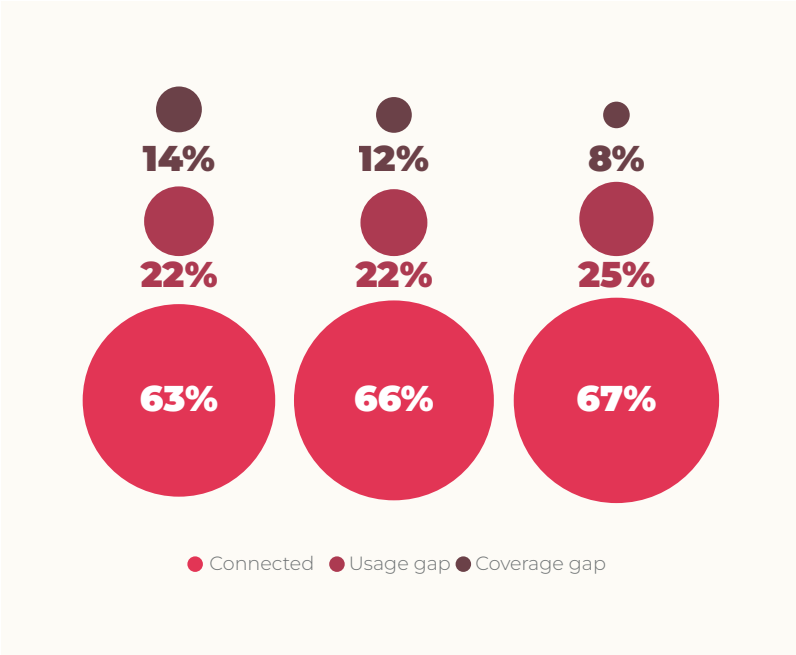


Figure 2: *Mobile Internet Connectivity in Brazil 2020- 2022*
Source: *GSMA Intelligence, Anatel.*

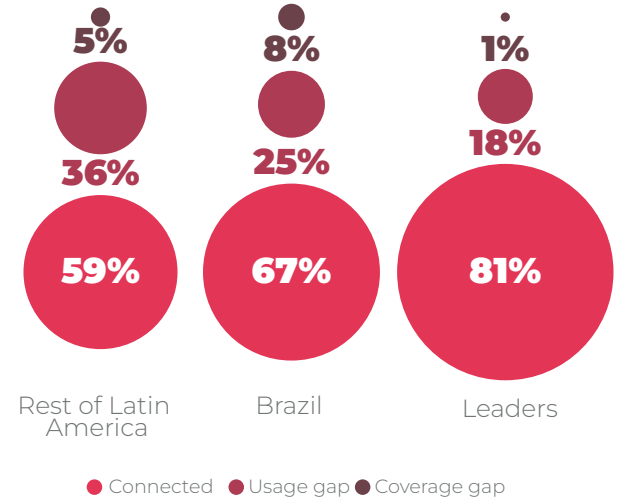


Figure 3: *Mobile internet connectivity in Brazil, rest of Latin America and leader countries, 2021.*
Base: *total population.*
Source: *GSMA, The State of Mobile Internet Connectivity 2023.*

MNO initiatives in the Amazon region focused on expanding connectivity

Given the unequal access to mobile connectivity described above, MNOs' engagement in the Amazon region is mostly focused on expanding connectivity to both urban and rural areas in the region. These connectivity projects, especially in rural areas, are largely driven by governmental regulations that require MNOs to expand coverage as part of spectrum licensing. Examples of these mandates can be seen in Brazil (Vivo and Oi) and Peru (Telefónica – IPT). Projects in Brazil have enabled connectivity in schools and other rural locations. Similar efforts have been undertaken in rural regions of Ecuador and Bolivia. Below are some examples of connectivity expansion projects in LAC, including rural areas and the Amazon region.

Internet para Todos

was launched in 2019 as a union of shareholders, including Meta, Telefónica, IDB Invest and CAF. In Peru, there is a digital gap of six million unconnected people who reside mostly in rural areas. IPT's objective has been to develop a network as a service company that provides internet to settlements and helps create a self-sustaining business. IPT received the necessary assets from Telefónica: 3,000 towers with 2G satellite services, with the goal of overlaying and upgrading these sites to provide internet solutions. The updated technical infrastructure and solutions will benefit not only Telefónica but other MNOs in Peru as well. The current area of coverage is three million people with 4G internet services, which means the IPT project has reached 50% of the target population identified. The remaining 50% includes small towns and settlements in the Amazon region, including the lower and upper rainforest and other hard to reach areas.

- "Connecta Selva" with Eutelsat and Telespazio provide connectivity to remote regions of the Amazon rainforest[28] [29].

- IDB Invest and Tigo provide rural mobile broadband in Colombia.

- Rural Women, Agents of Digital Transformation is a program by ANDITEL with funding from the United States Agency for International Development (USAID) and Microsoft that seeks to bridge the digital divide by establishing high-speed internet connection in remote areas, while implementing empowerment projects in rural communities, particularly for women.

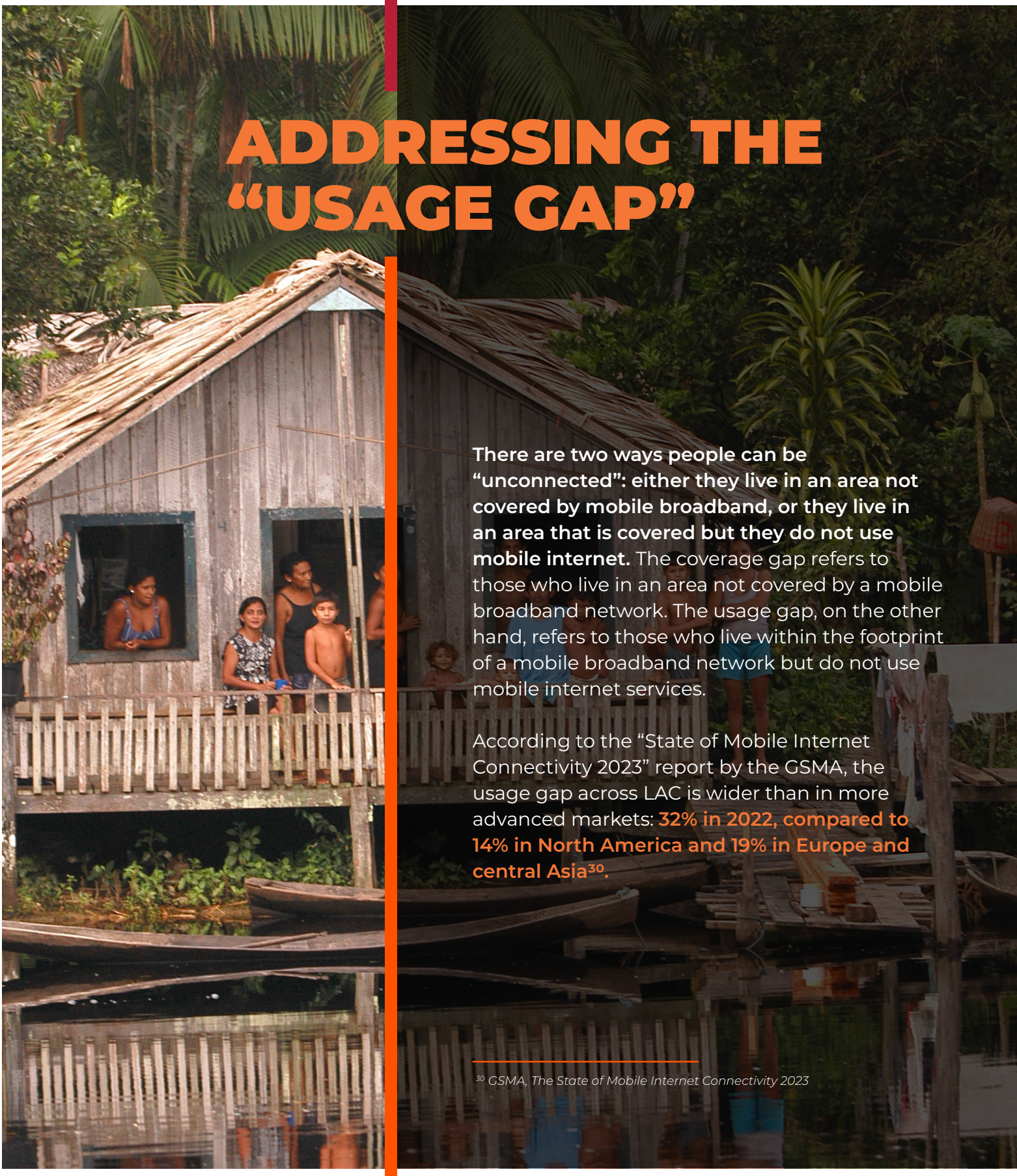
[28] *https://www.eutelsat.com/en/case-study/satellite-brings-broadband-to-remote-areas-of-Amazon-rainforest.html*
[29] *chrome-extension: https://www.usaid.gov/sites/default/files/2023-03/USAID_Microsoft_Airband_Factsheet_Anditel.pdf*

MNO and satellite partnerships to enable remote connectivity

Traditionally, satellite and non-terrestrial solutions (NTNs) have provided connectivity on a much lower scale than telecoms networks due to several limiting factors, including uncompetitive costs, limited ecosystem support, and high latency. However, NTNs have seen recent advances in performance improvement, lower deployment costs and much more viable business models. This trend is driving new partnerships with telecoms operators in ways that could reshape the connectivity landscape. Telecoms networks now cover more than 95% of the world's population but less than 45% of the world's landmass. Satellites and NTNs are well suited to deliver connectivity in maritime, remote, and polar areas where deploying conventional terrestrial networks could be costly and challenging. Over the past two years, there has been a growing number of partnerships between telecoms operators and satellite companies, spanning several continents and use cases, including rural coverage and disaster relief. Telefónica is a leading example of this, having partnerships with Comtech Telecommunications, Gilat Satellite Networks, Hispasat, ST Engineering iDirect, and Viasat. In August 2023, Telefónica Global Solutions also struck a partnership with SpaceX's satellite constellation arm Starlink, with a launch in Mexico and extensions planned for Brazil and Spain.

Such partnerships can be gamechangers in enabling digital inclusion in remote and previously unconnected parts of the Amazon.

Source: *"The Mobile Economy 2024", GSMA, Feb 2024 and TelcoTitans.*

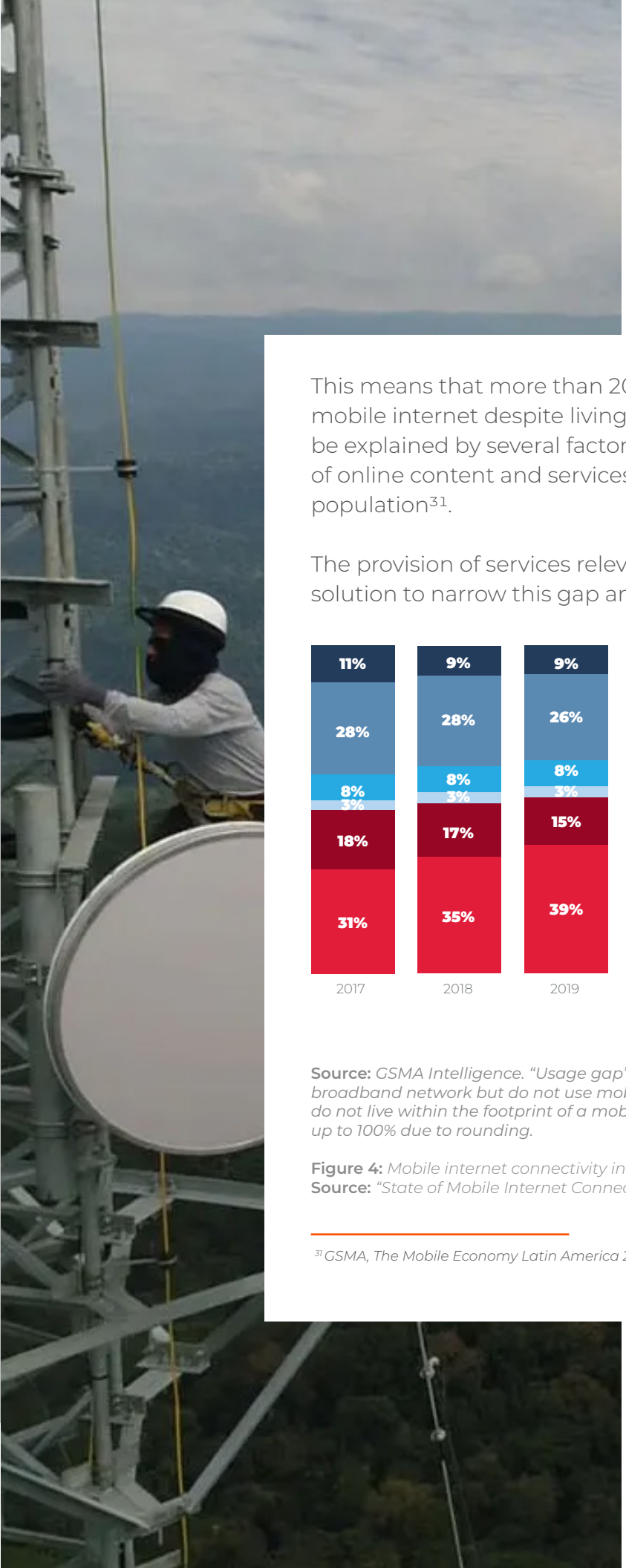


ADDRESSING THE "USAGE GAP"

There are two ways people can be "unconnected": either they live in an area not covered by mobile broadband, or they live in an area that is covered but they do not use mobile internet. The coverage gap refers to those who live in an area not covered by a mobile broadband network. The usage gap, on the other hand, refers to those who live within the footprint of a mobile broadband network but do not use mobile internet services.

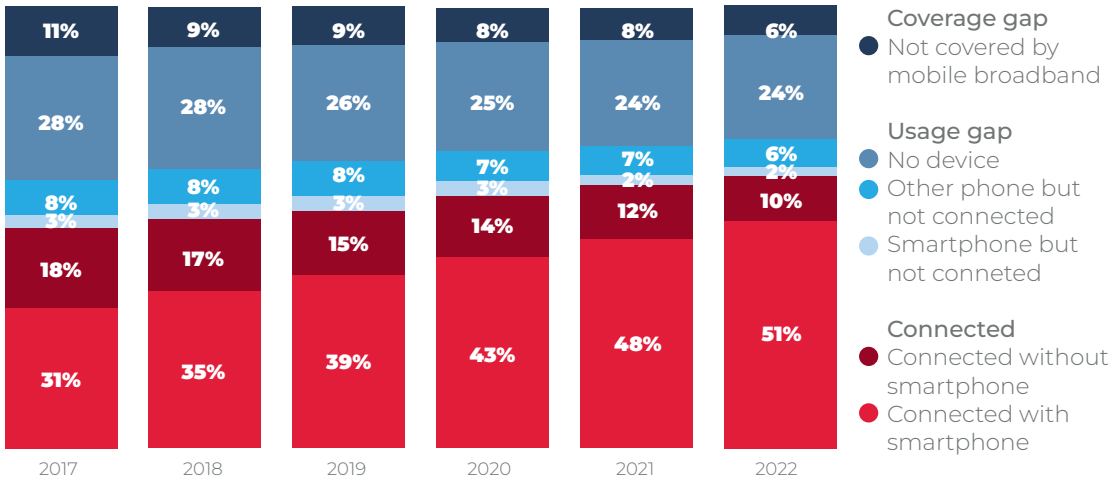
According to the "State of Mobile Internet Connectivity 2023" report by the GSMA, the usage gap across LAC is wider than in more advanced markets: **32% in 2022, compared to 14% in North America and 19% in Europe and central Asia[30].**

[30] *GSMA, The State of Mobile Internet Connectivity 2023*



This means that more than 200 million people in LAC are still not using mobile internet despite living within mobile broadband coverage. This can be explained by several factors, from device affordability to the availability of online content and services that are accessible and relevant to the local population[31].

The provision of services relevant to the local population points to a possible solution to narrow this gap and increase MNO profitability.



Source: *GSMA Intelligence. "Usage gap" refers to populations that live within the footprint of a mobile broadband network but do not use mobile internet services. 'Coverage gap' refers to populations that do not live within the footprint of a mobile broadband network (3G or above). NB: totals may not add up to 100% due to rounding.*

Figure 4: *Mobile internet connectivity in Latin America and the Caribbean.*
Source: *"State of Mobile Internet Connectivity 2023", GSMA.*

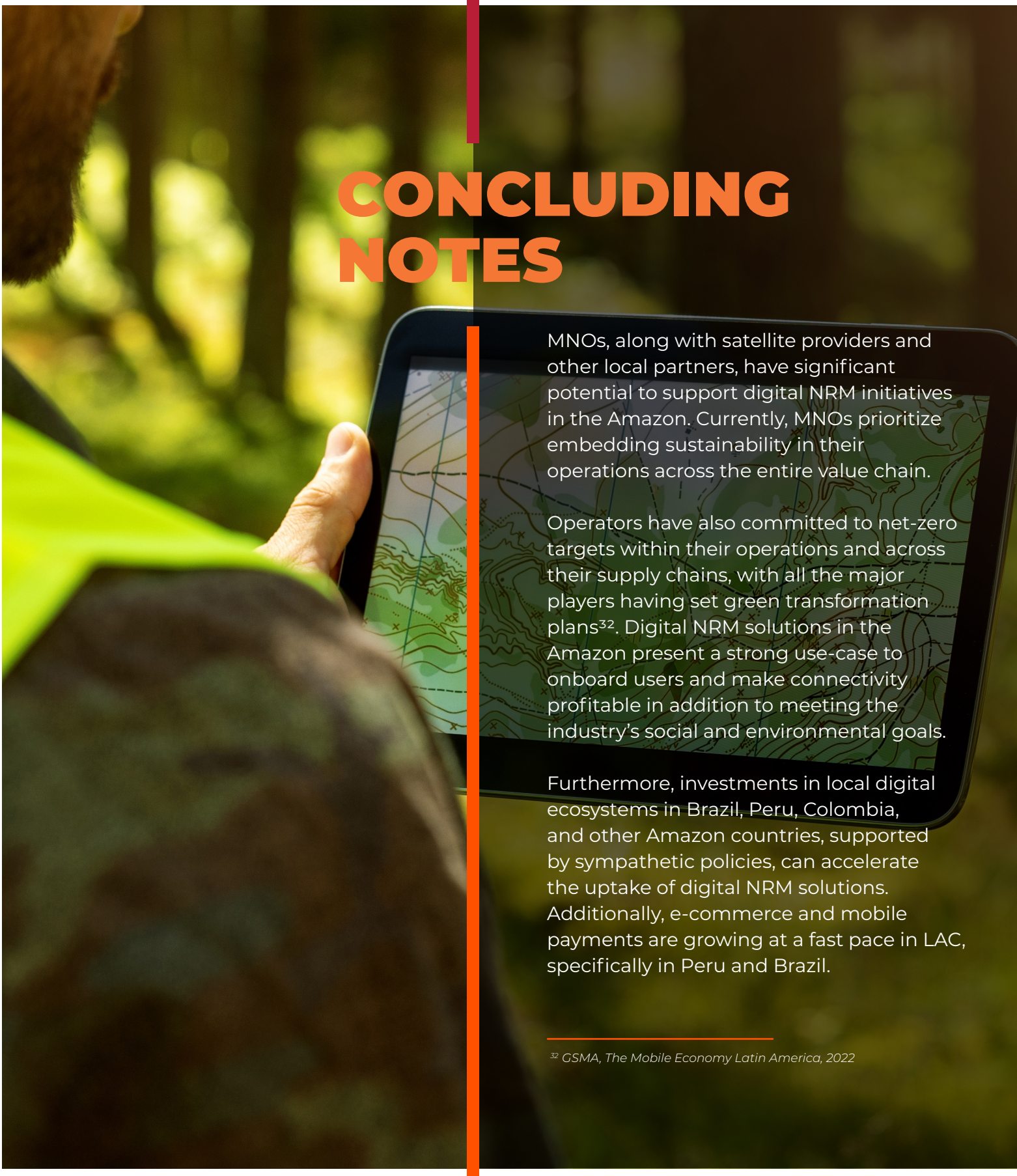
[31] *GSMA, The Mobile Economy Latin America 2022*

MNO and satellite provider initiatives to bridge the usage gap by providing local content

Beyond connectivity, MNOs and satellite providers have participated in projects, along with development banks and NGOs, that provide added services to rural populations. These services have mostly focused on education and health with less emphasis on business or NRM services.

- In 2021, IPT worked with Cedro and USAID to bring high-speed internet to 10 towns, thereby facilitating enhanced bioeconomy businesses, which in turn encouraged new planting of cacao to replace the previous cultivation of coca leaves. The benefits afforded to local farmers were access to markets, improved local knowledge, and not having to commute to areas with connectivity to sell their products.

- Hispasat has conducted small pilots in Colombia and Ecuador focusing on digital health and education projects, providing added services on top of connectivity and engaging local communities to create and deliver these services.



CONCLUDING NOTES

MNOs, along with satellite providers and other local partners, have significant potential to support digital NRM initiatives in the Amazon. Currently, MNOs prioritize embedding sustainability in their operations across the entire value chain.

Operators have also committed to net-zero targets within their operations and across their supply chains, with all the major players having set green transformation plans[32]. Digital NRM solutions in the Amazon present a strong use-case to onboard users and make connectivity profitable in addition to meeting the industry's social and environmental goals.

Furthermore, investments in local digital ecosystems in Brazil, Peru, Colombia, and other Amazon countries, supported by sympathetic policies, can accelerate the uptake of digital NRM solutions. Additionally, e-commerce and mobile payments are growing at a fast pace in LAC, specifically in Peru and Brazil.

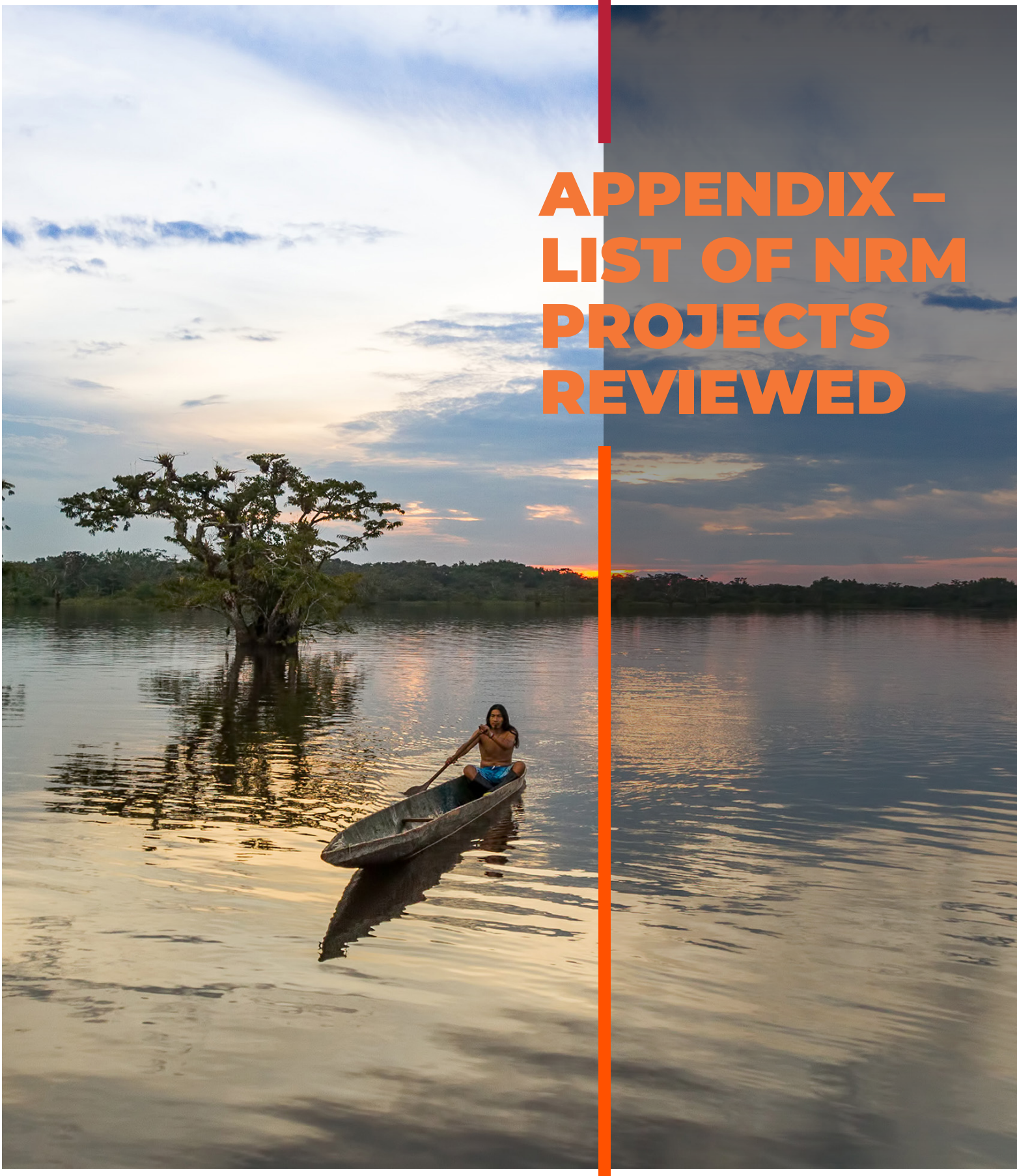
[32] *GSMA, The Mobile Economy Latin America, 2022*

Figure 5: *MNOs partnerships with NGOs and Startups and NRM services opportunities.*
Source*: as Author's analysis.*

Populations that were previously unbanked use these services and offer a pathway to expand services to the Amazon region in a way that is both profitable for the MNOs and income generating for local populations. For example, integrating e-commerce and mobile payments into bioeconomy initiatives, such as Partners for the Amazon Platform, could bring direct economic benefits to both entrepreneurs and the local economy while improving the return on investment of network services for MNOs.

Expanding NRM services to the most remote areas should be assessed in terms of trade-offs; the expansion of transportation networks in the past resulted in deforestation[33]. IP&LC must be involved to ensure that the solutions positively impact their livelihoods while supporting the preservation and sustainable use of their territories. According to analysis from RAISG, a key implementer of the MapBiomas project, most of the deforestation (87.5%) that occurred between 2012 and 2020 took place outside PNAs and ITs[34]. This highlights the role of local and indigenous communities as protectors of the standing forest, preserving the biological and cultural diversity of the Amazon region with traditional methods, using its resources in a sustainable way.

[33] *The Guardian. Amazon's Road to Ruin: Highway Threatens Heart of the Rainforest, 5 June 2023, www.theguardian.com/environment/2023/jun/05/amazon-road-ruin-highway-threatens-heart-rainforest*
[34] *Amazonian Network of Georeferenced Socio-environmental Information (RAISG), Amazonia Under Pressure, December 2020*



APPENDIX – LIST OF NRM PROJECTS REVIEWED

Program name	Primary Tech	NRM Sector	Location	Link
Treevia	IoT, drones	Forest management	Amazon	Treevia.br
EcoMatcher	Blockchain	Forest management	Ecuador	EcoMatcher - Ecuador
Tangará da Serra	Satellite	Securing land rights	Mato, Brazil	The Amazon Forest Preservation by Clarifying Property Rights and Potential Conflicts: How Experiments Using Fit-for-Purpose Can Help
Programa Socio Bosque (PSB)	Drones	Payment for ecosystem services	Northern Ecuadorian Amazon	
Land in Peace	Satellite	Securing land rights	Colombia	Fit-For-Purpose Applications in Colombia: Defining Land Boundary Conflicts between Indigenous Sikuani and Neighboring Settler Farmers
USAID Prevent Project	Apps, drones	Wildlife species preservation	Loreto, Madre de Dios and Ucayali, Peru	Prevent FS-English-Aug 2021.docx (usaid.gov)
MOSS Earth	Blockchain, tokenized carbon credit listed in Coinbase	Protected area conservation	Amazon River/Brazil	MCO2 Token - MOSS Earth
Ready for REDD (Reducing Emissions from Deforestation and Forest Degradation): Acre's State Programs for Sustainable Development and Deforestation Control	Satellite	Protected area conservation	Acre, Brazil	Acre's State Programs for Sustainable Development: Promoting Ecological, Social, and Economic Development
Camino Verde RealTrees Transparency Program	Blockchain and AI	Forest Management	Located 5km from Puerto Maldonado, regional capital of Madre de Dios 15 hectares (37 acres) total area for the center, of which: 6 hectares (15 acres) reforested with diverse polyculture agroforestry systems	RealTrees — Camino Verde

Program name	Primary Tech	NRM Sector	Location	Link
Wildlife Insights + Amazon Sustainable Landscapes (ASL) Data Explorer Tool	Machine learning	Wildlife preservation and habitat protection	ASL pilot sites across Amazonia countries	Calendar (worldbank.org), Page 85 of ASL progress report 2022
Courageous Land Agroforestry Platform	AI	Forest management	Amazon Basin and other tropical regions	Courageous Land
Ictio	Inventory management tools	Wildlife preservation and habitat protection	Amazon Basin	Overview - Ictio
Conservation Strategy Fund (CSF) Mining Calculator	Data visualization tools	Protected area conservation	Brazil. Ecuador, Peru, Colombia	Calculator | CSF (conservation-strategy.org)
WRI Global Forest Watch	Satellite data, advanced computer algorithms and cloud computing power	Forest management	Global	Global Forest Watch | World Resources Institute (wri.org)
Colpa de Loros Cooperative in Peru	Maps, digital platforms, and traceability	Bioeconomy	Padre Abad in Ucayali, Peru	UNDP Assistance Helps Farmers to Meet New EU Deforestation Rules | Inter Press Service (ipsnews.net)
CRAFT	Geospatial mapping	Protected area conservation	Brazil (and worldwide)	greenclimate.fund
Decarbonize Pará: Policy Reform Project for Sustainable Development in the Amazon	Satellites and biotechnology	Forest management	Amazon Basin	IDB | Decarbonize Pará: Policy Reform Project for Sustainable Development in the Amazon (iadb.org)
Amazonia 4.0	Satellites	Bioeconomy	Brazil	Plataforma Parceiros pela Amazônia
Solinftec	AI, IoT and SaaS	Agriculture tech	Brazil + Colombia	2050 Vision for Sustainability & ESG - Solinftec
Umgrauemeio (Pantera Platform)	Platform for fire management, NFTs	Protected area conservation	Brazil	Embrace Pantanal (umgrauemeio.com)

Appendix D: Stakeholder list

GSMA and IDB would like to acknowledge the contributions of the stakeholders interviewed and those who provided feedback during the course of this research. The organizations that took part in discussions about digital approaches to NRM are listed below:

- Umgrauemeio
- USAID Prevent
- USAID Brazil – Partners for the Amazon Platform
- IDB Crowdsourcing for Digital Connectivity in Brazil (C2DB)
- IDB Enhancing the market for biodiversity credits through the implementation of digital tokens under an integrity protocol
- WRI Global Forest Watch
- WEF Uplink Challenge
- Instituto del Bien Comun (IBC) MapBiomas Amazonas implementation partner in Peru
- Hispasat
- Internet para Todos: Peru
- Camino Verde
- Courageous Lands

GSMA IDB Invest

@idbinvest

www.idbinvest.org