Briefing Paper

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How forest bioeconomies can support nature-based solutions

Summary

- Addressing biodiversity loss and mitigating climate change will require dramatic shifts in current ecological stewardship practices. Investment in nature-based solutions – actions that generate multiple biodiversity and social benefits through the conservation, management or restoration of ecosystems – needs to be increased.
- Private capital investment in nature-based solutions is currently limited by perceptions of high investment risk, but the use of such solutions in the forest sector, where institutional investors already have a track record of investing, could help bridge the financing gap.
- Policy, market and innovation trends point towards a growing global bioeconomy to replace fossil fuel-derived supply chains with bio-based alternatives. However, growing market demand for biomaterials could contribute to a land 'crunch', with land availability being limited by competing pressures as the global population seeks to meet all its needs.
- Pressure on land can be mitigated by the rapid decarbonization of energy and industry sectors, reducing reliance on carbon sequestration within natural ecosystems. Establishing nature-based solutions in the forest sector can support systems of land use that provide long-lasting ecological restoration, biodiversity protection and livelihood opportunities, thereby further reducing pressure on land.
- Land-use modelling exercises would help to quantify market, environmental and social outcomes for future demand and technology scenarios in the bioeconomy. This information could then be used to identify the policies, investments and innovations that support the optimal scaling of nature-based solutions in the forest sector.

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Introduction

The next decade will be of pivotal importance in terms of efforts to tackle the global climate and biodiversity crises, and to provide safe and secure future livelihoods for populations. Projections based on preliminary estimates of 2022 emissions levels indicate that, at the beginning of 2023, there were only nine years to go until atmospheric greenhouse gas emissions reach the threshold at which global warming surpasses the higher-ambition 1.5°C target above pre-industrial levels that was laid out in the Paris Agreement.[1]

How land is used will be crucial to efforts to limit global warming to 1.5°C, as well as to protecting biodiversity. All analysed pathways cited by the Intergovernmental Panel on Climate Change (IPCC) as being compliant with the 1.5°C target involve the rapid decarbonization of both the energy system and heavily emitting industries such as the aviation and construction sectors (on average accounting for 74 per cent of emissions reductions in modelled pathways that reach global net zero greenhouse gas emissions) and the removal of greenhouse gases from the atmosphere through negative-emission technologies (26 per cent). It is estimated that half of this greenhouse gas removal can be achieved from carbon dioxide removal via shifts in agriculture, forestry and other land-use (AFOLU) practices.[2] The remainder should result from lowering emissions of non-carbon dioxide greenhouse gases, such as methane. Again, the AFOLU sector will contribute to this shift.

Changes in land use will also be critical to tackling biodiversity loss. At and following COP26, 145 national leaders signed the Glasgow Leaders' Declaration on Forests and Land Use, which committed them to 'working collectively to halt and reverse forest loss […] by 2030 while delivering sustainable development and promoting an inclusive rural transformation'.[3] At the 15th United Nations Biodiversity Conference (COP15), held in Kunming, China and Montreal, Canada, in two phases between 2021 and 2022, signatory countries to the Kunming–Montreal Global Biodiversity Framework agreed to collaborate in protecting 30 per cent of the world's land and restoring 30 per cent of the world's degraded ecosystems by 2030.[4]

It is anticipated that nature-based solutions – activities that protect, manage or restore ecosystems to generate multiple biodiversity and social benefits – will constitute an important tool in efforts to manage land use to meet climate and biodiversity targets, while also protecting livelihoods. Nature-based solutions cover a wide range of land-use activities: examples include the restoration of mangrove forests in coastal wetlands to improve resilience to storm surges, or the transformation of semi-degraded lands for the sustainable production of commodities for local communities.

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1 Friedlingstein, P. et al. (2022), 'Global Carbon Budget 2022', *Earth System Science Data*, 14(11), pp. 4811–900, https://doi.org/10.5194/essd-14-4811-2022.
2 Intergovernmental Panel on Climate Change (2022), 'Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development', in *Global Warming of 1.5°C: An IPCC Special Report on impacts of global warming of 1.5°C above pre-industrial levels in context of strengthening response to climate change, sustainable development, and efforts to eradicate poverty*, pp. 93–174, Cambridge: Cambridge University Press, https://doi.org/10.1017/9781009157940.004; Intergovernmental Panel on Climate Change (2022), 'Summary for Policymakers', in *Climate Change 2022: Mitigation of Climate Change: Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge and New York: Cambridge University Press, p. 12, https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_SPM.pdf.
3 UN Climate Change Conference UK 2021 (2021), 'Glasgow Leaders' Declaration on Forests and Land Use', 2 November 2021, https://ukcop26.org/glasgow-leaders-declaration-on-forests-and-land-use.
4 Convention on Biological Diversity (2022), 'Final Text of Kunming–Montreal Global Biodiversity Framework available in all languages', 22 December 2022, p. 2, https://prod.drupal.www.infra.cbd.int/sites/default/files/2022-12/221222-CBD-PressRelease-COP15-Final.pdf.

The United Nations Environment Programme (UNEP) estimates that it would cost up to $11 trillion invested in nature-based solutions between 2022 and 2050, alongside rapid mitigation of emissions from the energy and industry sectors, to limit global warming to 1.5°C.[5] In the same report, UNEP also estimates that meeting this challenge will require investments in nature-based solutions to triple in value terms by 2030.[6] While this funding gap could be addressed through the private sector, accessing increased flows of private sector capital may require nature-based solutions to deliver market rates of return. By tapping into mainstream investment flows that are committed to climate action, nature protection and ecological restoration, the current reliance of nature-based solutions on public funding via grants and concessional financing would be reduced.

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Existing commitments on the part of many investors to improving the environmental and social outcomes of their business-as-usual activities may help to close this financing gap. Investor coalitions such as the Glasgow Financial Alliance for Net Zero (GFANZ) – which has assets of $130 trillion – ask signatories to commit to collaborating on an economy-wide transition to net zero emissions.[7] Along with supporting initiatives which aim to rapidly reduce greenhouse gas emissions from energy-related sectors, some private financial institutions have committed to activities that aim to stop or reverse natural habitat conversion and biodiversity loss. By the end of 2022 some 126 financial institutions had signed up to the Finance for Biodiversity Pledge. This aims to achieve the reversal of biodiversity loss by 2030. Signatories commit to collaborating and sharing knowledge, engaging with investee companies, setting (and disclosing) targets and reporting publicly on their biodiversity impact.[8]

While these initiatives reflect the growing momentum in the private sector for fighting biodiversity loss, they have not yet translated into sufficient investment in nature-based solutions at the scale needed to fully address these challenges.[9] Multiple avenues must be developed in order that nature-based solutions projects can secure funding and scale activity.

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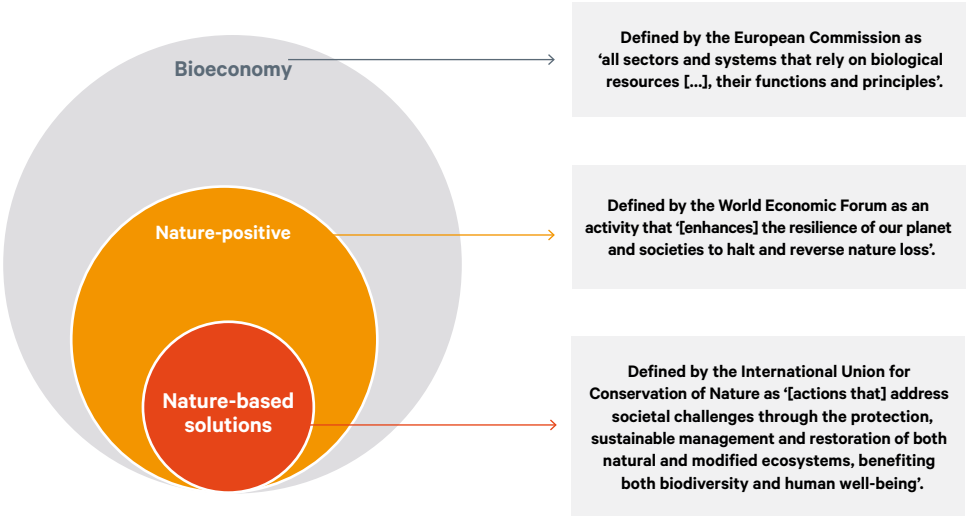
5 United Nations Environment Programme (2022), *State of Finance for Nature 2022: Time to act – Doubling investment by 2025 and eliminating nature-negative finance flows*, Nairobi: UNEP, p. 39, https://wedocs.unep.org/20.500.11822/41333.
6 Ibid., p. 27.
7 Glasgow Financial Alliance for Net Zero (2021), 'Amount of finance committed to achieving 1.5°C now at scale needed to deliver the transition', 3 November 2021, https://www.gfanzero.com/press/amount-of-finance-committed-to-achieving-1-5c-now-at-scale-needed-to-deliver-the-transition.
8 Finance for Biodiversity (2022), 'Finance for Biodiversity Pledge', https://www.financeforbiodiversity.org (accessed 22 Dec. 2022).
9 United Nations Environment Programme (2022), *State of Finance for Nature 2022*; Deutz, A. et al. (2020), *Financing Nature: Closing the Global Biodiversity Financing Gap*, Report, Chicago: Paulson Institute, The Nature Conservancy and Cornell Atkinson Center for Sustainability, https://www.paulsoninstitute.org/conservation/financing-nature-report.

For example, finance could be unlocked for some types of nature-based solutions by generating revenues from providing environmental services (as happens, for example, in schemes involving carbon or biodiversity credits) and combining them with revenues created in forest product supply chains (see 'Investments in nature-based solutions', Table 1). This is a growing opportunity for finance, as products grown in forests constitute part of a broader shift in supply chains across sectors as diverse as construction, pharmaceuticals, fibres and plastics towards inputs that are derived from biological materials rather than from fossil fuels. Such products are included in what is known as the bioeconomy. The European Commission describes the bioeconomy as 'all sectors and systems that rely on biological resources – animals, plants, micro-organisms and derived biomass, including organic waste – as well as their functions and principles'.[10]

The private forestry sector could play an important role in linking the global bioeconomy and local nature-based solutions, by creating investible 'nature-positive' investment opportunities to channel institutional finance to nature-based solutions. The relationships between the bioeconomy, nature-positive actions and nature-based solutions are depicted in Figure 1.

Figure 1. How the bioeconomy, nature-positive actions and nature-based solutions are linked



Source: European Commission, Directorate-General for Research and Innovation (2019), *Bioeconomy – the European way to use our natural resources: action plan 2018*, Brussels: Publications Office, https://data.europa.eu/doi/10.2777/79401; Holdorf, D. B. et al. (2021), 'What is 'nature positive' and why is it the key to our future?', World Economic Forum, 23 June 2021, https://www.weforum.org/agenda/2021/06/what-is-nature-positive-and-why-is-it-the-key-to-our-future; and International Union for Conservation of Nature (IUCN) (2022), 'Nature-based Solutions', https://www.iucn.org/our-work/nature-based-solutions.

10 European Commission, Directorate-General for Research and Innovation (2019), *Bioeconomy – the European way to use our natural resources: action plan 2018*, Brussels: Publications Office, https://data.europa.eu/doi/10.2777/79401.

Such a shift from fossil fuel- to bio-based supply chains may make it easier for some types of nature-based solutions to secure increased amounts of finance that requires a market rate of return. Projects which support ecological restoration, biodiversity protection or carbon storage, for example, could be funded through financial returns from growing and selling sustainably produced biological commodities.

However, few analyses exist on how much land is needed to grow the biological materials required to meet demand for bioeconomic activities and displace the fossil fuel economy – and what this expansion would mean for biological diversity and livelihood opportunities locally.

This briefing paper outlines the importance of forest restoration as a nature-based solution. It assesses the opportunities for – as well as the risks of – incorporating nature-based solutions into global bioeconomy supply chains to deliver environmentally, socially and financially feasible projects, and evaluates the likely consequences. As the bioeconomy is fast evolving, the paper explores three key trends – in policy, markets and innovations – that will shape what the forest bioeconomy might look like in the future. It then outlines the general implications for land availability and land use, and, in turn, for nature-based solutions in the forest context, before discussing how to manage these implications while ensuring the best possible outcomes for climate, biodiversity and populations. Finally, this paper identifies how the forest sector can support the integration of nature-based solutions into the mainstream within the broader forest bioeconomy.

Nature-based solutions and the financing gap

Nature-based solutions encompass many activities that are managed by local stakeholders, communities or businesses and involve the conservation, restoration and management of natural ecosystems on land (such as forests, agricultural areas, grasslands and peatland) and at sea.

Box 1. Nature-based solutions in forests: the terminology used in this paper

- **Natural climate solutions:** Activities that conserve, restore and improve the management of land so as to increase carbon storage and/or avoid greenhouse gas emissions from natural ecosystems.[11]
- **Reforestation:** The replanting of tree species in a previously forested area that has undergone deforestation.[12]
- **Restoration:** A process of assisting in the recovery of previously degraded or destroyed ecosystems to produce healthier ecosystems with richer biodiversity.[13]

11 Griscom, B. W. et al. (2017), 'Natural climate solutions', *PNAS*, 114 (44), https://doi.org/10.1073/pnas.1710465114.
12 Food and Agriculture Organization of the United Nations (2000), *Forest Resources Assessment 2000: Definitions of forest change processes*, http://www.fao.org/3/ad665e/ad665e04.htm.
13 United Nations Decade on Ecosystem Restoration 2021–2030 (2021), 'What is ecosystem restoration?', https://www.decadeonrestoration.org/what-ecosystem-restoration.

Nature-based solutions have many functions, including carbon sequestration, biodiversity protection, the provision of sustainable livelihood opportunities for local communities and – by increasing resilience to extreme weather events such as flooding – disaster risk reduction. In turn, these functions contribute to many of the UN Sustainable Development Goals (SDGs), including SDG 1 (no poverty), SDG 8 (decent work and economic growth), SDG 12 (responsible consumption and production), SDG 13 (climate action) and SDG 15 (life on land).

When one function is prioritized at the expense of others (such as when carbon storage is accorded a higher priority at the expense of biodiversity protection), the overall outcome across all ecosystem functions is undermined. This is especially true in the case of forests. For example, over a 25-year period between 1986 and 2011, a government-subsidized programme of plantation expansion in Chile replaced native tree species with imported species in an effort to increase carbon sequestration. The scheme caused a 13 per cent decline in native species against an increase of just 2 per cent in carbon storage.[14] This example demonstrates the importance of managing competing functions.

The IPCC estimates that more than 10 per cent of global ice-free land is suitable for reforestation that produces co-benefits for local challenges and climate change mitigation, without affecting food security.

This briefing paper focuses on nature-based solutions that support reforestation activities, which play an important role, alongside conservation and sustainable management practices, in delivering on global greenhouse gas reduction, nature restoration and biodiversity protection targets. The IPCC estimates that more than 10 per cent of global ice-free land is suitable for reforestation that produces co-benefits for local challenges and climate change mitigation, without affecting food security.[15]

The IPCC also highlights the importance of sustainable reforestation, with the multiple functions of nature-based solutions kept in mind: it estimates in its 2019 *Climate Change and Land* report that afforestation (the planting of forest landscapes where there were previously none), reforestation and the use of land to provide feedstock for bioenergy could contribute to several gigatonnes of carbon dioxide removal in carbon sequestration – but goes on to state that chasing the maximum carbon storage potential would have massive knock-on impacts for land conversion, with ramifications for food production and biodiversity protection, and could be used as an excuse for continued carbon emissions.[16] Instead, restoration (for example, planting with native tree species) that is integrated into sustainable landscapes

14 Heilmayr, R., Eschevvería, C. and Lambin, E. F. (2020), 'Impacts of Chilean forest subsidies on forest cover, carbon and biodiversity', *Nature Sustainability*, 3, pp. 701–09, https://doi.org/10.1038/s41893-020-0547-0.
15 Intergovernmental Panel on Climate Change (2019), *Climate Change and Land: An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems*, p. 62, https://www.ipcc.ch/site/assets/uploads/2019/11/SRCCL-Full-Report-Compiled-191128.pdf.
16 Ibid., pp. 19–25.

'at appropriate scales', leading to landscapes that deliver multiple environmental and social benefits, should be prioritized and should be conducted through active engagement with local communities.[17]

Investments in nature-based solutions

Public sector organizations provide a disproportionately high share of investments in nature-based solutions compared to private sector finance. In 2022, according to UNEP, public sources accounted for 83 per cent of the estimated $154 billion in annual investments in nature-based solutions.[18]

Increasing the overall amount and share of private sector investment in forest restoration as a nature-based solution remains a challenge. Many institutional investors perceive investing in nature-based solutions to be high-risk or have generally low expectations in terms of financial returns.[19]

Among the commonly cited perceived risks involved in investing in nature-based solutions are, first, a lack of clarity for investors on current and future cash flows that will cover the cost of the investment and, second, a lack of 'investible pipeline' – in other words, a dearth of investible projects.[20] The latter could be for a number of reasons: the amount of the upfront investment might be too small for large-scale investors; the complexity of many forest projects might call for high levels of technical knowledge on the part of potential investors; or there might be jurisdictional risks – such as unstable or ineffective regulation – or geopolitical and currency risks associated with forest projects proposed for frontier regions of emerging markets.[21] Finally, investments in forestry often entail a higher reputational exposure to scrutiny by environmental interests.[22]

There are many ways for nature-based solutions to provide investment returns. Some of these returns can be created by the implementation of forest functions, as when carbon credits are awarded in exchange for storing carbon dioxide, or when biodiversity credits are associated with protecting wildlife.[23] Some of the ways in which nature-based solutions in the forestry sector can lead to revenue

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17 Ibid.
18 United Nations Environment Programme (2022), *State of Finance for Nature 2022*, p. 5.
19 Yang, A. and Harrison, T. (2019), 'Closing the Gap: Overcoming Barriers to Investment in Forests', Chatham House Sustainability Accelerator, 10 May 2019, https://accelerator.chathamhouse.org/article/closing-the-gap-overcoming-practical-and-financial-barriers-to-investment-in-forests.
20 Throp, H., Yang, A. and Sherman, S. (2021), 'Building Investor Confidence in Nature-based Solutions', Chatham House Sustainability Accelerator, 29 November 2021, https://accelerator.chathamhouse.org/article/building-investor-confidence-in-nature-based-solutions; WWF and Terranomics (2022), 'Nature Based Solutions – a review of current financing barriers and how to overcome these', https://www.wwf.org.uk/sites/default/files/2022-06/WWF-NBS-Public-Report-Final-270622.pdf.
21 The Nature Conservancy (2019), 'Investing in Nature: Private finance for nature-based resilience', https://www.nature.org/content/dam/tnc/nature/en/documents/TNC-INVESTING-IN-NATURE_Report_01.pdf; Yang and Harrison (2019), 'Closing the Gap'; Throp et al. (2021), 'Building Investor Confidence in Nature-based Solutions'; WWF and Terranomics (2022), 'Nature Based Solutions'; Chatham House Sustainability Accelerator (2021), 'An Investor Framework for Nature-based Solutions', 9 December 2021, https://accelerator.chathamhouse.org/article/investor-framework-for-nature-based-solutions.
22 United Nations Principles for Responsible Investment (2019), 'ESG Factors in Forestry Investing', 15 May 2019, https://www.unpri.org/forestry/esg-factors-in-forestry-investing/4392.article.
23 Biodiversity credits are economic instruments that allow investments to be made in activities that improve biodiversity in a local region. See World Economic Forum (2022), *Biodiversity Credits: Unlocking Financial Markets for Nature-Positive Outcomes*, Briefing Paper, Geneva: World Economic Forum, https://www3.weforum.org/docs/WEF_Biodiversity_Credit_Market_2022.pdf.

creation are shown in Table 1, below. Combining new and additional income streams from multiple functions can help to overcome investor concerns about cash-flow uncertainty when investing in nature-based solutions.[24]

Table 1. Examples of revenue-generation outcomes for nature-based solutions in the forestry sector

Type of nature-based solution	Source(s) of income	Rationale
Biodiversity protection	Biodiversity credits and the sale of licences for sustainable fishing and hunting	Reforested areas can provide significantly more land for at-risk species to thrive in a protected environment
Ecosystem services	Payments for water retention and quality provision through ecosystem restoration, carbon offset credits and conservation easements	Reforested areas can provide a variety of ecosystem services, such as: • Providing water and water filtration; • Pest control; • Replenishment of healthy soils; and • Nutrient recycling
Disaster risk reduction	Resilience bonds or lower insurance costs	Forest landscapes can reduce the risks of natural disaster through: • Regulating weather cycles; • Acting as natural flood defences against storm surges and tsunamis; and • Disease control
Carbon sequestration	Carbon offset credits	Forests can be utilized as a carbon sink within the biosphere
Sustainably produced forest products	Sales of wood, wood fibre and non-wood products; appreciation in value of land	Forest commodities can provide products across a variety of sectors, including construction, pharmaceuticals, energy, pulp and paper, consumables and clothing

Source: Adapted from CREO Syndicate (2020), 'An Investment Primer for Reforestation: Carbon removal, environmental and social impacts, and financial potential', p. 6, https://docslib.org/doc/355594/an-investment-primer-for-reforestation-carbon-removal-environmental-and-social-impacts-and-financial-potential.

The bioeconomy: providing cashflow certainty for nature-based solutions

Selling forest products can provide cashflow security for investors. Forest products – and the wider forest sector which governs the production, distribution and consumption of these products – are already an established part of the forest economy, with links to institutional mainstream investment.

Many institutional investors have already invested in forest assets, as they look for opportunities to decarbonize their investment portfolios or diversify their investments to reduce their financial risk. Global institutional investment in the

24 CREO Syndicate (2020), 'An Investment Primer for Reforestation: Carbon removal, environmental and social impacts, and financial potential', https://docslib.org/doc/355594/an-investment-primer-for-reforestation-carbon-removal-environmental-and-social-impacts-and-financial-potential.

acquisition and management of timberland assets was estimated to have reached up to $100 billion by 2021.[25] While this is a relatively low level of investment (compared, for instance, to the estimated $4 trillion of institutional investments in private equity), it is significantly higher than the $26 billion of private finance invested in nature-based solutions in 2022.[26]

Box 2, below, presents some definitions of terms associated with the bioeconomy and the materials, supply chains and sectors that make it up.

Box 2. Bioeconomy-related definitions

- **Bio-based product:** Defined by the European Commission as products that are 'wholly or partly derived from materials of biological origin'.[27] Bio-based products are used in many industries, including construction, pulp and paper, textiles, pharmaceuticals and chemicals.
- **Forest products:** Bio-based products that are sourced from forest landscapes.
- **Forestry sector:** Defined by the Food and Agriculture Organization of the United Nations (FAO) as 'all economic activities that mostly depend on the production of goods and services from forests'.[28]

The private forest sector is not exempt from requirements for investors and businesses to show that their activities are delivering positive environmental, social and governance (ESG) outcomes. The normalization of more stringent and comprehensive investor reporting standards means that investors are looking to finance activities that deliver ESG benefits. Such developments in reporting standards are being driven by initiatives such as the establishment of 'taskforces' for nature- and climate-related disclosures. Although voluntary, these initiatives have gathered momentum – the Task Force on Climate-Related Financial Disclosures (TCFD), created in 2015, claimed 4,000 supporters across 101 jurisdictions by February 2023.[29]

For the forest sector to continue to be able to access capital from investors, the sectoral business model should support both nature- and climate-positive activities. First, the forest sector should ensure its activities do not drive illegal logging activities or conversion of natural habitats. Second, the sector should incorporate nature-based solutions into forestry activities to create environmental and social benefits. Lastly, by diversifying its production model away from monoculture (single-species)

25 Fu, C.-H. (2021), *Timber Investments: A Primer*, Brookline, MA: Timberland Investment Resources, https://tirllc.com/wp-content/uploads/2021/07/Timberland-Investments-A-Primer-2021-07-07.pdf.
26 Stewart, F. and Power, S. (2021) 'Seeing the forest for the trees: Why pension funds should take another look at forestry as an asset class', 1 March 2021, World Bank Blogs, https://blogs.worldbank.org/psd/seeing-forest-trees-why-pension-funds-should-take-another-look-forestry-asset-class; United Nations Environment Programme (2022), *State of Finance for Nature 2022*.
27 European Commission (2020), 'Bio-based products', https://single-market-economy.ec.europa.eu/sectors/biotechnology/bio-based-products_en.
28 Food and Agricultural Organization of the United Nations, cited in Baumgartner, R. J. (2019), 'Sustainable Development Goals and the Forest Sector – A Complex Relationship', *Forests*, 10(2): 152, https://doi.org/10.3390/f10020152.
29 Task Force on Climate-Related Financial Disclosures (2022), 'TCFD supporters around the world', https://www.fsb-tcfd.org/support-tcfd (accessed 6 Feb. 2023).

commercial plantations and adopting polyculture (multiple-species) practices, the forest sector can better integrate with the natural habitat, improving the resilience of landscapes to pests and diseases and allowing greater biodiversity to thrive.

Trends already at play in the global bioeconomy can facilitate shifts in commodity production within the forest sector. First, bio-based alternatives are increasingly being used to replace fossil fuel inputs in supply chains. Research from McKinsey Global Institute estimates that up to 60 per cent of global inputs have already been – or could feasibly be – replaced with biomaterials. The same source estimates that advances in the use of biological inputs in the production of materials, chemicals or energy could generate between $200 billion and $300 billion in global market growth in the period to 2040.[30]

Some advocates of the bioeconomy propose that it can make a strong contribution in the phasing out of fossil fuels by providing replacements for carbon-intensive products such as plastics, synthetic textiles and building materials, and through the production of bioenergy. Other advocates argue that it could provide a transformative development model that can shape development pathways and technological routes for entire nations.[31] There are also concerns: detractors argue that an over-reliance on the bioeconomy to replace fossil fuels could lead to a 'land crunch' as more land is allocated to producing bio-based products. Market-driven land allocation (where land is allocated so as to produce the greatest financial gain) may incentivize land managers to create landscapes for commodity production or carbon dioxide sequestration, rather than for ecological restoration and biodiversity enhancement.[32] Other critics argue that bio-based approaches – especially bioenergy and carbon capture storage (BECCS) – may be co-opted by fossil fuel interests to delay the decarbonization of energy production by justifying the continued use of fossil fuels through carbon offset programmes.[33]

The bioeconomy is generally categorized into three 'visions':[34]

- **Biotechnology:** creates economic growth and new jobs through the adoption of new technologies. This vision relies on the integration of advanced biotechnology with innovation approaches that seek to shorten the time it takes to roll out new technologies to market, through more effective research and development (R&D);
- **Bioresource:** combines economic growth and sustainability by improving land use and supply-chain processes which enable more effective land management; and
- **Bioecology:** protects and enhances biodiversity in landscapes and integrates protections with agroecological practices that deliver benefits to local communities.

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30 Brennan, T., Chui, M., Chyan, W. and Spamann, A. (2021), 'The third wave of biomaterials: When innovation meets demand', McKinsey & Company, 18 November 2021, https://www.mckinsey.com/industries/chemicals/our-insights/the-third-wave-of-biomaterials-when-innovation-meets-demand.
31 Debref, R., Pyka, A. and Morone, P. (2022), 'For an Institutionalist Approach to the Bioeconomy: Innovation, Green Growth and the Rise of New Development Models', *Journal of Innovation Economics & Management*, 38(2), pp. 1–9, https://doi.org/10.3917/jie.038.0001.
32 Friends of the Earth Europe (2016), *Land under Pressure: Global Impacts of the EU Bioeconomy*, Report, https://friendsoftheearth.eu/publication/land-under-pressure-global-impacts-of-the-eu-bioeconomy.
33 Quiggin, D. (2021), *BECCS deployment: the risks of policies forging ahead of the evidence*, Research Paper, London: Royal Institute of International Affairs, https://www.chathamhouse.org/2021/10/beccs-deployment.
34 Bugge, M. M., Hansen, T. and Klitkou, A. (2016), 'What Is the Bioeconomy? A Review of the Literature', *Sustainability*, 8(7), 691, https://doi.org/10.3390/su8070691.

The adoption of national and local bioeconomy strategies is likely to combine a mix of these visions depending on the specific priorities of the country or region, as well as local factors such as land, water and other bioresource availability; the presence of companies that use (or could use) biomaterials – such as pharmaceutical, biotechnology or forest sector enterprises; and the availability of research and innovation capabilities.

Bioeconomy strategies are becoming prominent in the policy planning of national governments and local authorities in many countries, as well as in the deliberations of supranational bodies or blocs such as the EU.

In recent years, global momentum in this area has grown considerably. Bioeconomy strategies are becoming prominent in the policy planning of national governments and local authorities in many countries, as well as in the deliberations of supranational bodies or blocs such as the European Union (EU). In 2020, almost 60 countries across several continents were seeking to develop bioeconomy-related strategies.[35] Currently, there are many public policy strategies in place, including in China, Colombia, Germany, Japan, South Africa and the US.[36] Notably, three multilateral bioeconomy strategies exist – the Eastern African Regional Bioeconomy Strategy (2020),[37] the European Bioeconomy Strategy (conceived in 2012 and updated in 2018)[38] and the Nordic Bioeconomy Programme (2018).[39]

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35 International Advisory Council on Global Bioeconomy (IACGB) (2020), *Global Bioeconomy Policy Report (IV): A decade of bioeconomy policy development around the world*, Berlin: Secretariat of the Global Bioeconomy Summit 2020, https://knowledge4policy.ec.europa.eu/publication/global-bioeconomy-policy-report-iv-decade-bioeconomy-policy-development-around-world_en.

36 European Commission (2020), *The German National Bioeconomy Strategy*, https://knowledge4policy.ec.europa.eu/publication/german-national-bioeconomy-strategy_en; Bioökonomie.de (2021), 'Colombia', 16 December 2021, https://biooekonomie.de/en/topics/in-depth-reports-worldwide/colombia; United States Department of Commerce, International Trade Administration (2021), 'Japan Bioeconomy Strategy', 9 January 2021, https://www.trade.gov/market-intelligence/japan-bioeconomy-strategy; Republic of South Africa, Department of Science and Technology (2013), *The Bio-economy Strategy*, https://www.gov.za/sites/default/files/gcis_document/201409/bioeconomy-strategya.pdf; White House (2022), 'Executive Order on Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy', Executive Order, 12 September 2022, https://www.whitehouse.gov/briefing-room/presidential-actions/2022/09/12/executive-order-on-advancing-biotechnology-and-biomanufacturing-innovation-for-a-sustainable-safe-and-secure-american-bioeconomy; Ouyang, S. (2022), 'Bioeconomy prominent on growth agenda', People's Republic of China, State Council, 11 May 2022, https://english.www.gov.cn/policies/policywatch/202205/11/content_WS627b169ec6d02e533532a879.html.

37 East African Science and Technology Commission (2020), *The Eastern African Regional Bioeconomy Strategy – A Summary*, October 2020, http://repository.eac.int:8080/handle/11671/24293.

38 European Commission (2019), *Updated Bioeconomy Strategy 2018*, 5 March 2019, https://knowledge4policy.ec.europa.eu/publication/updated-bioeconomy-strategy-2018_en.

39 Nordic Co-operation (2018), *Nordic Bioeconomy Programme: 15 Action Points for Sustainable Change*, Copenhagen: Nordic Council of Ministers, https://www.norden.org/en/publication/nordic-bioeconomy-programme.

Policy, market and innovation trends shaping the bioeconomy

Three broad trends – in policy, markets and innovations – will shape the bioeconomy and have the potential to change market conditions for the forest sector, in turn improving prospects for the financing of nature-based solutions that benefit people and the environment. However, the implementation of novel policies and innovations carries some risks, and it is critical that nature-based solutions which deliver the most beneficial environmental and social outcomes are financially competitive with forestry activities that do not.

Policy trends

The bioeconomy strategies and action plans highlighted above aim to unlock public funding, stimulating public R&D in technology programmes and promoting the development of bioeconomy-related standards, as well as providing tax incentives. These policy signals provide investors with greater confidence that substantial policy will underpin the bioeconomy. While not always legally binding, strategies drawn up by local and national governments and supranational bodies can help build policy certainty and emphasize the future importance of the bioeconomy in achieving sustainability ambitions. For example, the EU's European bioeconomy strategy, as updated in 2018, aimed to disburse research and innovation grants via the Horizon 2020 programme and committed to creating a €100 million Circular Bioeconomy Thematic Investment Platform.[40]

Market trends

Consumer awareness surveys point to increasing concern over the consumption of forest-based products and the risk that their production and trade may bring about environmental harm. These environmental concerns are driving consumers' purchasing choices. A survey conducted in 2021 on behalf of the Forest Stewardship Council (FSC), an international certification organization, identified that 86 per cent of the sample interviewed (which amounted to 12,000 participants across 15 countries) preferred to avoid buying forestry products that directly cause damage to biodiversity.[41]

Procurement policies are a powerful tool shaping demand for biomaterials in global markets. The need to decarbonize heavy industry and curb carbon-intensive production of concrete and steel has begun to influence public and private procurement policies, which are shifting towards the increased use of biomaterials.

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40 European Commission, Directorate-General for Research and Innovation (2018), *A sustainable bioeconomy for Europe: strengthening the connection between economy, society and the environment*, Brussels: Publications Office, https://data.europa.eu/doi/10.2777/792130.
41 GlobeScan (2021), '2021 Global Consumer Research Reveals Escalating Concerns about Climate Change and Threats to Forest Biodiversity', 21 October 2021, https://globescan.com/2021/10/21/consumer-research-reveals-escalating-concerns-about-climate-change-forest-biodiversity.

For example, in September 2022, the Biden–Harris administration in the US announced a new Buy Clean Initiative, prioritizing low-carbon construction materials for 98 per cent of the materials purchased by the federal government.[42]

Shifting demand in the construction materials sector has translated into long-term market demand for long-lived wood products. For example, in recent years there has been increased demand in both the US and Europe for bio-based materials such as cross-laminated timber (CLT). According to one estimate, the global CLT market is expected to show a compound annual growth rate of more than 13 per cent between 2021 and 2028.[43]

Innovation trends

Innovation and emergent technology can be integrated at different stages along the forestry supply chain. For example, the use at the planting and growing stage of precision forestry, which uses sensors and artificial intelligence-powered decision-making tools, can automate the precise application of water or fertilizers to support the growth and development of young trees or plants.[44]

At the supply-chain stage, new processing technologies can transform raw feedstocks (i.e. harvested plants and trees) into new types of bio-based products. For example, lignin, a by-product of the pulp and paper industry, is increasingly being integrated into pharmaceuticals, fibres and 3D printing composites, after being fractionated in advanced biorefineries.[45]

Business models in the forest sector have traditionally been based around plantations of introduced monoculture of non-native tree species. There is increasing recognition of the economic opportunities offered by increasing the genetic diversity of plantations and, notably, by planting native tree species, both of which can provide new avenues for the creation of bio-based products. There is also a growing recognition of the risks to biodiversity from the monoculture model. The Green Climate Fund's Amazon Bioeconomy Fund – a $600 million investment programme – is investing in native tree species and aims to encourage private investment in six key areas of the bioeconomy in the Amazon region.[46]

The use of innovative technology will improve the resilience of plants and trees to pests, fungal disease and long-term acute effects of climate change such as reduced rainfall. It may include the use of new synthetic technologies that allow scientists

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42 White House (2022), 'Fact Sheet: Biden–Harris Administration Announces New Buy Clean Actions to Ensure American Manufacturing Leads in the 21st Century', 15 September 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/09/15/fact-sheet-biden-harris-administration-announces-new-buy-clean-actions-to-ensure-american-manufacturing-leads-in-the-21st-century.
43 Grand View Research (2020), *Cross Laminated Timber Market Size, Share & Trends Analysis Report By Product (Adhesive Bonded CLT, Mechanically Fastened CLT), By Application (Residential, Institutional), By Region, And Segment Forecasts, 2021–2028*, https://www.grandviewresearch.com/industry-analysis/cross-laminated-timber-market.
44 El Karoui, M., Hoyos-Flight, M. and Fletcher, L. (2019), 'Future Trends in Synthetic Biology – A Report', *Frontiers in Bioengineering and Biotechnology*, 7, 175, https://doi.org/10.3389/fbioe.2019.00175; Voigt, C. A. (2020), 'Synthetic biology 2020–2030: six commercially-available products that are changing our world', *Nature Communications*, 11, 6379, pp. 1–6, https://doi.org/10.1038/s41467-020-20122-2; Candelon, F. et al. (2022), 'Synthetic Biology Is About To Disrupt Your Industry', Boston Consulting Group, 10 February 2022, https://www.bcg.com/publications/2022/synthetic-biology-is-about-to-disrupt-your-industry; Hassegawa, M., Karlberg, A., Hertzberg, M. and Verkerk, P. J. (2022), 'Innovative forest products in the circular bioeconomy [version 2; peer review: 2 approved]', *Open Research Europe*, 2, 19, https://doi.org/10.12688/openreseurope.14413.2.
45 Hassegawa, Karlberg, Hertzberg and Verkerk (2022), 'Innovative forest products in the circular bioeconomy'.
46 Green Climate Fund (2021), 'FP173: The Amazon Bioeconomy Fund', https://www.greenclimate.fund/project/fp173.

to genetically alter the genes of trees and plants, and their offspring, to reinforce characteristics that may improve their resilience to climate change impacts. However, the introduction of synthetic technologies can have unintended consequences or create novel risks, altering ecosystems in complex, unpredictable ways[47] and giving rise to public concern.[48]

Implications for land availability and land-use dynamics

Trends in policy, markets and innovation, among others, will also affect the total land footprint of the bioeconomy – in other words, the area of land that needs to be designated for growing sufficient numbers of plants and trees to meet increased demand for bio-based products. However, there will be competing demands for this space. In 2020, the Corporate Statistical Database division of the Food and Agriculture Organization of the UN (FAOSTAT) estimated that nearly 37 per cent of the world's land area (excluding Antarctica) was allocated to agriculture and more than 31 per cent to forests.[49] Forecasts by the World Resources Institute indicate that in the period to 2050 there will be increased demand for land across a number of non-forestry sectors: for example, animal-based products, crops, bioenergy and urban development.[50]

The findings of a remote sensing survey conducted by the Food and Agriculture Organization of the UN and published in 2021 indicated that agricultural expansion drove almost 90 per cent of global deforestation between 2000 and 2018.

These land-use dynamics will have cascading impacts on global supply chains as well as on prices for goods and services. For example, one study estimates that, globally, the expansion of urban land into agricultural areas will bring about a decline in crop production (rice, wheat, maize and potatoes) of between 1 per cent and 4 per cent by 2100.[51] The IPCC has estimated that large-scale afforestation (being the planting of new forests on previously unforested land, which is different to reforestation or forest restoration – see Box 1) could increase food prices by up

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47 Ledford, H. (2019), 'Transgenic trees face rocky path from farm to forest', *Nature*, 8 January 2019, https://www.nature.com/articles/d41586-019-00072-6.
48 Hobman, E. V., Mankad, A. and Carter, L. (2022), 'Public Perceptions of Synthetic Biology Solutions for Environmental Problems', *Frontiers in Environmental Science*, 10, 928732, https://doi.org/10.3389/fenvs.2022.928732.
49 FAOSTAT (2020) 'Land Use > World + (Total) > Area > Land area + Agriculture + Forest Land + Planted Forest > 2020', https://www.fao.org/faostat/en/#data/RL (accessed 25 Nov. 2022).
50 Searchinger, T. et al. (2019), *Creating a Sustainable Food Future (Final Report)*, Washington, DC: World Resources Institute, https://www.wri.org/research/creating-sustainable-food-future; Gresham House (2020), *Gresham House Global Timber Outlook*, London: Gresham House Asset Management Limited, https://greshamhouse.com/wp-content/uploads/2020/07/GHGTO2020FINAL.pdf; Chen, G. et al. (2020), 'Global projections of future urban land expansion under shared socioeconomic pathways', *Nature Communications*, 11, 537, https://doi.org/10.1038/s41467-020-14386-x; Quiggin (2021), *BECCS deployment*. According to the UN Population Division, the population of the world is projected to reach 9.71 billion in 2050 and 10.35 billion in 2100. See United Nations, Department of Economic and Social Affairs, Population Division (2022), *World Population Prospects: The 2022 Revision*, custom data acquired via https://population.un.org/dataportal/data/indicators/49/locations/900/start/2020/end/2100/line/linetimeplot (accessed 13 Feb. 2023).
51 Chen et al. (2020), 'Global projections of future urban land expansion under shared socioeconomic pathways'.

to 80 per cent in 2050.[52] The findings of a remote sensing survey conducted by the Food and Agriculture Organization of the UN and published in 2021 indicated that agricultural expansion drove almost 90 per cent of global deforestation between 2000 and 2018.[53]

Prioritizing land uses that deliver multiple functions – by combining production, biodiversity protection and livelihood creation – will enable more to be done with less. But identifying where it is best to prioritize certain types of land allocation will require land-use models that connect demand scenarios for the bioeconomy with proposals for combining the provision of ecosystem services and livelihood creation, alongside other types of land use. The analysis needs to take account of projections for future demand as well as for future technological adoption and land footprint.

How can the forest sector support the scaling-up of nature-based solutions?

The forest sector may provide a route for making nature-based solutions more investible for private finance. But in order for the sector to deliver positive social and environmental outcomes, forestry businesses must first eliminate harmful or unproductive land-use practices, prioritize meaningful stakeholder management and adopt more sustainable business models. The following three actions can be undertaken with respect to the elimination of negative land-use practices:

1. Ensuring there is no more conversion of forests or natural habitats to meet competing land needs.
2. Promoting a worldwide rapid and continued whole-economy decarbonization which does not rely on land-based carbon sequestration. Over-reliance on land-based carbon sequestration has multiple adverse effects. Notably, it could result in delayed or deterred greenhouse gas emissions reductions in high-emitting industries (such as the energy sector).
3. Shifting production in the bioeconomy from bioenergy products into long-lived wood products with higher carbon storage potential. Using land for bioenergy production could indirectly cause the displacement of agricultural activity or other productive forestry activities. For example, according to one estimate the UK would need to convert between 27 per cent and 31 per cent of its agricultural land area to meet the Climate Change Committee's 'Further Ambition' scenario for BECCS feedstock production in the UK by 2050.[54]

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52 Intergovernmental Panel on Climate Change (2019), *Climate Change and Land*, p. 25.
53 Food and Agriculture Organization of the United Nations (2021), 'FAO Remote Sensing Survey', Rome: FAO, https://www.fao.org/3/cb7449en/cb7449en.pdf.
54 Quiggin (2021), *BECCS deployment*, p. 33; Climate Change Committee (2019), *Net Zero: The UK's contribution to stopping global warming*, London: Climate Change Committee, https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming, p. 149.

Managing stakeholders to maximize social outcomes

Many stakeholders have a role in shaping forest supply chains to address their needs and priorities, including local forest communities, consumers, civil society organizations, investors, policymakers and the private sector. Figure 2 shows key actors in the forest supply chain and identifies the roles that they can play in encouraging the whole forest sector to shift towards a more socially and environmentally positive business model. In some cases, there can be a conflict of interest between the priorities of different stakeholders. Power dynamics between businesses and communities can result in the initiation of forest projects that do not deliver benefits equally to all stakeholders.

Figure 2. The variety of actors across the value chain of the forest bioeconomy

Source: Authors' elaboration.

No single type of stakeholder can move the entire forest bioeconomy system towards an evolved version that can better support the scaling-up of nature-based solutions. Instead, each actor can influence the system – and other actors present within it – in unique ways. For example, consumers drive demand to which the private sector responds, which in turn can create end markets that investors may seek to grow.

Good governance practices are needed to design forest projects that can win the endorsement of all stakeholder groups. Free, prior and informed consent processes are a baseline requirement to achieve this, but co-governance projects can also create co-ownership between stakeholders. Dialogue between stakeholders is not

always easy to achieve. Time must be taken over negotiations to foster mutual trust between parties, while space must be made to amplify the voices of communities or groups who might otherwise be excluded from the project development.

The principle of a 'just transition' should lie at the centre of engagement approaches. A just transition is the process of maximizing social or economic opportunities for local communities when undertaking climate action – while ensuring that these communities do not incur financial or well-being losses through forest restoration. Equally, mechanisms for sharing project benefits with local communities need to be identified ahead of a project's launch. In order that businesses operating within the forest bioeconomy can build trust with landowners, local groups and indigenous communities, they must clarify how their activities would deliver equal social and economic opportunities for local stakeholders.

The International Labour Organization, in collaboration with the International Union for Conservation of Nature and UNEP, have estimated that up to 20 million more jobs could be created by tripling investment in nature-based solutions by 2030.[55] Measuring progress against this target will require reporting on issues ranging from gainful and secure employment, safe working conditions, wealth, income, and land rights and access, to the provision of high-quality food and water.

Improving forest management to maximize biodiversity outcomes

By definition, nature-based solutions must provide benefits for local biodiversity. However, business models must also deliver financial returns that allow forestry businesses to continue to operate.

It can take time to develop the business models that best align increased biodiversity with financial reward. A wider and deeper understanding of native tree and plant species is required if different species are to be successfully introduced into innovative business models. Beyond the species that currently account for the greatest shares of global timber markets, many hundreds of tree species could be integrated into biodiverse and ecologically rich forest landscapes that can then be harvested and turned into bio-based products.[56] For each of the species that could be incorporated into existing landscapes, knowledge gaps remain in terms of propagation, optimum growing conditions, harvesting techniques and end-market potential.

The combination and arrangement of tree species also affect the environmental outcomes of a forest-based project. Businesses must determine whether their forestry project will be a monoculture (single-species) or a polyculture (multiple-species) plantation, the latter being associated with offering increased biodiversity and resilience to pests and disease. For example, a recent study of plantation types (mixed-species, monoculture and native forests) as part of China's Grain for Green Programme found higher levels of bird and bee biodiversity – in terms of both abundance and species richness – in native forests and polyculture plantations

55 International Labour Organization, UNEP and IUCN (2022), *Decent Work in Nature-based Solutions 2022*, Geneva: ILO, https://wedocs.unep.org/bitstream/handle/20.500.11822/41401/Decent_Work_in_NbS.pdf.
56 Waack, R. S. (2021), 'O Continuo Florestal – e a Continuidade das Florestas', Pagina22, 1 June 2021, https://www.p22on.com.br/en/2021/06/01/o-continuo-florestal-e-a-continuidade-das-florestas.

than in monoculture alternatives.[57] Mosaic forests – which incorporate patches of different types of forest activities (which may be based on different tree species) mixed with natural habitats serving as ecological corridors can also be sites of increased biodiversity.

The further enhancement of environmental benefits on a more extensive scale (for example, by increasing populations of flora or fauna through ecological corridors) requires coordination across different land-use management approaches, as well as between multiple landowners or managers, creating a whole-of-landscape approach to nature restoration.

It is important to note that the delivery of nature-based solutions by forestry businesses is associated with decisions and choices that should reflect practical local environmental or social contexts. These decisions will then affect the investment required to achieve the intended outcome. For example, a highly degraded land that has been compacted by years of livestock grazing will require significant investment to convert it into a productive and biodiverse forestland – more than would be needed for a degraded forest that has not been subject to substantial interventions, but has been allowed to recover and regenerate naturally over time, creating a secondary (second-growth) forest. The most suitable forest management or restoration activity can only be identified after consideration of the potential environmental and societal benefits it will entail. The potential benefits (and risks) should be evaluated over the whole life cycle of the forest restoration, so as not to prioritize projects that deliver benefits quickly but are unsustainable or damaging in the long run.

Conclusion

The natural world is facing simultaneous and grave threats from climate change, biodiversity loss and ecosystem degradation. Nature-based solutions constitute a key approach to addressing this triple crisis, but do not currently attract sufficient investment to effectively combat biodiversity loss and ecosystem degradation on a global scale. Accessing increased flows of private sector finance will require changing investor perceptions that nature-based solutions carry a high investment risk. The forest sector can play a role in bridging the gap between private finance and nature-based solutions as an investible industry. This process can help the private finance sector deliver on net zero commitments and improve companies' own environmental and social credentials.

Demand for bio-based products will have consequences in terms of land footprint – how much land is assigned to growing the tree species needed to supply these markets. Available land being a finite resource, the land footprint of the bioeconomy will come under increasing pressure from urban expansion, as well as from growing demand for food production. These pressures reaffirm the need for nature-based solutions in landscapes that deliver multiple environmental and social benefits.

57 Wang, X., Hua, F., Wang, L., Wilcove, D. S and Yu, D. W. (2019), 'The biodiversity benefit of native forests and mixed-species plantations over monoculture plantations', *Diversity and Distributions*, 25, pp. 1721–35, https://doi.org/10.1111/ddi.12972.

The above context makes it essential to build understanding and decision-making capability among key stakeholders, such as policymakers, investors, businesses and forest communities, on the future trajectories of the bioeconomy – and of how its land footprint will contribute to environmental and social outcomes. This process can help inform the business governance and development opportunities that should shape the type of forest sector activities that can be constructed around nature-based solutions.

First, a broad understanding of the potential of the bioeconomy should be fostered by the implementation of land-use modelling exercises to determine the land footprint required and how it should be allocated to different activities, based on projections of future demand and innovation within the bioeconomy. Environmental and social outcomes should be evaluated across these scenarios to create a clear picture of the local and global landscape functions that can be delivered over time by the bioeconomy. Second, the modelling exercises should inform a wider debate on which policies, investment patterns and innovation can be implemented – and where – in order to shift the bioeconomy on to specific development pathways that provide the best incentives for forest sector businesses to incorporate nature-based solutions into their business models.

About the authors

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Cover image: Officials grow native plants from seeds to support farmers in Izmir, Türkiye, 20 April 2022.
Photo credit: Copyright © Omer Evren Atalay/Anadolu Agency/Getty Images

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