The Nature Tech Market.

Necessary, Emergent, Dynamic

Jaclyn Wei-Lin Eng, David King, Bruce A. Strong
Capital for Climate

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Nature 4Climate

Acknowledgments

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They include:

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"Nature tech promises to make the case for deeper investments in nature-based solutions easier to justify, by providing better clarity about their impact over time and by helping make them even more cost-effective. As you'll learn in this white paper, many of the underlying enablers for nature tech, such as artificial intelligence, advanced robotics, biomimicry and more, have their roots elsewhere. But as more companies and investors wake up to importance of putting biodiversity and nature at the center of climate strategy, nature tech is coming into its own — and beginning to earn the respect, and capital, that it deserves."
Heather Clancy,
Editorial Director,
Greenbiz

"A thorough and helpful review of the evolving nature tech landscape. This paper presents a snapshot in a fast and growing market that requires social and environmental safeguards throughout its evolution."
Manuel Piñuela,
Co-founder and CEO,
Cultivo

"To move at the pace that our planet demands, we need unprecedented, catalytic investments in nature. By harnessing the latest advancements in nature tech, we can deliver the transparency, accountability and integrity needed to rebuild trust and unlock funding to restore nature at scale."
Diego Saez Gil,
Co-founder and CEO,
Pachama

"We're excited that nature tech is being put in the spotlight. Natural ecosystems are incredible carbon sinks and biodiversity havens, so we must do everything we can to ensure they are properly protected and developed. At Sylvera, we're applying state of the art technology - like LiDAR scanning drones and advanced machine learning - to track and measure with incredible precision how carbon offsetting projects are managed around the world. As a result, buyers will know which projects are high quality and which are not. Ultimately, investment should only flow into legitimate projects, helping them to scale over time and to increase their positive impact on the climate."
Sam Gill,
Co-founder and President,
Sylvera

"Nature4Climate's work on nature tech is bringing together all the elements needed to create a new investment class. This is helping companies and investors figure out new ways of working together to tackle climate change and biodiversity loss simultaneously."
Ian Oxley,
Investor

"Nature tech will be one of the critical enablers to build a nature positive and net zero economy – this timely report provides great insight on the emerging opportunities that are finally making nature investable."
Justin Adams,
Partner,
Just Climate

"Technology should never be the end goal in working towards our global goals, but used as part of increasing positive impact, it can be incredibly powerful. Nature tech accelerates, augments and accounts for action on nature which helps us solve the interrelated challenges of nature loss and climate change. This new paper helps us understand how."
Niraj Swami,
Sr. Director,
Conservation Technology Strategy & Enablement,
The Nature Conservancy

"Works like this are critical to bring greater understanding and trust, and one of the threads tying together the coherence and cohesion required for nature-based solutions (NbS) and the carbon markets."
Bruce Keith,
Senior Investment Officer,
International Finance Corporation

"Forest resources can be managed truly sustainably and for-profit, and we are investing in innovative new business models that both help local people thrive and protect Peru's remarkable fauna and flora for posterity. We are strongly supportive of nature tech and are always looking for smart solutions that help us improve forest management. We encourage innovators to research and test new technologies with us in the field."
Stuart Clenaghan,
Co-founder,
Green Gold Forestry Peru SA

"The use of nature tech is key to the acceleration required for the implementation of nature-based solutions at scale, which play a crucial role in mitigating against the dual climate and biodiversity crisis. At Space Intelligence, we use nature tech in the form of satellite data and AI, to create maps of habitat and carbon stock to monitor the progress of reforestation and forest protection projects globally. We welcome this report and the insight it provides on the current and predicted future state of the nature tech market. With scientific integrity and increased transparency behind its use, we believe that nature tech will drive the further investment required for high impact nature-based solutions."
Dr Alexis Moyer,
Head of ESG & Spatial Finance at Space Intelligence

"Nature tech is enabling the development of essential infrastructure to allow for the robust execution of carbon transactions, as well as the ability to crunch big data to better understand and articulate the premium that high-quality nature-based solutions should demand. But to realise its true potential, we must ensure that we deliver through platforms that are underpinned by trust and transparency."
Mikkel Larsen,
CEO,
Climate Impact X

"In recent years, societies have increasingly recognized the importance of restoring ecosystems to protect cities and improve human health and well-being. However, nature is complex, and we lack even simple data and information to effectively prioritize, implement, and monitor these initiatives. Emerging technologies have opened up tremendous opportunities for understanding how to restore and build nature in an efficient and cost-effective way. While nature tech is only one part of this complex solution, I'm thrilled to support the development of new training and support to students and practitioners working towards innovative nature-based solutions."
Dr Nadina Galle,
Researcher,
Engineer and host of Internet of Nature podcast

"The impacts of climate change and nature degradation can be thought of as a carbon pandemic. Earth is suffering from significant symptoms and damage due to increasing carbon dioxide and other greenhouse gases and the non-sustainable use of our natural resources. And yet, in contrast to modern medicine, we have no globally reliable diagnostic and treatment system to quantify the causes and implement the needed mitigation measures. Nature tech is the collective range of applicable technologies to address this urgent situation. Aligned with venture and growth capital structures it is our last hope to deliver on restoration and stewardship now required."
Holt Thrasher,
Co-founder and CEO,
Synovia Capital

"Our species is equipped with the intelligence and creativity to innovate for the benefit of all life on planet earth, including humanity. These new technologies advance our ability to precisely measure, monitor, manage and protect biodiversity and ecosystems at scale, enabling data-driven mechanisms to assess and communicate the value of nature and the ecological services provided, ultimately de-risking investment to finance the future of our planet, rather than the short-term exploitation of it. We have the tools at our disposal. The urgent need is the willingness to pick them up and the responsibility to use them wisely."
Peter Houlihan,
Executive Vice President, Biodiversity & Conservation, X Prize

"Like nature itself, nature tech comes in all shapes and sizes. To meet our goals of limiting climate change, protecting our land and water and achieving sustainable land management we will require an ecosystem of technologies that can work together to support markets to drive finance to where it is most needed. The inaugural nature tech market landscaping is an importing first step in this process, and the FLINTpro team look forward to future versions and seeing all the new technology coming online."
Rob Waterworth,
CEO,
FLINTpro / The Mullion Group

"Technology is crucial to understanding and deploying land use and management changes at scale to meet global climate and nature goals. This report provides the first comprehensive overview of the rapidly evolving nature tech space and identifies a number of exciting technologies with the potential to transform how we measure, value and restore nature. As the first large scale asset manager dedicated exclusively to nature, Climate Asset Management welcomes this thoughtful overview and we will continue to partner with nature tech innovators to design and implement projects that create benefits for climate, nature, and communities."
Megan Reilly Cayten,
Senior Investment Manager, Climate Asset Management

"Technology must be part of the solution set to accelerate the implementation, adoption and scaling of NbS, which provide the basis for global value creation and are critical for humanity's well-being. Equally important is how technology can help connect actors across the NbS value chain from the field to the boardroom. This report presents a comprehensive view of the fast-growing nature tech market and provides an essential resource for investors interested in this sector."
Hari Balasubramanian,
Founding Managing Partner, EcoAdvisors

"It is an exciting time for nature tech, with significant resources being leveraged to apply advanced direct and remote sensing, software, modeling, and other technologies to solve the climate crisis. Through this time of innovation and acceleration, integrity of results and claims is paramount. Rigorous scientific methods must be applied in a transparent way to reduce uncertainty and ensure that new tech is used responsibly to scale up climate-smart agriculture through stable carbon financing frameworks, benefiting farmers, society, and the earth."
Max DuBuisson,
VP, Head of Sustainability Policy & Engagement, Indigo Ag

"With capital deployments into nature-based solutions poised to rapidly grow in the coming years, it will be critical that such investments are held to the highest transparency standards and support the integration of multiple ecological functions alongside carbon benefits. Nature tech forms the foundation for this effort – it will not only be critical for reducing implementation costs and allowing land managers to apply integrative, landscape-scale approaches, but also in ensuring the benefits of such projects flow equitably to stakeholders on the ground. We welcome this flagship landscaping report as a critical jumping-off point for advancing the sector."
Gabriela Leslie,
Sector Manager, Food, Ag, & Natural Capital, CREO

"Current approaches to protecting tropical rainforests are struggling to scale to the levels needed to halt old forest loss this decade. At the Cambridge Centre for Carbon Credits (4C) we are addressing the deficiencies by applying science, satellite data, and computing power. We support industry collaborations such as nature tech to build on our work and spark planet positive action."
Professor Anil Madhavapeddy,
University of Cambridge

"If we are to meet our collective net-zero goals we need technology that can increase the speed of deployment of the capital to impactful activities and measure the impact with transparency and accuracy. Our portfolio company, Forest Carbon [a carbon project developer based in Singapore/Indonesia], has developed advanced systems for rapid screening of site suitability for peatland restoration and conservation to speed up capital deployment. Their projects are also monitored using a tech-integrated platform that combines fire risk data, peat hydrology models and GIS tracks of patrols and biodiversity monitoring data. As we continue to build our portfolio and the activities of our portfolio companies, we will continue to push for high levels of tech deployment to support the scaling of forest conservation and restoration on the ground."
Adam Gibbon,
Natural Capital Lead, AXA Investment Managers UK Ltd.

Foreword

Manuel Piñuela, co-founder of Cultivo, used just nine words to capture a central theme of this report: 'Capital moves to nature at the speed of trust.'

This sentiment lies behind why this report was commissioned: to describe a new market that is critical for creating the trust required to adequately fund nature-based solutions (NbS).

That market is nature tech.

The words "trust" and "tech" may seem like strange bedfellows, but when it comes to NbS, nature tech is foundational. With it, improvements (and impairments) to nature can be measured, often for the first time, with integrity. Transactions can be made transparent so that nature-positive efforts can be rewarded at the top and bottom of supply chains. And millions of people, many of them resource-constrained, can work together to preserve, manage, and restore nature, all while reliably benefiting from that work.

Nature tech is emergent. The market contours and boundaries are still difficult to discern. Ways of defining and describing its components– its taxonomy – are likewise just coming into focus. The commercial investment databases are not yet 'tagged' for nature tech, making it difficult to assess current and addressable market sizes.

One of the goals of this white paper therefore is to introduce a taxonomy – distinct from climate tech and ag tech – that will help investors and users of nature tech to identify it and describe it consistently. It builds upon an earlier paper produced by Nature4Climate called What you Can Measure, You can Manage: How Nature Tech can help us solve the climate and nature crises.

A final word about our research: we interviewed dozens of market leaders to get their sense of today's nature tech accelerants and inhibitors, and their notions of the market's future. From this, we derived a picture of a market that is dynamic, growing, and investable. That said, it is highly likely that we've missed many players that would otherwise merit mention. If your organization is one of them, please reach out to us so that we can include you in future work.

Tony Lent
Co-founder, Capital for Climate

Lucy Almond
Chair, Nature4Climate

Executive Summary

Nature is a vital resource, necessary for our health, livelihoods, and well-being. According to the World Economic Forum, $44 trillion of economic value generation – more than half of the world's total GDP – is moderately or highly dependent on nature and its services. The degradation of this vital resource is happening at an alarming rate: 32% of the world's forest area has been destroyed; more than 85% of wetlands are gone; 33% of fish stocks are overfished; 50% of coral systems have been destroyed; and since 1970 there has been a 60% population decline across vertebrates.[1]

Climate scientists, ecologists, agronomists, and others have identified a set of nature-based solutions (NbS) that can be used to protect, restore, and manage natural systems and ecosystems. The aims of NbS are threefold: 1) to protect nature and biodiversity, 2) to mitigate climate change, and 3) to ensure that the billion or so people involved with nature on a daily basis, many of them resource-poor, can thrive.

The challenges of implementing NbS are increasingly well understood. These challenges include the following:

- It can be difficult to monitor and to verify the efficacy of NbS projects
- Many NbS projects can be labor-intensive
- NbS require new ways of working and practitioners across value chains don't know how to practice NbS effectively
- Many millions of people need to be mobilized to deploy NbS projects
- The current monocrop-oriented supply chains aren't configured to handle NbS outputs
- Current tools and technology aren't fit-to-purpose for NbS
- The investment ecosystem isn't yet well structured to do NbS investing

These challenges have led to a massive underfunding of NbS. According to Vivid Economics, "**investment in NbS ought to increase four-fold in real terms by 2050 if the world is to meet its climate change, biodiversity and land degradation targets.** This acceleration would equate to cumulative total investment of up to USD 8.1 trillion, and a future annual investment rate of USD 536 billion."[2]

Nature tech is designed to address all of these issues. **Nature tech encompasses any technology that can be applied to enable, accelerate, and scale-up Nature-based Solutions (NbS).** ***Nature tech is differentiated from AgTech and ClimateTech in that its primary focus is on impacts on the natural world.***

The nature tech market can be broadly divided into four categories:

1. **Deployment:** Interventions that help producers boost crop yield and livestock productivity while minimizing the environmental impact of agriculture; tools to facilitate the sustainable utilization, restoration and implementation of natural capital; and techniques to manipulate environmental systems for increased carbon sequestration, biodiversity preservation, and ecosystem service provision.
2. **Measurement, Reporting and Verification (MRV):** MRV refers to the multi-step process to measure climate, biodiversity, and social benefits resulting from an activity, and reporting these findings to management, investors, accreditation bodies, and government entities. MRV creates value by proving that an activity has actually improved these factors so that actions can be converted into credits with monetary value.
3. **Transparency** makes visible the ownership and transactions of natural assets. Traceability enables better decision making for natural asset management and increased accountability. Often used to trace commodities from their point of origination to their eventual use, they build trust between multiple stakeholders including producers, consumers, governments, investors, land owners, and Indigenous peoples and local communities (IPLC).
4. **Connection** is used to connect – at scale – individuals, communities, and organizations to technical assistance, communities of practice, and marketplaces (for financing, inputs, offtakes, etc.).

Today, the nature tech market mainly consists of many smaller players offering point solutions which haven't yet achieved scale. Trends are still difficult to discern. Ways of talking about the market – its taxonomy – are likewise just coming into focus.

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At this point, sizing the nature tech market is difficult because the commercial databases that track investment don't include it as a category. Using a heuristic approach we approximate that the current market size is about $2 billion and that it will grow to $6 billion in less than ten years.

Pressure from policymakers and consumers, and the climate crisis, are driving demand. Solution providers are being rewarded with more productive farms, forests, and landscapes, nature-based credits (e.g., carbon and biodiversity credits), and increasingly premium pricing for their products.

While the nature tech market's growth seems certain, it's anybody's guess as to what directions it will take in the next five to ten years. Nonetheless, four trends seem clear:

1. Nature tech's ability to value and report on nature will greatly improve, providing increasingly bankable benefits for those who protect, restore, and manage natural systems, ecosystems, and landscapes;
2. The main driver of nature tech market growth won't be technology per se, but the world's ability to create effective policy, and to build human capacity and community;
3. As nature tech solutions mature and scale, the market will undergo considerable consolidation and vertical integration, but perhaps with a "mass customization" twist driven by the move away from large-scale industrial agricultural and forest practices;
4. Some of the most important innovations in nature tech will come from the Global South where innovators are actively catering to the needs of local smallholders in ways that may disrupt incumbents in OECD markets.

The nature tech market is emergent, dynamic and investable. Whether you're a nature tech user, developer, or investor, expect the sprint to 2030 to spur innovation and growth.

The Nature Tech Market and Why It Matters

According to the World Economic Forum, $44 trillion of economic value generation – more than half of the world's total GDP – is moderately or highly dependent on nature and its services. The degradation of this vital resource is happening at an alarming rate: 32% of the world's forest area has been destroyed; more than 85% of wetlands are gone; 33% of fish stocks are overfished; 50% of coral systems have been destroyed; and since 1970 there has been a 60% population decline across vertebrates.[3]

Figure 1: Human activity is eroding the world's ecological foundations[4]

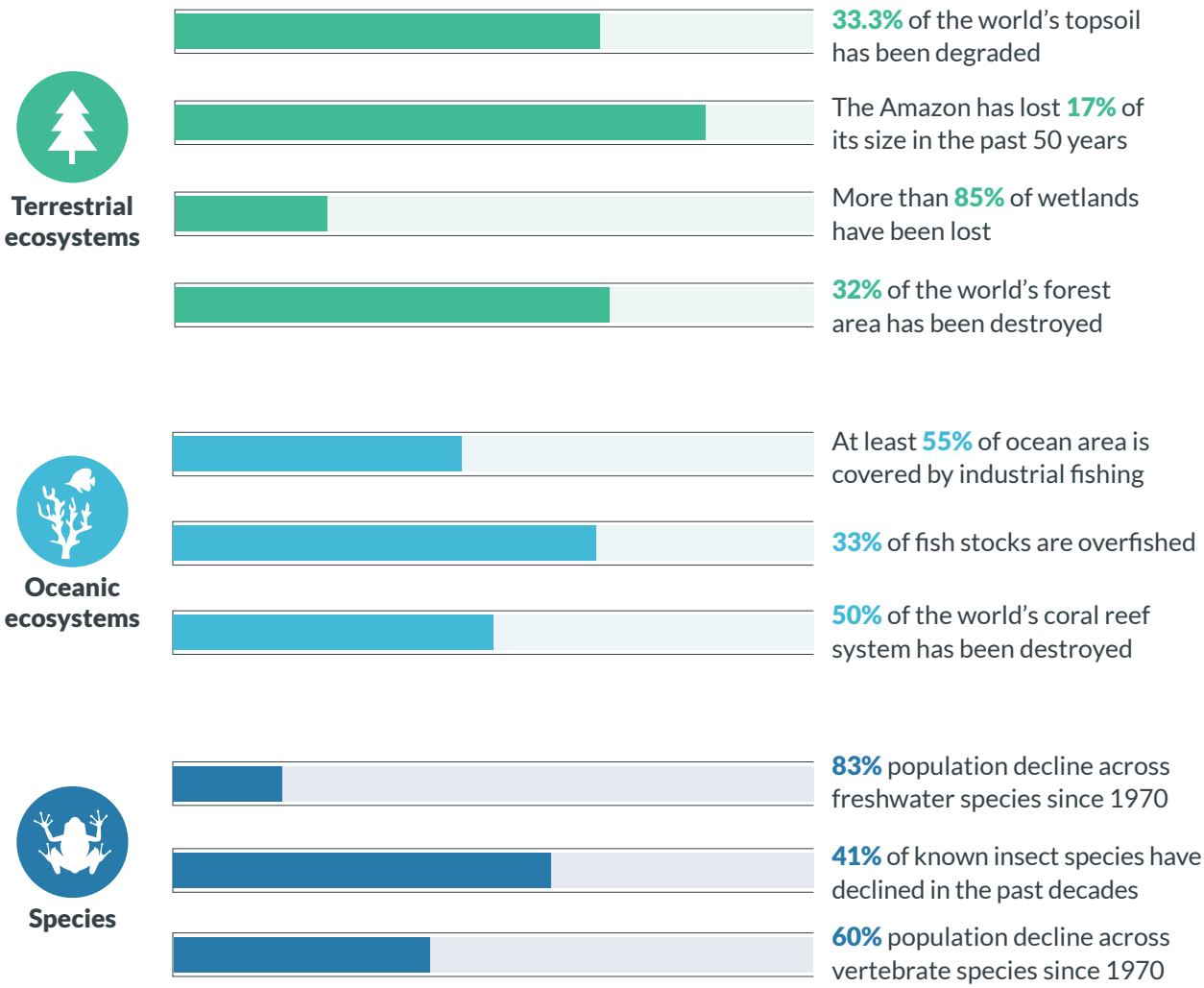

Image adapted from: Nature Risk Rising: Why the Crisis Engulfing Nature Matters for Business and the Economy (https://www3.weforum.org/docs/WEF_New_Nature_Economy_Report_2020.pdf) Source: IPBES, 2019, "Global assessment report on biodiversity and ecosystem services"; Maria-Helena Semedo of the Food and Agriculture Organization (FAO) at World Soil Day 2014; The Economist, 2019, "On the brink – The Amazon is approaching an irreversible tipping point"; WWF, 2018, "Living planet report – 2018: Aiming higher"; F. Sánchez-Bayo and K.A.G. Wyckhuys, 2019, "Worldwide decline of the entomofauna: A review of its drivers", Biological Conservation.

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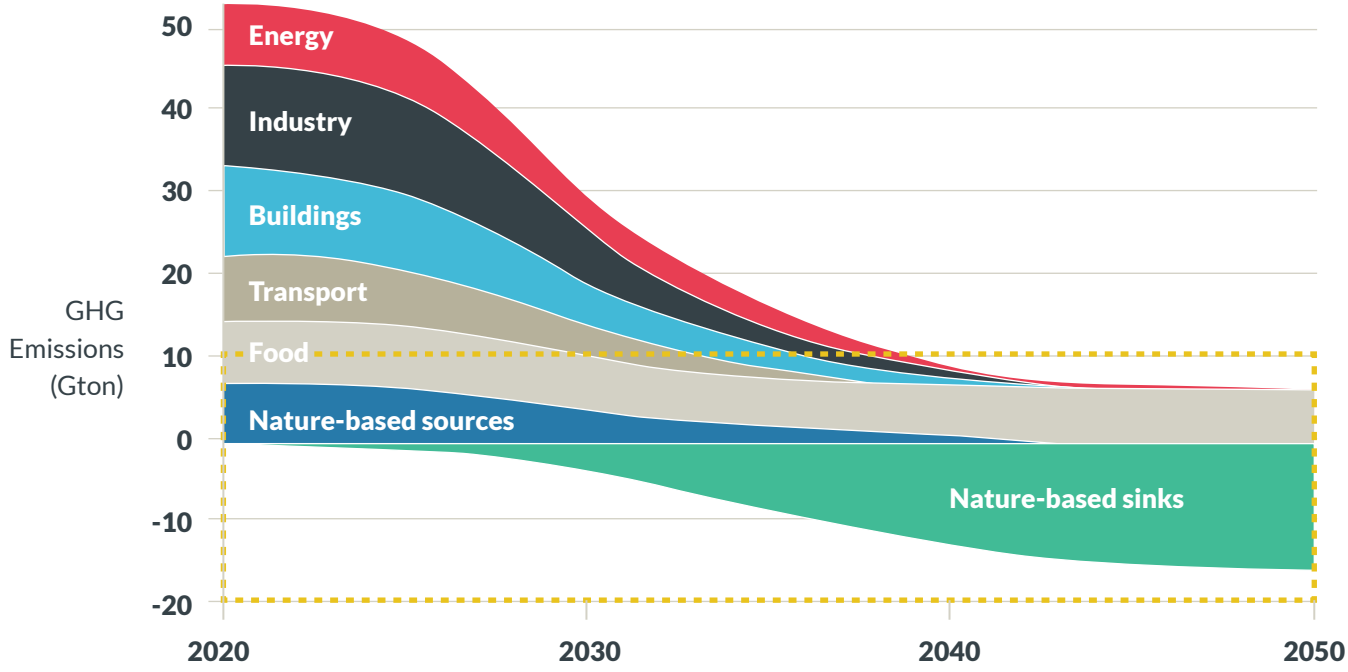
The degradation of nature threatens our economic health, and much more.

Nature tech encompasses any technology that can be applied to enable, accelerate, and scale-up Nature-based Solutions (NbS).

NbS are designed to restore, preserve, and manage nature while mitigating climate change and facilitating a just transition. *Nature tech is differentiated from AgTech and ClimateTech in that it focuses on impacts to the natural world.*

To understand the need for nature tech, one has to understand the importance of NbS, and the challenges of deploying these solutions.

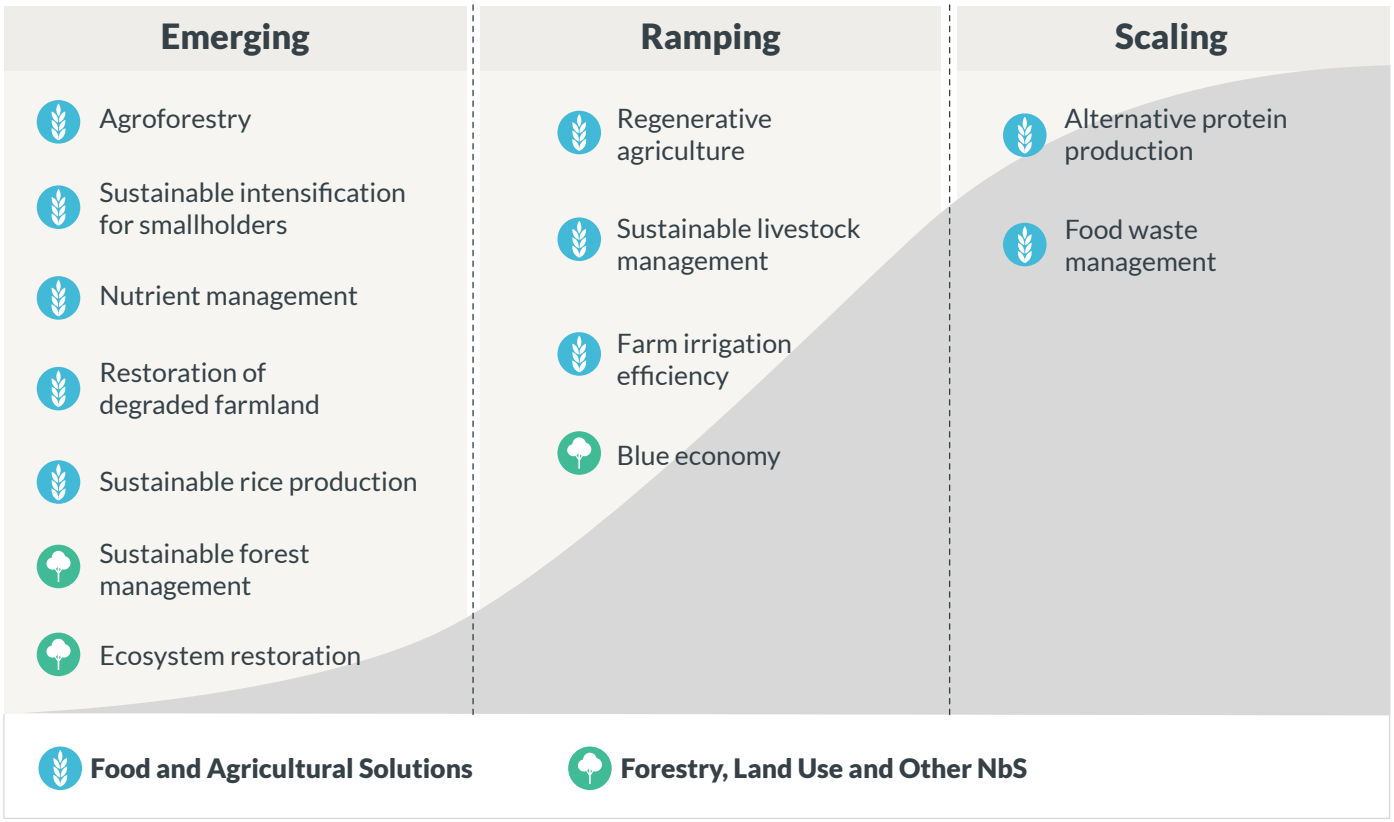
Figure 2: Decarbonization pathways



The area demarcated by the yellow rectangle represents the parts of the decarbonizing roadmap addressed by NbS. Without engaging these sectors – food, nature-based sources, and sinks – achieving net zero by 2050 will be impossible.[5]

Climate scientists, ecologists, agronomists, and others have identified a set of NbS to protect, manage and restore natural systems, ecosystems, and landscapes. They include avoided deforestation, sustainable forest management, agroforestry, intensification for smallholder farmers, nutrient management, restoration of degraded farmland, sustainable rice production, ecosystem restoration, regenerative agriculture, sustainable livestock management, farm irrigation efficiency, the blue economy, alternative protein production, and food waste management. (See NbS.capitalforclimate.com for descriptions and investment theses for each of these solutions.)

Figure 3: Nature-based solution maturity map



Source: https://nbs.capitalforclimate.com/solutions

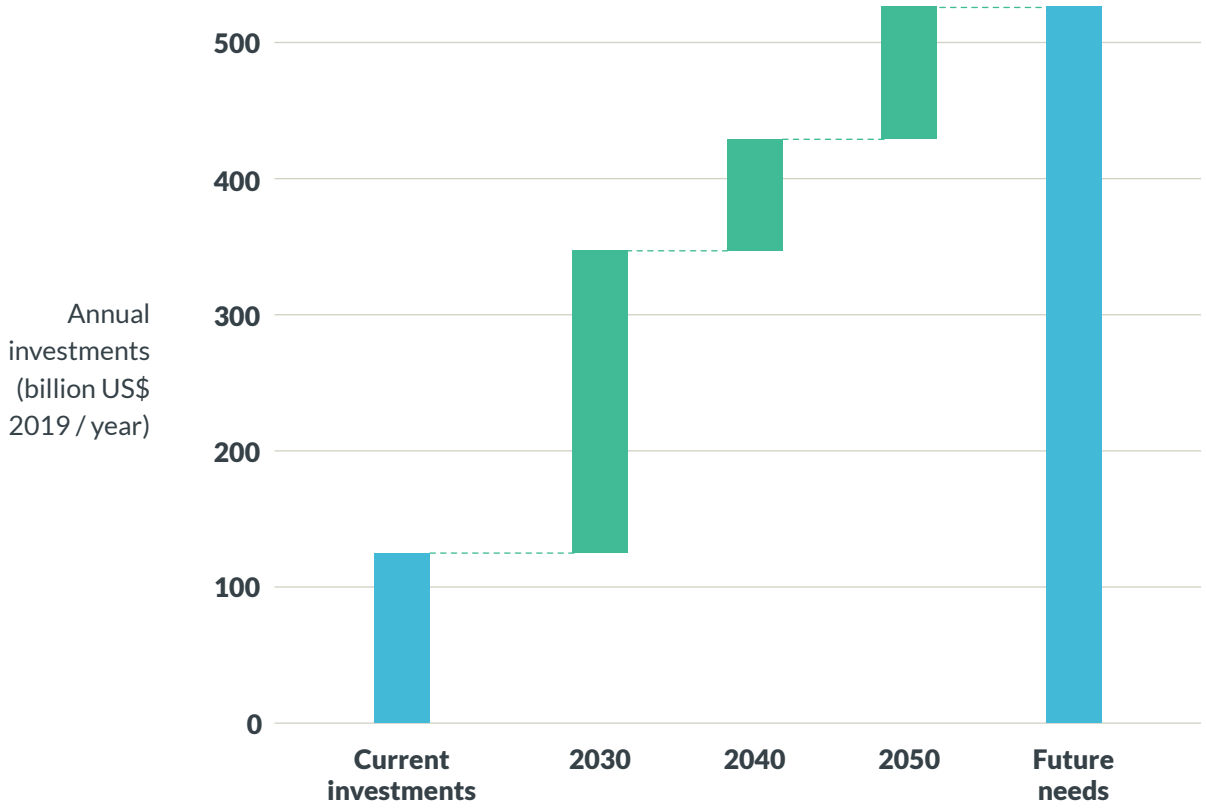
Together, these NbS are our most capital-efficient route to reducing GHG emissions and removing carbon from the atmosphere. According to a 2021 McKinsey/Vivid Economics/ World Economic Forum study, NbS can collectively provide 33% of the CO_2e reductions required by 2030 to achieve net zero by 2050.[6] This can be done in a cost effective way. The same paper estimates that carbon removal with NbS would cost about $50/ton of CO_2e. Compare this with direct air capture: the World Resources Institute estimates that "the range of costs for DAC vary between $250 and $600 [per ton of CO_2e] today, depending on the technology choice, low-carbon energy source, and the scale of their deployment."[7]

According to the Food and Land Use Coalition, investment in NbS could generate a societal return of around $5.7 trillion annually, more than 15 times the investment of $300 billion to $350 billion per year (less than 0.5 percent of global GDP), and would create new business opportunities worth up to $4.5 trillion a year by 2030.[8]

Conversely, biodiversity loss creates material economic loss. For instance, according to The World Bank, "the disappearance of pollinators would have immediate knock-on effects on the US$235 billion to US$577 billion[9] of annual crop output that is directly attributable to animal pollination. Likewise…the loss of critical marine ecosystems such as mangroves, seagrass beds, and coral reefs would affect global marine fisheries that underpin important value chains."[10]

In other words, we ignore Mother Nature at our peril.

Figure 4: Trajectory of annual NbS investment needs to limit climate change to below 2C, halt biodiversity loss and achieve land degradation neutrality, $ billions (2022 USD)



Note: These figures are taken from the Model of Agricultural Production and its Impacts on the Environment (MAgPIE v4.1), which was used to estimate investment need for forest-based NbS (which includes reforestation and afforestation cost estimates), and taken from separately estimated figures for silvopasture (planting trees on agricultural land), mangrove restoration and peatland conservation and restoration. Source: Vivid Economics.

For all their advantages, NbS are massively underfunded.

According to Vivid Economics, "**investment in NbS ought to increase four-fold in real terms by 2050 if the world is to meet its climate change, biodiversity and land degradation targets.** This acceleration would equate to cumulative total investment of up to USD 8.1 trillion, and a future annual investment rate of USD 536 billion. Forest-based solutions alone would amount to USD 203 billion/year, followed by silvopasture with USD 193 billion/ year, peatland restoration USD 7 billion/year, and mangrove restoration USD 0.5 billion/year." (The Vivid report does not cover all types of NbS; for example, marine environments were excluded.)

Another group, The Paulson Institute, estimates that the biodiversity financing gap over the next decade will be $711 billion per year.[11]

Whatever the number is, we know it's massive, and currently there are no firm commitments to address the gap.

The challenges to funding and deploying NbS

So, if NbS are so great, why aren't they being scaled to their full capacity?

Nonprofits, while they serve an important catalytic function, simply don't have the funds required to fully deploy NbS. Commercial implementations of NbS – necessary for sustained funding and deployment – in many cases still don't have a well-defined path to monetization. And NbS approaches differ – sometimes radically – from business-as-usual practices across the entire value chain. Users, suppliers, offtakers, and funders need to rethink how they do business. These kinds of changes are never easy.

The following sums up some of the key challenges to widespread NbS adoption:

1. **Measuring efficacy is difficult:** It is hard to establish baselines, to monitor, and to verify the efficacy of NbS projects. This uncertainty results in the undervaluing of projects designed to enhance ecosystems, damaging their economic viability. Funders also worry about greenwashing from over-optimistic or fraudulent estimations.
2. **Labor intensity:** Many NbS are more labor-intensive than current agriculture and land-management practices. This is especially problematic in many rural areas because of tight labor markets resulting from rural-to-urban migration patterns.
3. **Capability gaps:** NbS require new ways of working, but practitioners across the supply and value chains don't know how to practice NbS effectively.
4. **The need to mobilize multitudes:** Scaling NbS most often involves many individuals and communities – e.g., millions of smallholder farmers and Indigenous peoples – making capacity building more challenging than other less labor-intensive climate solutions.
5. **New value chain requirements:** NbS approaches like regenerative agriculture often work in smaller batches than monocrop systems. Market infrastructure – inputs, payments, offtake, storage, etc. – is currently not optimally configured to support small batch sizes.
6. **Lack of NbS-specific toolsets:** Many NbS (e.g., multi-crop regenerative agriculture systems or ecosystem restoration) require more fine-grained situational awareness because they are more complex than business-as-usual practices. To reap NbS cost, quality, and ecological benefits, practitioners must more carefully utilize inputs like labor, seeds and seedlings, nutrients, water, and pest management.
7. **Investment-related issues:** New financing instruments are required because NbS have longer time-to-value than business-as-usual. Because NbS investment is new for some, the capital stack isn't efficient because players at different levels – from angels to growth equity and private debt – don't yet know each other. And sometimes the underlying asset ownership isn't well established because land titles in developing areas aren't clear.

Nature tech solutions are being designed to address these challenges.

Nature tech to the rescue

Today's market for nature tech can be divided into four broad categories:

Deployment

Deployment is designed to alleviate the challenges faced by NbS practitioners (producers, foresters, ecosystem providers). It includes:

Interventions that help producers boost crop yield and livestock productivity while minimizing the environmental impact of agriculture; tools to facilitate the sustainable utilization, restoration and implementation of natural capital; and techniques to manipulate environmental systems for increased carbon sequestration, biodiversity preservation, and ecosystem service provision.

MRV

Measurement, Reporting and Verification (MRV) refers to the multi-step process to measure climate, biodiversity, and social benefits resulting from an activity, and reporting these findings to management, investors, accreditation bodies, and government entities. A third party then verifies the report so that the results can be certified and carbon credits issued.

MRV creates value by proving that an activity has actually improved these factors so that actions can be converted into credits with monetary value.

Transparency

Transparency makes visible the ownership and transactions of natural assets. Transparency enables better decision making for natural asset management, and increased accountability. Often used to trace commodities from their point of origination to their eventual use, they build trust between multiple stakeholders including producers, consumers, governments, investors, land owners, and Indigenous peoples and local communities (IPLC).

For instance, tech-enabled supply chain traceability can use distributed ledgers (blockchain) to provide valid data on cattle sourcing such as health protocols, genetic fingerprint, performance indicators, geographic location, deforestation-free certifications, and CO_2e emissions.

Connection

Connection is used to connect – at scale – individuals, communities, and organizations to technical assistance, communities of practice, and marketplaces (for financing, inputs, offtakes, etc.).

Connection platforms work to enhance people's capacity to use NbS effectively and in a manner that enables economic empowerment.

Each nature tech solution addresses two or more of the challenges identified above:

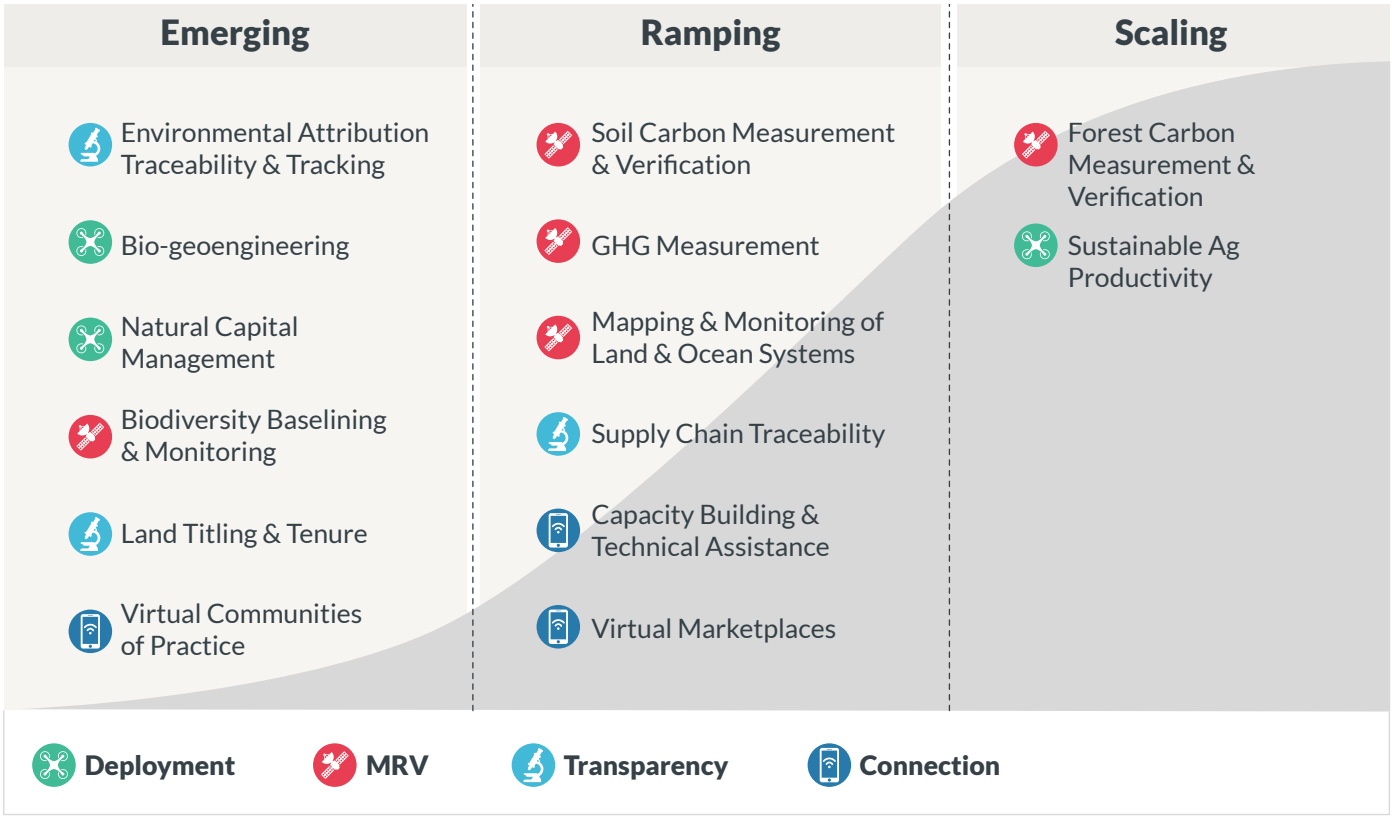
NbS Challenges	Deployment	MRV	Transparency	Connection
Measuring efficacy		✓		
Labor intensity	✓	✓		✓
Capability gaps				✓
Mobilizing multitudes				✓
Value-chain issues			✓	✓
Lack of NbS-specific toolset	✓			
Investor-related issues			✓	✓

More than one person we interviewed said that while agriculture was usually a tech-taker, not a tech-maker, *nature tech was a tech-taker from agriculture.* In other words, nature tech stands on the shoulders of others. The current nature tech market is too small, from a profit-making standpoint, to economically justify the development of much of its own technology from scratch. Artificial intelligence, robotics, and advanced satellite imaging applications are being developed in other sectors and then adapted to the logic of nature tech. This isn't necessarily a bad thing; many of the technologies upon which nature tech is built have been incredibly expensive to develop and are now relatively robust.

Market Maturity and Size

The nature tech market is still in its infancy, with the majority of applications still in the emerging and ramping phases of development and deployment, as shown in Figure 5.

Figure 5: Maturity of nature tech Applications



At this point, sizing the nature tech market is difficult because the commercial databases that track investment don't include it as a category, and no one has yet done a detailed analysis of how much is being paid to purchase nature tech products and services. But we can use a heuristic approach to arrive at an approximation. Public and private flows into NbS are about $154 billion per year, with 25% of that capital being private.[12] Our assumption, based on our own investment experience, is that approximately 1% of the public and 2% of the private investment would be in nature tech. This would imply that the current market size is about $2 billion. If, as the Vivid Economics UNEP report states, we need to invest at least three times this by 2030, then this would imply a market size of approximately $6 billion in less than ten years.

Deployment Technology: Solving Nature-based Solutions' Scaling Challenges

Addressing biodiversity loss and the impacts of climate change **will require the deployment of NbS across billions of hectares.**

According to the Exponential Roadmap for Natural Climate Solutions, to meet climate goals we need to restore 350 million hectares, protect 45 million hectares of forests and wetlands, and adopt more sustainable practices in at least two billion hectares of working land.[13] This amounts to 1.5 times the total landmass of Russia. It needs to be done by 2050.

The problem is that NbS are generally labor intensive and the current toolsets – more suited for monocrop agriculture and industrial forestry – aren't fit-for-purpose.

For instance, restoring whole ecosystems requires native fauna to be replanted in degraded landscapes. Currently, most of this is done through manual direct planting which is limited by human capacity. On average, a professionally trained tree planter can only plant about 1,000 seedlings a day.[14] Relying solely on manual labor would be insufficient for restoring whole ecosystems across millions of hectares by 2050. In addition, cultivating seedlings and establishing an efficient supply chain necessary for large-scale restoration requires time, intricate logistics and money.

Deployment technology aims to alleviate these challenges by implementing NbS more efficiently, quickly, and at lower cost. While drones and aerial seeding often come to mind, nature tech deployment encompasses a whole suite of technologies spanning biotechnology to robotics. It can be broadly classified into:

1. Bio-geoengineering;
2. Natural capital management; and
3. Sustainable agriculture productivity.

With less than 3% of the world's ecosystems left intact,[15] a million species at risk of extinction,[16] and the Amazon (one of the world's largest carbon sinks) at a "tipping point" of becoming a carbon emitter,[17] **bio-geoengineering** offers hope by utilizing biologically-based technology to either deliberately manipulate or leverage natural biological processes for increased carbon sequestration, biodiversity preservation, and sustainable use of natural resources.

Examples of bio-geoengineering include genetically modifying tree seedlings to sequester more carbon, spreading silicate rock over agricultural land for large-scale carbon removal, creating novel and engineered genetics for kelp forest conservation and better resiliency, and cultivating fungi for enhanced mycoremediation of waste or environmental recovery.

Natural capital is a cornerstone of human well-being and underpins a vast majority of economic activities, especially in developing countries.[18] However, management of these assets has often been extractive, resulting in the widespread degradation, destruction, and depletion of both managed and natural ecosystems. Increasingly scarce resources and growing consumer demand are shifting **natural capital management** from extractive to protective and regenerative practices.

Technology can be used to enable and support continued ecosystem service provision that supports livelihoods, biodiversity, and economic development. Examples include remote sensing imagery to map non-timber forest products for sustainable harvesting, combining satellite imagery and on-the ground Internet of Things (IoT) sensors to track the distribution of invasive species that threaten native biodiversity, unmanned aerial vehicles (drones) for large-scale seeding, acoustic sensors combined with remote sensing to detect illegal activity in forests, and IoT sensors to detect forest fires.

Agricultural land expansion and the intensive use of synthetic agrichemicals pose large threats to natural ecosystems and the biodiversity they harbor.[19] Yet agriculture forms the backbone of

many developing economies and is necessary to support a growing global population. Tech-enabled **sustainable ag productivity** enables increased productivity while minimizing environmental impact. The range of technologies for this kind of productivity improvement is often termed "precision agriculture" or "climate-smart agriculture." The underlying technologies are wide-ranging and include IoT in-field sensors, drones, and robots for crop monitoring. Their adoption and use helps farming communities to become more adaptable and resilient in the face of climate change.

Because smallholder agriculture contributes between 20% to 40% of all deforestation and is especially prevalent in the tropics and semi-tropics,[20] making these technological innovations and sustainable farming practices accessible to smallholder farmers is critical. Smallholder farmers number nearly a billion; most operate at low rates of productivity and are often in, or at the edge of, forests. Encroachment on forests often occurs because productivity declines after a few years due to soil nutrient depletion, resulting in declining crop yields.[21]

Examples of how technology can be deployed to improve agricultural productivity include biofertilizers that preserve soil microbes for soil health while increasing fertility, using satellite imagery to track the distribution of certain invasive species and pests, using AI algorithms on data gathered from agriculture IoT sensors to provide producers with recommendations for irrigation and nutrient management, and autonomous agricultural robots that assess the ripeness of fruit and execute selective harvesting.

Investment snapshot and market buzz for Deployment Technologies

Nature-driven precision agriculture has strong investor interest. Investment platform **PitchBook** reports that startups in this area attracted more than $2 billion in funding through 159 deals in 2021.[22] That is a 42.6% increase year-over-year. Agricultural robotics and drones are another area with investor interest. The market for agricultural drones is forecast to reach about $5.9 billion by 2026, at a CAGR of close to 30%.[23] Innovation and investor interest will likely experience continued growth driven by increasing production volatility due to climate change, especially in places where the current one-size-fits-all solutions are no longer viable.

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Traditional agricultural incumbents have also been investing in precision agriculture. John Deere recently invested in Innerplant, a biotechnology company focused on developing genetically engineered crops that give farmers early warning signals when, for example, they are being attacked by pests or are in need of irrigation.[24]

The necessity for large-scale restoration is now being recognized as a huge investment opportunity. This has resulted in the emergence of several high-profile funds such as Mirova's $200 million Land Degradation Neutrality Fund[25], BTG Pactual Timberland Investment Group's (TIG)[26] Restoration Fund that seeks to mobilize $1 billion[27] over five years to acquire, protect, restore, and plant forests in Latin America, and Climate Asset Management's aim to raise $1.6 billion across its two long-dated natural capital and carbon investment strategies.[28]

Very large-scale opportunities in restoration of degraded agland, restoration of ecosystems, carbon project development, and reforestation have led to the formation of a number of platform companies blurring the line between traditional project development and technology providers. These platform companies are becoming prominent players in the NbS market. Emergent companies include Terraformation, EarthShot Labs, re.green, and Mombak.

Terraformation, founded by ex-Reddit CEO Yishan Wong, has generated a lot of buzz since its launch. Bringing Wong's Silicon Valley expertise in scaling, Terraformation describes itself as a forest carbon accelerator that supports early-stage forestry teams in launching, building, and scaling biodiverse reforestation projects globally. Restoration partners are provided with access to seed, training and equipment, funding, and land and water availability, all of which have been identified as bottlenecks to large-scale restoration. In 2019, Terraformation embarked on its first pilot restoration site—Pacific Flight at Kaupalaoa—in the northern region of Hawai'i Island. The team built a fully off-grid, 100% solar-powered desalination system to supply sustainable freshwater to the site, enabling planting of native seedlings. The company is looking to launch a $100 million fund[29] focused on early-stage projects in emerging markets in late 2022. Terraformation has raised a total of $40 million in funding[30] over four rounds. Their latest funding was raised on April 5, 2022, from a Series C round.

Mombak and re.green – two Brazilian project developers – combine technology, science, sustainable native hardwood forestry and carbon credits to achieve large-scale restoration of tropical rainforests. Mombak focuses primarily on the Amazon while re.green has a focus on both the Amazon and the Atlantic Forest. Through the restoration of native, biodiverse ecosystems, both companies are expected to catalyze the carbon market in Brazil through the creation of high-quality carbon credits from their projects.

Aerial seeding drone companies have also been attracting investor attention globally with several companies closing multi-million venture deals over the past year. DroneSeed (profiled below) closed a $36 million Series A round in late 2021.[31] It is expected that this sector will continue to see positive growth.

While sustainable agriculture productivity technology is scaling, bio-geoengineering is still considered emergent technology and it remains to be seen how the field will evolve.

Examples of how technological innovation has spurred the emergence of companies in this sector include:

Pivot Bio, a biotechnology company based in California that has developed a proprietary microbial nitrogen fertilizer using a fermentation production process. Its aim is to increase agricultural productivity with minimal environmental impact. The company's biofertilizer offers a direct replacement to synthetic nitrogen fertilizer with a 98% lower carbon footprint, and is designed to work on cereal crops, which are some of the most nitrogen-intensive. Pivot Bio has raised a total of $616.9 million in funding over six rounds.[32] Their latest funding was raised on July 19, 2021, from a Series D round and was one of the biggest agtech rounds of the year, according to the annual investment report by AgFunder.

Another biofertilizer company is Kula Bio, which was founded in 2018 and is built upon research from Harvard University. The research showed how beneficial natural nitrogen-fixing bacteria could be propagated and then "supercharged" with a carbon-rich energy source to produce Kula-N, a crop-agnostic, sustainable, and organic biofertilizer. The company has raised a total of $72.1 million in funding[33] over seven rounds with a $50 million Series A round[34] closed in January 2022.

Trace Genomics is a San Francisco startup that uses metagenomics[35] and AI-enabled diagnostics to analyze soil to predict soil health and crop quality. Farmers can use Trace's analytics to make decisions on crop selection, nutrient management, and rotational practices that increase yields and decrease input costs and waste. The company has received over $39.7 million over nine rounds, with the latest round closed at the end of November 2021.[36] Pattern Ag is a similar company that provides producers with soil microbiome analysis and recommendations for input. The company has raised a total of $50 million over three funding rounds.[37] Their latest was raised on August 25, 2022, from a Series B round.

A move towards sustainable agricultural practices requires new tools. Autonomous smaller, lighter, robotic units that can be used in swarm configuration in more complex systems are highly desirable in the tight labor markets often found in rural areas. The newest models can weed, harvest, and plant. Examples include French-based Naïo Technologies, which has designed three robots for a range of agricultural functions. Last year, the company closed a $15.5 million Series A funding round.[38] Aigen, a US startup, raised a $4 million Seed round for its solar-powered weeding autonomous robot earlier this year.[39]

Droneseed is an example of a company enabling the sustainable management of natural capital. Founded in 2016, Droneseed is a vertically integrated aerial seeding company that offers seed, seedlings, reforestation, and carbon-credit services. It is the only company approved by the US Federal Aviation Agency to deploy heavy-lift drones to reforest after wildfires. The company claims to have accelerated the growth process of its seedlings from a three-year cycle to "just months" with its proprietary seed vessels. DroneSeed recently announced that it had raised $36 million in a Series A round led by Social Capital and Seven Seven Six.[40] In total, the company has raised $41.3 million in funding over eight rounds.[41] In 2021, the company acquired Silvaseed Company, one of the largest private forestry seed suppliers in the Western US. Dendra Systems is another aerial seeding company with roots in the UK and Australia. They have raised a total of $15.7 million in funding over four rounds[42] with $10 million raised from a Series A round that closed in September 2020.[43]

Ensuring the protection of forests against wildfires, Dryad Networks is a German company using a large-scale IoT network of sensors to provide early warning of wildfires and tree monitoring for public and private forests. Dryad developed a wireless environmental sensor network based on LoRaWAN: an open-standard for long-range radio IoT networks. Their patent-pending distributed architecture enables large-scale deployments in areas without existing network coverage. The company has raised a total of €13.9 million in funding over three rounds, the latest in August 2022.[44]

The majority of bio-geoengineering companies are early-stage. **Living Carbon** is a bio-geoengineering company founded in 2019 that is genetically modifying trees for increased carbon sequestration by enhancing the plants' ability to photosynthesize. Living Carbon trees were found to accumulate 53% more biomass than control seedlings, with faster growth and more carbon capture. In addition, the company has also developed a "metal accumulation trait" so that trees can absorb more metals and be planted to remediate polluted land. Living Carbon has raised a total of $15 million in funding over two rounds with the latest in February 2022.[45]

FUNGA is a recent US soil inoculation startup that is using modern DNA sequencing tools and machine learning to analyze forest fungal microbiomes that improve forestry outcomes. Mycorrhizal fungi and plant roots live in symbiotic relationship, which leads to improved soil carbon sequestration. A study has found that, globally, these mycorrhizal networks sequester about 5 billion tons of carbon annually.[46] FUNGA is hoping to capitalize on fungi's potential by inoculating forests with its appropriate native, biodiverse communities of mycorrhizal fungi, leading to quicker growth, more carbon sequestered, and more-resilient forests.

Biophilica is a UK company that has developed Treekind, a plant-based leather alternative for the fashion industry. Treekind is made from green waste (lignocellulosic feedstock) and uses a plant-derived and biodegradable binder to create a novel material that closely resembles leather. In April 2022, the company raised a £1.2m Seed round to bring its plastic-free leather alternative to market.[47] Rhapsody Venture Partners led the round.

Zero-G Horizons Technologies was founded in 2018 to design and build sustainable technologies for space applications and marine ecosystems. The company developed a two-part modular coral mounting system that assists in coral replanting for coral reef restoration. Current coral planting is done manually, which is time-consuming, with divers only able to plant about 20 specimens over an hour-long dive.[48] These modular anchors could help speed up the process significantly, to almost 15 times the rate of manual outplanting. Conservation X-Labs is a partner.

See the nature tech company directory at the end of this report.

MRV Technology: Measuring Value to Create Value

Today, we live in the anthropocene. There is no part of nature that is not significantly affected by humans. To date, most human activity has been detrimental. We can no longer just hope that nature will take care of itself. Like it or not, we must manage it. And to manage nature, we must measure it.

Measuring, reporting, and verification (MRV) gives us the ability to baseline the health of nature – biodiversity, resilience, etc. – and to measure whether a human activity improves or worsens it. MRV allows us to see what works and what doesn't, so that we can set effective policy. It also gives us data so that we can reward those who successfully improve the natural environment and those who do no harm.

Measuring the effect of human activity on nature is difficult. Determining the health of ecosystems is a complex, multivariate affair that has to take into account geography, season, weather, and much more. And there are epistemological issues that go beyond the science. Will preserving a particular patch of forest prevent it from becoming a parking lot in five years, avoiding the resultant additional carbon emissions and biodiversity loss? How do we value a counterfactual?

These are the challenges that MRV is designed to address.

As currently defined, MRV is a three-step process:

- **Measuring** climate, biodiversity, and social benefits resulting from an activity;
- **Reporting** these findings to management, investors, accreditation bodies, and government entities; and
- **Verifying**, through an independent third party, the accuracy and completeness of the report so that the results can be certified and carbon credits can be issued. [49]

Today, these processes are implemented by a variety of institutions, including governments, civil society, research organizations, and consultants.[50]

What is the status of the MRV technology market?

"Carbon offset markets are the most powerful nature-linked revenue-generating machine." - Taskforce on Nature Markets

The primary driver of investment in MRV is the strong demand for carbon credits by corporates to counterbalance their emissions. According to Forest Trends & Ecosystem Marketplace, the Voluntary Carbon Market (VCM) is now estimated at almost $2 billion.[51] This number is up from $1 billion in 2021, $473 in 2020, and $320 in 2019.[52] Now, with Article 6 of the Paris Agreement from COP26 set to further bolster the VCM, quality credits will be in even greater demand. Guy Turner, from Trove Research, predicts that carbon credit spending may jump by a factor of twenty over the next ten years.[53]

"Article 6 of the Paris Agreement allows countries to voluntarily cooperate with each other to achieve emission reduction targets set out in their NDCs. This means that, under Article 6, a country (or countries) will be able to transfer carbon credits earned from the reduction of GHG emissions to help one or more countries meet climate targets." - The World Bank

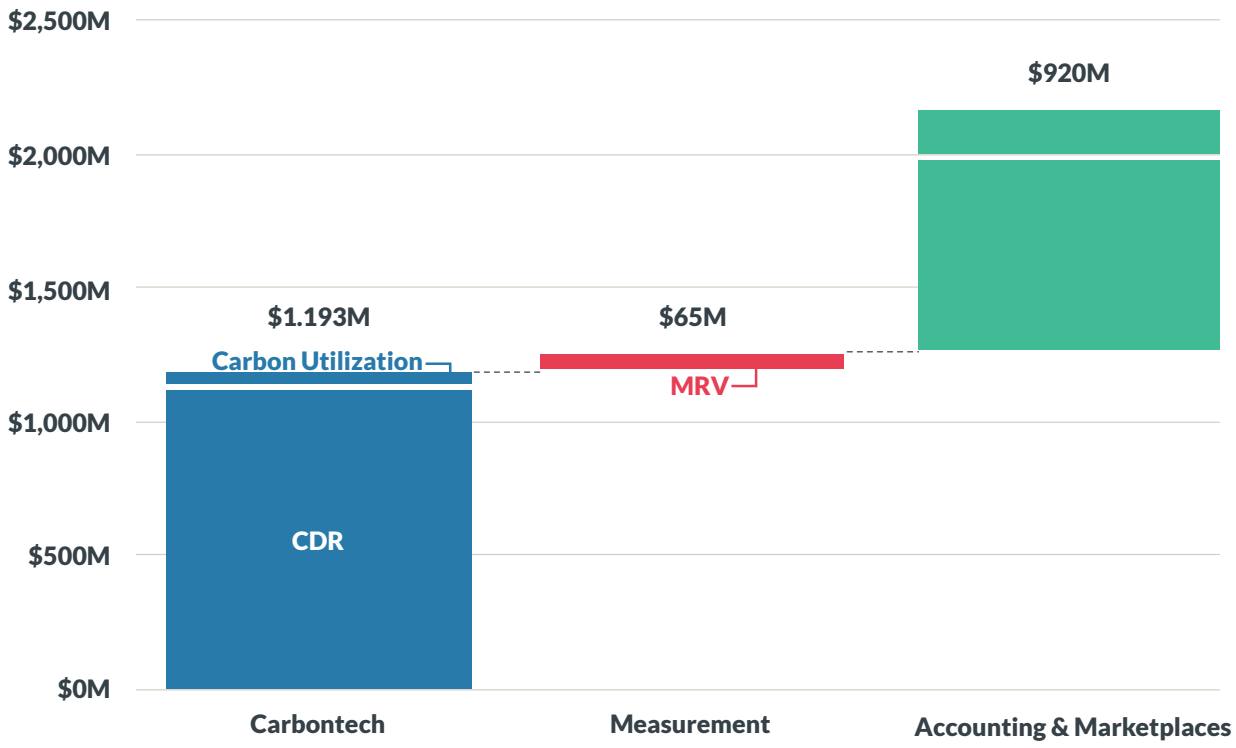
Biodiversity credits and payment for ecosystem services (PES) – nascent but growing forms of remuneration for stewarding ecosystems – are also becoming factors in the demand for MRV.

While the outlook for payment systems for nature is bullish, the market is nonetheless acutely constrained by the current state of MRV. Until now, MRV has mostly been bespoke, labor intensive, plagued by long turnaround times, lacking in geospatial explicitness, not informed by standard methodologies, expensive, and generally deemed unreliable. According to a report by ClimateCHECK, Gold Standard, and IOTA, more than 90% of standard MRV practices are analog and manual processes.[54]

MRV also has a credibility problem. Articles like this one in The Guardian – "Australia's carbon credit scheme 'largely a sham', says whistleblower who tried to rein it in" – and exposés by popular figures like John Oliver – where he casts doubt on the veracity of carbon credits – make potential buyers wary.

These challenges have contributed to a diminished confidence in the VCM sector and a corresponding underfunding from the VC market in MRV.[55] "MRV tools make up only 3% of carbon removal venture funding" at just $65 million.[56]

Figure 6: Carbon removal funding by approach



Source: https://climatetechvc.substack.com/p/-a-big-week-for-cdr-98

Today's MRV technology is designed to address these challenges. NbS carbon crediting approaches are also continually improving with better standards, new science, updated methodologies and approaches, and evolving technology. The following technologies are radically reducing MRV's cost and improving its accuracy in the following areas:

1. **Biodiversity Baselining & Monitoring:** The assessment of the condition of an ecosystem[57] – including its species richness – in a given area through surveying, monitoring, and verification is enhanced through improved bioacoustics, biologically-based technology, remote sensing, and artificial intelligence.
2. **Forest Carbon Measurement & Verification:** The process of assessing and validating the amount of carbon stored, or that could be stored, in the woody and non-woody biomass of trees as well as the rate new carbon is being sequestered into biomass from biological growth is improved through enhanced remote sensing, artificial intelligence, and data analytics.

3. **GHG Measurement:** The assessment of the levels of greenhouse gas emissions with the unit of measure as tonnes of carbon dioxide equivalent (tCO_2e) is improved through enhanced remote sensing, IoT sensors and artificial intelligence.
4. **Mapping & Monitoring of Land & Ocean Systems:** The process of understanding the topography of a given area in terrestrial and marine ecosystems, their current conditions and how these are changing, or could be changed, over time is improved through enhanced remote sensing and IoT sensors.
5. **Soil Carbon Measurement & Verification:** The process of assessing and validating the amount of carbon stored in global soils either as organic (SOC) or inorganic (SIC) matter is improved through enhanced remote sensing, IoT sensors, data analytics, and artificial intelligence.

There are at least three trends in MRV technology worth watching:

Digital MRV and MRV 2.0 are two efforts to move away from loosely coupled point solutions to fully integrate the three components of measurement, reporting, and validation into the nature value chain. "Digital MRV" is a consortium formed by ClimateCHECK, Gold Standard, and IOTA.[58] The World Bank is promoting "MRV 2.0".[59]

Common to these efforts are the following principles:

- Ensure cohesiveness, interoperability, and systems access to all through a technical backbone that will be: open source, without user fees, low-energy to support remote users, modular, and with high levels of data integrity and security;
- Integrate with other digital platforms, hubs, and infrastructure, and support proprietary applications where applicable to reward market leaders;
- Govern collaboratively by fostering online user communities for standards development and assurance; and
- Provide support for new business models, digital currency transactions, and smart contracts.

These efforts are still in their early days and their ideal end state may or may not be reached. Nonetheless, they represent significant efforts to standardize and rationalize MRV in order to meet the strong demand for solutions.

"Good enough" solutions promote using *only* remote sensing to keep the costs of MRV very low so that even smallholder farmers can participate in carbon markets economically. The logic behind these efforts is that, as long as there isn't systematic bias in the measurement, the law of large numbers will create reliable credits. Technological improvements in remote sensitivity now allow daily sampling at the 30 metres granularity. AI programs have become more powerful for analyzing this data.[60] The result is much higher accuracy, as proven by on-the-ground sample testing. Boomitra (described later) is an example of a company promoting this.

Using AI to solve the counterfactual problem. How can a developer or investor determine what would have happened had there not been an intervention? As Pachama puts it, "Paying landowners who are already protecting their forests clearly does not reduce emissions."[61] To address this issue, companies like Pachama use satellites to observe the constantly changing reality on the ground. They match each satellite pixel in a project to a pixel outside the project across a range of attributes, such as "the distance to the nearest road, topography, and forest vegetation density." This gives them the ability to create a dynamic baseline that adjusts to "political events, economic swings, or other unexpected shocks that alter background deforestation."

Internet of Things (IoT) sensor technology:
Devices that collect data by detecting changes in the physical environment and which are connected to the internet or other communication networks to enable real-time smarter decision-making. Examples of the types of information IoT sensors can collect include temperature, humidity, soil moisture/pH, fire detection, air and water quality, and the presence of pests.

Remote-sensing technology:
Technology that allows data (physical characteristics of an area) to be gathered from a distance without the need for direct contact for image processing and interpretation. Types of remote-sensing technology include lasers, radars, electromagnetic radiation sensors, and infrared. Examples of how remote-sensing technology can be applied includes light detection and ranging (LIDAR) for ocean and coastal mapping, infrared sensors for camera traps, and electromagnetic radiation sensors on satellites to monitor land use changes.

Below are a few examples of companies looking to contribute to a more robust MRV landscape:

Pachama: combines machine learning with satellite and airborne observations to measure carbon captured in forests. Currently Pachama is developing a dynamic baseline to evaluate existing carbon projects and originate new projects. Pachama's dynamic baseline attempts to reduce uncertainty around a project's baseline by observing carbon emissions in a control area against a "placebo project" – an area without a carbon project, selected at random – rather than by trying to predict future deforestation.[62] Their current work is focused on avoided deforestation projects, but they are looking to use this approach for reforestation and improved forest management (IFM) projects, too.[63] Pachama has raised a total of $79.3 million over six rounds.[64]

> "The leading edge of the financial community is retooling itself to deal with nature, just as it has increasingly done over the last years for aspects of the climate challenge." - Taskforce on Nature Markets

Perennial (formerly Cloud Agronomics): is an MRV platform for tracking soil-based carbon removal. By combining machine learning, ground observations, and remote sensing, Perennial seeks to map historical, present, and future soil carbon and land-based emissions.[65] They use an in-house archive of in-situ soil samples across cropland, pastureland, and rangeland joined with remote sensing and environmental variables to train their machine learning algorithms for the prediction of soil organic carbon content over time.[66] They offer fully annualized emissions breakdowns by source for CO_2, N_2O, and CH_4. Perennial's aim is to cut MRV costs through reducing or eliminating the need for soil sampling and practice data.[67] Perennial's MRV platform enables both carbon offsetting and insetting and assists agri-food companies with measuring and reducing emissions within their value chains.[68] Additionally, they partner with companies that are developing non-food-related soil carbon crediting projects to monitor and verify them.[69] Perennial has raised a total of $24.5 million in funding over five rounds across eight investors. Their latest funding was a series A in May 2022.[70]

NatureMetrics: wants to bridge the gap between molecular ecologists and environmental managers by making biodiversity data easily accessible to any user. Their technology seeks to foster greater accuracy in measuring and monitoring biodiversity through custom-designed sampling kits and bespoke training services.[71] NatureMetrics currently works with businesses and conservation groups looking for environmental impact assessments and is developing their ability to deliver nature data to ESG investors, consumer supply chains, and governments.[72] NatureMetrics has raised a total of $27.4M in funding over four rounds – their latest a Series B in May 2022.[73]

Yard Stick: measures soil carbon and seeks to enable soil carbon removal at scale through the use of soil spectroscopy. Yard Stick's platform is embedded in a hand-held probe that uses spectral analysis, resistance sensors, machine learning, and agricultural statistics to measure and calculate soil carbon.[74] Alongside their hand-held device they are also piloting a project data platform. Yard Stick provides a web-based planning dashboard where users can upload farm and field boundaries and select a project methodology (e.g., CAR SEP, Verra VM0042).[75] Yard Stick believes it can reduce the cost of measuring soil carbon by more than 90 percent vs. more traditional manual methods.[76] The company has raised $25.4 million in funding over six rounds. Their latest funding was a grant in September 2022.[77]

Boomitra: uses satellites and AI to measure a variety of soil properties, including soil carbon, soil moisture, nitrogen, phosphorus, and more. In an attempt to remove costly hardware and labor-intensive soil sampling, Boomitra is championing "best estimates" rather than precision agriculture.[78] Boomitra believes that a directly accurate soil carbon measurement is not usually needed for interpreting the accuracy of the carbon credits themselves.[79] According to Boomitra, their technology has been validated against much more expensive methods in a variety of ways: trials with actual soil sensors and sampling, comparative plant-health studies on farms using Boomitra, and by third-party evaluations in internationally-certified carbon projects.[80] Boomitra has raised a total of $4.1 million in funding over two rounds, their last a Seed round in June 2021.[81]

FLINTpro: offers SaaS and API services designed to enable carbon markets, ESG reporting, and sustainable land management. The software supports a broad range of businesses including those involving forests, agriculture, soils, and blue carbon. The platform enables emissions reporting for land managers as well as large agribusiness, corporates, and financial organizations. FLINTpro claims that it can incorporate nearly all remote sensing products on the market, and is configurable to model forests and other landscapes depending on the reporting needs, data availability, and output requirements.[82]

Additionally, FLINTpro attests to cover all three IPCC Tiers, and claims the ability to align with specific modeling frameworks required under market mechanisms and credit programs.[83] On August 10th, 2022, it was announced that a group of 10 farms would partake in a trial of FLINTpro as part of the Target Net Zero for Farms Project sponsored by the Australian government.[84] The project's aim is to help grain producers confidently and efficiently measure and report farm emissions.[85] Once ended, the trial will be assessed on its ability to scale to more grain producers across the country.[86] FLINTpro raised $1.2 million in a Seed round in March 2018.[87]

Earthbanc: is a data-driven carbon and finance marketplace. It is financing carbon projects greater than 100 million hectares by leveraging digital MRV, AI and Web3 to scale climate solutions. Earthbanc has raised a total of $3 million in funding over two rounds. Their latest funding was raised on April 5, 2022, from a Pre-Seed round.[88]

Below are some initiatives in the MRV space:

The Science Based Targets initiative's Request for Proposals: The SBTi is interested in awarding a contract for the development of the technical foundations for its MRV project. The RfP is looking for a clear and standardized mechanism to assess, verify and enhance corporate accountability on progress towards science-based targets.[89] The goal is to give companies and financial institutions coherent expectations and guidance on how to measure, report and verify progress against the achievement of targets. The RfP includes a landscape analysis on MRV with internal and external resources, including SBTi key staff and partners, companies, civil society (business-facing CSOs, advocacy NGOs/campaigners, and policymakers/policy experts), investors, media, amongst others.[90]

Climate TRACE: is harnessing satellites and artificial intelligence to advance emissions monitoring through direct observation and open data. The inaugural Climate TRACE dataset unveiled in September 2021 covers annual emissions for every country on Earth across 10 sectors and 38 subsectors for the years 2015 through 2020. Some of the biggest developments coming down the Climate TRACE tech pipeline include adding both temporal and spatial granularity.[91]

Despite its growing pains, a high-integrity voluntary carbon market has the potential to mobilize, at speed and scale, billions of dollars a year in additional climate finance that removes carbon or cuts emissions that help the world stay within the 1.5C limit of the Paris Agreement, and that benefits communities and ecosystems more broadly.

With high-integrity standards in place, the voluntary carbon market can also build resilience and transfer wealth to the world's most vulnerable countries and support sustainable development and the livelihoods of Indigenous peoples and local communities.

See the nature tech company directory at the end of this report for additional MRV companies.

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Transparency Technology: Bringing Accountability, Fairness, and Integrity to NbS

Today, many economic systems don't put a value on nature. Nature is treated as an externality. It doesn't appear on balance sheets, nor is it considered in the value chain. Economically invisible, nature is degraded without apparent consequence because there is no cost associated with its destruction.

Transparency makes the *value* of natural assets visible to all stakeholders. Transparency traces value through its different owners as it is transacted across value chains. A key attribute of transparency is visibility into the provenance of the information being shared. Accountability is created because transactions, and how they are recorded and by whom, are no longer hidden within black boxes.

There are billions of dollars of willing capital waiting to invest in NbS, and hundreds of large corporates interested in sourcing NbS products from sustainable sources. Leading financial institutions with over $8.7 trillion in assets under management have committed to tackling agricultural commodity-driven deforestation, with a desire for supply chain traceability playing a key role.[92] But without transparency, NbS are difficult to fund. While most NbS create intrinsic value, their investability significantly increases if the value of nature is recognized. Transparency makes trading natural assets and products possible, for example in the form of carbon credits, payments for ecosystem services (PES), and biodiversity credits. Transparency creates trust that nature is being valued accurately without greenwashing, and this accelerates investment in NbS. *As Manuel Piñuela, co-founder of Cultivo puts it, "Capital moves to nature at the speed of trust."*

Transparency also enables better natural resource management and enhances value chain accountability across multiple players. For instance, we know that at least 17% of all Brazilian beef exports to the EU are linked to illegal deforestation in the Amazon and Cerrado.[93] Policies can now be devised that make it illegal to import beef raised in this way, which would force offtakers to ensure that their beef is deforestation-free. This would incentivize investors and producers to use NbS to address this situation through applications like silvopasture and rotational grazing practices. These NbS would reduce the destruction of these vital biomes while also improving the livelihoods of producers.

Traceability-focused nature tech is being used today in three ways to greatly enhance the investment in, and deployment of, NbS. It is being used to create transparency in:

1. **Supply chains;**
2. **Environmental attribution markets; and**
3. **Land titling and tenure.**

Historically, production of commodities has contributed to immense land-use changes, habitat degradation and social inequality. In today's global world, supply chains are complex, opaque, fragmented, and often geographically dispersed, making tracking food and consumer products difficult.

Tech-enabled transparency helps identify and track the provenance and journey of products and their inputs as they move along the supply chain from source to consumer.[94] Currently, the majority of supply chain traceability applications are used for agribusiness commodities like soy, livestock, cotton, corn, and timber, but are also beginning to be used for agroforestry products like cacao and coffee and seafood.

Examples of technology used for transparency include using blockchain technology for beef traceability that allows consumers visibility on animal data such as health protocols, performance indicators, and geographic location.[95] Remote-sensing technology combined with animal tagging can also allow for deforestation-free certification and, in some cases, even track CO_2e emissions.[96] Remote-sensing technology, combined with DNA identification and blockchain technology, can be used to trace timber products' origins and validate their legality.[97] DNA-based techniques can also be used to identify species and the geographical origin of fish to combat illegal, unreported, and unregulated (IUU) fishing.[98] Blockchain technology can also be used to trace produce from smallholder farmers, which can certify fair labor standards.[99]

Environmental attribution markets include the voluntary carbon market (VCM)[100], payments for ecosystem services (PES), and biodiversity credits. The historical lack of transparency has severely constrained the growth of these markets.

Technology such as distributed ledger technology (DLT) helps to alleviate some of these issues by enabling the digital documentation and tracking of transactions within a distributed network. This reduces market intermediation and allows for more precise and timely data sharing among participants.[101] In forest carbon credits, blockchain has demonstrated its potential to improve the verifiability of credits and to reduce transaction costs.[102] In addition, because data is recorded as a permanent ledger that cannot be modified, transparency is increased. The risk of "double counting" of credits is also reduced as transaction information is readily available for verification.

An example of how DLT could be employed is a blockchain prototype developed by the Commonwealth Bank of Australia (CBA) and BioDiversity Solutions Australia (BDS) in 2019.[103] Through the creation of tradable digital tokens (BioTokens), the initiative aims to boost sustainable development while enabling investment opportunities for landowners, environmental groups, and developers. Blockchain allows for the verifiable delivery of BioTokens and enables transactions to be tracked.

Carbon registries such as The Voluntary Registry Offsets Database, developed by the Berkeley Carbon Trading Project at CEEP[104] in collaboration with Carbon Direct, also play a critical role in increasing the transparency of the voluntary carbon market by providing visibility on credits and projects. The database contains all carbon projects, credit issuances, and credit retirements listed globally by four major voluntary carbon market project registries—Climate Action Reserve (CAR), American Carbon Registry (ACR), Verra (VCS), and Gold Standard.

The Amazon Bank of Codes (ABC), an initiative developed by the World Economic Forum, is another example of how blockchain technology could be applied. ABC is an open, digital platform that puts genetic codes of Amazonian biodiversity on a blockchain and codifies rights and obligations related to their use. The aim is to open up innovation while preventing "biopiracy".[105] Companies that want access to the data will have to buy it using a cryptocurrency where a portion of the revenue will be paid to the communities taking care of the rainforest. The ABC is a pilot for a larger Earth Bank of Codes (EBC) – the global version of the same idea.

Technology has the potential to bring clarity to the determination, recording, and dissemination of land ownership, as well as to the value and use of the land and its associated resources. In many parts of the developing world, land tenureship and titling are unclear. Current methods of land administration, if there are records at all, use printed documents, which can be easily replicated, tampered with, or even destroyed.

Investment in NbS where property rights are not established is very challenging. Unclear titling has led to real estate speculation, land grabbing, illegal utilization of resources, and in some cases violent conflict involving disputes between forest communities and parties trying to appropriate land.[106]

Digital ledger technology (DLT) – which is designed to reliably and inexpensively establish clear ownership rights and the provenance of those rights – can help. Examples include using a blockchain to record land transactions in a decentralized Land Registry,[107] using remote-sensing technology[108] such as drones, camera traps, and GPS to map and protect territory, and machine-learning algorithms for land valuation.

Traceability tech market sizing and some key players

The demand for traceability is growing, driven by increasing regulatory requirements for organizations to disclose their climate and nature-related risks. Global governments have started to adopt mandatory climate-related disclosure legislation in line with the Task Force on Climate-related Financial Disclosure (TCFD)[109] recommendations.

Emulating the TCFD framework, the Task Force on Nature-related Financial Disclosures (TNFD) – a global, market-led initiative established to factor nature-related risks into financial and business decisions – was launched in 2021. TNFD released its first beta version of the TNFD Nature-related Risk & Opportunity Management and Disclosure Framework in March 2022, marking the beginning of an 18-month consultation and development process. Its final recommendations are slated for release in September 2023. Like TCFD, TNFD recommendations will most likely become mandatory in some jurisdictions.

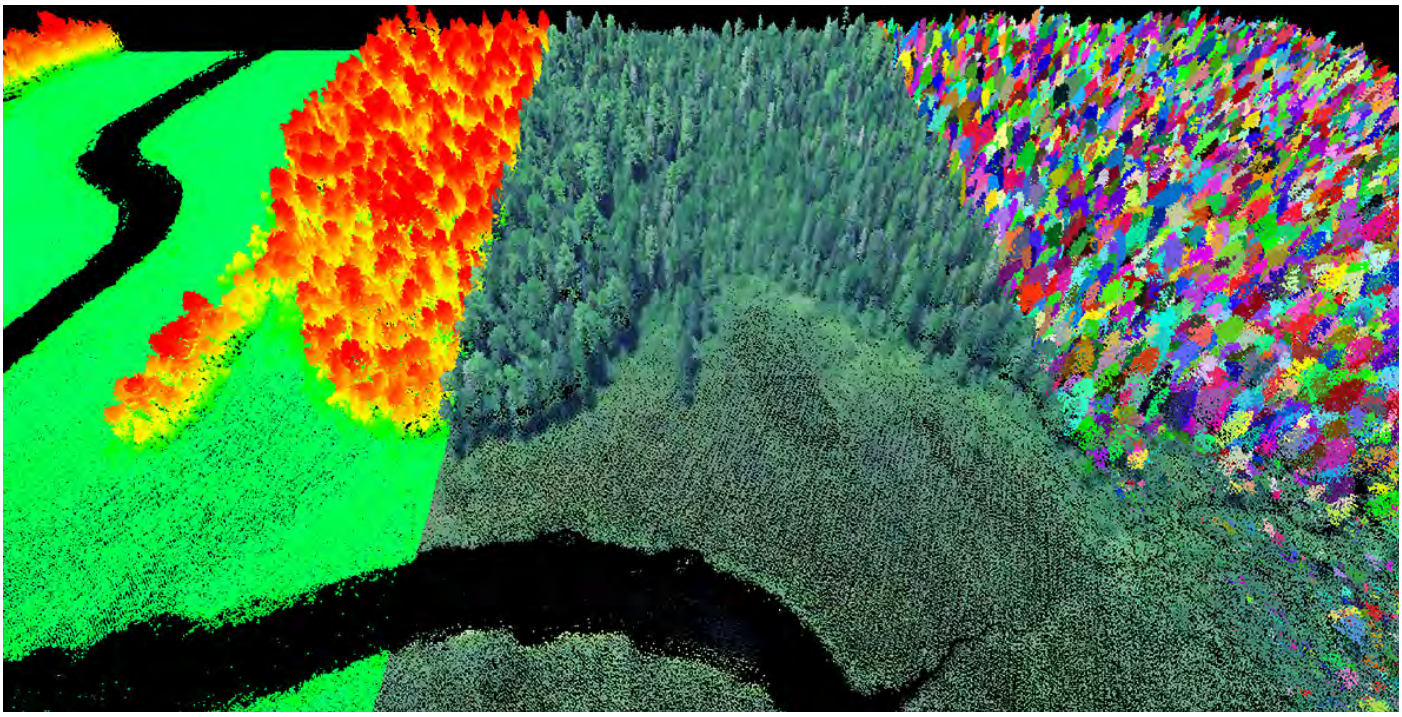
Some corporations aren't waiting for TNFD as they anticipate policy shifts, take into account increasing consumer awareness, and consider growing supply chain risks. According to Bain's recent Global State of Traceability survey[110], 68% of executives[111] now view traceability as "very or extremely important." An example of how corporations are taking action is Unilever's partnership with SAP[112], a German software company that has developed GreenToken[113], a blockchain technology. This partnership will allow the consumer goods giant to trace its global palm oil resources. The company has already conducted a successful proof of concept in Indonesia where it applied GreenToken to source more than 188,000 tons of oil palm fruit for deforestation-free palm oil.

In just the food traceability market alone, forecasts have the sector growing at a CAGR of 9.1% to reach $18.5 billion by 2023.[114] In 2020, venture investments in upstream and midstream technologies such as food traceability surpassed downstream investments for the first time in seven years.[115] Midstream technology absorbed the most capital with US$ 5.3 billion across 338 deals reported. Demand from corporates concerned with brand reputation and supply chain risks has resulted in the emergence of innovative companies and initiatives that bring transparency and clarity to these complex markets.

Below are a few examples from the market:

Veritree is an integrated platform using blockchain technology to verify tree-planting initiatives. By combining geolocation technology with blockchain verification, Veritree is aiming to "revolutionize" the restoration space by making projects verifiable and transparent. The platform is used by project organizers in various geographies, from Nepal (habitat and soil restoration) to Madagascar (carbon sequestration with mangrove trees) and Indonesia (carbon sequestration and coastal erosion). In April 2022, the company announced its 10 Million Verified Tree Challenge, uniting 30 corporate partners to invest in restoration projects in critical habitats in the same year.[116] Companies utilizing Veritree include: Samsung, Cardano, and Jeep, among others.

Founder Derrick Emsley envisions a rich sensory (blockchain-powered) network that monitors trees and uses sensors to report on environmental conditions like air temperature, soil moisture, and nitrogen levels.[117] This information would be logged as a digital public record of vital statistics for each tree to give stakeholders a way to monitor their reforestation projects, and could also be used to calculate stats like each tree's net carbon storage. These verifiable projects could then be used to produce high-integrity carbon credits.



© Satellite-based or airborne remote sensing data such as optical imagery, lidar and radar, when used together can provide a 3D structure of a landscape. (Visualisation from Pachama)

Recently, the International Finance Corporation (IFC) launched the Carbon Opportunities Fund, a blockchain-enabled platform to trade carbon credits.[118] Seeded with $10 million for a proof-of-concept, the fund will buy carbon credits from projects chosen by sustainability finance company Aspiration and biodiversity investor Cultivo. The credits will then be tokenized using blockchain technology from Chia Network, and tracked using the World Bank's Climate Warehouse database.

Web 3.0 technology companies are also starting to enter the natural capital and carbon markets, and some have taken the plunge in a big way. In May of 2022, Ripple, a San Francisco-based fintech company offering crypto solutions for financial transactions, announced a $100 million investment to help ramp up the deployment of blockchain and crypto in carbon markets.[119]

Moss is a Brazilian climate tech startup using blockchain technology to tokenize carbon credits (MCO2 tokens) generated from the Amazon rainforest. One MCO2 token is equal to one ton of carbon dioxide saved. These tokens are available for purchase by individuals or corporates to counterbalance their own carbon emissions. The token is also available for trading on major cryptocurrency exchanges such as Coinbase, Gemini, and Mercado Bitcoin, and on the Celo Network.

Since the launch of its tokens, Moss has raised $30 million for projects that preserve the Amazon and avoided 1.33 million tons of emissions.[120] The company counts some of Brazil's largest corporations as clients, including Hering, Arezzo, and iFood, as well as North American financial institutions One River Asset and Skybridge. Founded in 2020, the company has raised $10 million in Series A funding with investors SP Ventures and Acre Venture Partners as anchors.

In a similar vein, blockchain technology can also be used to track commodities such as beef. In an effort to combat deforestation-linked cattle production, Carne Validades, a private Argentinian supply chain traceability company, recently helped to tokenize and validate its first Argentine beef export to Dubai. Public and private tech platforms have also recently been launched to address the challenge, and include Partnership for Forests (P4F)'s Conecta – Partnerships for Responsible Agriculture and Imaflora's Beef on Track.

Trase, launched in 2020, is a data-driven transparency initiative, developed in collaboration with Global Canopy and the Stockholm Environment Institute. The platform features supply chain mapping using publicly available data to highlight environmental risks associated with commodity supply chains including soy, shrimp, corn, cotton and beef. In addition, the organization has developed several online tools and regularly produces reports to enable companies, financial institutions, governments and civil society organizations to take practical steps to address deforestation.

The **Sustainable Trade Initiative** (IDH) is an organization that works across sectors to drive sustainable production and trade in emerging economies. IDH has worked with over 600 companies and governments to reach over 4 million producers in 30 countries. The organization is active in promoting supply chain traceability initiatives and has been a partner in several high profile case studies, including with Carrefour Group Brazil to produce the first batch of 100% deforestation-free beef traced from birth to shelf.[121] IDH also has a working group on palm oil traceability and has co-developed a study on cocoa traceability[122] in Côte d'Ivoire, Ghana and Cameroon with the National Initiatives on Sustainable Cocoa in Europe (ISCO's). In May 2021, IDH launched SourceUp, a collaboration platform connecting sustainable producers to companies and the global market that aims to drive supply chain sustainability. IDH has also partnered with Fairtrade to enable living wages and income in food supply chains[123].

(En)visible is a US-based company working to enable trust, coordination, and transparency in fragmented global supply chains. Using blockchain technology, the company created the **Wholechain** traceability system. In 2022, IDH and Wholechain presented a model for deforestation-free soybeans destined for the fish food industry. Using blockchain technology, soybeans can be sourced and traced at the jurisdictional level in Brazil[124]. Wholechain is also a partner on Mastercard's blockchain and a former winner of the Fish 2.0 Competition at Stanford for Supply Chain Innovation and a winner of the FDA's New Era of Smarter Food Safety Food Traceability Challenge. The company is now expanding its focus from seafood to include beef and poultry.

Roambee is another supply chain solution provider. Using low-cost IoT sensor tags that collect and report a wide variety of data– including location, temperature, and humidity–and powered by an AI platform, Roambee offers supply chain visibility across a wide range of sectors including food. So far, the company has raised $43.3 million in funding over five rounds and closed a Series B in early 2021.[125]

Meridia, a Dutch enterprise founded in 2015, is providing an end-to-end solution for land and property documentation for farming communities in emerging economies. The company has developed an Android-based app that collects land data via connected GPS hardware that allows land to be surveyed even in remote rural regions. This data is then integrated with drone and remote-sensing data streams to validate and analyze land documentation for smallholders, who often are unable to afford land-mapping and processing services.

The company has worked with the Government of Indonesia, registering 5,000 land parcels across three provinces. Meridia also worked with international chocolatier Mondelēz International's initiative **Cocoa Life** to map 47,000 farms in Ghana in 2019, and in 2022 will map all new farmland under the Cocoa Life program. The company in 2019 raised an undisclosed amount from Mercy Corps Ventures.

Similarly, **Cadasta** is a US-based, mission-driven organization providing technical services and simple digital tools to support documentation of land and resource rights. The company has created the **Global Impact Dashboard**, a platform for the digital recording of land, property, and resource rights.[126] Cadasta partners with a wide range of stakeholders to advocate for secure land tenureship for smallholders and marginalized communities.

See nature tech Company Directory for additional Transparency companies

Connecting Technology: Connecting Millions to Community, Markets, and Learning

You can't scale up NbS without engaging, consulting, and including the people who work in nature every day. And there are a lot of them. It's estimated that there are more than 570 million farms in the world.[127] According to the United Nations, "1.6 billion people, or 25% of the global population, rely on forests for their subsistence needs, livelihoods, employment, and income."[128] Approximately 750 million live within forests.[129] Many of these Indigenous People and Local Communities (IPLCs) are low-income and marginalized, in isolated areas with poor access to infrastructure.

Globally, approximately 478 million farms are on two hectares or less. In India alone, there are 129 million smallholder farmers.[130]

Connectivity is about linking up entrepreneurs and IPLCs in the NbS business value chain to the resources required – financing, inputs, technical assistance, MRV, offtaker markets, community – to increase the health and robustness of the underlying NbS enterprises.

The challenge is immense. We need to connect to billions of people – traditionally hard to reach and expensive to serve[131] – in order to employ, at scale, new and relatively sophisticated NbS practices such as regenerative agriculture, silvopasture, agroforestry, and ecosystem protection and restoration.

NbS practices affecting this population suffer from some of the same issues that nature-agnostic ones do. It is estimated that smallholder farmers and supply chain actors across developing countries lose an average of 15% of their income to food spoilage.[132] Additionally, around $170 billion of the global demand for smallholder farmer finance goes unmet.[133] These issues must be addressed for NbS to be successful.

This is the challenge that the Connections segment of the nature tech market is seeking to address. It aims to reach billions of people in three primary ways:

1. By connecting people to markets – including financing, offtake, premium pricing for nature-positive goods and carbon credits and payments for ecosystem services;
2. By connecting people to learning resources and technical assistance; and
3. By bringing people together in communities of practice for support, co-creation, and mutual learning.

As this market develops to address the above goals, so too will the opportunity to create value for local, indigenous and forest communities. More trust in NbS through improved MRV will, as the Task for Nature Markets writes, "attract extraordinary levels of financial flows to countries — many of them happen to be low- and middle-income countries and fragile states —leading to a significant uplift in benefits in a number of important ways."[134]

Companies deploying Connection technology tend to be multi-sided platforms delivering a suite of services. They are often mission-driven, with a focus on improving economic livelihoods for ILPCs, reducing GHGs, and protecting or enhancing biodiversity. And as we'll see, there are also open-source efforts focused on bringing the benefits of nature tech-enabled connectivity to people via a pre-competitive paradigm.

Examples of some these companies are:

Indigo Ag, founded in 2013, has a mission to "help farmers enhance their profitability and soil health, improve the quantity, quality, and traceability of the food available to consumers, and protect the environment by reducing and removing harmful greenhouse gasses from the atmosphere, while incentivizing sustainable land stewardship practices." Indigo has raised $1.63 billion to date[135] and was recently valued at $3.5 billion.[136]

Indigo Ag started as a soil amendment company using biotech to create a non-GMO treatment for corn, wheat, soybeans, rice, and cotton. Its treatment is designed to maximize yields while reducing water and nitrogen fertilizer use, as well as reducing use of fungicides and other chemicals, cutting costs and environmental impact.

Like most of the Connection platforms, Indigo Ag has taken a strong position in a niche and expanded into adjacent

areas. Today it uses AI and machine learning to analyze satellite data so that it can help farmers earn income "for adopting sustainable practices that lead to the production of high-quality, registry-issued carbon credits." It claims to be the largest carbon farming program by acreage and the first to produce registry-issued agricultural credits at scale. According to Max DuBuisson, Indigo Ag's Head of Sustainability Policy & Engagement, farmers receive at least 75% of the revenue from the sale of credits generated from their fields.

Indigo Ag also provides digital merchandising software to streamline transactions and to create traceability for sustainably grown crops to meet demand and provide farmers with a premium price. Its target market is primarily the United States, but it has a growing presence in Europe, India, and South America.

OpenTEAM takes a non-commercial approach to connecting small farmers to the new knowledge and tools they need. A partnership of over 60 organizations, its mission is to "equip food systems leaders with an equitable, accessible, and interoperable toolkit for universal access to agricultural knowledge and better soil health." OpenTEAM was awarded up to $35 million by the USDA for climate-smart agriculture.[137]

OpenTEAM is using open source to build a technology ecosystem that includes field-level carbon measurement, digital management records, remote sensing, predictive analytics, and input and economic management decision support. This connected technology toolkit is meant to support adaptive soil health management for farms of all scales, geographies and production systems and is designed to reduce the need for farmer data entry. Through working groups and eight-week design sprints called Collabathons, functionality is added over time to the toolkit.

While Indigo Ag and OpenTEAM's primary users to date are from OECD countries, several other companies focus on smallholders in developing nations. These include Indonesian-based companies **PemPem** and **Koltiva**, both venture-backed businesses.

Perhaps the largest, best-funded (over $125m)[138] smallholder-focused Connection platform is Swiss-Indian **Innoterra**. As of March 2021, Innoterra was working with around 160,000 farmer families.[139] It provides a wide suite of products and services, including:

- Agricultural inputs (e.g., seeds, fertilizers), farm equipment (e.g., tractors, irrigation systems), and technology (e.g., sensors and drones);
- Finance and insurance;
- Gamified learning platform where successful completion of modules earns credits to buy inputs and discounts; and
- Market access, including marketing and branding, storage and last-mile distribution, traceability and certification.

Innoterra's operations are based in India, a country where the challenges of connecting to people across different ecological, linguistic, and cultural contexts are substantial. Digital literacy in rural India has been estimated to be only 25%[140], with around 30% of that population unable to read or write at all.[141]

Undaunted, Innoterra has created an app to deliver its products and services to be used in rural India. It conducted face-to-face interviews with farmers across 5 states, 6 districts, and 27 villages to understand the problems they faced and how they would interact with the app. "[142]

Innoterra is also acting as a catalyst for building farmer communities of practice. In the Konkan region of India, Innoterra has partnered with over 2,000 alphonso mango farmers to create a new brand: "Ekyaam."

Initially, farmers were wary. Traditionally, mango farmers in the Konkan region didn't favor collective action. But the advantages of "banding and branding" together overcame their reticence. The Ekyaam branding will enable farmers to develop premium national and international markets for alphonso, increasing profitability.[143]

Innoterra's goals are ambitious. By 2026 it wants to support more than 5 million farmers, process $2 billion GMV on the platform, double farmers' average net income, and to have implemented a carbon credits program that rewards regenerative farming.[144]

California-based startup **Cultivo** works in both OECD and developing countries. ***It connects landowners, NGOs, and investors to promote nature as an asset class.***

It uses nature tech – specifically, sophisticated algorithms that process huge amounts of historical data – to identify degraded agricultural, forest, and wetland areas that could have significant productive, ecological, and climate upsides. It then works with the landowners and local NGOs and environmental consultancies "who really know the particular ecosystem" to create investable projects that derive value from increased land productivity, carbon credits, and payment for ecosystem services. Cultivo then creates portfolios of projects with investment structures that match the natural capital stack.

Cultivo solves both supply and demand issues. As co-founder Manuel Piñuela puts it:

> *"On the supply side the landowners had two main questions. They knew their land was degraded and degrading, and they could see yields coming down. But they didn't know if their land could bounce back. And they didn't know what the value of any bounce-back might be: whether the natural capital could make their business more sustainable. On the demand side you have the financial institutions and corporations trying to invest in natural capital as a new asset class. But the issue has been that they could not find large enough deals, nor see how it could become scalable."*

Cultivo has raised a total of $6m in funding, including a Seed round in August 2021. Its board includes Mark Carney, the former Bank of England governor and United Nations special envoy for climate action and finance. The company's ambition is to restore 1% of the world's surface (an area about the size of Mongolia) or 150 million hectares.[145]

Finally, in May 2021, **The Sustainable Trade Initiative** (known as IDH) launched SourceUp, a collaboration platform connecting sustainable producers to companies and the global market that aims to drive supply chain sustainability. IDH has also partnered with Fairtrade to enable living wages and income in food supply chains[146].

See nature tech Company Directory for additional Connection companies.

What is the outlook for the Connection segment of the Nature Tech market?

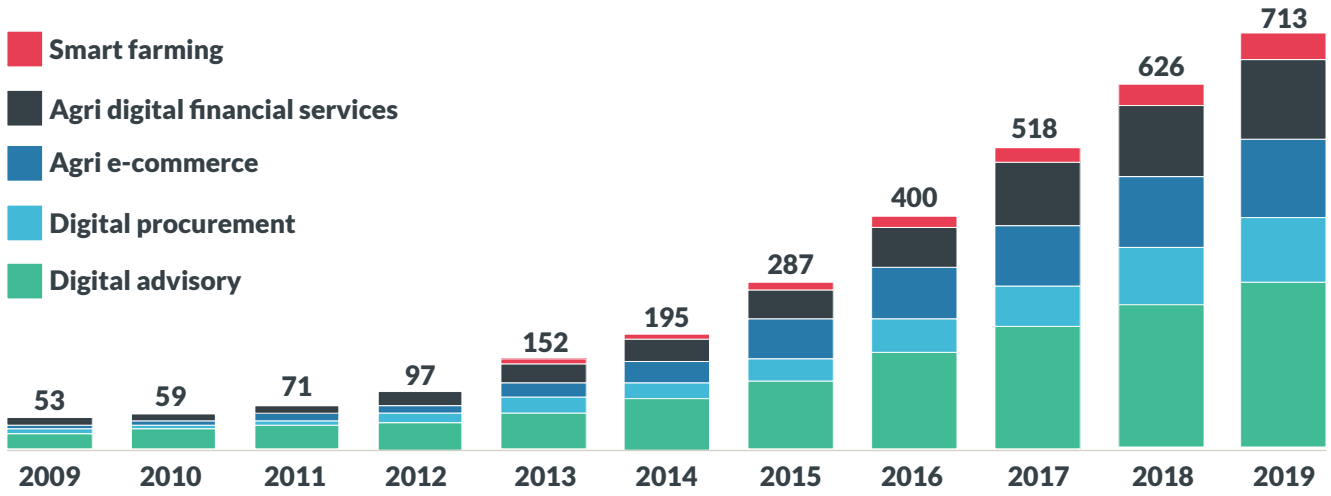
There are many signs pointing to robust growth for the Connection segment. Having successful single-focused companies convert themselves organically or through M&As to Connection platforms makes sense. NbS require integration across the value chain – from capacity building to deployment, to MRV, to creating carbon credits and payments for ecosystem services, to providing transparency all the way to the consumer. Becoming a one-stop shop creates efficiencies for landowners, offtakers, and the connecting entities.

Landowners can use one platform that has a holistic view of their business, which allows it to provide tailored products and services. Many, even those with low incomes, have access to digital technology (at the least, increasingly powerful mobile phones) and network connectivity. This offers them the opportunity to see market trends, safely make payments and get paid, and monitor their crops in ways that would have been inconceivable just a few years ago.

Connecting platforms create synergies through vertical integration. They derisk their businesses by offering a portfolio of products and services. And they differentiate themselves in an increasingly overcrowded market.

As the rapid growth of platforms like Indigo Agriculture and Innoterra seems to indicate, the potential addressable market for Connection platforms – hundreds of millions of landowners – would appear to be huge and largely untapped.

Figure 7: Digital agricultural services (2009-2019)



Note: Government digital services not included. Multiple services can be offered by a single provider. Source: "AGRICULTURAL "PLATFORMS" IN A DIGITAL ERA: Defining the landscape" https://isfadvisors.org/wp-content/uploads/2021/03/ISF_RAFLL_Agricultural_Platforms_Report.pdf

Inhibiting the growth of the Connection segment are several factors. Landowners are, by nature, slow to adopt new practices and are often, with good reason, suspicious of new business models being introduced by people they don't know. Much of the data about farms, forests and wetlands is still collected and transmitted non-digitally, making its processing expensive and difficult to scale. (Though this is beginning to change with IOT sensors and Farming 4.0 digitalization.)[147]

That said, of all the nature tech sectors, Connection is the largest and fastest-growing. And much of the market is as of yet untouched. Seventy-five percent of the platforms are operated by tech start-ups, less than 25% reach more than 100,000 farmers, and only 10% have more than a million users.[148] At this size, many platforms are just beginning to see significant network effects.

A theme that runs throughout all of nature tech – whether it be MRV, Deployment, Transparency or Connection – is that one of its key functions is to build trust. The Connection segment promotes, perhaps more than any of the other segments, the personal connections between people and organizations that bolster the deployment of effective NbS.

The Future of the Nature Tech Market

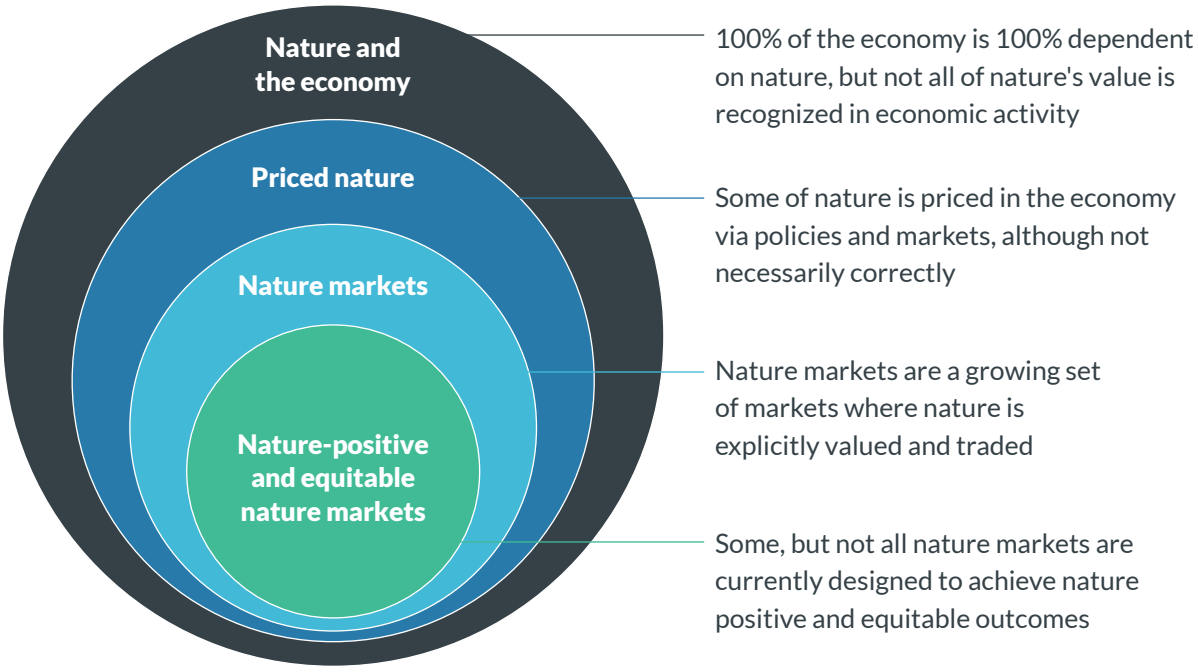
It's a safe bet to go long on nature. Nature is too important to the economy and human well-being for its destruction to be ignored. For these reasons, it's highly likely that the market for nature tech, and the NbS that it supports, will scale exponentially.

This means that we're moving to a state where the two smallest circles in the diagram below – "nature markets" and "nature-positive and equitable nature markets" – both of which represent nature as a valued asset, will get much larger in the years to come. (They would be much smaller today if drawn to scale.)

Today's nature tech market is emergent. It's anybody's guess as to what directions it will take in the next five to ten years. Nonetheless, four trends seem clear:

1. Nature tech's ability to value and report on nature will greatly improve, providing increasingly bankable benefits for those who protect, restore, and manage natural systems, ecosystems, and landscapes;
2. The main driver of nature tech market growth won't be technology per se, but the world's ability to create effective policy, and to build human capacity and community;
3. As nature tech solutions mature and scale, the market will undergo considerable consolidation and vertical integration, but perhaps with a "mass customization" twist driven by the move away from large-scale industrial agricultural and forest practices;
4. Some of the most important innovations in nature tech will come from the Global South where innovators are actively catering to the needs of local smallholders in ways that may disrupt incumbents in OECD markets.

Figure 8: Nature, Economy, and Nature Markets



Source: Taskforce on Nature markets. From "The Future of Nature Markets"[149]

The role of "big tech" in nature tech

The hyper-scale technology giants, such as Amazon, Microsoft, Google (Alphabet), Facebook (Meta) and Apple, have made varying levels of commitments and investments into tackling climate change, including some focus on NbS. Today, Amazon, Google and Microsoft alone are responsible for around a quarter of all climate tech funding.[150]

A prime example is Microsoft's Planetary Computer, a multi-petabyte database of global environmental data that sustainability practitioners can use, via tools like searchable satellite data and machine learning, to evaluate planetary health. APIs and a searchable catalog make the data accessible. [151]

The ultimate impact of big tech on nature tech remains to be seen, but it is bound to have a role to play.

MRV today is still unsystematic, expensive, and inaccurate. The systems in place under the Kyoto Protocol – the current international treaty committing that state parties reduce GHG emissions – are, according to a paper co-authored by ClimateCHECK, Gold Standard, and IOTA Foundation, "characterized by arbitrary target setting, loose alignment of accounting systems, manual collection and reporting of data and manual, on-site assurance, where it exists at all."[152] The situation at the project level is no better. Interviews with field experts reveal that it is common for error bars around project carbon remediation to be more than 200%.

But the experts we interviewed were generally sanguine that in five years measurement will greatly improve. For instance, satellites today can provide images with 30cm resolution[153], and this type of precision can make a huge difference in accuracy for measuring nature remotely.[154] These improvements will go far in helping developers know what is working on the ground, while reducing reputational risk for carbon credit buyers, further stimulating the market.

Nonetheless, technology will not be the primary lever for accelerating nature tech market growth; human processes and activity will. Loose, ineffective guidelines like the Kyoto Protocol will be replaced – perhaps as soon as COP15 in Montreal – with clearer and more enforceable standards. Efforts like the Task Force on Nature-related Financial Disclosures (TNFD) – a global, market-led initiative established to factor nature-related risks into financial and business decisions – will help. The recommendations are slated for release in September 2023 and it's likely that they will become mandatory in some jurisdictions. Efforts like the voluntary carbon market are an extremely important pioneering step. But the world also needs mandatory markets created by national governments and internationally to forge markets big and stable enough to meet the challenge.

Rationalizing and digitizing the MRV process – necessary to create efficiency, transparency, and credibility – won't happen overnight. It's estimated that only 10% of MRV activities use effective digital tools.[155] But if policy requires more carbon credits to be transacted, digitization will quickly follow.

Project registries – the embattled champions of the global voluntary carbon markets – are overwhelmed by demand, constrained by capacity, and are losing talent as well funded ventures hire their talent away. The primary registries – VERRA, ACR, Gold Standard, Plan Vivo, CAR – are crucial to the short- and medium-term growth and credibility of the voluntary carbon market (VCM). This human problem needs to be addressed so that the VCM can flourish.

In the Connections section of this report, we wrote that nearly a billion people across the globe need to be enrolled and enabled to deploy NbS and the nature tech that supports them. In some ways, NbS and nature tech will look more like a movement than a market per se. The total number of jobs in the global wind industry in 2020 was about 1.2 million.[156] That's a lot of workers, but it's still tiny compared to the armies of people that will need to be mobilized for nature. Smallholder communities, investor communities, open source development communities, and industry groups are all forming to support the deployment of NbS and the nature tech that supports it.

Movement or not, **nature tech is definitely a market too, and as it matures, it is consolidating and becoming more vertically integrated, just like any other.** Platforms that started with narrow offerings – perhaps in the MRV space – are now also providing inputs and helping with financing, offtaking, and carbon market integration. Some are even taking on project development. Enterprises like Cultivo, Indigo, Innoterra, NCX, and Pachama are starting to do, or have already done, significant vertical integration. These platforms could grow very large and become unicorns.

What about the incumbents: huge companies like John Deere, Caterpillar, AGCO, Claas KGaA? Will they come to dominate this market or will they be disrupted? We'll see. They may confront the "innovator's dilemma"[157] wherein it is too painful for them to change their business models to meet competition from below. The tendency for these players has been to build bigger and more expensive machines – like the ~$750,000 X Series Combines by John Deere – that are only affordable for very large-scale monocrop farming. Will they be able to adapt to serving NbS projects on multicrop smaller farms?

Or will the nature tech market move towards "mass customization"?[158] If you buy an X Series Combine, you have to use it in the way that the machine and economics dictate: You need to harvest cereals on a very large tract of land. Nature tech offerings need to adapt to the needs of the individual smallholder and be both less expensive and more often than not less specialized.

For this reason, **it is likely that much of the innovation for nature tech will come from the Global South rather than from the North.** The largest tractor manufacturer in the world (in terms of volume) is Mahindra. Mahindra's initial market entry was in India where it focused on small to medium-sized farmers who were highly price-sensitive and without ready access to sophisticated repair facilities. The tractor had to be cheap, rugged, and versatile to support many different crops and needs. The innovations that Mahindra applied to the Indian market were exactly what other markets around the globe needed, including in OECD countries – and they were innovations that the incumbents (whose business models relied on more expensive machines) were not interested in, or capable of, emulating.

This type of "reverse innovation"[159] is evident in the offerings of platforms like India-based Innoterra and Indonesia-based companies PemPem and Koltiva, which are providing fully integrated, robust solutions for deploying NbS at low per-unit cost. Expect more of the same from Latin America and Africa.

To sum up, as we've said throughout this paper, the nature tech market is necessary, emergent, and dynamic. Whether you're a nature tech user, developer, or investor, expect the sprint to 2030 to spur innovation and growth. Stay tuned.

Nature Tech Company Directory

This is a partial listing of nature tech companies.

	Deployment	MRV	Transparency	Connection
Agerpoint		●		
Agriprove	●	◐		◐
AidEnvironment		●	◐	
Aigen	●			
Aquabyte	◐	●		
Arborea	●			
Biophilica	●			
Boomitra	◐	●		
Bushel	◐		●	
Cadasta			●	◐
Carbon Co-op				●
Carbonplace			●	◐
CarbonStack		◐	●	
Carne Validades			●	
Chipsafer	●	◐		
Chloris Geospatial		●		
Climate Impact X			●	◐
Climate TRACE		●	◐	
Climate Vault				●
Conecta – Partnerships for Responsible Agriculture		●	●	◐
CreditNature			●	
Cultivo	◐	◐		●
Databoi			●	
Dendra Systems	●	◐		

	Deployment	MRV	Transparency	Connection
Downforce Technologies		●		
DroneSeed	●			
Dryad Networks	●	◐		
Earth Defenders Toolkit		◐		●
Earthbanc		●	◐	
Earthly				●
Earthshot Labs		◐	◐	●
Ecometric		●		◐
Ecometrica		●	◐	
(En)visible			●	◐
FarmRaise				●
Flash Forest	●	◐		
FLINTpro	◐	●		
ForestSAT		●		
FUNGA	●			
GEDI Ecosystem Lidar		●		
Impact Observatory		●		
Indigo Ag	◐	◐	◐	●
Innoterra				●
IPAM's Cerrado Deforestation Alert System		●	◐	
Kilimo	●	◐		
Koltiva		◐	●	●
Kula Bio	●			
LandGriffon	●	◐	◐	
LandScale		●		●
Living Carbon	●			
Meridia.Land			●	
Moja Global		●	◐	

	Deployment	MRV	Transparency	Connection
Mombak	●			◐
Moss.Earth			●	
MRV Collective		●	●	◐
Naïo Technologies	●			
NatureMetrics		●		
NCX				●
Nori			●	
Oceandrone		●		
OpenTEAM				●
Pachama		●		●
Pattern Ag	●	●		
PemPem			◐	●
Perennial		●		
Pivot Bio	●			
Planet		●		
Puro.Earth				●
Rainforest Connection		●		
re:wild	◐			●
re.green	●			
RefiDAO			●	
Regen Network			●	
Restor	●			●
Ripple			●	
Roambee			●	
RS Aqua		●		◐
Saildrone		●		
Sentera		●		

	Deployment	MRV	Transparency	Connection
Soilify		●		●
Solidaridad Network				●
Sound Ag	●			
Sound Forest Lab				●
Space Intelligence		●	◑	
Strobilo		●		
Sustainable Trade Initiative			◑	●
SwarmFarm	●			
Sylvera		◑		●
Taking Root	◑	◑	◑	●
Terraformation	●			
Toucan Protocol			●	
Trace Genomics	●			
Trase			●	
University of Cambridge '4C'			●	◑
UpTerra	●			
VanderSat		●		
Vence	●	◑		
Veritree		◑	●	◑
Wildlife Insights		●		
World Forest ID		●		
WorldTree	●			◑
Yard Stick		●		
Zulu Forest Science	●	●	◑	◑

Glossary

Nature-based Solutions (NbS)	Interventions and actions to protect, sustainably manage and restore natural and modified ecosystems to address climate change mitigation, continued ecosystem service provisioning, sustainable economic development, and biodiversity preservation.
Nature Technology (Nature Tech, NT)	Any technology that can be applied to enable, accelerate, or scale-up Nature-based Solutions.

Nature Tech Applications by Segment

Segment	Applications	
Deployment	**Bio-geoengineering**	Interventions that seek to deliberately manipulate natural biological processes for increased carbon sequestration, biodiversity preservation, ecosystem service provision, and the continued sustainable use of natural resources.
	Natural Capital Management	Interventions that enable the sustainable utilization of natural capital (such as land, water, air, minerals, forests, fisheries, and wild flora and fauna) for continued ecosystem service provision to support human life and economic processes. Natural capital management includes both managed and natural ecosystems.
	Sustainable Ag Productivity	Interventions that help producers boost crop yield and livestock productivity while minimizing the environmental impact of agriculture.
Measurement, Reporting, and Verification (MRV)	**Biodiversity Baselining & Monitoring**	The assessment of species richness in a given area through surveying, monitoring, and verification. This can include flora, fauna, and/or funga.
	Forest Carbon Measurement & Verification	The process of assessing and validating the amount of carbon stored in the woody and non-woody biomass of trees as well as the rate new carbon is being sequestered into biomass from vegetation growth. Forest carbon measurement and validation is applicable to plantation forestry, natural forests (tropical, temperate & boreal), agroforestry systems and mangroves.
	GHG Measurement	The assessment of the levels of greenhouse gas emissions with the unit of measure as tonnes of carbon dioxide equivalent (tCO_2e).
	Mapping & Monitoring of Land & Ocean Systems	The process of understanding the topography of a given area in terrestrial and marine ecosystems, their current conditions, and how they are changing over time.
	Soil Carbon Measurement & Verification	The process of assessing and validating the amount of carbon stored in global soils either as organic (SOC) or inorganic (SIC) matter. The majority of applications have focused on SOC as a climate mitigation strategy however, there is increasing awareness that SIC losses are more significant than previously thought. Soil carbon measurement and validation can be used on Agricultural land, Grassland & Savannah-type habitats.

Segment	Applications	
Transparency	Environmental Market Attribution	The ability to identify, track, and trace the provenance and transactions of credits or payments derived from Nature. Includes voluntary carbon markets (VCMs), payments for ecosystem services (PES), and biodiversity credits.
	Land Titling and Tenure	Interventions related to land administration that make possible the determination, recording, and disseminating of information about ownership, value, and use of land and its associated resources.
	Supply Chain Traceability	The ability to identify, track, and trace the provenance and journey of products and their inputs as they move along the supply chain from source to consumer
Connection	Capacity Building & Community Engagement	Any intervention that develops and strengthens an individual's, community's, and/or organization's skills and ability to adopt sustainable practices. Ideally, these interventions also support decision-making that enables economic empowerment while mitigating anthropogenic impacts on biodiversity and climate change/environment.

Nature Technology

Artificial Intelligence (AI) Technology	Technology based on the theory and development of computer programs to perform tasks and solve problems that resemble human cognitive function. Such programs can iteratively improve themselves based on the information they collect. Machine learning, deep learning technology and natural language processing (NLP) are all subsets of AI.
Bioacoustic Technology	Technology related to capturing sounds of the natural world as a way of surveying, monitoring, and verifying biodiversity richness, human activity, and ecosystem health.
Biologically-based Technology	Technology based on biology that harnesses or mimics cellular and biomolecular processes to reduce the anthropogenic impacts on the planet.
Data and Analytics (D&A) Technology	Technology that explores and analyzes datasets to draw insights about the information they contain. Types of data analytics include Prescriptive, Predictive, Diagnostic, Descriptive, and Cognitive. Data analytics can draw on a series of techniques to make these determinations, including artificial intelligence (AI), data mining, machine learning, modeling, and statistics.
Distributed Ledger Technology (DLT) & Other Tagging Technology	A digital system for recording the transaction of assets/commodities in a permanent manner which also allows for simultaneous access and validation across a network that is spread across multiple entities or locations, increasing transparency of supply chains. Blockchain is an example of DLT. Other tagging technology includes near-field communication (NFC) and molecular tagging, all of which enhance transparency of supply chains and enable traceability.
Internet of Things (IoT) Sensor Technology	Devices that collect data by detecting changes in the physical environment and which are connected to the internet or other communication networks to enable smarter real-time decision-making.
Remote Sensing Technology	Allows data (physical characteristics of an area) to be gathered from a distance without the need for direct contact for image processing and interpretation. Types of remote sensing technology include lasers, radars, electromagnetic radiation sensors, and infrared.
Robotics	Technology related to the design, construction and operation of robots in automation that can be used to replace and/or enhance human activity for the benefit of nature. This can include drones for reforestation and agricultural robots for weeding/planting/harvesting.
Social Learning & Doing Platform Technology	Technology that facilitates social interactions through the dissemination of information and is enabled by a communications capability.

About Nature4Climate and Capital for Climate

Nature4Climate (N4C) is a communications and advocacy platform that works to increase investment in and action on nature-based solutions. N4C is composed of 20 of the world's leading conservation, multilateral, and business organizations and seeks to further catalyze partnerships between governments, civil society, businesses, and investors, based on the urgency to protect, restore, and fund nature-based solutions. N4C believes in the importance of integrating nature across all government decision-making, that NDCs can be greatly enhanced using nature-based solutions, and that finance flows to nature-based solutions need to be increased, and in many areas, reformed.

Capital for Climate (C4C) is accelerating capital deployment to climate solutions required to achieve a 1.5°C degree outcome. It provides an integrated offering, including a climate solution intelligence platform, hosted investor communities, and education and strategic advisory services. At COP26, in collaboration with the U.N.'s High-Level Climate Champions, C4C launched a free, public-purpose pilot version of their platform **focused on Nature-based Solutions**. Early funders include the Finance Hub of the Gordon and Betty Moore Foundation, Quadrature Climate Foundation, Wells Fargo Foundation, and Climateworks Foundation.

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