

The Nature Tech Nexus: Bridging biodiversity and business

Strengthening biodiversity solutions
through mobile and digital technologies



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The GSMA ClimateTech programme unlocks the power of digital technology in low- and middle-income countries to enable their transition towards a low-carbon and climate resilient future. We do this with the collective support of the mobile industry, as well as public and private actors. Through our research and in-market expertise, we catalyse strong partnerships, facilitating innovative digital solutions that address key challenges. Our work spans climate mitigation, adaptation and resilience strategies across the globe.

For more information about the ClimateTech programme, visit www.gsma.com/climatetech



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Glossary of terms

	Definition
Biodiversity	The diversity within species, between species and of ecosystems in a specific geographical area.
Biodiversity credit	Biodiversity credits are a verifiable, quantifiable and tradeable financial instrument that rewards positive nature and biodiversity outcomes (e.g. species, ecosystems and natural habitats) through the creation and sale of either land or ocean-based biodiversity units over a fixed period.
Biodiversity impact	Physical and direct forces that have a negative impact on nature. Those with the greatest global impact include destructive changes in land use, exploitation of marine and terrestrial organisms, pollution and invasive species. These forces have contributed directly to biodiversity loss as a result of anthropogenic development over the past century.
Carbon credits	Measurable and verifiable emissions reductions from certified climate action projects that reduce, avoid or remove greenhouse gas (GHG) emissions.
Conservation	“Ex-situ conservation” means the conservation of components of biological diversity outside their natural habitats. “In-situ conservation” refers to the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties.
Dynamic biodiversity token	A virtual token representing a unit of regenerated biodiversity on a specific plot of land, such as one hectare.
Ecosystem	A dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit.
Ecosystem service	Air, water and soil quality, climatic regulation, pollination services and pest control are all natural services provided by nature. These services provide humans with the ability to maintain food systems, produce medicines and access resources to construct shelter and engage in economic activities.
Insetting	The implementation of nature-based solutions (NbS), such as reforestation, agroforestry, renewable energy and regenerative agriculture, applied within a company’s own value chain.
Nature-based solutions	NbS leverage nature and the power of healthy ecosystems to protect people, optimise infrastructure and safeguard a stable and biodiverse future.
Nature technology	“Nature tech” is a broad set of technologies that can accelerate and scale the implementation of high-quality NbS.
Offsetting	Biodiversity offsets are measurable conservation outcomes designed to compensate for adverse and/or unavoidable impacts of project activities in addition to implementing prevention and mitigation measures. Offsetting aims to achieve No Net Loss of biodiversity overall.
Restoration	Any deliberate action aimed at initiating or expediting the recovery of an ecosystem from a degraded state. Restoration can include active planting or alleviating pressures to allow nature to regenerate on its own.
Social impact	Biodiversity loss can have significant direct impacts on humans if ecosystem services are no longer adequate to meet social needs. Indirectly, alterations in ecosystem services can affect livelihoods, income, local migration and even exacerbate or create conflict.
Supply chain transformation/monitoring	When an organisation integrates or takes steps to accomplish its social, environmental and economic goals. For example, a company’s efforts to reduce waste and preserve natural resources in its operations and supply chain. Transformation can include rethinking production processes to integrate nature-related impacts and dependencies to transition to a model that generates less negative impacts on biodiversity and causes less exploitation or strain on ecosystems.
Sustainable use	Using the components of biodiversity in a way and at a rate that does not lead to the long-term decline of biodiversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations.
Venture capital	Private equity investment that investors provide to start-up companies and small businesses with potential for growth.



Acronyms and abbreviations

CBD	Convention on Biological Diversity	KPI	Key Performance Indicator
COP15	The United Nations Biodiversity Conference of the Parties	LMIC	Low- and Middle-Income Country
CSR	Corporate Social Responsibility	MNO	Mobile Network Operator
CSRD	Corporate Sustainability Reporting Directive	NbS	Nature-based Solution
DBT	Dynamic Biodiversity Token	NDC	Nationally Determined Contribution
ESG	Environmental, Social and Governance	NFT	Non-Fungible Token
ESRS	European Sustainability Reporting Standards	NTFP	Non-Timber Forest Product
GBF	Global Biodiversity Framework	OECD	Organisation for Economic Co-operation and Development
HIC	High-Income Country	PES	Payments for Ecosystem Services
HWC	Human-Wildlife Conflict	SaaS	Software as a Service
IPLC	Indigenous Peoples and Local Communities	SBTN	Science-Based Targets Network
(I)NGO	(International) Non-Governmental Organisation	TNFD	Taskforce on Nature-related Financial Disclosures
KBA	Key Biodiversity Area	UNEP	United Nations Environment Programme
		VC	Venture Capital

Executive summary

Biodiversity loss, driven primarily by human activities, is one of the most pressing environmental challenges of our time. Up to one million species are at risk of extinction while 75% of the earth's land surface has been significantly altered by human activities and more than 85% of wetlands have been lost.¹ The staggering decline of species diversity and ecosystem health worldwide not only threatens the survival of countless plant and animal species, but also has far-reaching consequences for human well-being, including the provision of food, water, security and livelihoods.

Polymita picta, also known as Cuban snails, are a rare, endangered and protected species found in Cuba.

¹ IPBES. (2019). [Summary for policymakers of the global assessment report on biodiversity and ecosystem services](#).

Low- and middle-income countries (LMICs) host the world's biodiversity hotspots and experience the greatest impacts of nature loss.² The interconnected biodiversity and climate crises are exacerbating inequalities for vulnerable communities in LMICs by reducing their access to essential natural resources, livelihood opportunities and resilience to environmental challenges. Indigenous peoples and local communities (IPLCs), which have long been the custodians of biodiverse ecosystems, bear the brunt of these impacts.

The urgency of tackling biodiversity loss was recognised and solidified with the adoption of the Kunming-Montreal Global Biodiversity Framework (GBF) at COP15 in 2022. The GBF underscores the need for global collaboration among governments, civil society and the private sector to protect nature. However, the financing gap for biodiversity, which currently stands at more than \$700 billion annually until 2030,³ has been a significant obstacle.

Bridging this gap requires the united efforts of a variety of stakeholders, and there is increasing pressure on the private sector to demonstrate its commitment to biodiversity targets and disclose its contributions. This stems from new international agreements, government regulations and growing consumer demand for action on biodiversity. In response, many companies, including mobile network operators (MNOs), are crafting biodiversity strategies, setting objectives and implementing monitoring, reporting and verification (MRV) mechanisms to track their progress.

Mobile and digital technologies offer promising ways to address biodiversity loss, from prevention and restoration to sustainable use and access, as well as benefit sharing. There has been a boom in "nature tech" solutions – technologies that help to accelerate and strengthen nature-based solutions (NbS). Examples include the use of eDNA for species detection, artificial intelligence (AI) for data analysis and prediction, satellite imagery for project monitoring and blockchain for transparency.

A growing number of start-ups are emerging in parallel and creating tailored mobile and digital solutions to address the biodiversity needs of nature, IPLCs, business and government alike.

While mobile and digital solutions are advancing, more evidence is needed to ensure they are sustainable and continue to have a positive impact on biodiversity over the long term. Drawing on desk research, key informant interviews (KIIs) with more than 30 industry experts and analysis of successful case studies, this report explores how mobile and digital technologies are addressing biodiversity loss in LMICs, and examines the mechanisms and business models for financing and scaling these solutions.

It also considers the role of the private sector in driving biodiversity efforts, including the current involvement of MNOs. By highlighting the opportunities available to the mobile industry, this report seeks to support innovative solutions that address biodiversity loss and protect the planet's invaluable natural resources to foster a sustainable and resilient future for all.

² Eight out of the 10 most biodiverse countries are Brazil, Indonesia, China, Colombia, Mexico, Peru, India and Ecuador.

³ Convention on Biological Diversity. (2022). "[Outcomes](#)". United Nations Biodiversity Conference website.



1. Introduction

Preserving life's tapestry: Navigating the biodiversity challenge

Global biodiversity loss is advancing at an unprecedented scale and poses an urgent risk to all forms of life on Earth.

Biodiversity, defined by the Convention on Biological Diversity (CBD) as “the diversity within species, between species, and of ecosystems”⁴ underpins human existence and provides critical ecosystem services upon which we depend for all areas of life. Air, water and soil quality, climate regulation, pollination and pest control are services provided by nature that enable us to maintain food systems, produce medicines and access resources to construct shelter and engage in economic activities.⁵

The leading causes of biodiversity loss on a global scale are climate change, land and sea use change, (over)exploitation of natural resources, pollution and the spread of invasive species (Figure 1).⁶ The biggest driver is land and sea use change, much of which is influenced by global agricultural systems. More than 420 million hectares of forest have been lost since 1990 due to land conversion, and agricultural expansion and production threaten 85% of species already at risk of extinction.⁷

Agricultural systems and land conversion lead to increased pollution, the introduction of invasive species (which can wreak havoc on local ecosystems) and overexploitation of soils and waterways. Food production systems and areas with high land conversion rates are often located in low- and middle-income countries, exacerbating regional land degradation and biodiversity decline while also contributing to impacts on a global scale.

More than 420 million hectares of forest have been lost since 1990 due to land conversion, and agricultural expansion and production threaten 85% of species already at risk of extinction.

4 Convention on Biological Diversity. (2022). “[Outcomes](#)”. United Nations Biodiversity Conference website.

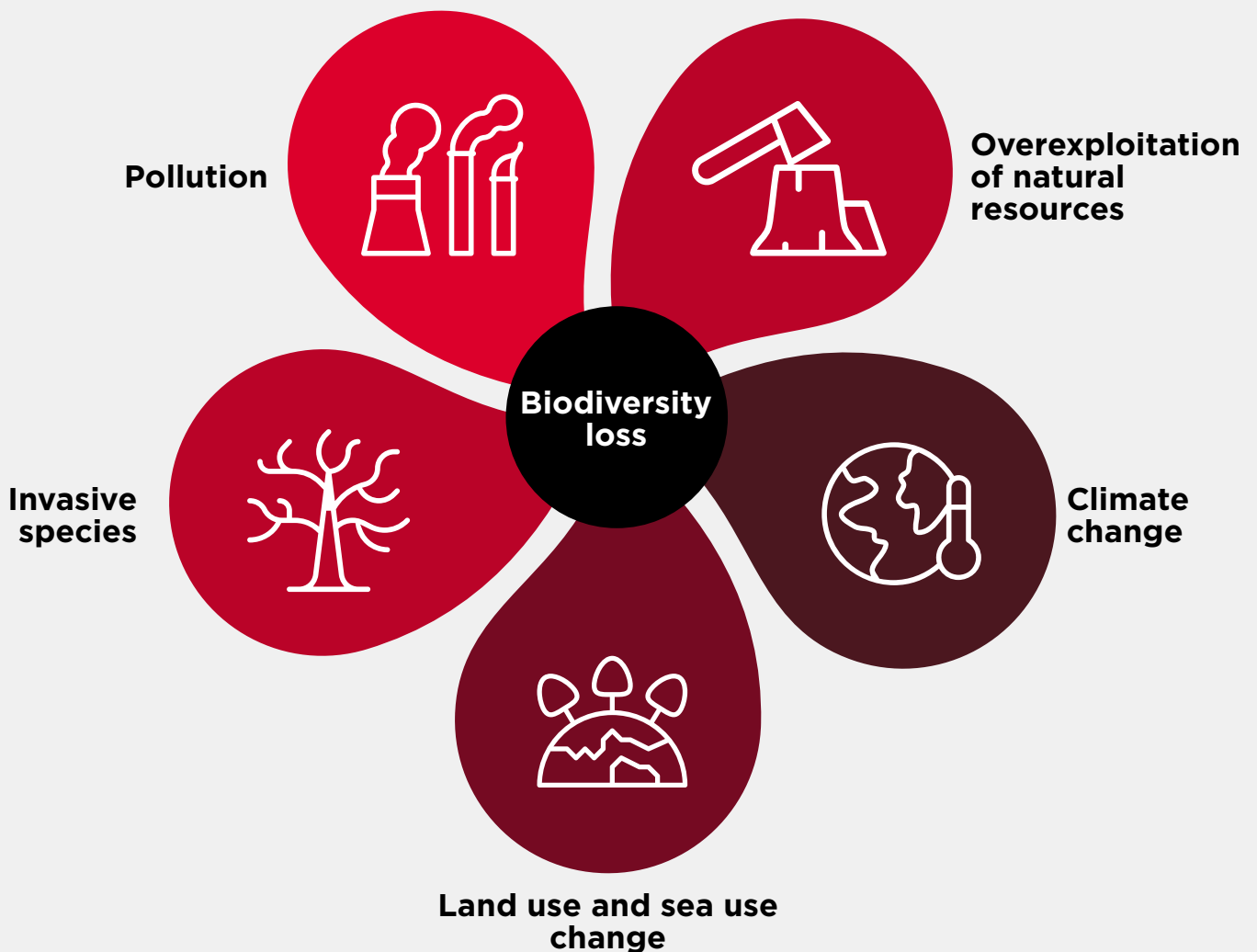
5 IPBES. (2019). [Summary for policymakers of the global assessment report on biodiversity and ecosystem services](#).

6 Ibid.

7 FAO. (2020). [Global Forest Resources Assessment 2020](#).

Figure 1

Key drivers of biodiversity loss



Biodiversity and climate crises are inextricably linked

Climate change and biodiversity loss are closely connected, and one cannot be solved without addressing the other. Biodiversity loss and ecosystem degradation exacerbate the impacts of climate change, such as the loss of forested areas and the decline of pollinators. For example, when land conversion reduces forested areas and other ecosystems vital for carbon capture, increasing greenhouse gases in the atmosphere, thus exacerbating climate change. At the same time, climate change accelerates harm to terrestrial, freshwater and marine ecosystems, creating a harmful feedback loop between the two crises.

Both climate change and biodiversity loss have accelerated in recent decades, endangering entire natural and economic systems. By 2022, six out of nine planetary boundaries had been breached, with severe consequences for nature, human society and economic and financial systems.⁸ Meanwhile, economic damages resulting from natural disasters totalled \$150 billion from 2013 to 2022.⁹ The current scale of natural capital loss threatens global financial systems, livelihoods and quality of life, energy and food security, as well as our ability to build resilience to climate change.

⁸ The nine planetary boundaries are a set of boundaries that humanity can develop and thrive within. They represent nine key processes responsible for regulating the stability and resilience of the Earth. As of 2023, six of these boundaries have been crossed, meaning pressure on Earth systems has reached an unsafe operating level for humanity. Stockholm Resilience Centre. (2023). [Planetary boundaries](#).

⁹ Our World in Data. (2022). [Global damage costs from natural disasters](#).

Biodiversity loss is hitting LMICs hardest

The effects of climate change and biodiversity loss are felt most keenly in low- and middle-income countries, where some of the world's poorest reside. These communities face challenges in meeting basic subsistence needs and often lack the resources and capacities to adapt to the impacts of these crises. LMICs are also home to most of the world's remaining intact biodiversity and have economies that rely heavily on natural capital. Consequently, they face a disproportionate threat from the biodiversity crisis and are particularly vulnerable to the effects of climate change. For instance, the degradation and loss of ecosystem services pose significant risks for LMICs – the collapse of pollination systems, fisheries and native forests could cause GDP to decline as much as 10% a year by 2030.¹⁰

Adding to the complexity, around 80% of individuals living in poverty are in rural areas, and 90% of those experiencing extreme poverty rely on forests for their livelihoods.¹¹ Both groups are heavily dependent on biodiversity for subsistence and are disproportionately impacted by its loss and degradation.

Indigenous peoples and local communities (IPLCs) who act as custodians of key biodiversity hotspots play a crucial role in biodiversity conservation. Despite constituting only 6% of the global population, IPLCs safeguard 80% of the world's biodiversity.¹² Their reliance on local biodiversity and ecosystem services for homes and livelihoods underscores their vital connection to conservation efforts.

It is widely acknowledged that involving IPLCs in the development of solutions and incorporating their traditional practices are fundamental to successful conservation.¹³ It is also essential to ensure that IPLCs reap clear economic benefits from their conservation and restoration efforts. Such incentives can prevent communities from resorting to destructive practices like deforestation and land conversion for agricultural expansion, and help to preserve both biodiversity and traditional practices.

Despite constituting only 6% of the global population, IPLCs safeguard 80% of the world's biodiversity.



10 Johnson, J. A. et al. (2021). [The Economic Case for Nature](#). World Bank Group.

11 IUCN. (n.d.). "[Forests and climate](#)"; FAO. (2020). [Global Forest Resources Assessment 2020](#).

12 World Bank. (n.d.). "[Indigenous Peoples](#)".

13 Urzedo, D., Westerlaken, M. and Gabrys, J. (2022). "[Digitalizing forest landscape restoration: a social and political analysis of emerging technological practices](#)". *Environmental Politics*, 32(3).

Global response to biodiversity loss

In recognition of the growing urgency of the biodiversity crisis, the [Kunming-Montreal Global Biodiversity Framework](#) (GBF) was adopted in December 2022 at the 15th Conference of the Parties (COP15) in Montreal. The GBF sets out an ambitious pathway to achieve a global vision of a world living in harmony with nature by 2050. It includes four goals for 2050 and 23 targets for 2030 to halt biodiversity loss and bring humankind into harmony with nature. There are three overarching themes: conservation, restoration and sustainable use. An emphasis on a whole-of-government and whole-of-society approach highlights that everyone – including IPLCs and the public and private sectors – must contribute to the recovery of biodiversity and achieve positive biodiversity impacts.¹⁴

Key targets of the GBF¹⁵ underscore the significant global financing gap for nature and the urgent need to mobilise substantial funds. Currently estimated at more than \$700 billion per year, this gap cannot be addressed through public finance alone.¹⁶ It is also imperative to mobilise private finance and increase the involvement of the private sector to bridge this considerable shortfall. As governments begin to translate the GBF into national-level targets, regulations and policies, new opportunities are emerging for the private sector to engage in reversing the biodiversity crisis. Reporting frameworks for nature-related risks and dependencies in the private sector are under development, with some becoming mandatory.¹⁷ These frameworks and systems are creating the need for companies, and the private sector at large, to explore and understand their impacts, dependencies and risks related to nature.

Mobile and digital solutions are positioned to be part of the solution

To achieve the goals and targets set by the GBF, there is a pressing need for innovative and high-impact solutions. Nature-based solutions (NbS)¹⁸ stand out in this endeavour. By leveraging the inherent power of nature and healthy ecosystems, NbS can help safeguard a stable and biodiverse future while optimising existing infrastructure and protecting communities. These solutions are centred around deploying tools and techniques to address biodiversity challenges; measuring, reporting and verifying (MRV) climate and biodiversity data; fostering transparency and accountability (e.g., tracing the sources of natural resources in supply chains); and facilitating connections among individuals and communities to share knowledge and best practices.

Rapid advancements in mobile and digital technologies can strengthen efforts to combat biodiversity loss, when applied appropriately. Growing demand for NbS, conservation and restoration projects – and the accompanying need to measure and monitor biodiversity outcomes – has created a vibrant scene of start-ups, NGOs and companies that are using technology to conserve and protect nature.

New business models are incorporating innovative mobile and digital solutions to address diverse aspects of the biodiversity crisis. Analysis of the biodiversity start-up sector in 2023 revealed significant growth in small enterprises using technology for nature, most of which are based in high-income countries (HICs). Two-thirds of these start-ups have launched since 2020, a sign of rapid market growth.¹⁹ Meanwhile, approximately one in 10 (11%) applications from start-ups in LMICs to the [GSMA Innovation Fund for Climate Resilience and Adaptation 2.0](#) placed significant emphasis on enhancing biodiversity. These start-ups are developing solutions that range from monitoring and measuring biodiversity for sustainable land and species management, to apps that help make resource use more efficient (e.g., through targeted irrigation systems and drone-based seeding), to platforms for knowledge sharing and awareness raising.

¹⁴ UNEP. (19 December 2022). [Convention on Biological Diversity](#).

¹⁵ See targets 14, 18, 19 and 23 and Goal D.

¹⁶ UNEP. (19 December 2022). [Convention on Biological Diversity](#).

¹⁷ For example, the Corporate Sustainability Reporting Directive (CSRD) in the European Union and Article 29 in France.

¹⁸ Nature-based solutions are actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems that address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits. Source: [UNEP/EA 2022](#).

¹⁹ Dellecker, A. (2023). [LinkedIn post on the biodiversity start-up ecosystem](#). IMD.

Developing and scaling effective, high-impact technological solutions is crucial for stemming, and ultimately reversing, biodiversity loss. While numerous technological and digital solutions are being deployed worldwide, most of the start-ups developing them are still in early stages and rely heavily on grant funding. A better understanding is needed of viable business models and revenue streams capable of directing financing to these

solutions and helping them to scale. While there are many examples of new biodiversity technology solutions around the world, most projects and available capital are still concentrated in HICs. More investment is needed in LMICs to ensure these solutions are tailored to the contexts where they will be used and that IPLCs benefit from them, too.

Research objectives and methodology

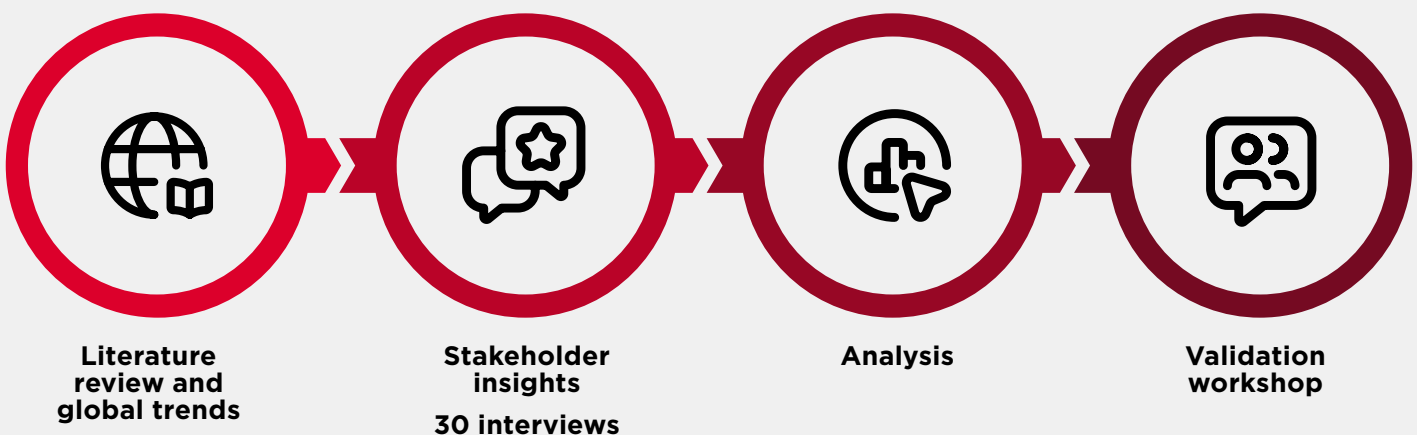
This report seeks to address the evidence gap highlighted above. It explores the current role of technological solutions in LMICs for biodiversity protection and regeneration; business models and revenue streams that are creating benefits for people, nature and investors; and the actions and roles of different stakeholders in reducing biodiversity loss. The study explores four key themes:

- Mobile and digital solutions addressing biodiversity challenges in LMICs
- Business models used to address biodiversity challenges
- The role and motivations of MNOs engaged in biodiversity conservation
- Opportunities and tipping points for mobile and digital solutions to strengthen biodiversity, particularly for MNOs and start-ups

The research included a literature review to explore the current role of mobile and digital solutions in addressing biodiversity loss, particularly in LMICs. Fifteen interviews were conducted with stakeholders and experts to better understand incentives for the private sector to invest in biodiversity solutions, as well as existing initiatives and needs.

To better understand business model trends and the strategies and actions being tested by MNOs, an additional 15 interviews were conducted – eight with organisations leveraging nature tech and seven with MNOs. The insights gleaned from this literature review and the 30 interviews were presented for discussion at a workshop in January 2024 to test and validate the findings.

Figure 2
Research methodology





2. Exploring nature tech: Mobile and digital solutions for biodiversity

2.1 Key trends in nature tech

In recent years, technology has played a crucial role in addressing climate change and natural resource management (NRM), particularly in advancing adaptation, mitigation and resilience efforts. Mobile and digital solutions hold immense potential to combat biodiversity loss which has created the development of a new nature tech market. These tools can contribute to more granular spatial and temporal monitoring of biodiversity and ecosystems, support targeted solutions, refine existing approaches and empower communities with the information they need to create more sustainable livelihoods.

Mobile and digital solutions can contribute to concepts at the heart of the GBF and the United Nations Sustainable Development Goals (SDGs): conservation, restoration and sustainable use of biodiversity. While some technologies are used to implement conservation and restoration efforts or to track the sustainable use of biodiversity, they often contribute to these three goals simultaneously. For example, it is common for satellite imagery and drones to be used to combat deforestation. Not only can they identify areas for conservation and restoration activities, but also track over time whether more sustainable management approaches are increasing canopy coverage.

Table 1 illustrates some of the most common mobile or digital technologies used in biodiversity efforts, as identified in the research. This includes interfaces

and back-end tech that range from more traditional solutions to frontier technologies.

Table 1:

Technologies being leveraged to combat biodiversity loss

Solutions	Overview	Example applications for biodiversity
Camera traps	Cameras placed in areas with wildlife and other biodiversity that aid in remote data collection.	Identifying species and individual animals in an area, which can be used to alert authorities or land managers of dangers such as poaching.
Satellites	Used to generate images and data at a macro level for monitoring large areas.	Developing high-resolution maps of canopy cover for forest areas and tracking changes over time.
Spatial data analysis/ modelling software (GPS and GIS)	<p>GPS enables the tracking of exact locations of subjects on a map and stores location-based data.</p> <p>GIS is used to analyse and visualise geospatial data.</p>	Monitoring movements of species, for example, to reduce occurrences of human-wildlife conflict (HWC).
Unmanned aerial vehicles (UAVs), including drones	Hardware devices that can fly over areas of land and are controlled remotely.	<p>Examples include:</p> <ul style="list-style-type: none"> — Measuring and mapping out large land areas — Remote seeding and data collection
Bioacoustics and ecoacoustics	Sensors placed in the field that capture and store acoustic data, which can be used for identifying species and patterns in diverse locations.	Identification of species in an area, such as elephants or birds, through recording and recognition of acoustics associated with certain species. This data can then be used to prevent HWC.
Mobile apps and digital platforms	<p>Apps and platforms for mobile devices that enable users to access information or tools to empower them to engage in conservation and restoration.</p> <p>Online web-based platforms, often in the form of dashboards and libraries of educational resources, that enable users to engage in conservation and restoration activities. These platforms often enable communities to form.</p>	<p>Examples include:</p> <ul style="list-style-type: none"> — Dissemination of educational information and tools to communities, for example, educating local farmers on more sustainable, regenerative land management techniques. — Engaging a wider audience in conservation and restoration issues. Applications and platforms with nature-themed videos and games can increase the participation of even faraway concerned citizens. — Enabling citizen scientists to participate in conservation and restoration projects, such as providing data on a particular species observed in an area or an inventory to track species abundance over time.

Solutions	Overview	Example applications for biodiversity
<p>Artificial intelligence (AI) and machine learning</p>	<p>AI is the ability of a machine or computer to emulate human tasks through learning and automation.</p> <p>Machine learning, a subset of AI, uses computer-based algorithms to find patterns across data sets.</p>	<p>Examples include:</p> <ul style="list-style-type: none"> – AI is increasingly being used in combination with other tech solutions for biodiversity conservation and restoration. – When trained and applied to images generated from camera traps, AI can be used to identify rare species present in the photos. This can reduce human labour hours and effort, maximising potential for data collection and analysis.
<p>Blockchain</p>	<p>A decentralised public ledger that keeps track of transactions in an immutable fashion so that data cannot be edited or manipulated. This increases transparency and reduces fraud.</p> <p>Blockchain is the underlying technology of cryptocurrencies. It is used to keep track of transactions and store ownership information. It is also used to store tokenised assets and makes exchanges more efficient by removing the need for intermediaries.</p>	<p>Information on land tenure can be entered and stored on the blockchain. This information is then publicly available and can be made completely transparent in a format that cannot be edited. This can help to clarify land claims by IPLCs and cement their rights to manage and implement conservation and restoration projects in key biodiversity areas (KBAs).</p>
<p>Networked sensors/ Internet of Things (IoT)</p>	<p>Underpins the connection of digital ecosystems. IoT is a network of sensors and objects that are connected to the internet and are Wi-Fi enabled.</p>	<p>Connecting different sensors (bioacoustic, satellite, etc.) to monitor the environmental status of an area in real time.</p>
<p>eDNA</p>	<p>Used to collect a variety of biodiversity data quickly and easily, usually by scanning samples of water or soil.</p> <p>Due to the wealth of DNA that can be collected in small samples from many different species, eDNA can provide a snapshot of an ecosystem efficiently and quickly.</p>	<p>Collection of small samples of soil eDNA to identify the abundance of an endangered species in an area and inform appropriate management decisions to help conserve such species.</p>



Over the past decade, both software- and hardware-based technologies have undergone significant enhancements to capture data with greater detail and accuracy.

More conventional solutions have also been applied successfully. For example, [Mast Reforestation](#)'s DroneSeed uses drones to provide aerial seeding services for more efficient reforestation. [Africam](#) has used technology such as camera traps to identify poachers in areas with endangered animals, which enables park rangers to track and stop poachers.

As mobile connectivity becomes more widespread in forests, smartphones are growing in popularity for nature and environmental management. They can be used by communities in a range of contexts to collect data and support the monitoring and management of resources, as well as spread information and educate communities, such as the [Greener.Land](#) platform that provides education on landscape restoration techniques.

Many existing technologies are being used as MRV tools to monitor (changes in) the state of biodiversity and verify reported data. This includes satellites, sensors and camera traps, which are being combined with emerging tools such as AI and machine learning to enhance data analysis and storage.

Mobile apps also underpin a range of solutions, including citizen science platforms, dashboards and communication channels. Apps are crucial in rapidly disseminating information, facilitating decentralised monitoring and verification and educating and raising awareness about biodiversity.²⁰ For example, [iCow](#) in Kenya uses mobile-based solutions to empower farmers with educational content on regenerative agricultural practices, designed to improve soil quality and livelihoods.

20 OECD. (2019). [Biodiversity: Finance and the Economic and Business Case for Action](#).

In parallel, there has been a rapid emergence of advanced technologies and digital solutions to support biodiversity objectives. This includes AI and machine learning, as well as eDNA and hybrid developments like IoT and blockchain.²¹ Such technologies and solutions are being used to map biodiversity, generate baselines and develop risk scenarios, identify priority conservation and restoration areas and develop sustainable land management approaches.²² For example, J-Palm in Liberia is transforming the sustainability of wild palm oil by providing local harvesters with access to ecological information and using mobile blockchain technology to improve traceability.

The research also highlighted technologies that are being integrated to generate positive impacts for biodiversity. For example, Gamma Earth is a start-up that is combining satellite imagery with AI to increase the image resolution of spatial data and mapping at a low cost. AI and machine learning are commonly combined with other technologies to combat illegal activities and enhance wildlife conservation. Rainforest Connection has successfully used bioacoustic sensors and AI to identify illegal loggers in rainforests around the world and send real-time alerts to local authorities responsible for tracking and preventing these activities.

The evolution of interconnected digital technologies has enhanced remote monitoring of the natural world on a larger scale, at finer resolution and even in traditionally inaccessible or hazardous environments. IoT and network-based sensor systems are being used to connect different data repositories, enabling the integration of large data collections generated by various types of technologies. For example, BENAA is using IoT to support water resource management by helping small farms in rural Egypt convert wastewater into irrigation water. Blockchain and AI are being used to analyse and store this data so that it can be processed and used for decision-making and monitoring by various actors.

When applied effectively, these advancements are also helping to democratise biodiversity management, conservation and restoration by empowering IPLCs to participate. Digital payment systems, mobile money apps and the tokenisation of biodiversity – for example, through non-fungible tokens (NFTs) and dynamic biodiversity tokens (DBTs) – may present additional opportunities for local stewards to receive recognition and compensation for safeguarding biodiversity areas. To drive the uptake and impact of any digital solution, IPLCs should be at the centre of design and development. More of these solutions also need to originate from LMICs to ensure they are tailored to the environmental and social needs of IPLCs and local biodiversity.

The nature tech sector is changing rapidly, with new and improved technologies emerging frequently. Although many of these developments are being used and combined in different ways, a number of technologies were identified in the literature review and expert interviews as the most promising in terms of demand, implementation and their ability to contribute to solutions and improve applications.

MRV tools, including improved satellite imagery, sensors and other hardware, are seeing rapid uptake and increased investor interest due to recent legislation, such as the EU's Corporate Sustainability Reporting Directive (CSRD). At the same time, many conventional technologies are being combined with AI and other software-based solutions to enhance data quality, quantity and analysis. This is illustrated further in Chapter 3.

21 Wildlabs.net. (2023). The State of Conservation Technology.

22 UNEP-WCMC. (14 September 2023). Webinar: "Leveraging existing and emerging technologies for biodiversity monitoring in land-use investments".

2.2 An emerging biodiversity start-up ecosystem

While most of the privately funded biodiversity tech solutions identified in this research are being developed in HICs, there is a need to support and champion innovations that originate in communities tackling biodiversity challenges. With this in mind, the [GSMA Innovation Fund for Climate Resilience and Adaptation 2.0](#)²³ was launched in 2023. The Fund is designed to accelerate the testing, adoption and scalability of digital innovations that enable the world's most vulnerable populations to adapt to,

anticipate and absorb the negative impacts of climate change, or to strengthen biodiversity.

A total of 593 applications were received from 83 countries, 63 of which had an explicit focus on biodiversity conservation, restoration or sustainable use. This sample provided unique insight into the burgeoning biodiversity start-up ecosystem in LMICs and the ways in which mobile and digital technologies are being leveraged.



Business models

The start-up business models focused on addressing private sector requirements, with **the majority (89%) of biodiversity start-ups targeting the private sector** as their primary users. Additionally, 78% had designed projects targeting consumers (including smallholder farmers, fishers and IPLCs) and 49% on government stakeholders. The vast majority catered to at least two of these stakeholder groups for their revenue streams by offering tailored products, with only 5% targeting just one user group.



Maturity

In line with global biodiversity trends, most of the start-ups were newly established, with half (51%) only operating since 2020. As a result, 71% were either at **pre-seed** (22%) or **seed stage** (49%). This revealed how young the biodiversity start-up sector is and its potential for development and growth.



Geography

The highest proportion of applications came from **East Africa** (38%) and **West Africa** (22%), where there is both a vibrant start-up scene and high need for biodiversity solutions. Fewer pitches were received from **Asia** (19%) and **Latin America and the Caribbean** (10%) in this round.



Partnerships

Start-ups were not working in silos, and instead were actively collaborating with a range of groups to strengthen their biodiversity solutions. **90% reported they were already working in partnership with public or private organisations**, including MNOs, academic institutions and notable NGOs in the biodiversity space.



Sector

Solutions were most likely to be designed for **agriculture** (68%) or **forestry** (46%), where more funding is typically channelled. However, there were emerging solutions tackling **regenerative agriculture** (27%) and some that aimed to strengthen **fishing or aquaculture** (13%).



Tech

The vast majority (95%) of enterprises integrated multiple technologies in their solutions, primarily relying on traditional technologies such as mobile apps (65%) with voice or USSD components (54%). Nearly half (49%) had already integrated, or were seeking to integrate, mobile money in their product – a potential opportunity for MNOs. A smaller percentage were using frontier technologies, with less than a third employing AI, big data, blockchain or IoT solutions despite their growing prominence in biodiversity solutions in HICs. AI was being used by more than a quarter of start-ups (27%), usually in combination with satellite or mobile apps.

²³ The GSMA Innovation Fund for Climate Resilience and Adaptation 2.0 was launched in February 2023 with funding from the UK Foreign, Commonwealth & Development Office (FCDO) and the Swedish International Development Cooperation Agency (Sida). The Fund is designed to pilot and scale up digital technology innovations that have a positive socio-economic and environmental impact in areas with communities most vulnerable to current or future climate risks.



Nature tech: Environmental and social risks and safeguards

Rigorous verification of biodiversity impacts will be vital to ensure that nature tech solutions are creating meaningful outcomes. Measuring biodiversity is complex, for example, with technology often capturing a subset of biodiversity. As such, the integration of MRV technologies may skew towards measuring easier to capture indicators. This risks providing an inaccurate image of the real state of biodiversity. Other risks include access to data by different stakeholders (e.g. exact location data of endangered species may expose them to risk), or malfunction of equipment leading to unforeseen consequences. This could be even more challenging where projects are located in isolated ecosystems such as rainforests. The desire to bring a product to market may be at odds with delivering meaningful biodiversity impacts and adhering to standards of scientific rigor. Thorough risk identification and mitigation measures are thus an important step to take when developing new nature tech solutions. Collaboration with research institutes, NGOs, and local experts on the ground can be a way to safeguard against such risks. In addition, a [Global Biodiversity Standard](#) for interventions aimed at biodiversity protection and restoration is currently being developed and open for pilot testing.

If nature tech is applied to protect Key Biodiversity Areas (KBAs), caution must be taken to discern what the rights are of IPLCs within these areas, including the potential existence of human-wildlife conflicts (HWCs) and how such conflicts can be solved. If nature tech is applied within business models focusing on the protection of biodiversity, de facto making nature an asset or revenue stream, attention must be paid on how to safeguard land tenure rights and benefit sharing. These are considerations that may not be front of mind for nature tech entrepreneurs but are of utmost importance for technologies applied in the context of LMICs and KBAs. This is especially the case where IPLCs are custodians of the landscape, and where their way of life may be influenced or threatened by the introduction of new technologies.

Other social issues exist in relation to fair and equitable access to technologies and issues surrounding data ownership, stewardship, and privacy. Some key resources for identifying and managing environmental and social risks and implementing proper safeguards include the [WWF Environment and Social Safeguards: Integrated Policies and Procedures](#) and the [FAO Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security](#).

2.3 Investment trends in biodiversity and nature tech

The nascent nature tech market is poised to drive innovation

Nature tech encompasses an array of technologies and solutions aimed at enhancing impacts of NbS and accelerating and scaling these impacts.²⁴ It has swiftly become a significant market, currently valued at \$2 billion and projected to reach \$6 billion within the next decade, an indication of its pivotal role in addressing the biodiversity crisis.²⁵ Despite the rapid growth of venture capital (VC) investments in climate tech, which surpassed \$40 billion in the past decade,

the nature tech market remains relatively small compared to overall NbS investment. In recent years, VC organisations have emerged that are dedicated to biodiversity, including Superorganism and Planet A. Although a sign of growing interest in biodiversity investment, a better understanding of the nature tech market and increased capital mobilisation are both needed.

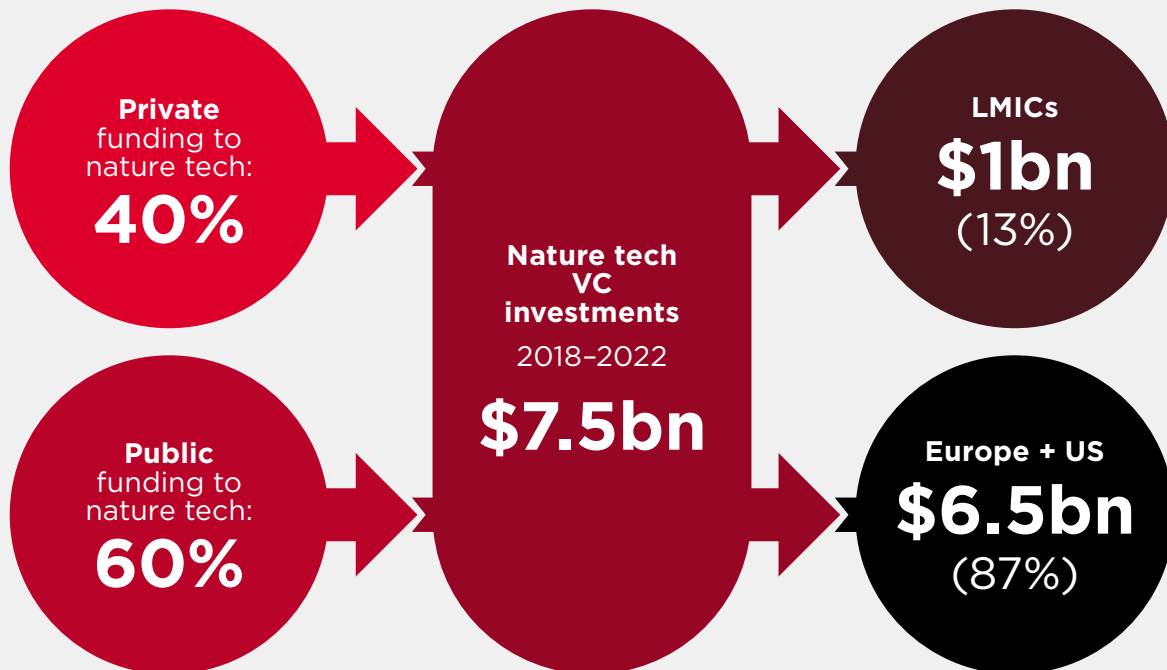
High-income countries have received the lion's share of nature tech funding

Despite key biodiversity hotspots being concentrated in LMICs, funding for nature tech solutions remains disproportionately in HICs. Between 2018 and 2022, only \$0.4 billion was allocated to projects in Asia, \$0.01 billion in Africa and \$0.06 billion in South America, while funding for projects in the United States and Europe totalled \$6.48 billion.²⁶ Project ticket sizes in these regions are typically higher, making them more appealing to investors.

With LMICs expected to bear the brunt of the impacts of climate change and biodiversity loss, there is an urgent need to accelerate investment in local biodiversity innovations and projects. To drive uptake and increase their impact, mobile and digital solutions should originate from communities in LMICs.²⁷ It is also vital to tailor them to the needs of the communities that inhabit or manage biodiversity hotspots and will be implementing the solutions.

Figure 3

Nature tech funding



²⁴ The definition of nature tech is derived from research and analysis conducted by Nature4Climate.

²⁵ Nature4Climate. (2023). The state of nature tech: building confidence in a growing market.

²⁶ Nature4Climate. (2023). The state of nature tech: building confidence in a growing market.

²⁷ Colquhoun, A. et al. (2023). Exploring barriers and incentives to digital solutions in Natural Resource Management. GSMA.

Private sector interest in nature tech is growing

So far, investment in NbS has largely relied on public sector funding. Of the estimated \$200 billion currently allocated to NbS, governments contribute 82%.²⁸ Private investors remain hesitant to engage in biodiversity initiatives for several reasons: a lack of expertise and understanding of business models in the nature tech sector; perceived lower returns over longer periods; smaller investment ticket sizes; high transaction costs; and a lack of cost-effective, internationally accepted, high-quality data and metrics for measuring the progress and success of projects. Investors require evidence of effective and proven business models that generate financial returns while also benefiting biodiversity and communities.

In the nature tech sector, around 40% of all financing comes from the private sector, while 60% is provided by the public sector. This level of private investment exceeds that of NbS, which typically sees private investment ranging from 15% to 25%. This disparity may be due to the private sector having a stronger grasp of technology-driven business models compared to revenue streams and business cases for conventional restoration projects.

Greater collaboration between the public and private sectors could unlock new investment opportunities for nature tech solutions and maximise their potential to scale.

Navigating barriers to nature tech investment

While finance for biodiversity and NbS, including nature tech, is on the rise, attracting sustainable levels of funding remains a challenge. For the commercial viability of projects to be clear to investors, and for project developers to access the resources they need to scale their solutions effectively, they need to speak a common language and understand each other's needs. Investors require a better understanding of the risks and opportunities associated with nature tech and its underlying business models. In this emerging market, trust needs to be established between tech service providers and private investors to instil confidence in transformative tech solutions and their business models. Moreover, investors need to seek out models that create social impact for IPLCs and conduct thorough due diligence to ensure projects produce positive impacts and benefits for communities in KBAs. This added responsibility can complicate investors' understanding and willingness to invest in nature tech initiatives.

However, securing sustainable finance remains a significant challenge for many nature tech start-ups, particularly for those in LMICs as they transition from smaller grant amounts to larger financing needs (for example, over \$5 million).²⁹ Organisations are emerging that are focused on scaling biodiversity finance. Throughout this research, numerous cases were identified that relied on public finance, often in the form of grants and subsidies, especially in the early stages of development. Blended finance models offer a potential solution, leveraging public finance to pilot and test new ventures, develop bankable project pipelines and mitigate investment risks for the private sector.

In the nature tech sector, around 40% of all financing comes from the private sector, while 60% is provided by the public sector.

Overall, investors have a better understanding of the risk profiles and expected time frames for returns in the agriculture and forestry sectors due to the similarities in business models with conventional practices. Start-ups in reforestation witnessed 44% growth in deal sizes from 2013 to 2023, and smart agriculture and regenerative agriculture-based start-ups experienced rapid investment growth, with an increase of 24% over the same period.³⁰ Presenting examples of successful business cases can enhance investor engagement and investment in nature tech projects, as these examples can provide insights into revenue streams, return on investment and added value.

28 UNEP. (2023). [State of Finance for Nature 2023](#).

29 PwC. (2023). [Accelerating Finance for Nature: Barriers and recommendations for scaling private sector investment](#).

30 Economist Impact. (2023) [Creating a market for biodiversity](#).

New regulations driving innovation and opportunities

Interest and investment in nature tech are being driven by new regulations, especially related to reporting and disclosure. With developments such as the CSRD and voluntary frameworks like the Taskforce on Nature-related Financial Disclosures (TNFD),³¹ large corporations will need to start reporting and developing plans to manage and monitor nature-related impacts and dependencies.

The stringency with which governments impose mandatory disclosure requirements on the private sector – not only of their impacts on nature and dependencies, but also their transition plans – will determine the urgency and detail of corporate disclosures. This will also heighten demand for nature tech capable of providing granular spatial and temporal data.

Meanwhile, the investment discourse is shifting, with investors, asset managers and banks scrutinising reporting requirements and their implications for downstream investment portfolios. This increased awareness will prompt businesses to address the physical effects and risks of biodiversity loss throughout their operations and supply chains. The 30% target set by the GBF will drive demand for services and technology aimed at monitoring and verifying data across vast land and sea areas, with a surge in MRV buyers anticipated.³²

The nature tech market: What's next?

The future of nature tech will be ever-changing and fast paced to respond to the rate and complexity of biodiversity loss and its interconnectedness with climate change. Consequently, business models must evolve to reflect the realities and requirements of biodiversity and the communities safeguarding it.

While numerous innovations originate with small start-ups capable of forging new markets or transforming existing ones, the ability of their solutions to deliver tangible benefits for people and nature – and generate returns for investors – hinges on whether they align with the needs and perspectives of IPLCs. Despite promising investment opportunities and avenues for engagement, there are several barriers that need to be overcome to unleash the potential of nature tech solutions and their capacity to advance the objectives outlined in the GBF.

Since many companies lack an understanding of their impacts, risks, and dependencies related to biodiversity, they will need assistance and tools to begin biodiversity monitoring, managing and transforming their supply chain impacts and being transparent about these topics. Companies are seeking data that is reliable and trustworthy, this will drive investment in technologies that can provide accurate and actionable data and insights.

Greening and transforming supply chains is another big trend. There is a focus on supply chain traceability and identifying and responding to impacts generated along a company's entire value chain. Pressure is growing to create data repositories for monitoring targets and impacts that go beyond developing baselines. Demand is growing as suppliers want to know how they can demonstrate their goods are produced sustainably and ethically, while companies want to show that they are making progress on commitments to supply chain traceability and sustainability. This represents another major opportunity for service providers offering transparency and insights via data provision and analysis.

Building trust in markets for emerging technologies and their underlying business models will be crucial to ensure that finance is mobilised effectively to meet the needs of developers. The public sector can play a role in de-risking investment by providing grants or guarantees, or acting as a co-investor, for projects to move past the proof-of-concept stage and attract private investment to scale. Given that many of the key drivers are still unfolding – implementation of the CSRD, environmental, social and governance (ESG) practices and corporate social responsibility (CSR) initiatives, the GBF and recognition of biodiversity as a material issue by private sector entities – the speed at which nature tech will scale remains uncertain. Still, the nascent stage of the nature tech market underscores not only the urgency of accelerated investment, but also the emergence of promising investment opportunities that can pave the way for transformative change in biodiversity conservation and sustainable development.

³¹ A market-led, science-based, and government-backed initiative providing organisations with the tools to act on evolving nature-related issues.

³² PwC. (2023). [Accelerating Finance for Nature: Barriers and recommendations for scaling private sector investment](#).



Investing in nature tech: Environmental and social risks and safeguards

A potential risk that investors will have to grapple with is identifying and financing projects that generate positive impacts for both biodiversity and people, without inadvertently leading to negative consequences. Conducting adequate due diligence to ensure environmental and social safeguards are in place will be an essential pre-requisite for investing in nature tech solutions. This is particularly the case for projects that use nature tech or nature tech solution providers that offer integrated solutions, including biodiversity conservation or restoration projects. In such cases, project developers must use a free, prior, and informed consent (FPIC) process to ensure that local communities are involved in, and consent to, projects that will affect their lands and resources. Resources such as the FAOs [FPIC Toolkit](#) can provide guidance on how to apply these principles.

Investors can consider the level of inclusion of IPLCs in implementing solutions to verify that projects adequately safeguard them. Where technologies depend partly on IPLCs in KBAs for implementation, mechanisms must be in place to ensure that the communities are consulted at each stage of the project, educated on how to use relevant technologies, are provided access to these technologies at no cost of their own and are verifiably compensated for their contributions to ecosystem conservation and restoration. Projects that integrate IPLCs in development of solutions can contribute to developing business cases that are fit-for-purpose and more likely to be taken up, as local communities can better understand and reap the benefits of these solutions.

Environmental risks for the application of nature tech are particularly high if investors and investees rush to bring a solution to market, or if capabilities are overstated to drive economic performance, leading to application of solutions that are not fit-for-purpose. Bringing in third-party experts as part of due diligence before investing in a nature tech solution can mitigate this risk, as well as increase transparency between provider and investor.

Beyond the resources on risks and safeguards for nature tech entrepreneurs and project developers, guidance exists for investors, such as the [Equator Principles](#) and the [IFC Performance Standards](#).



3. Exploring biodiversity business models

A growing number of start-ups are leveraging mobile or digital technologies to tackle biodiversity challenges in LMICs. However, early-stage enterprises remain primarily dependent on grant funding, and many start-ups in LMICs struggle to access financing to develop and scale. To catalyse sustainable solutions, it is important for projects to diversify their funding streams. The research delved into promising business models aimed at bolstering the growing start-up ecosystem and identifying potential revenue streams to facilitate scaling beyond grant support.

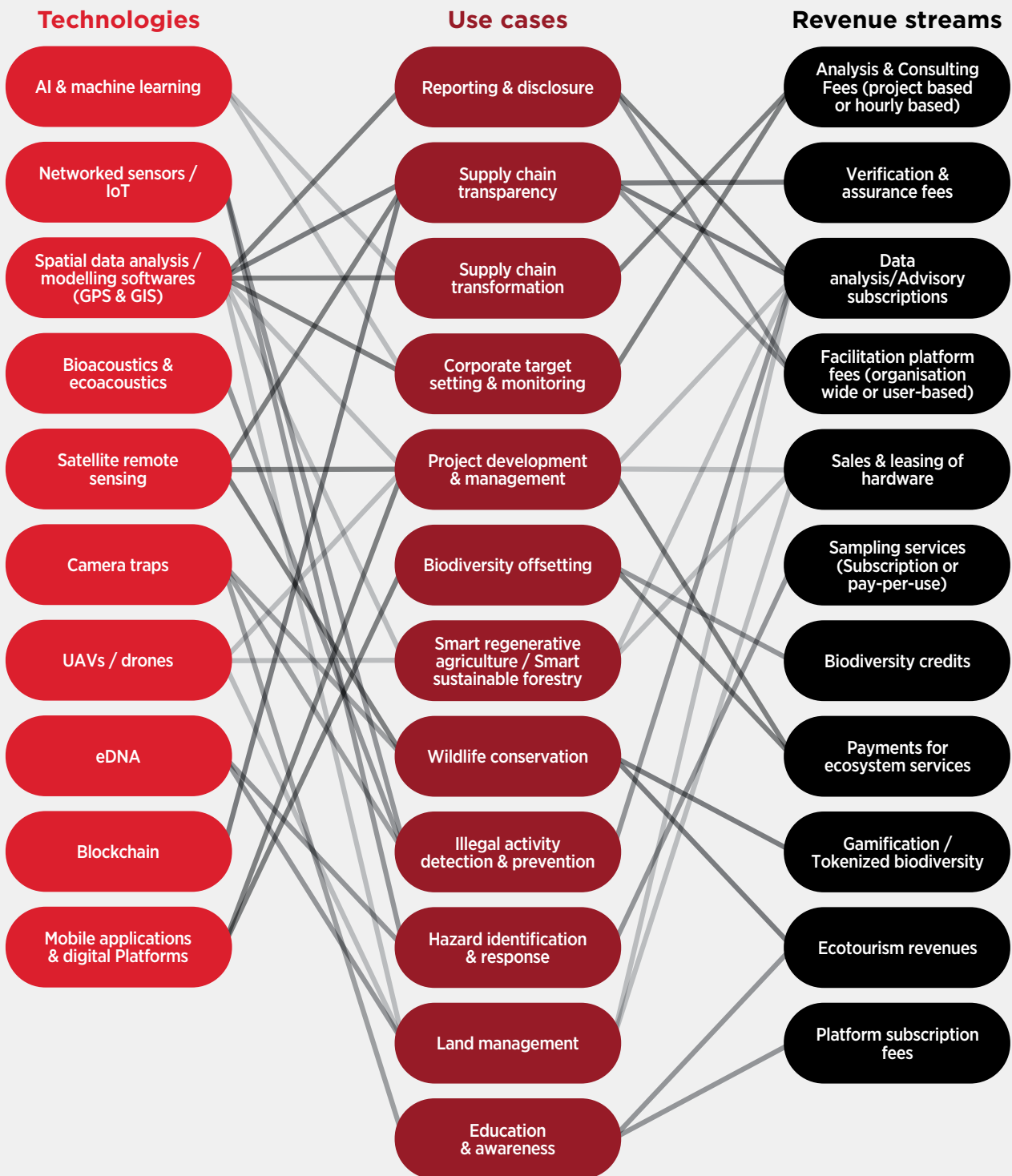
For the purpose of this research, a nature tech business model includes four key components:

- The technologies being leveraged to implement a solution
- The use case(s) of the solution (i.e., the value proposition of the solution and the pain point it is addressing)
- The revenue streams being used to sustain and grow the business
- Positive impacts on biodiversity while safeguarding the rights and interests of IPLCs

There are countless possibilities for mixing and matching technologies, use cases and revenue streams (see Figure 4). The vast majority (90%) of biodiversity projects analysed use at least two technologies and draw from multiple revenue streams. Many start-ups are experimenting with overlapping combinations of revenue streams and technologies, offering diverse products to different stakeholders and attracting clients from various sectors.

Figure 4

Biodiversity Business Model - example combinations





3.1 Emerging use cases

While many tried and tested biodiversity use cases – such as wildlife conservation, ecotourism or smart forestry – have potential for growth, analysis from the desk research and stakeholder interviews identified several promising use cases for nature tech. Many are already gaining traction in HICs, but it is essential that more use cases are developed and applied in LMICs to protect and restore KBAs. These use cases are noteworthy because they align with key drivers of interest in biodiversity for the private sector. They encompass areas where numerous start-ups

are emerging and where projects are anticipated to continue to scale in the foreseeable future. In the next section, five use cases are broken down in more detail: reporting and disclosure, supply chain transformation, corporate target setting, biodiversity offsetting, and project development and management. These use cases have been identified as most promising in terms of demand for these services and potential for the greatest near-term growth.

Reporting and disclosure

Demand for use cases that improve nature reporting and disclosures is fuelled primarily by upcoming mandatory and voluntary reporting requirements, such as the [CSRD](#) and [TFND](#). As these requirements come into effect, companies are seeking assistance to understand their biodiversity impacts and to develop and implement strategies for measuring and monitoring these impacts to meet disclosure obligations. Consequently, organisations are emerging that support companies in these areas, offering suites of solutions and products that cover all aspects of measuring, monitoring, reporting and

disclosure – guiding companies through the entire process. The need for disclosure and transparency in carbon and biodiversity markets is also increasing demand for such use cases. For example, the [Open Forest Protocol](#) (OFP) is paving the way to create transparency at scale for afforestation and reforestation-based carbon credit project developers and buyers. OFP is leveraging MRV tools to provide validation services for projects, to create transparency and build trust between project developers and credit buyers.

3.1.2 Supply chain transformation

Creating transformational change involves looking at all parts of a company's value chain. As a result, decarbonised and nature-positive supply chains are generating more attention, for example, the transition to regenerative agricultural models. For companies to transform their business practices, they need a firm understanding of their impacts and dependencies on nature in every step of their supply chain.

Demand is also growing for solutions that enhance traceability in supply chains, measure and monitor the impacts of suppliers on nature and biodiversity and identify alternative or more sustainable commodities and/or sourcing approaches. With emerging legislation on supply chain due diligence, such as the [Corporate Sustainability Due Diligence Directive \(CSDDD\)](#) or the [EU Deforestation Regulation](#), demand will increase for solutions that can help companies identify, assess and respond to nature-related risks across their value chains. While such regulations often originate from a specific jurisdiction (such as the EU), many companies are opting to proactively implement these requirements across their supply chain to avoid the complexities associated with segregated streams. Some regulations extend to subsidiaries of European companies operating outside Europe, requiring transparency and traceability throughout entire value chains, including those in LMICs.

Corporate target setting

To set ambitious, science-based targets for biodiversity, companies need information on their current interactions and intersections with biodiversity and nature to establish baselines. They also need guidance on how to design ambitious but attainable targets and strategies for monitoring and measuring progress. Interest has grown in aligning targets with the [Science Based Targets for Nature \(SBTN\)](#)³³ guidance due to a number of factors related to CSR and ESG reporting. Companies are becoming interested in developing powerful impact stories and need data to show progress and

To reduce exposure to risks associated with the effects of climate change and biodiversity loss, such as increased price volatility, less secure supply chains and idle production assets, companies are seeking to make their supply chains more resilient. This is driving demand for tools and solutions that will help them do this. For example, [Bioverse](#), a Brazilian start-up, helps Amazonian communities locate and map the locations of non-timber forest products (NTFPs) and harvest these products without negative impacts on local biodiversity.

An important consideration in supply chain transformation is how to act on the impacts and risks revealed by MRV technologies. Rather than simply putting a stop to sourcing inputs from high-risk landscapes or KBAs – and abandoning a landscape and its communities in the process – it may be more impactful, though more challenging, to help transform practices and manage the risks and impacts in these landscapes. MRV nature tech that can provide data at the right scale (both spatial and temporal) can be used to monitor the changes and positive impacts of supply chain transformation, rather than just functioning as tools to highlight risks.

ambition. For example, [NatureMetrics](#), a company offering tailored biodiversity monitoring solutions using AI and eDNA, helps organisations develop and monitor nature strategies and science-based targets. As companies are already required to publish their climate transition plans and are poised to develop biodiversity transition plans, there may be a further surge in demand for products offering assistance and advisory services in corporate target setting, particularly for biodiversity, and the integration of biodiversity and climate considerations.

³³ The SBTN enables companies and cities to play a vital role in creating an equitable, nature positive, net-zero future using science-based targets. Science-based targets give companies and cities a clear pathway to competitiveness and resilience by using science to define their role in protecting and restoring nature.

Biodiversity offsetting

If companies fail to sufficiently transform their operations or supply chains to achieve net positive outcomes within their own sphere of control, they may increasingly turn to biodiversity offsetting to achieve nature-positive outcomes. This motivation could arise from residual impacts (an aspect still under debate as a potential use case for biodiversity offsetting) or their aspiration or legal obligation to exceed the mitigation hierarchy³⁴ and achieve net biodiversity gains. Global demand for voluntary biodiversity credits is projected to reach \$2 billion by 2030 and \$69 billion by 2050, a sign of growing interest in this use case.³⁵ Mapping of the voluntary biodiversity market from [Bloom Labs](#) shows hundreds of companies now active in this emerging space. Based in South Africa and piloting projects across Zambia, Uganda and Mexico, [ValueNature](#) is one organisation leading the way on biodiversity credits. They have developed a biodiversity certification system and help investors identify and invest in projects that have positive impacts on biodiversity.

The rate of adoption will, in part, depend on the establishment of robust governance models and quality assurance measures and metrics – areas where nature tech can contribute. Effective governance and quality assurance are essential environmental and social safeguards for nature-positive and socially desirable outcomes. As mentioned above, there is ongoing debate (and contention) about residual impacts and the feasibility of “like-for-like” biodiversity offsets. Achieving consensus on these matters will ultimately determine the adoption and potential of this use case.

Project development and management

To develop and manage projects that focus on the conservation, restoration and sustainable use of biodiversity, project developers need tools and solutions to implement and monitor their initiatives efficiently. The increasing number of restoration and conservation projects globally is driving demand for use cases that can streamline implementation and management. Examples include monitoring and measurement regimes to track progress, employing unmanned aerial vehicles (UAVs) for seed planting in reforestation efforts and analysing tree growth trends in reforested areas.

Another critical governance issue is the role of IPLCs in biodiversity offsetting schemes, much like the debates in carbon offsetting projects. Proper governance requires respecting the rights of IPLCs and acknowledging their role in safeguarding the ecosystems they inhabit. It also involves ensuring they share the revenues derived from the protection, restoration and management of biodiversity.

Insetting – the financing of biodiversity restoration and conservation efforts within a company’s own value chain – is another potential use case closely related to biodiversity offsetting. Insetting can be more complex in terms of monitoring, as companies are more likely to be working with many smallholders³⁶ in various locations. Monitoring the biodiversity impacts of a vast group of smallholders needs to be conducted at a much smaller spatial scale than large-scale, single location offsetting projects. Nature tech can assist in reducing monitoring costs per farmer and location while unlocking the potential for insetting, often considered a more elegant way to create impact for biodiversity than offsetting. [Forested](#), which operates in Kenya and Ethiopia, is an insets marketplace that partners with consumer packaged goods brands to source more regenerative ingredients in their supply chains. Forested also upskills Indigenous forest communities and producers (e.g., on technical agroforestry production, processing capacity and business skills) to increase the commercial value of their natural ingredients.

With the anticipated establishment of biodiversity credit systems, demand is expected to rise even further. This will necessitate the development of solutions that can measure, monitor and verify large numbers of projects that aim to use credits as a revenue stream. For example, [Pachama](#) uses AI and geospatial data to provide data analysis services for project developers. These tools enable them to screen project areas, design implementation and financing plans, access inputs such as seedlings and monitor the progress of reforestation or afforestation over time.

³⁴ The mitigation hierarchy is a set of guidelines to help development projects limit negative impacts on biodiversity and aim to achieve no net loss of biodiversity.

³⁵ World Economic Forum. (2023). [Biodiversity Credits: Demand Analysis and Market Outlook](#).

³⁶ Smallholders are small-scale farmers, pastoralists, forest keepers, fishers who manage areas varying from less than one hectare to 10 hectares.



Nature tech use cases: Environmental and social risks and safeguards

Specific risks exist for MRV technologies with regards to data ownership, stewardship, and validity. [Guidance](#) and [principles](#) exist to help with getting this right, including the FAIR (findable, accessible, interoperable, reusable) and CARE (collective benefit, authority to control, responsibility and ethics) guiding principles. Another risk with the application of MRV technologies relates to biodiversity data robustness. Even if sensors or models are precise and accurate, they may not necessarily measure the right indicators, or only cover a subset of relevant indicators, to build decisions on. To understand this better, it is important to distinguish between accuracy, preciseness, and robustness of biodiversity data. Data accuracy refers to whether the measurement is in fact correct, data preciseness is how exact a measurement is, and data robustness refers to whether you are measuring the right things and able to overcome errors and outliers.

For use cases focused on supply chain transformation, a key risk is whether implementing changes to the supply chain results in further elevating locations that are the “best-performers”, while leaving the most vulnerable landscapes and their communities behind. Use cases focused on biodiversity offsetting must be vigilant when it comes to safeguarding the rights of IPLCs, preventing land tenure issues and human-wildlife conflicts, as well as ensuring good quality governance models and biodiversity credits. To the latter points, the [Global Biodiversity Standard](#) may be used as a safeguard to guide developers and investors.

Land tenure issues, safeguarding the rights of IPLCs, and access to data are specific risks for project development and management use cases. Having established processes and mechanisms in place that create official channels for IPLC involvement and feedback to project implementation can help safeguard against this, such as by following the WWF's [Standard on Stakeholder Engagement](#). This can help to ensure that there is community participation in the design of the project, and that any potential unforeseen risks can be identified by leveraging learnings and knowledge of local communities.

Furthermore, where implementation of a project will involve IPLCs engaging in data collection, monitoring processes or activities that involve certain technologies, there are multiple risks involved. Communities will not have access to these technologies without assistance, may not yet know how to use them, or may be constrained by digital illiteracy. To overcome these risks, project developers should have plans and measures in place to co-create solutions, supply appropriate and contextually-relevant solutions to IPLCs and to provide training to use these technologies. Provision of resources and training, or ensuring that technologies leveraged in an area match the level digital literacy or technical expertise of IPLCs is a key safeguard against this risk.

3.2 Emerging revenue streams

Through analysis and interviews, several revenue streams were explored as promising mechanisms in nature tech business models. These were highlighted consistently in the literature review, stakeholder interviews and the examination of existing business cases. The following are breakdowns of these key revenue streams, including data services, biodiversity credits and payments for ecosystem services. Each has potential to: a) be widely applied and provide a foundation for many start-up business cases; b) experience significant increases in demand from potential buyers; and c) be poised to generate substantial impact and value for people, planet and profit.

Data services

As the need for quality data collection, analysis and verification grows for project development and brokerage, the costs of these services on a case-by-case basis increase significantly. This provides a real opportunity for data and platform providers offering software-as-a-service (SaaS) products that are cost-effective on a subscription basis. However, such platforms often have high initial development and fixed costs and relatively low marginal costs, which means this revenue stream can only be cost effective

for the client and the service provider if it is operated at a certain scale. At an earlier stage, this can often be mitigated by using this revenue stream in tandem with more conventional consulting and advisory services charged on a project or hourly basis. There are also opportunities for those that gather and use data through nature tech. Before transitioning to platforms as a primary revenue stream, companies (and communities) can monetise data collection and analysis services tailored to project and client needs.

Case study



Location: Brazil

Solution type: Conservation, Sustainable use

Based in Brazil, Bioverse leverages emerging technologies to build profitable forest economies that protect threatened ecosystems. This assists IPLCs by helping them to locate valuable NTFPs like Brazil nut trees or Acai berry palms. Bioverse aims to ensure that local communities can sustainably harvest NTFPs to generate income and transform existing supply chains while also maintaining important ecosystems.

Bioverse uses three layers of technology: satellite imagery for NTFP density estimates, drones to find exact locations of each NTFP specimen and mobile phones to make this information available to the community and help them generate yield forecasts and coordinate with their supply chain. Forest maps can also be printed and distributed to communities that may not have strong signal when harvesting. Bioverse collaborates with local cooperatives within target communities to ensure information is shared exclusively with those the community trusts.

Bioverse's key revenue streams come from two main customer segments: cosmetic and food companies that want to scale up their supply of NTFPs, and biodiversity and carbon project developers that want to add revenue to their projects while improving outcomes for local communities. Bioverse has been supported by grants from UNICEF, UNDP and the Brazilian government.

Looking ahead, Bioverse is seeking partnerships with companies that want to strengthen their NTFP supply chains. They are also seeking carbon credit project developers and biodiversity project developers that are willing to invest in new revenue streams with the potential to outpace monetary returns from credit markets, while also ensuring that benefits flow to IPLCs.

Biodiversity credits

As mentioned earlier, global demand for voluntary biodiversity credits is predicted to increase significantly, creating a clear case as a promising revenue stream. Although these proceeds will be directed primarily to biodiversity impacts and restoration efforts, innovators can unlock future revenue streams by providing services or platforms that offer (a combination of) transparency and governance services, monitoring and verification services, or marketplace services, in return for a fixed fee or percentage of the value of the traded biodiversity credits. There is ongoing debate about

the best metrics and standards for assessing and validating biodiversity credits. Given the complexity and multifaceted nature of biodiversity, along with potential negative feedback loops and unintended consequences of targeting specific biodiversity impacts, discussions revolve around how and what should be measured and monitored. Biodiversity credits as a revenue stream are still under development. There is not yet a mature market for them, but they offer notable potential for project developers and start-ups in the future.

Payments for ecosystem services

Payments for ecosystem services (PES) are voluntary payments made by beneficiaries to ensure the provision of specific ecosystem services. Current payment schemes are focused primarily on watershed protection or being integrated in agri-environmental programmes. Unlike biodiversity credits, PES directly connect the beneficiary with the ecosystem service provided. This also allows payments to be linked to the implementation of certain practices, rather than being contingent on monitored and verified outcomes, which has historically allowed such schemes to be implemented without large tech components.

As technologies evolve and PES schemes mature, revenue streams akin to biodiversity credits may emerge. In such streams, service providers, including IPLCs, could be compensated for their roles in transparency and governance services, monitoring and verification services or marketplace services. This trend is already evident in growing interest to link PES schemes to key performance indicators (KPIs) rather than solely to the implementation of best practices. Supply chain product premiums could also be layered onto PES by employing similar KPIs. This can be achieved by integrating platforms and blockchain with monitoring technology, which could unlock even more revenue streams.

Despite interest in PES as a revenue stream for businesses, and its existence for a considerable period of time, it is far from mature. Challenges persist in accurately and consistently attributing payments and ensuring they reach those responsible for biodiversity-positive impacts. Establishing robust connections with local NGOs can help companies manage the distribution of fees generated in pay-to-grow systems, as they can facilitate the processing of fees for local communities. Mobile money payments are one method of facilitating PES and improving traceability and fair distribution of payments within a community. However, challenges can arise when attempting to scale this revenue stream across international borders. While this revenue stream holds significant promise to support local communities working to protect biodiversity, the ease with which PES can be facilitated depends on the jurisdiction and its regulations.

Case study



Location: Africa and South America

Solution type: Conservation, Restoration

Greenstand is a non-profit organisation that pays local landowners, farmers and foresters to participate in tree planting and forest conservation through a digital platform that enables:

- Local communities and practitioners to be paid for the actual results and long-term impacts of their restoration and conservation efforts, including for planting and maintaining trees
- Corporate, individual and organisational donors to monitor the trees they support and their ecological impacts
- Verification of data to provide proof of impact and generate impact tokens³⁷ based on the ecological value of planted trees
- Access to an impact wallet³⁸ so that buyers and investors can purchase, sell or trade their impact tokens

Reaching up to 20,000 farmers in Africa and Central and South America through reforestation and farmer-managed natural regeneration (FMNR) projects, Greenstand offers the free Treetracker app that allows users to geotag tree planting locations and monitor tree growth. Participants are rewarded for their contributions to reforestation with token credits or other compensation tied to tree planting activities. Greenstand uses **blockchain technology to ensure transparency and accountability in their tree planting initiatives** and accurately assign responsibility for positive impacts to actors. By tokenising the ecological impact of planted trees and linking them to verified planting activities, Greenstand creates a traceable record of reforestation efforts and tree maintenance. The ecological value of trees is determined by a point system, for example, one point is awarded for planting a native species and one point for social impact. Tree planters are ultimately rewarded more for taking biodiversity into account and actively working to restore it, which encourages behavioural change and promotes the idea that there is value in nature. Greenstand also leverages PES to create impactful social outcomes. They focus heavily on ensuring payments reach those responsible for contributing to positive biodiversity outcomes, which in turn contributes to alleviating poverty.

Greenstand has scaled by drawing on several revenue streams, including: **PES (for farmers and landscape practitioners), platform facilitation fees** and **SaaS**. The company's ideal use case is projects that emphasise PES provided by individual farmers. The platform charges a 3% fee to organisations purchasing tree tokens, which covers all platform facilitation fees and generates returns for the company. In exchange, the platform enables landowners to generate income from trees and is scalable to millions of smallholder farmers worldwide. Local farmers and community members are compensated for their conservation and restoration activities and are engaged in replanting and managing reforested areas, providing on-the-ground verification of conservation efforts by uploading photos to the Greenstand platform.

³⁷ Impact Tokens are digital tokens that represent the relative impact value of a tree, based on the positive environmental and social impacts created by planting/maintaining a tree.'

³⁸ An Impact Wallet is a digital wallet for storing, accessing, and trading Impact Tokens.



Inclusive revenue streams and IPLCs

The Global Biodiversity Framework negotiations emphasised the inseparable connection between nature and people, highlighting the role of local communities in achieving global biodiversity and climate goals. This underscores the responsibility of nature tech companies to develop inclusive business models that respect the rights of IPLCs, including traditional land tenure rights, and to facilitate revenue sharing. This approach empowers communities to actively participate in safeguarding ecosystems and conserving biodiversity. A notable example is Savimbo, which was built by, and for, Indigenous peoples and smallholder farmers in tropical forests to disintermediate climate markets. IPLCs are paid directly for the preservation and reforestation of their lands through the sale of a range of biodiversity and carbon credits that generate shared revenue. Fostering trust between nature tech companies and local communities that are responsible for biodiversity will be essential to implementing solutions effectively, as the engagement and acceptance of IPLCs is often needed to apply technologies in these areas.

Biodiversity credits and PES systems present opportunities for IPLCs to become more empowered

and engaged in the protection, restoration and management of biodiversity. PES systems enable local custodians to receive direct payments for the effort and time they invest in maintaining and enhancing biodiversity. The research revealed various business cases being piloted worldwide. Platforms have been developed to connect corporate clients, NGOs and private donors/philanthropists with projects implemented by IPLCs, local farmers and community organisations. These platforms typically charge a flat percentage fee to buyers who purchase tokens representing conserved, restored or sustainably managed ecosystems (e.g., trees). Buyers use these tokens for various purposes, from brand initiatives to meeting CSR and ESG targets. Funds generated by sales of these tokens are directed straight to those responsible for conservation and restoration activities, as well as to verify the work of others in their local area. Blockchain applications can be used to store and verify data for biodiversity credits and PES-based schemes, to authenticate and document: a) the impacts on biodiversity; b) the people responsible for conservation, restoration or management efforts; and c) payments made for contributions (by whom and to whom).

3.3 Transformative enabling technologies: Monitoring, reporting and verification (MRV) and Artificial Intelligence (AI)

MRV technologies and AI have seen some of the highest investment, private sector interest and growth in recent years. These tech solutions have the power to transform conventional tech applications and existing business models, opening doors to a diverse range of use cases and revenue streams. MRV technologies – used to monitor the state of biodiversity over time and validate reported claims – are being combined in innovative ways to deliver products for clients and generate impacts for people and biodiversity. Increasingly, AI is being applied alongside data gathering and storage technologies to provide different types of products for a range of potential clients. This enables businesses to unlock a range of revenue streams from which they can pick and choose to fit their particular use case and aims. As MRV technologies are implemented and refined, and combined with other technologies to improve analysis and interpretation of the data they gather, more promising combinations of use cases, revenue streams and technologies will arise.

Various technologies are being combined in innovative ways to offer diverse MRV products and generate impacts for people and biodiversity. These solutions help to make decision-making more objective by improving data accuracy through more frequent data collection, by fostering trust and by enabling access to data, thereby empowering stakeholders to act. AI integration with data technologies can also expand revenue streams and possibilities with data analytics, allowing businesses to tailor products to specific use cases. These technology combinations, alongside software solutions and diverse revenue models, benefit IPLCs, creating employment opportunities and enhancing local involvement in biodiversity management.

A prevalent business model involves integrating MRV technologies and AI with revenue streams focused on platform fees and subscription services for monitoring, analysis, advisory and strategy development. While subscription-based services are common in early stages, transitioning to platform-based models can unlock potential for scaling despite higher initial costs. Developing and applying MRV technologies is also crucial for proving their reliability and scalability in biodiversity conservation and restoration efforts. Enhanced MRV technologies address challenges in data reliability and measurement standardisation, fostering trust among stakeholders and facilitating the growth of credit and PES markets as viable revenue streams (outlined in the following case study). AI can further strengthen revenue streams and business models when integrated with MRV technologies, as it can reduce the cost of processing and analysing large quantities of data and provide more tailored insights for customers.

Business models for nature tech solutions are developing rapidly and in a variety of forms. The emergence of new markets for biodiversity will soon create new opportunities for solution developers. While the potential of biodiversity credit and PES markets has not yet been realised, businesses should focus on diversifying their revenue streams through the many proven approaches available to them. Using different combinations of technologies, such as MRV tools and AI, can open new revenue streams and potential use cases. As Figure 4 highlights, **the possibilities for developers are endless, and start-ups should find the best mix for their own use cases and contexts.**



Locations: Gabon, Democratic Republic of Congo (DRC), Sierra Leone

Solution type: Conservation, Restoration

Okala's mission is to develop high-quality, dependable biodiversity **MRV methodologies** that are affordable, transparent and trusted - **generating traceable data stored on the blockchain**. Okala designs biomonitoring projects, develops measurement and reporting strategies and supplies monitoring tools, data collection and analytical instruments to mitigate deforestation and biodiversity loss.

Okala has garnered support from the Africa Transformation and Industrialization Fund's (ATIF) equity investment fund, and is engaged in projects across Gabon, the Democratic Republic of the Congo (DRC) and Sierra Leone.

Okala serves a diverse clientele, including carbon project developers, universities, research institutes, governments, consultancies, national parks and private individuals. Using a combination of **eDNA**, **bioacoustics** and **camera traps**, they establish biodiversity baselines within defined project areas and monitor biodiversity trends over time.

The company has a number of products and services that generate revenue, with solutions tailored to the type of client and project. Examples include:

An MRV product for project owners or corporations. Okala delivers tailored strategies for monitoring the progress and achievement of ESG goals, or for aligning with reporting requirements. Okala determines and provides the data these companies need to meet their goals and sells this as a package or offers services in data analysis and interpretation.

A revenue-sharing agreement in the DRC. Through a framework agreement with the Government of the DRC, Okala invested \$40 million upfront to measure the biodiversity of 12 million hectares of forest and peatland. The data from this analysis will be used to calculate the value of the biodiversity and local ecosystems in the country and the value of nature credits associated with this land. Okala expects these credits will eventually be sold and they will recoup their initial investment. Currently, these credits are estimated to have the potential to generate \$700 million. The revenue-sharing agreement denotes that local communities, national parks and local implementers (including scientists) will receive 25% of all revenues generated from the project.

Nature-based solutions/project management packages. Targeted at projects over large areas of land where **local communities help to co-develop sustainable business models**. In Gabon, a pilot project of sustainable honey production and nature tourism combines different revenue streams to maximise potential benefits for both Okala and local communities. Okala prioritises supporting local communities through investments in existing infrastructure, and providing the funding to train local scientists and pay a stable income. Okala also invests in supplying the resources to local communities so they can monitor their biodiversity projects themselves. As the implementers and data gatherers of Okala's biodiversity monitoring strategies, local communities are essential to Okala's business model.



Nature tech business models: Environmental and social risks and safeguards

Sharing more of the benefits with local communities may lower the short-term profitability of a business and a prolonged validation period for a new technology may delay the product launch or lower the return on investment. On the other hand, putting in place environmental and social safeguards are essential to the long-term viability of nature tech solutions. Moreover, they are prerequisites to nature tech being a force for good. Setting up transparent and clear PES systems, for example, can help to increase the credibility of a business case to both investors and to IPLCs, further ensuring community buy-in. Leveraging technologies such as blockchain to store data openly and immutably regarding conservation or restoration activities, land rights, and documenting transactions can increase trust and create traceability.

Tackling environmental and social risks head-on may seem costly, especially in the case of an emerging business model, but getting it right can also be an integral part of developing attractive value propositions and unlocking finance from impact investors. One way to include environmental and social values within the business model is by using the [Sustainable Business Model Canvas](#) or the [Triple Layered Business Model Canvas](#).



4. Biodiversity and the mobile industry

Biodiversity is moving up the private sector agenda and the mobile industry is no exception. MNOs can have biodiversity-related impacts across the value chain, from the sourcing of raw materials needed to manufacture goods, to impacts on land from network infrastructure or sites, to potential contamination from waste disposal.³⁹ MNOs in LMICs are expected to have even greater impacts on biodiversity due to their widespread rural networks, demanding more immediate action.

To gain insights into the status of biodiversity in the mobile industry:

- A review of publicly available information was conducted for 25 of the largest MNOs with substantial operations across Africa and Asia
- Consultations were conducted with seven MNOs with active biodiversity initiatives in Africa or Asia
- Analysis was conducted on requests from biodiversity partners and value propositions from the 63 biodiversity start-ups that applied to the GSMA Innovation Fund

³⁹ GSMA. (2023). [Material sustainability issues for the mobile sector: 2023 update](#).

Biodiversity is gaining traction in the mobile industry, but few MNOs have a strategy in place

MNOs are reporting a greater focus on biodiversity in their business. As mentioned earlier, this has been driven largely by new nature-related reporting requirements, notably the GBF and CSRD. However, biodiversity is still a relatively nascent focus for the sector, trailing other climate action and net-zero commitments. Most MNOs are in the initial

stages of grappling with new biodiversity reporting requirements, conducting materiality assessments to understand the significance of biodiversity risks and opportunities. Some MNOs are in the process of developing stand-alone biodiversity strategies, with many expected to be published in 2024.

GSMA Biodiversity Taskforce

As part of the industry's commitment to biodiversity, a project group of 36 global MNOs has been established to take a consistent approach to understanding and analysing what biodiversity means for the mobile industry and what risks and opportunities should be considered when investigating impacts on biodiversity.

Biodiversity: From philanthropy to core business

Several MNOs are already active in biodiversity-related activities. For example, [Safaricom](#) has partnered with the Kenya Forest Service to plant 5 million trees by 2030, while [Airtel Africa](#) is using data technology to help monitor and protect rhinos. Elsewhere, MNOs such as [Huawei](#) and [Orange](#) are leveraging their technologies to support

governments and academic institutions in monitoring and managing biodiversity hotspots, or to drive customer education and engagement – for example, in the Philippines, where [Globe](#) offers tree planting as a reward for customers using their mobile money service.



Spotlight: MNOs tackling biodiversity loss with technology

Huawei: Enabling smart nature conservation with digital technologies



Initiative: [Tech4Nature](#)

Locations: 300 protected areas, including China, Brazil, Kenya and Mexico

Partnerships: International Union for Conservation of Nature (IUCN) and various partners

Huawei's TECH4ALL initiative was founded with the aim to promote inclusion and sustainability in the digital world through innovative technologies and partnerships. In 2020, the Tech4Nature initiative was launched as a collaboration between Huawei and the International Union for Conservation of Nature (IUCN). The Tech4Nature programme uses digital technology to promote the effective conservation and management of more than 300 protected areas worldwide on the [IUCN Green List](#).

This has included leveraging a range of Huawei and its partners' technologies, from acoustics and visual data to wired and wireless connections, cloud and AI services, to improve the management of protected areas; develop unique benchmarking tools that use digital technology to track progress and improve the monitoring and assessment of protected areas; and certify at least 100 protected areas against green list standards. Tech4Nature will move into Phase 2 in 2024, which will focus on collaborations between the information and communication technology (ICT) and conservation sectors.

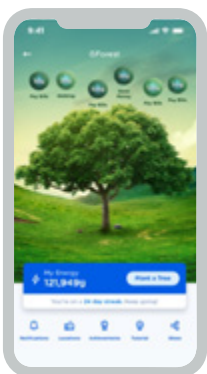
Globe: Supporting nature-based solutions to protect biodiversity in the Philippines



Initiatives: [GForest](#)

Location: The Philippines

Partnerships: The Biodiversity Finance Initiative, WWF Philippines, among others



Globe is using NbS and harnessing technology to tackle biodiversity loss and climate change in the Philippines. It has engaged in reforestation and mangrove conservation initiatives nationwide. As well as nature conservation, these initiatives seek to create sustainable incomes for local communities.

Globe also uses their digital platforms to encourage customers to take environmental action. The GForest interactive climate tech platform enables Globe customers to contribute to the restoration of Philippine forests by transitioning to digital transactions and reducing their carbon footprint. Through GCash, Globe's fintech arm, users earn green energy points for every online transaction, which can be exchanged for tree planting. Since 2019, Globe has planted more than 2.5 million trees in partnership with its collaborators.

Safaricom: Investing in Kenya's forests



Initiatives: reforestation, wildlife conservation

Location: Kenya

Partnerships: Kenya Forest Service and government

Safaricom's current nature and biodiversity initiatives involve investments in conservation and ecological projects, as well as partnerships with governmental and private sector stakeholders engaged in biodiversity conservation. These projects are delivered through the Safaricom and M-PESA Foundations, which serve as the primary channels for fulfilling the MNO's SDG targets.

Safaricom has a particular focus on reforestation and wildlife conservation. Initiatives include partnering with the Kenya Forest Service to plant 5 million trees across the country by 2025 to offset up to 26% of Safaricom's carbon emissions once the trees have grown to maturity. They also provide funding for the conservation of endangered roan antelope and rhinos. Notably, Safaricom was one of the first MNOs to sign the Business for Nature Pledge, advocating for mandatory nature reporting for the private sector.⁴⁰

⁴⁰ Business for Nature, [Make it Mandatory campaign](#)

To date, most biodiversity projects undertaken by MNOs have fallen within CSR or sustainability functions. However, the research found that some biodiversity initiatives are shifting to be tied more explicitly to consider the triple bottom-line principle of People, Planet and Profit, aligning with MNOs' business strategies to future-proof operations. Two examples are presented in the following case studies.

Indosat Ooredoo Hutchison: Digitalising mangrove conservation in Indonesia



Context

Mangroves help protect the environment by providing clean water and air and preserving biodiversity – critical to reducing global warming and mitigating the impacts of climate change. In North Kalimantan in Indonesia, the livelihoods of most communities depend on seaweed farming and shrimp farming, both of which pose a significant threat to mangrove and coastal conservation.

In 2023, Indosat Ooredoo Hutchison (IOH) partnered with the GSMA's Mobile Innovation Hub and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on a pilot project trialling innovative digital solutions to reduce the destruction of mangroves in collaboration with the North Kalimantan community.

The solution

Mobile geospatial technology was used to map the use of the coastal belt and monitor the distribution and clearance of mangroves. **Smartphones** captured and communicated data on mangrove conditions and the state of the surrounding ecosystem. The second component of the project focused on tackling a belief among shrimp farmers that mangroves negatively impact their productivity, which leads them to clear mangroves to start new ponds. To encourage more sustainable shrimp farming practices, IOH provided **IoT sensors** to collect data on water quality, which gave farmers the information they needed to improve the productivity of their ponds.

Scaling the solution

The project tackled the triple bottom line by **safeguarding mangroves** (*Planet*), **enhancing livelihoods** (*People*) and providing **compelling evidence of the potential for IOH's IoT services** (*Profit*). This has helped to accumulate evidence for their IoT product as a use case for business, and because the data was produced in partnership with a local university, it had more credibility. While this began as a sustainability-focused pilot project, the results have helped the sales team prove the impact of the IoT solution and raise the internal profile of the technology's profitability beyond this pilot alone. As a result, IOH will expand this initiative to multiple regions in 2024 to bolster nationwide conservation efforts, disaster resilience and the development of community-based tourism, while also supporting their broader business needs.



Vodafone, Safaricom: Preventing human-wildlife conflict using AI technology in Kenya



Context

Human-wildlife conflict (HWC) occurs when human encounters with wildlife result in negative consequences for both parties, including property loss, livelihood disruptions and fatalities. HWC raises both conservation and humanitarian concerns, which disproportionately affect low-income communities.

The solution

M-Twiga is being designed to act as an early warning and deterrent system that prevents elephants from crop raiding and stops predators attacking livestock, while also notifying communities of the presence of specific wildlife species. It is the result of a collaboration between technology and conservation experts from Vodafone, Safaricom and WWF. Using infra-red cameras and AI software, the system can detect and identify various predator species and send an SMS to predetermined numbers to alert nearby communities. It is designed to recognise animals moving at different speeds and in various weather conditions, both day and night. Powered by an integrated solar photovoltaic cell with rechargeable battery back-up, m-Twiga is intended to be robust, simple and suitable for off-grid regions. It operates via SMS, ensuring functionality even with limited coverage, and the deterrent feature will work independently of coverage.

Scaling the solution

While the m-Twiga solution is still in early proof of concept stages, it presents a compelling case for the involvement of MNOs in addressing conservation issues. Longevity has been central to its design, with an emphasis on being low cost, scalable and adaptable to different environmental contexts. Various business models are being explored, for instance, its potential application in ecotourism or within national parks. The objective is to ensure the project is sustainable beyond the initial business support. In doing so, the m-Twiga team hopes to scale the solution to protect wildlife, manage natural resources and mitigate the loss of property, livelihoods and lives.

These examples underscore the potential of the mobile industry to link vulnerable communities with digital solutions that empower them to safeguard biodiversity and bolster their resilience to climate change, while also addressing the core business needs of MNOs. As the examples show, an effective model for MNOs is to deploy their technology to address biodiversity issues and test their capabilities in real-world settings. This not only enables them to demonstrate the credibility of their technology, but also showcase potential applications to prospective business users. This provides an incentive for MNOs to keep investing in nature tech solutions and lend support to biodiversity initiatives.

While discussions with MNOs revealed a growing interest in deploying solutions to combat biodiversity loss, stakeholders highlighted potential barriers to engagement and action:

- **Understanding biodiversity impacts** – Currently, the focus of the mobile industry is on assessing the materiality of biodiversity impacts. Given that many of them have global operations, this requires a complex assessment of impact, dependencies and traceability to make informed and actionable decisions in supply chain sourcing.

Key motivators for MNOs to engage with biodiversity

Increased engagement with biodiversity in the mobile industry has been motivated by various factors, from sustainability and nature-reporting requirements to commercial opportunities. Figure 5 outlines the key motivators driving MNOs to participate in biodiversity efforts and the potential benefits identified by the research.

Reporting requirements:

Interviews with MNOs highlighted that the most immediate motivating factor is the growing importance of ESG reporting and biodiversity disclosures, with MNOs under increasing pressure to report and act on nature-related dependencies, impacts and risks. While many are still in the early assessment stages, biodiversity strategies are being formulated and will outline more explicit plans for the sector to address this business imperative, intensifying focus on the topic.

Investment opportunities:

Investors are increasingly prioritising the future resilience of businesses to biodiversity risks. This heightened focus on nature means that listed companies such as MNOs are under growing pressure to actively address biodiversity loss and enhance their credibility and appeal for investors and lenders.

- **Making a compelling internal case** – While biodiversity is gaining traction, it lacks the prominence and commitment of other climate-related concerns. Making a clear internal case for greater engagement (such as investments, pilots and partnerships) in this area can sometimes be challenging. As outlined in chapter 2, there is a need for clear value propositions from partners and sustainable, scalable business models to illustrate the value of investing in this space and more explicitly presenting opportunities for the MNO business case.
- **Having the right investment opportunities, initiatives and partnerships** – Action on biodiversity requires a host of stakeholders working collaboratively. Partnerships with aligned goals and resource requirements are crucial and range from start-ups to NGOs, academia and government entities.

While these considerations are front of mind, there are significant opportunities for the sector to more actively engage in biodiversity solutions, as detailed below.

In 2023, Kenyan MNO Safaricom secured a \$102.95 million loan from a consortium of domestic banks⁴¹ to fund environmentally sustainable projects focused on water conservation, renewable energy and energy efficiency. A new record for the largest sustainability-linked loan facility in East Africa, securing this investment was also seen as a vote of confidence for Safaricom's sustainability credentials.

Commercial returns:

Several opportunities were identified in the research for MNOs to increase business revenues by focusing on nature, including increased demand for mobile services and data use, particularly in biodiversity hotspots where network expansion can help MNOs extend their reach to underserved areas. Understanding the needs and preferences of these customer groups in new locations could also inform the development of new products and services. Other examples highlighted in interviews include the integration of mobile money services with biodiversity solutions or projects, such as PES, insurance services, agricultural solutions and carbon credit platforms, or for accessing national parks. In such cases, the MNO earns transaction fees from the use of the mobile money platform. The provision of MNO technology to biodiversity initiatives can also

41 Standard Chartered Bank Kenya, Stanbic Bank, ABSA Bank Kenya and KCB Bank.

help develop the business offering and use cases for their emerging solutions. For example, a marketplace can be created for the biodiversity data generated by an MNO's IoT solutions, which serve a range of customers (such as government, local businesses and academic institutions). Partnering with biodiversity projects, particularly start-ups, can also help ensure MNOs are at the forefront of new technology solutions. Several MNOs have investment arms that support or trial pilot projects, giving them a low-risk stake in new or emerging technologies, particularly in light of the growing market for nature tech.

Resources and ecosystem services required for the business:

Biodiversity has a direct impact on operations and supply chains by affecting access to raw

materials such as water, food and minerals, as well as ecosystem services like pollination and climate regulation. Sustainable livelihoods for communities where MNOs operate are essential to the success of their business, as thriving communities contribute to a stable customer base.

Brand:

MNOs can enhance their brand reputation by supporting government efforts to monitor biodiversity hotspots and meet a country's National Determined Contributions (NDCs). Differentiating their brand through sustainability initiatives not only satisfies consumer expectations, but also boosts employee engagement and aligns with customer demands for sustainable products.

Figure 5

Drivers and opportunities for the mobile industry on biodiversity



How can MNOs support biodiversity efforts?

After analysing requests from biodiversity partners, and the perceived value proposition of working with MNOs according to the 63 biodiversity start-ups that

applied to the GSMA Innovation Fund, “asks” were grouped into the following four categories:

01. Connectivity and accessibility

Communities that live near biodiversity hotspots are usually living in poverty and are the least likely to be online or use digital services at scale. A common call from NGOs and start-ups was for MNOs to support last-mile connectivity to give rural communities better access to mobile services, which would open more opportunities to introduce digital solutions to support community conservation and restoration efforts. There was a particularly strong appetite for MNOs to bundle existing solutions with their existing preinstalled mobile apps to reach target users and/

or environmentally-conscious customers. Others highlighted the value of free SMS or hotline services to provide information to local communities. For example, Viamo’s partnership with local MNOs in Mozambique (Vodafone and TMCEL) underpins their national toll-free public information service, the 3-2-1 Service, which is accessible through interactive voice response (IVR). The service allows anyone with access to a mobile phone to call and learn about agriculture (among other topics) and make informed decisions to improve their livelihoods.

02. Cost reduction and subsidies

The provision of low-cost handsets, subsidised or free data services and packages can provide crucial support to biodiversity projects. Start-ups and NGOs saw significant value in MNOs providing affordable access to frontier technologies, such as subsidising access to IoT for conservation initiatives. For example, [Telkomsel](#) in Indonesia facilitated a nationwide study to investigate levels and spatial patterns of domestic wildlife use, using songbird

ownership and shark product consumption as case studies due to their widespread occurrence in all 34 Indonesian provinces. The network operator sent SMS messages to 340,000 of their customers and incentivised responses with a mobile data package. This demonstrated the potential of SMS surveys to understand local wildlife consumption patterns and identified hotspots for further investigation.

03. Capacity building and technical support

Drawing on the wealth of in-house expertise at MNOs, biodiversity partners called for technical assistance programmes or capacity building support to enhance the development of high-impact digital solutions. These initiatives could improve organisational capacities, as well as the skills of community members, ultimately increasing access to and use of

MNO services. A handful of MNOs reported hosting “hackathons”, with staff and partner organisations collaborating to address nature-related challenges with novel mobile or digital solutions. This approach has increased the visibility of biodiversity partners, established new partnerships and fostered innovative solutions.

04. Investment

Above all, there was a call for more partnerships and investment in promising start-ups and the technology solutions required to tackle biodiversity challenges. MNOs were seen as having a key potential role in leveraging private finance, promoting blended finance or strategies for raising new and additional resources. Investment through venture funds can also help to close the financing gap for impactful biodiversity projects. For example, in the Philippines, Globe’s venture builder, 917 ventures, seconds staff to work on ESG-focused projects where the MNO’s expertise and investment is leveraged to create and fund new solutions.

The mobile industry has a significant role to play in supporting biodiversity efforts. This includes enhancing connectivity and accessibility, reducing costs, providing capacity building and technical support and increasing investment in promising start-ups and technology solutions. As the industry continues to evolve, MNOs will have the opportunity to become leaders in biodiversity conservation, driving positive change for both nature and their own businesses.



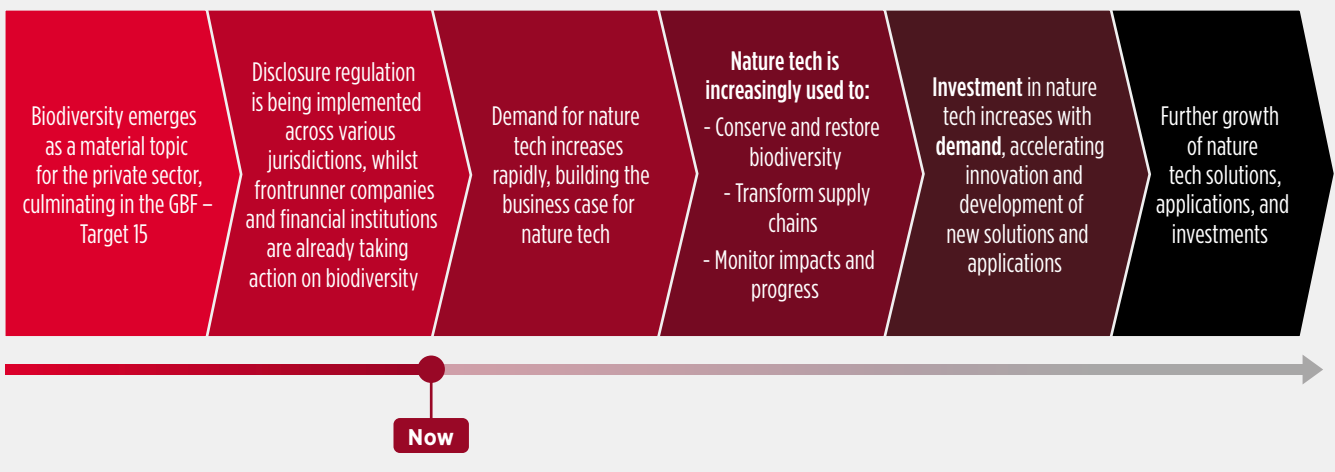
5. Conclusions and recommendations

While still in a nascent stage, nature tech is undeniably gaining momentum. As mobile and digital solutions steadily advance and gain traction in LMICs, heightened awareness of biodiversity risks and the adoption of disclosure policy frameworks are fuelling demand for them. These concurrent developments suggest this rapidly growing sector is approaching a tipping point. Although the magnitude of this surge is difficult to predict, progress will depend on:

- How quickly the capabilities of nature tech develop, particularly measuring biodiversity accurately across diverse areas and over time to create more granular assessments
- The rigour of regulatory frameworks for disclosure and transformative actions
- The tangible demonstration of the impacts of biodiversity loss within private sector operations and supply chains
- Societal attitudes towards biodiversity and expectations of companies to address it

Figure 6

Predicted trajectory of the nature tech market



Realising the full potential of mobile and digital innovations to combat biodiversity loss relies on the collaboration of key stakeholders, including MNOs, start-ups, donors and investors. Recommendations

for each of these stakeholder groups are outlined below, drawing on the points explored in earlier chapters.

Recommendations for the mobile industry

Become a launching customer or investor in nature tech by:

- Developing, trialling and piloting mobile and digital tech solutions to position MNOs ahead of the curve in the growing nature tech market
- Investing in technology for biodiversity, which has the added benefit of driving innovation and creating new business opportunities
- Using investment arms to focus on biodiversity initiatives, leveraging CSR-driven projects, which can be commercially scaled after testing
- Demanding high-quality carbon or biodiversity credits with strong social and environmental impact credentials

Facilitate the scaling and impact of existing biodiversity solutions by:

- Providing connectivity to nature tech, particularly around biodiversity hotspots
- Supporting nature tech with expertise, for example, using informal internal initiatives such as

hackathons or employee-led projects to co-create new ideas with conservation partners or start-ups, seed new ideas and motivate employees

- Leveraging the customer base to engage in biodiversity and drive consumer awareness and action

Explore ways to transform the business operations of MNOs by:

- Giving biodiversity a strategic focus on par with climate change
- Transitioning operations to be nature positive, using MRV nature tech and supply chain transparency tools to transform the value chain
- Working closely with others in the industry to set clear standards for biodiversity measurement and disclosure and collaborate on initiatives
- Sharing examples and best practices on projects with direct and indirect impacts, including business processes, to help the mobile industry progress

Recommendations for nature tech start-ups

- Continue to **develop and implement nature tech solutions tailored specifically to LMIC contexts**. This could involve fostering collaboration and partnerships between entities in HICs and LMICs to place LMIC initiatives on a more equal footing.
- **Engage directly with IPLCs to co-develop solutions and business models**, drawing on their existing knowledge and practices. This should include consideration of low-tech solutions that align with the digital literacy and connectivity levels of communities.
- **Diversify revenue streams** and explore the potential for nature tech solutions to deliver value across various use cases and target clients (businesses, governments and communities).

- **Strengthen start-up value propositions** for potential partners or investors by clearly showcasing both commercial viability and social and environmental impacts. This includes ensuring data quality and adherence to standards, as well as implementing safeguards for IPLC rights.
- **Investigate opportunities for MRV applications** in response to CSRD and other disclosure regulations. Provide solutions that not only facilitate monitoring and disclosure, but also drive improvements and facilitate transformative change.
- **Consider future market-based opportunities** (particularly PES and biodiversity markets) with a focus on governance, quality assurance, IPLC rights and equitable benefit sharing.

Recommendations for donors and investors

- **Explore, fund and champion nature tech solutions that originate in LMICs** to foster innovation and the development of sustainable solutions tailored to these countries. Consider de-risking through grants or blended finance models.
- **Collaborate with the public sector, NGOs and knowledge and research institutions** to accelerate lower-risk investments. This can help to:
 - Improve understanding of underlying business models, thereby lowering risk premiums, as unfamiliar structures often entail higher costs
 - Increase the quality of investment projects, lowering future reputational risks
- **Conduct comprehensive due diligence on social and environmental safeguards** and impacts prior to investing in nature tech solutions. The level of scrutiny should correspond to the level of integration. For example, a company that sells drones or sensors warrants less scrutiny than one involved in developing or brokering biodiversity restoration projects, or actively collecting data in sensitive areas. Caution should also be taken to ensure the integrity and privacy of data gathered when deploying biodiversity monitoring technologies and solutions. With the vast increase in data gathering and storage capabilities in recent years, concerns will likely arise about how this data is verified, stored, shared, and analysed.

Recommendations for government

- **Ensure that companies comply with mandatory requirements** to assess and disclose impacts and dependencies. Evaluate the level of detail critically – nature tech capabilities should allow for transparent reporting without concealment.
- Require companies to overhaul their **supply chains** to improve sustainability.
- Establish **standards for social and environmental safeguards** related to nature tech.
- Given that governments can be a significant client of nature tech solutions (both in terms of scale and influence), **evaluate the procurement of nature tech solutions** based on their performance against key standards.

Looking forward, the GSMA and its members can play a pivotal role in supporting global efforts to strengthen the conservation, restoration, and sustainable use of biodiversity.

The research underscores emerging opportunities for MNOs to leverage their resources and technical expertise in developing and applying mobile and digital solutions to bolster biodiversity efforts, particularly through collaborative partnerships.

The GSMA's ClimateTech programme is well-positioned to support this by actively assisting our members and development partners in identifying innovative opportunities.

By connecting stakeholders, including start-ups supported by GSMA innovation funding, the ClimateTech programme seeks to foster nature tech innovation, test new tech-enabled solutions and business models to promote scalability and strengthen the long-term sustainability of these innovations. We hope to contribute to the growing evidence base on understanding the potential impact that technology can play in helping both people and nature thrive.

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