The State of Finance for Nature in the G20

Leading by example to close the investment gap

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WORLD ECONOMIC FORUM
ELD THE ECONOMICS OF LAND DEGRADATION

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Executive Summary

Nature-based solutions (NbS) is a category of assets in which businesses, governments and citizens can invest in order to work with nature instead of seeing it as a barrier to economic development and progress. NbS places nature at the heart of many societal challenges, such as the climate and biodiversity crises, as well as disaster risk reduction, food security and human health. Through the improvement of carbon sequestration on agricultural lands and peatlands, defence from flooding by restoring mangrove populations, and the protection of global biodiversity through forest and other land conservation, nature-based solutions can help improve society today and in the future.

This report finds that in 2020 the G20 countries invested USD 120 billion in NbS.[1] This represents 92 per cent of global annual NbS investment, broadly in line with the G20's share of the global GDP of 80 per cent.[2] The vast majority of current spending by G20 countries, USD 105 billion, is allocated internally towards domestic government programs, a third of which is invested in programs to promote the protection of biodiversity and the landscape. The other two thirds of domestic government investment (USD 67 billion) funds water management, pollution abatement, general environmental protection, and measures for agriculture, forestry, fishing and hunting.

G20 official development assistance (ODA) and private sector investment in NbS is low compared to spending on NbS by domestic governments. The G20 currently invests approximately USD 2.4 billion annually in NbS-relevant ODA programs with a focus on biodiversity and environmental policy. The private sectors of G20 countries invest an additional USD 14 billion, the majority of which is allocated to improving the sustainability of supply chains or biodiversity offsets.

In order to achieve all future biodiversity, land degradation and climate targets, G20 countries would need to scale up their internal annual NbS spending by 140 per cent: an additional USD 165 billion, by 2050. This additional investment would allow G20 countries to reach a total annual spending of USD 285 billion by 2050. This estimate is based on an immediate action scenario in which the international community responds now to keep climate change warming at only 2°C in order to halt land degradation and to stabilize biodiversity and reverse its loss by 2050 at today's levels.[3]

Future G20 domestic investment needs to comprise 40 per cent of total global NbS investment. This estimate only takes into account four principal nature-based solutions: forestry, silvopasture, mangrove restoration and peatland restoration. Approximately USD 102 billion out of the USD 165 billion total additional investment needed in the G20 in 2050 would be invested in forestry, with USD 14 billion associated with plantation management and USD 88 billion with land conversion to forestry through restoration and afforestation. USD 63 billion annually would be invested in silvopasture and spent on its operation.

The remaining 60 per cent of annual future investment lies in developing countries where fiscal space to invest in NbS is limited. Future investment rates would be: forestry USD 101 billion, silvopasture USD 126 billion, peatland restoration USD 7 billion, and mangrove restoration USD 0.5 billion. All G20 members except India have investment grade sovereign debt, while most non-G20 countries do not. This means that it will be more expensive for non-G20 countries to borrow money on capital markets, limiting their fiscal bandwidth to fulfil NbS investment.

In many instances, NbS investments in developing countries are more cost effective in abating climate risk. For example, the average cost of land conversion to NbS in G20 countries is USD 2,600/hectare, while the average cost for non-G20 regions is USD 2,100/hectare. The situation is similar for mangrove restoration

[1] Please note that analysis for this report was limited to land-related NbS. The scope in the next report will cover both the terrestrial and marine environment more comprehensively.
[2] This number ranges from 74-92% because of uncertainty around the data.
[3] 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.

expenses, suggesting that G20 countries could improve their economic efficiency in NbS spending by investing in developing countries.

In line with the global report on the 'State of Finance for Nature', it is clear that both the volume of capital directed to NbS-relevant assets and activities and the share of private finance are currently insufficient to meet the climate, biodiversity and other human-induced crises. The investment case for NbS could be strengthened through a combination of regulation and economic incentives. G20 countries, which are among the richest nations on the planet, have a special responsibility to lead by example to reduce the gap between current NbS investment and what is needed to address the climate crisis, and to reverse land degradation and biodiversity loss. Opportunities to do this could involve:

- **G20 countries could align economic recovery post Covid-19 with both the Paris Agreement and future agreements on biodiversity**, focusing economies on being consistent with the 1.5°C warming above pre-industrial levels, as well as halting and reversing the loss of biodiversity. (Vivid Economics & Finance for Biodiversity Initiative 2021; United Nations Environment Programme [UNEP], Global Recovery Observatory, University of Oxford, 2021)

- **From a public funding perspective, G20 countries could pledge to:** a) increase ODA spending to help developing countries to reduce the NbS investment gap; and b) increase domestic expenditure for NbS-relevant sectors, including through repurposing agricultural subsidies. Other opportunities relate to: c) requesting multilateral development banks (MDBs) to expand NbS-relevant lending or debt relief to developing countries by supporting the issuance of IMF Special Drawing Rights (SDR); or, d) creating and expanding results-based financing schemes, such as nature performance bonds.

- **In order to stimulate private finance, G20 countries have numerous policy options available**, such as: a) incentivizing corporate and financial institutions to disclose nature-related risks; b) aligning portfolios to become 'nature positive' and strengthening risk management to reduce the potential for negative impacts on nature by clients, suppliers, etc.; c) strengthening the investment case for NbS by harnessing the potential of carbon markets and other nascent markets for ecosystem systems; and, d) increasing the availability of concessional capital in the form of subordinate loans, guarantees and grants, which is also needed to reduce the (perceived) risk for novel business models.

In the wake of the dire warnings from the latest Intergovernmental Panel on Climate Change (IPCC) report, and in the context of the world summit on transforming food systems, the role of investment in NbS is clear: it tackles these interlinked crises.

This report is a first step in measuring NbS investments in G20 countries and therefore has a number of limitations that should be addressed in future iterations. First, the scope only covers terrestrial ecosystems. Secondly, the data used in this report has limitations in tracking public and especially private investment in NbS due to the lack of internationally comparable datasets and NbS markers. The data presented in this report cannot be disaggregated by sex to conduct a gender analysis due to a lack of quantifiable metrics. Thirdly, it focuses on existing investment but does not estimate the benefits of investing in nature. Finally, it focuses on NbS positive investments and does not report on capital flows that negatively affect nature.

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1 Introduction

Nature-based Solutions (NbS) can contribute to the transition towards a net zero carbon, nature positive global economy by putting nature at the heart of addressing economic and societal challenges. Estimates suggest that more than half the world's GDP (USD 40 trillion) is moderately or highly dependent on nature and its services. (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES] 2019; World Economic Forum 2020) NbS can support the global economy, and can specifically contribute to achieving the objectives of the three Rio Conventions, by mitigating and adapting to the adverse effects of climate change, supporting environmental services, restoring degraded land, and halting and reversing biodiversity depletion. A healthy planet is also good for business and economies, because our livelihoods depend on nature. Emerging research, such as the Dasgupta Review (2021) and the State of Global Finance for Nature (2021), have made the economic case for triple action to tackle the climate, land degradation and biodiversity crises clearer and more compelling than ever. The loss of biodiversity poses enormous risks to human prosperity and wellbeing with disparities felt between genders. Investing in nature also provides multiple benefits, such as reducing the risk of future pandemics and accelerating global efforts to mitigate and adapt to climate change. Investing in nature-based solutions such as transitioning to deforestation-free sustainable agricultural production, natural infrastructure, etc. is smart from both a public and private sector perspective, for reasons including: (i) economic gains from job creation and from more productive sustainable natural resource use; (ii) avoiding the losses and costs required for protecting communities from hazards; and (iii) other social and environmental benefits. (Global Center on Adaptation 2020; World Resources Institute 2020) It is far cheaper to prevent environmental damage than to pay for its restoration afterwards. The most cost-effective policies are those that take a comprehensive approach towards appropriately valuing, protecting and restoring nature.

Investment flows into nature need to increase while shifting away from harmful activities. Studies have shown that governments spend around USD 500 billion per year globally to support activities that potentially harm nature. (Organisation for Economic Co-operation and Development [OECD] 2020) Public and private financial flows that are harmful to the biosphere significantly outweigh the investment aimed at protecting and restoring it. Political and economic systems and financial markets have so far failed to account for the full value of services that nature provides. Redirecting existing harmful financing, such as subsidies that encourage deforestation or environmental destruction, towards NbS can drive green growth and job creation while tackling the twin goals of the Paris Agreement on climate change and the anticipated Kunming Agreement on biodiversity. Incorporating NbS into financial and economic systems means that the two goals of sustainable natural resource management and socioeconomic growth can be addressed.

Recent global reports, such as the IPBES report on biodiversity and climate change and the Dasgupta Review on the economics of climate change, summarize the scientific grounds for policies that place us on a pathway towards sustainability.(IPBES 2019; Dasgupta 2021) Nature-based solutions and ecosystem-based approaches have emerged as crucial instruments for delivering multiple benefits, including addressing climate change mitigation, adaptation and biodiversity loss: reducing flood risk, filtering air pollutants, providing reliable supplies of drinking water, strengthening food security, contributing towards business and job opportunities, gender empowerment and, more broadly, achieving the 2030 Sustainable Development Goals. The G20 countries have also recognized that protected areas are a principal tool for halting biodiversity loss, and would support efforts to protect at least 30 per cent of global land and at least 30 per cent of the global ocean, with at least 10 per cent under strict protection, by 2030, according to national circumstances and approaches.

The G20 member states have expressed their commitment to taking the necessary actions to put nature and biodiversity on a path to recovery by 2030, for the benefit of people and the planet, and achieving the vision of 'Living in Harmony with Nature' by 2050. (G20 2021) They recognize the importance of advancing policies that protect and restore nature due to its cost-effectiveness and ability to provide multiple social, environmental and economic benefits. In 2021, they agreed to join efforts to advance together within a structured and ambitious agenda around ten key goals: (i) investment in nature as a means to address joint socioeconomic and environmental challenges; (ii) creation of an International Environmental Experts Network to boost capacity building; (iii) protection and restoration of degraded lands for an inclusive and sustainable recovery; (iv) sustainable water management; (v) protection of oceans and seas; (vi) reduction in marine plastic litter; (vii) improvements in sustainable and circular resource use; (viii) investment in circular cities; (ix) improvements in education, capacity-building and training; and, (x) growth of green finance and blue finance measures.

G20 countries recognize that 2021 is a critical year for increasing commitments towards tackling the crises of climate change, biodiversity loss and pollution exacerbated by unsustainable natural resource use. Nearly thirty years after the signing of the Rio Conventions, there are opportunities to build international cooperation through the UNFCCC and the Paris Agreement, the anticipated Kunming post-2020 Global Biodiversity Framework to be adopted at CBD COP15, and the Land Degradation Neutrality goal championed by the UNCCD, among others.

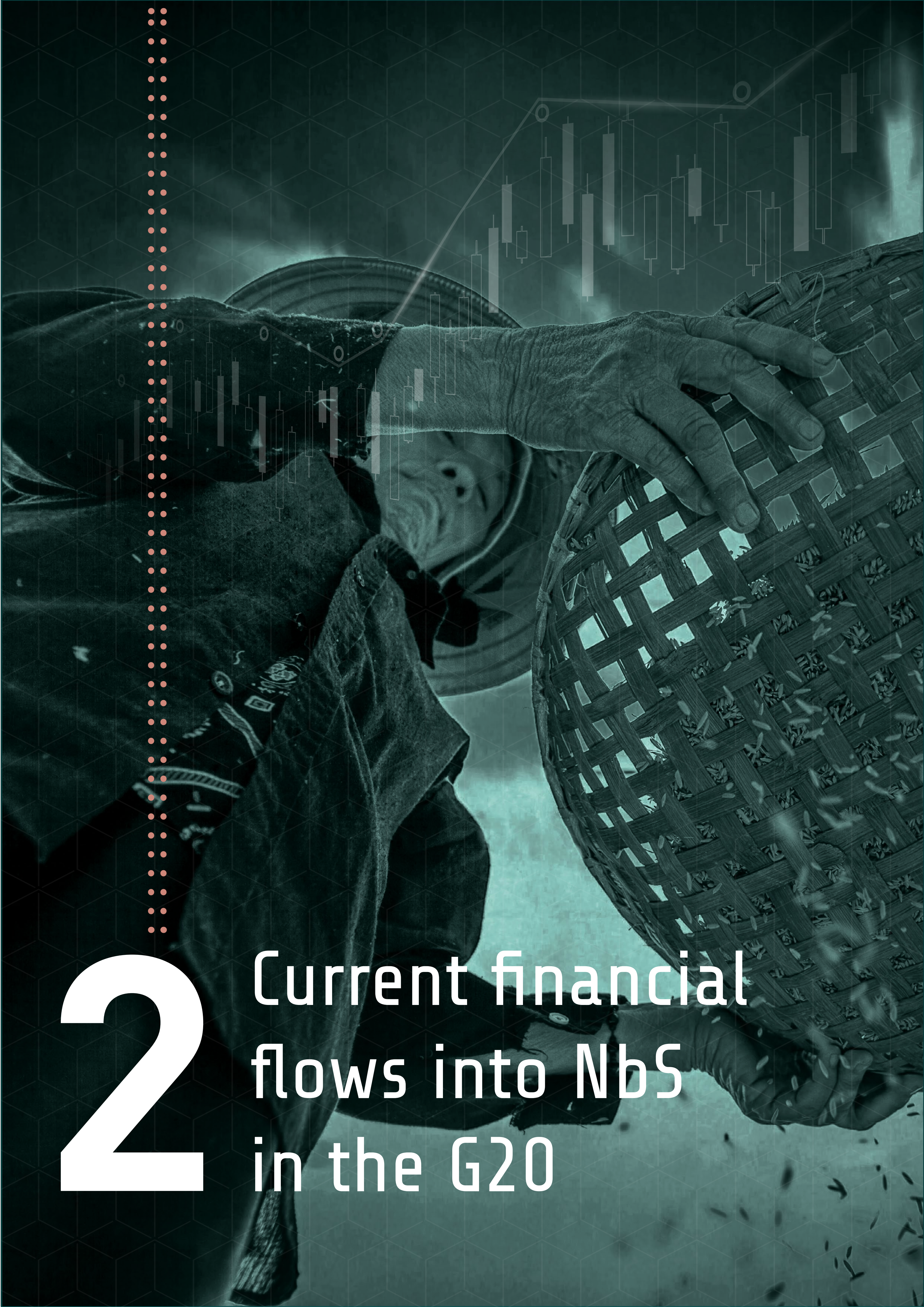
1.1 This report

This report builds on a global study (2021) entitled '*State of Finance for Nature – Tripling Investments in Nature-based Solutions by 2030*' ('The Global Report'). The Global Report estimates the current rate of investment in NbS globally and compares it to future investment needs to meet the objectives set out by the three Rio Conventions: the United Nations Framework Convention on Climate Change, the United Nations Convention to Combat Desertification and the Convention on Biological Diversity (CBD).

The Global Report finds that approximately USD 133 billion currently flows into land-related NbS annually (using circa 2020 as the base year), with public finance making up 86 per cent of the funds and private finance contributing 14 per cent. Over a third of the public funds, which total USD 115 billion annually, is invested by national governments in the protection of biodiversity and landscapes domestically. Nearly two thirds are spent on forest restoration, peatland restoration, regenerative agriculture, water conservation and natural pollution control systems. The private sector finance for NbS amounts to an additional annual USD 18 billion. This investment spans biodiversity offsets, sustainable supply chains, and private equity impact investing, and includes smaller amounts from philanthropic and private foundations. The total volume of finance flowing into nature is considerably less than the financial flow towards climate finance.

Future investment in NbS would need to at least triple in real terms by 2030 and increase four-fold by 2050 if the world is to meet its climate change, biodiversity and land degradation targets. This acceleration would equate to a cumulative total investment of up to USD 8.1 trillion, and a future annual investment rate of over USD 536 billion. Forest-based solutions alone would amount to USD 203 billion annually, followed by silvopasture at USD 193 billion, peatland restoration at USD 7 billion, and mangrove restoration at USD 0.5 billion. This report does not cover all types of NbS, and notably those in the marine environment were excluded. These will be included in future editions.

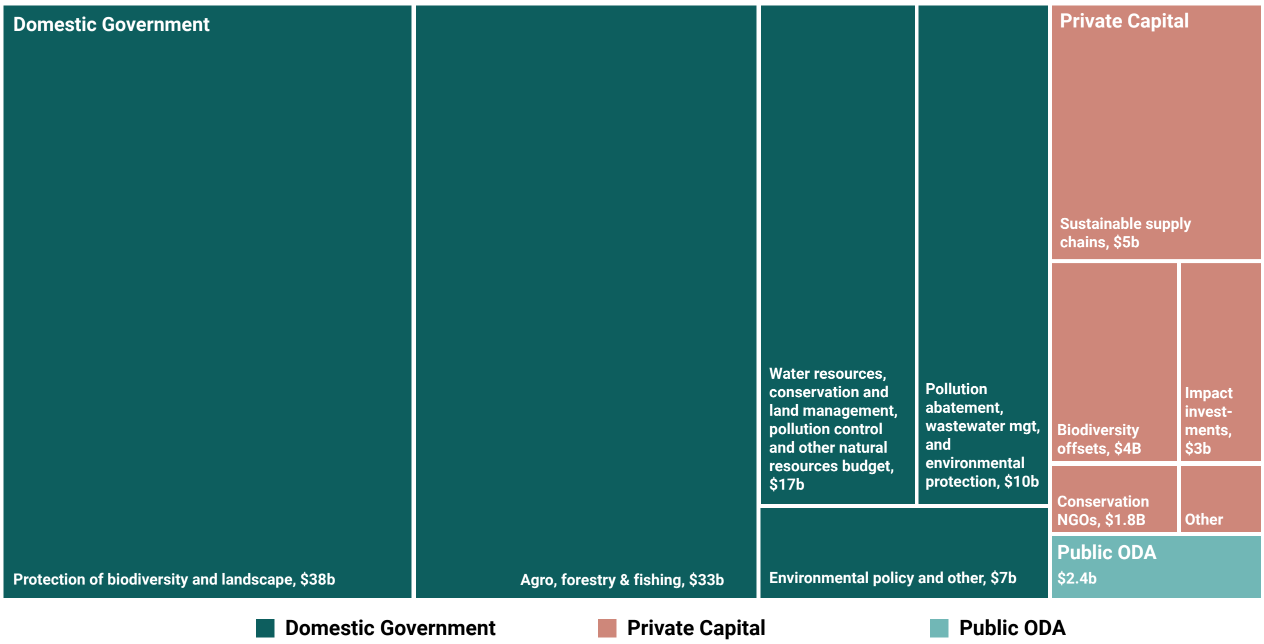
This report focuses specifically on how G20 countries are currently directing capital flows to NbS-relevant assets and activities, and how much additional investment is needed to tackle the climate, biodiversity and land degradation crisis. The analysis includes data from all G20 members in order to assess the current investment in NbS, covering both private and public financial flows. Given the improved quality and coverage of public and private sector data available for G20 countries, the methodology provides a more accurate picture and analysis of NbS investment needs and gaps for the G20 than does the global methodology. The report also provides recommendations, both technical and policy-related, to support decision-making among G20 countries. Like the global report, this report is limited to land-related NbS and focuses exclusively on disbursed investments, as opposed raised or pledged capital. We endeavour to focus on both the marine and terrestrial environment in future reports.



2 Current financial flows into NbS in the G20

According to G20-specific data, current G20 investment in NbS is estimated to total USD 120 billion annually, as shown in Figure 1. Domestic government spending accounts for the vast majority of overall NbS investment, at USD 105 billion. Within domestic investment, approximately USD 71 billion is allocated annually to the protection of biodiversity and landscapes, along with agriculture, forestry, fishing and hunting measures. Public ODA accounts for an additional USD 2.4 billion in G20 NbS public expenditure. The private sector contributes a meagre USD 14 billion to NbS, with a third of private contributions focused on supporting sustainable supply chains.

Figure 1. Classification of NbS finance, in USD billions



Source: Vivid Economics, adapted from OECD, IMF and other public data sources.

According to the Global Report data, G20 investments comprise 82 per cent of global NbS spending.[4] (UNEP 2021) The data used by the global report estimates the current G20 contribution to NbS investment at USD 110 billion, contributing 74 per cent of total global NbS spending. Additional data collected specifically on the G20 since the publication of the Global Report means that the updated estimate of USD 120 billion spent by the G20 on NbS would comprise 92 per cent of total global NbS investment. Despite G20 counties having more fiscal leeway to make these investments, the estimated share of investment in NbS by the G20 is broadly similar to the G20's current share of global GDP: approximately 80 per cent. (G20 2021)

There is a significant need for benchmarks, standards and markers to track public and private NbS investment. The estimates for G20 domestic and private investment are uncertain because countries and companies do not directly report their NbS spending. Data for domestic government spending was collected from annual national budgets and national reports. The same set of assumptions as employed in the global report were used to extract NbS-specific values from overall spending amounts. The data for private spending from the global report was transformed to yield the proportion of G20 private spending relative to the rest of the world, based on GDP. ODA data was directly obtained from the OECD and thus is comparatively more accurate.

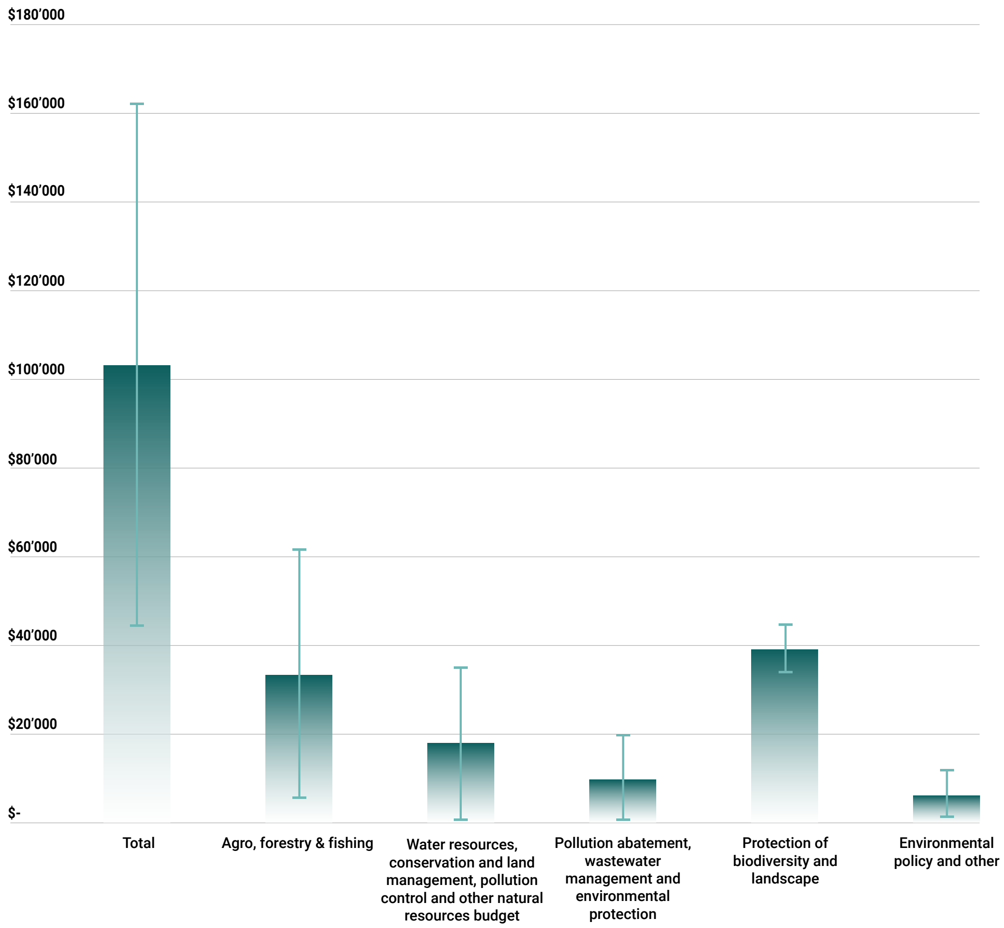
[4] This number ranges from 74-90% because of uncertainty around the data.

2.1 Domestic government investment

The vast majority of current G20 NbS investment is concentrated in domestic government programs, at USD 105 billion. Public sector domestic financing from the G20 contributes 87 per cent of the total USD 120 billion invested in NbS by the G20 annually, as can be seen in Figure 2. Domestic public finance is allocated across five key sectors: the protection of biodiversity and landscape; agriculture, forestry, fishing and hunting, and water management; pollution abatement; and general environmental protection. More than one third of total domestic government NbS spending, USD 38 billion, is assigned to the protection of biodiversity and the landscape. This category includes funding for initiatives such as conservation programs for endangered species or the establishment and maintenance of national parks.

An additional third of G20 domestic NbS spending, USD 33 billion, is focused on sustainable agriculture, forestry, fishing and hunting. This NbS category includes projects that promote biodiversity by improving agroecological systems, or that increase the carbon sequestration potential of soil by promoting soil health. The final third of domestic investment is distributed across an additional three categories: water resources, pollution abatement and general environmental protection. Actions such as water conservation, wastewater management and environmental policy measures fall within these categories.

Figure 2. G20 public-sector finance of NbS in 2018, by category



Note: The dark blue bars indicate the midpoint estimate and the light blue vertical lines the uncertainty range.
Source: Vivid Economics.

2.2 ODA and private sector investment

Despite large domestic public investments in NbS by the G20, ODA and private sector investments remain small. The G20 currently provides USD 2.4 billion annually to NbS-focused ODA programs, which makes up only 2 per cent of overall G20 NbS investment. The largest category of ODA spending is biodiversity projects at USD 880 million. An additional USD 740 million is allocated annually to environmental policy and education initiatives. The final USD 900 million is assigned to a combination of agriculture, forestry and water basin projects.

The private sector contributes 60 per cent of total national GDP in most G20 countries but invests just USD 14 billion annually in NbS, 11 per cent of overall G20 NbS spending. (International Monetary Fund [IMF] 2013) The majority of this investment, USD 9 billion, is spent on sustainable supply chain initiatives and biodiversity offsets. The additional USD 5 billion of private sector spending comes from private equity investing, conservation NGOs and additional miscellaneous sources.

3 Future investment needs

3.1 G20 domestic investment needs

In order to achieve all future biodiversity, land degradation and climate targets, G20 countries would need to scale up their total annual NbS spending by 140 per cent, an additional USD 165 billion, by 2050 (see Table 1). The G20 could increase domestic spending by USD 125 billion by 2030 and USD 140 billion by 2040 to meet this target. This additional investment would allow G20 countries to reach a total annual domestic spending of USD 270 billion by 2050 (the current annual domestic spending of 105 billion plus the increase in domestic spending of 165 billion). This increase in spending is 40 per cent of all future global investment needs.

This estimate is based on an immediate action scenario, in which the international community responds now to keep climate change warming at only 2°C, to halt land degradation, and to stabilize biodiversity and reverse its loss by 2050 at today's levels.[5] Economic modelling predicts the costs of transitioning from a business-as-usual trajectory to a trajectory that fulfils climate change, biodiversity and land degradation targets. The methodology (see Appendix for more detail) estimates the future NbS investment needs in G20 countries under the immediate action scenario targets for four asset types: forest, peatland, mangroves and agroforestry. Peatland and mangrove restoration have not been estimated for individual G20 countries, due to an absence of country level data, but are included in the global NbS estimates (see Table 1).

Table 1. Summary of future G20 investment needs

Type of NbS	G20 additional annual investment need (2021-2050) USD billion	Global future investment need, excluding G20
Forest management	14	21
Land restoration - forestry	88	80
Silvopasture - capital expenses	3	6
Silvopasture - operational expenses	60	120
Peatland restoration	-	7
Mangrove restoration	-	0.5
Total	**165**	**235**

Note on G20 figures: This table summarizes the additional annual spending needed by the G20, assuming that the current annual G20 spending of USD 120 billion remains constant.
Note on Global figures: This table shows the additional annual spending needed, assuming current annual world spending of USD 130 billion. Additionally, there was insufficient data to calculate peatland restoration and mangrove NbS for the G20 countries.
Source: Vivid Economics own calculations for the G20 figures and United Nations Environment Programme (2021). State of Finance for Nature 2021 for the global figures.

Across the G20 member states, future investment need is concentrated in the forestry space, with an increase of USD 88 billion and USD 14 billion per year for land restoration to forestry and for forest management, respectively. An additional USD 63 billion in NbS spending needs for the G20 is in capital and operational expenses for silvopasture (the integration of forests and livestock grazing).

[5] 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.

3.2 Global investment needs

By 2050, global NbS spending will need to increase from current levels by around USD 400 billion to a total annual expenditure of USD 536 billion to achieve all global sustainability targets. (UNEP 2021) This is more than quadrupling the total global NbS investment.

This estimate is based on an immediate action scenario and considers six categories: forest management, land restoration to forestry, silvopasture capital and operating expenses, peatland restoration, and mangrove restoration, as described in Table 1.[6]

Table 2. NbS in scope

	Forestry	Peatland	Mangroves	Regenerative agriculture
Restore	Managed afforestation (NPI and non-NPI); new timber plantations	Peatland restoration	Mangrove restoration	
Improve	Switch to sustainable management of timber plantations			Trees in cropland; silvopasture

Note: Empty boxes are not included in this study
Source: Vivid Economics

The largest proportion of future needs is in non-G20 countries, with USD 235 billion to meet Rio Convention objectives. Outside the G20, the region with the largest investment needs is sub-Saharan Africa, which will require an estimated increase of USD 54 billion in annual spending to achieve all climate and conservation targets. An additional USD 100 billion will be needed for land restoration to forestry and forest management, and USD 45 billion will be needed in Latin America. Finally, peatland and mangrove restoration will require an additional USD 7 billion and USD 0.5 billion, respectively.

The high values for forestry and silvopasture future investment needs do not imply that these NbS categories are more important for achieving sustainability goals. Rather, the larger numbers reveal that these NbS are more commonly known and supported with scientific and economic research, with peatlands and mangrove research emerging. Additionally, there are more areas where forestry and silvopasture can be implemented, compared to peatland or mangrove restoration. However, peatland and mangrove ecosystems hold a disproportate and substantial amount of carbon per land area than any other type of ecosystem - with peatlands alone storing more than twice the amount of carbon as all the world's forests combined (Crump 2017).

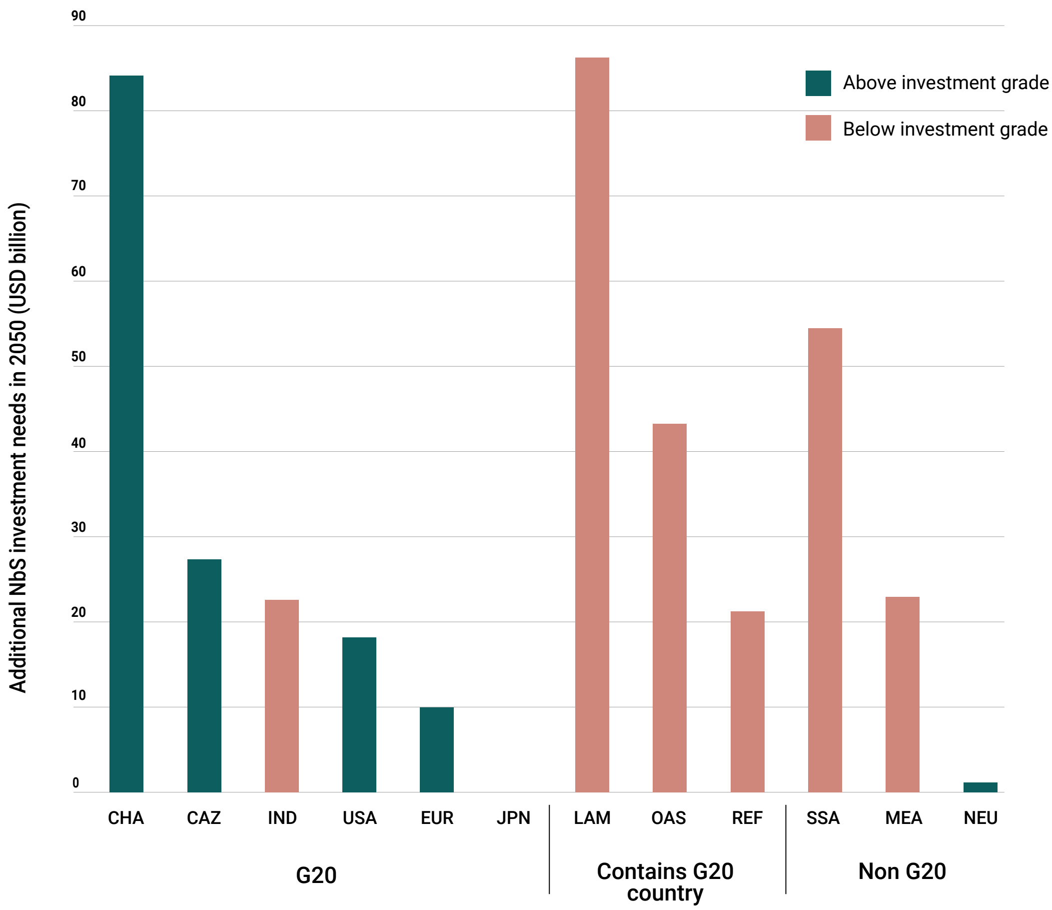
[6] Additional information on overall global estimates for NbS spending can be found in the State of Finance for Nature 2021 report.

4 Spending gap analysis

The spending gap in countries that are not part of the G20 is larger and more difficult to bridge than in G20 countries. Current G20 spending (USD 120 billion annually) is 42 per cent of the total future spending needs of member states (an additional average of USD 165 billion annually). Overall global future needs for NbS spending are much greater, however, with a global increase of more than four times the current spending levels needed. Excluding the G20, a total additional NbS investment of USD 235 billion is required annually by 2050. This value is 58 per cent of the additional total global NbS future needs, despite the fact that these countries contribute only 20 per cent of the world's GDP. It is important to highlight that the size of the gap presented in this report is conservative. The future spending estimates span only some of the current spending categories, and thus the gap is probably underestimated and the true increase in spending will need to be higher.

Non-G20 countries may not have enough fiscal space and access to global finance to allow them to make sufficient investment in NbS, especially after the Covid-19 pandemic. Figure 3 compares annual NbS future spending needs and long-term sovereign debt ratings, an indicator of ease of access to global financial markets. All G20 members except India have investment grade sovereign debt, while most non-G20 countries do not. This coincides with high investment needs, meaning that it will be more expensive for developing countries to borrow money on capital markets, but limited fiscal ability and ODA expenditures by rich countries mean that it will be more difficult to close the NbS investment gap.

Figure 3. Annual NbS future spending needs and sovereign debt investment grade



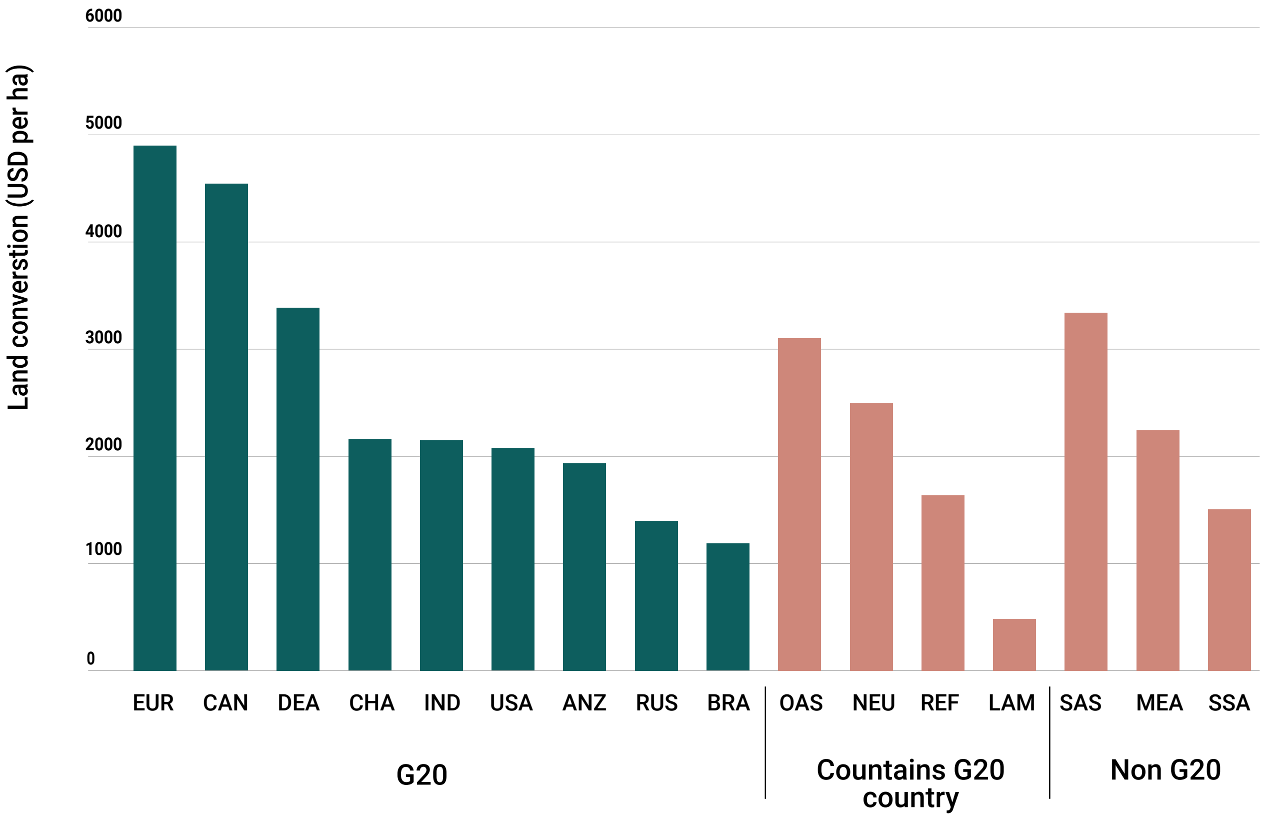
Note: Three letter code signifies country/region. CAZ = Canada, Australia, New Zealand. CHA = China. EUR = European Union. IND = India. JPN = Japan. LAM = Latin America (including Brazil, Argentina, Mexico). MEA = Middle East and North Africa. NEU = Europe, excluding European Union members. OAS = Asia (including South Korea). REF = Former Soviet Union (including Russia). SSA = Sub-Saharan Africa. USA = United States. Annual average of foreign currency long-term sovereign debt ratings by Moody's, Standard & Poor's, and Fitch Ratings.

Source: Vivid Economics based on World Bank and Bloomberg data.

The larger the government debt to GDP ratio, the greater the annual NbS future spending need, revealing the challenge of funding NbS investment outside the G20. The G20 countries tend to have a lower government debt to GDP ratio compared to future spending needs than non-G20 regions. A significant exception to this pattern is China, which has a low government debt to GDP ratio but high annual future spending needs. This future investment value is primarily caused by the considerable opportunity for land restoration to forestry within the country.

Although the G20 member states have the resources to achieve all domestic NbS spending goals, these countries may not be the most cost-efficient place to target NbS spending. For example, higher land prices in G20 countries mean that NbS project capital expenses based on land conversion costs per hectare are significantly greater in many G20 countries than in non-G20 countries, as can be seen in Figure 4.

Figure 4. NbS project capital expenses (land conversion cost), USD per ha



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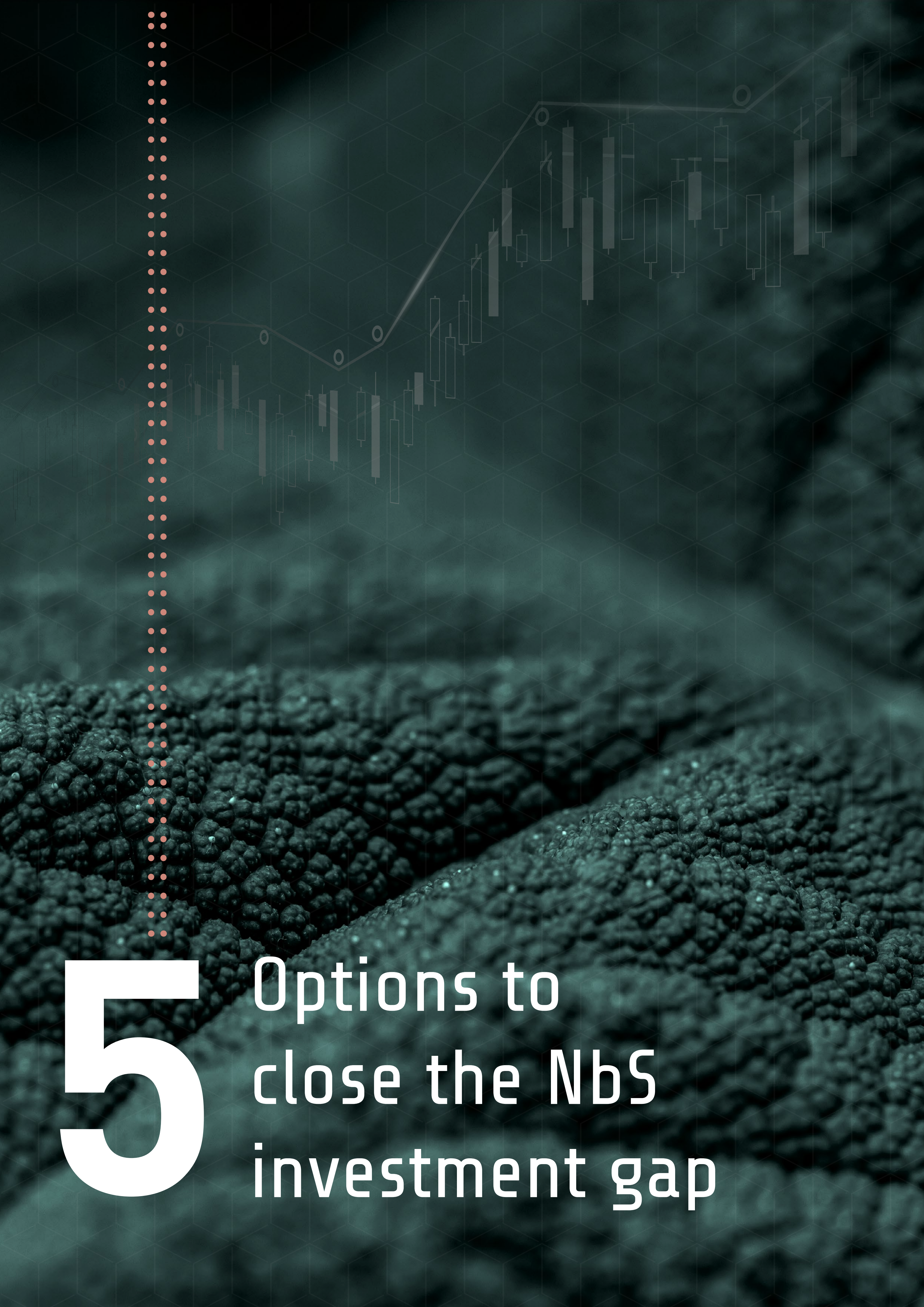
Source: Vivid Economics

There are many opportunities for NbS investment within non-G20 countries that are more cost effective than investing in the same NbS within the G20 member states. As seen in Figure 4, NbS capital land conversion costs are up to USD 2,600 per hectare in G20 countries. In contrast, costs are up to USD 2,100 per hectare in non-G20 regions.[7] This price difference means that Europe or Canada would be able to preserve more than three times as much land by conducting afforestation projects in Sub-Saharan Africa or Latin America than within their own countries with the same budget.

The same efficiency principle holds for other NbS categories, suggesting that the G20 member states would improve efficiency by investing in NbS outside their own countries. For example, average mangrove restoration costs in the southeastern US are estimated as USD 45,000 per ha, while average mangrove restoration costs in the rest of the Caribbean are estimated as only USD 23,000 per ha, despite both regions being in the same geographic area. (Menendez et al. 2020) These large investment cost differentials suggest that this efficiency principle should be considered when allocating NbS funding both domestically and abroad.

[7] Note: The three datapoints that include G20 regions (the bars in the included G20 section of Figure 4) are probably positively skewed due to the presence of G20 countries in the data. The ability to exclude the G20 countries from these data points would probably make the price per ha much lower, further providing an example of increased efficiency for investments.



5 Options to close the NbS investment gap

The governments of G20 countries could play a key role in mobilizing financial resources, sending clear signals and creating an enabling environment for investment in nature. There is currently an investment gap in achieving the global environmental objectives set out by the three Rio Conventions. The people of the G20 countries carry out the majority of global economic and financial activity and they have the capacity for leadership and decisive action. The world would benefit from a transition in global finance away from the current unsustainable use of Earth's resources towards activities that protect and restore the biosphere and support the sustainable use of its natural assets. G20 countries can carry out needed studies to calculate future NbS investment needs for restoration of peatland and mangrove ecosystems to enhance country level data and decision making.

The G20 could commit to investing in nature. In order to close the investment gap, the G20 could adopt policies that will increase domestic finance levels accordingly. These policies could include a range of financial and economic instruments that would channel public and private capital towards activities and assets that protect and restore nature. This includes support for NbS via policy and regulation, and by measuring, valuing and reporting on NbS at country level, creating a comprehensive national strategy that could be supported by the inclusion of restoration practices into the Nationally Determined Contributions (NDCs) of G20 countries while prohibiting further ecosystem degradation.

5.1 Align economic recovery post Covid-19 with international nature and climate agreements, scale up domestic spending, repurpose fiscal policies & trade tariffs

The G20 could align post Covid-19 economic recovery with both the Paris Agreement and any future biodiversity agreement, focusing economies on being consistent with 1.5°C warming above pre-industrial levels, as well as halting and reversing the loss of biodiversity. Although some G20 countries have put in place ambitious plans to build back better, many other G20 nations seem to be building back as usual. (Vivid Economics and Finance for Biodiversity Initiative 2021; UNEP, Global Recovery Observatory, University of Oxford 2021) With debt levels rising, this reduces the fiscal leeway to shift capital flows towards nature and climate-positive activities and assets in the near future.

Part of aligning post-Covid economic growth involves scaling up the internal annual NbS of the G20 spending by 140 per cent, an additional USD 165 billion annually, by 2050, as well as making agricultural subsidies nature-positive. These spending changes could be applied in the public and private sector, and would include land restoration to forestry, silvopasture, peatlands, and mangroves. A recently-released United Nations report found that around USD 470 billion in public funding for the agricultural sector consists mostly of price incentives, such as import tariffs and export subsidies, as well as fiscal subsidies which are tied to the production of a specific commodity or input. (UNEP, United Nations Development Programme [UNDP], Food and Agriculture Organisation of the United Nations [FAO] 2021) Many of these are inefficient, distort food prices, damage people's health, and are often inequitable, putting big agri-business ahead of smallholder farmers, a large proportion of whom are women. On the other hand, some USD 110 billion supports infrastructure, research and development, and benefits the general agricultural sector. Reconfiguring support for agricultural producers, rather than eliminating it, means it can be used to help end poverty, eradicate hunger, achieve food security, improve nutrition, promote sustainable agriculture, foster sustainable consumption and production, mitigate the climate crisis, nurture nature, limit pollution and reduce inequalities.

5.2 Scale up ODA, improve development finance and standardize NbS investment

Having recognized the additional challenges faced by lower income developing countries in mobilizing financial resources to meet climate, nature and land degradation targets, the G20 could commit to assisting developing countries to meet their financial obligations under the Rio Conventions. A specific set of actions would be needed. The links between finance, climate, biodiversity and land degradation suggest that such actions will be fundamental for achieving global sustainability targets.

Governments, public sector institutions and development finance institutions (DFI) could serve as cornerstone investors to supply catalytic and core capital to protect and restore nature. Cornerstone investment could include the creation and expansion of results-based financing schemes, such as nature performance bonds, the resilience bonds market, credit facilities for habitat restoration, nature-positive land use and water quality improvement, debt-for-nature swaps, blended finance mechanisms, credit guarantees and results-based payments for REDD+.

International financial institutions such as multilateral development banks (MDBs) could adjust existing financing mechanisms to ensure financial support is aligned with nature goals. These adjustments need not compromise the short-term aims of these financial flows nor the historic mandates of institutions focused on economic development. Four main actions could drive outcomes:

- **Foreign investment by DFIs in the agricultural sector could be channelled (exclusively) through green credit lines, to achieve overall nature, restoration and climate-positive outcomes.** The knowledge and financial infrastructure already exists in most biodiversity-rich developing countries, and DFIs could provide timely support.

- **IMF lending and Special Drawing Rights (from developed to developing countries) could include conditions on the maintainance and extension of environmental regulations.** In some locations, there is pressure to unwind such regulations, which would confer no material benefit in addressing the current Covid-19 crisis, and could threaten the ability of these sectors to trade internationally in the future. This could be complemented with official development assistance to provide direct budgetary top-ups and technical assistance for enforcement agencies.

- **Debt relief could be tied to existing and accelerated commitments to improved spatial planning practices which extend protected natural areas and accelerate forest restoration projects.** These conditions could accelerate the implementation of existing international commitments, such as the Paris Agreement, aligned with Nationally Determined Contributions. Such activities could help to support both rural communities, including gender equality, and nature. Budgetary commitments to these activities could be forward-looking and persist beyond the current crisis period.

- **More ambitiously, shareholders of international financial institutions could push for more profound transformations that prioritize NbS.** These transformations could involve the extension of mandates specifically to involve nature-positive investments. It could also require managers to stress test their portfolios to properly account for nature-related risks. Finally, credit risk assessment and due diligence processes could incorporate assessments that take nature into account.

G20 countries could assign organisations to report on G20 financial resource targets and commitments to support nature, which would work in collaboration with other relevant entities. This includes the need to **develop a global methodology and standardized approach** to classify, measure and value NbS in a way that allows cross-country comparison and analysis, and is meaningful for investment decision-making.

5.3 Strengthen the investment case for private sector investment

Private sector investment in NbS-relevant activities and assets is too small in volume and size because the investment case is often not strong enough. For example, demand for forest-carbon is still voluntary rather than compliance-driven, and there are limited ways at present to transfer credit risk that banks, investors and corporates are unable to absorb.

Governments can create stable, predictable revenues from ecosystems such as forest carbon to entice private investment in NbS. The provision of public goods and services, such as carbon sequestration by forests and carbon storage in peatlands, remains unrewarded by firm, stable and predictable cashflows. There is a lack of proper control over access and royalties, leading to the over-exploitation of common access resources, such as fisheries and water; and the benefits (for example in health) of other services such as flood risk management, regional climate regulation, pest control and citizen access to nature are massively undervalued. These distortions in economic incentives reduce the private returns to investment in NbS and hence discourage investors.

Members of the G20 could work together to develop new and innovative investment products and nature markets. The objective could be to scale and transform investment opportunities in NbS, such as carbon finance, to protect and restore ecosystems, using blended finance structures to increase impactful investment in high nature value locations

The G20 could help to close the finance gap by engaging the private sector and unlocking investments to scale up NbS finance. For example, transforming sustainable supply chains and corporate commitments to achieve net-zero emissions and nature positive trajectories could directly increase voluntary private NbS investment. Governments could also create nature markets to reward the transition towards sustainable and regenerative food production, including sustainable forestry and agriculture, and wider innovation in sustainable food systems. They could build on the existing Taskforce on Climate-related Financial Disclosure (TCFD) by supporting a new reporting framework for the disclosure of effects and risks related to nature for individual companies, scheduled to be released in 2023 by the Taskforce on Nature-related Financial Disclosure.

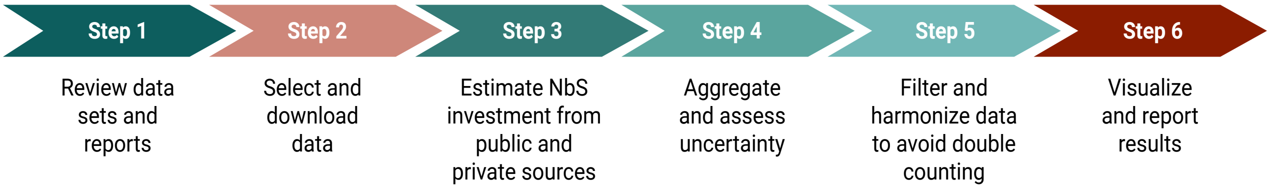
To guide future investments, the G20 could consider models that have an intersectional approach to the gender-NbS investments in support of women as drivers of net zero, nature-positive and resilient economies.

A Appendix[8]

A.1 Investment by public and private sectors in NbS

Estimating current investments began with the selection of data sources and the development of a methodology to extract NbS data.

Figure A 1. **MAgPIE: structure of the optimization process**



Source: Vivid Economics.

Step 1: Review data sets and reports

The team reviewed secondary sources complemented by stakeholder interviews. The most closely related studies found were:

1. **The Financing Nature Report (TNC, Cornell and Paulson 2020)**: This report is a global review of financing into biodiversity conservation. It uses a narrow definition of NbS as climate finance channeled through carbon markets, totaling USD 0.8 –1.4 billion per year in 2019. It also found a USD 124 - 143 billion flow of finance into biodiversity protection in 2019. The report does not distinguish between private and public flows.

2. **Global landscape of climate finance (CPI 2019):** This report is a review of global climate finance, updated in December 2020. It has no specific NbS definition. The report estimated the climate finance flowing into the land use sector in 2019 as USD 21 billion - USD 7 billion for disaster risk management and USD 13 billion for water and waste. The report had no figure for private finance flows into NbS.

3. **Climate finance report (joint MDB publication 2019):** This report is a review of total MDB financing globally. It contains no explicit NbS definition. It estimated investment in land use sectors in 2019 as USD 1.7 billion, and water and wastewater as USD 1.6 billion.

4. **A comprehensive overview of Global Biodiversity Finance (OECD 2020):** This report is a global review of financing into biodiversity conservation. It has no specific NbS definition. It found total expenditure in biodiversity conservation to be USD 78 - 91 billion per year (2015-2017 average) and private flows to be USD 6.6-14 billion per year.

5. **Nature-based solutions policy brief (Carbon Disclosure Project 2020):** This brief focuses on a survey-based assessment of corporate investment into NbS. Fifteen per cent of a total of 459 responding companies were investing in NbS. The brief did not contain information on the value invested.

[8] This appendix has been reproduced based on the State of Finance for Nature report, with adjustments for the differences in methodologies.

Step 2: Select and download the data

This study relies on two main data sources for the amount of finance of NbS in the public sector: data collected from domestic public expenditure (COFOG)[9] and data collected from the Creditor Reporting System (CRS) of the Aid Activity database[10] from the Organization for Economic Cooperation and Development (OECD).

The COFOG data contains government expenditure for 11 of the 20 G20 countries (Australia, China, France, Germany, Italy, Japan, Russia, South Africa, Turkey, United Kingdom and the USA). Additional datasets, primarily official annual government budgets, were consulted for the United States,[11] China,[12] India,[13] Canada,[14] Mexico,[15] Korea,[16] Argentina,[17] Brazil,[18] and Indonesia.[19, 20, 21] It was not possible to find data on NbS government expenditure for Saudi Arabia.

The CRS Aid Activity data contains expenditure targeted at global environmental objectives for official development assistance (ODA). The database presents basic data on where aid goes, the purposes it serves and the policies it aims to implement, on a comparable basis. The CRS covers 144 countries, with data collected at the donor level. This database included data on NbS investment donations for all G20 countries except Argentina, China, India, Indonesia, Mexico, and South Africa.

Specific to the private sector, the team identified sources of NbS finance in the literature and datasets that covered those sources. OECD data contains figures for philanthropies and foundations. This study extended the dataset by including figures from recent studies on biodiversity, conservation, ecosystem-based services, supply chains and voluntary carbon markets.

[9] This part of the dataset refers to the Classification of the Functions of Government (COFOG), which provides first- and second level COFOG, on government expenditure data from the System of National Accounts according to the purpose for which the funds are used. First-level COFOG splits expenditure data into ten “functional” groups or sub-sectors of expenditures (such as defence, education and social protection), and the second level COFOG further splits each first-level group into up to nine sub-groups. For this report, second level data is extracted and triangulated against both OECD sectoral guidance on inclusions and exclusions within each category and sub-categories, and other major reports and studies in each of the sectors that can potentially contribute to NbS, including those on biodiversity, peatland, and agriculture. Studies are referenced in the bibliography section.
[10] CRS data is monitored and analyzed by the OECD Development Assistance Committee (DAC). Data is collected on individual projects and programmes, with a focus on financial data. Within CRS, this study focuses on selected sectors and references for sectors relevant to NbS financing. A sector in this database refers to the main purpose category (e.g., health, agriculture, forestry, energy) of the intervention. The sectors represent first-level data. The sub-sector represents second-level data, which (as described above) goes into further detail and from which data linked to NbS is extracted. The data is subsequently cross-referenced with key sectoral studies.
[11] U.S. Government Federal Spending database (2021). Retrieved from: http://usaspending.gov/.
[12] CBD Financial Reporting Framework for China.
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[18] World Wildlife Fund (2018). Financiamento publico em meio ambiente (2018). Retrieved from: https://d3nehc6yl9qzo4.cloudfront.net/downloads/financiamentomma_final2_web.pdf.
[19] Indonesia Food Security Budget 2010-2020.
[20] Indonesia Infrastructure Budget 2015-2020.
[21] The World Bank Group. (2020). Spending for Better Results.

Table A 1. Data sources on private-sector finance of NbS used in this and previous published work

Category	OECD Report data	Paulson Report data	Data used in this report		
			OECD Report	Paulson Report	Mixed / Other
Sustainable supply chains	Data focuses on PEFC and FSC only (forestry and agriculture)	Data taken from four sectors (forestry, agriculture excl. palm oil, palm oil, fisheries)		x	
Biodiversity offsets	Data from Bennett et al (2017). Figure focuses on biodiversity offset programmes in 33 countries.	Figures are higher because report spans public and private finance of biodiversity offsets.	x		
Private equity impact investments	Not present in report	Data taken from GIIN Impact Investing 2020; Impact Assets portal ; SOPIC.		x	
Conservation NGOs	Data from five largest conservation NGOs	Paulson Report combines these two categories. The OECD and Paulson Report both rely on the same data sources.	x		
Philanthropy	Expenditure from 14 out of 26 philanthropies that reported to OECD.		x		
Private finance leveraged by multilateral orgs.	OECD Report and Paulson Report use data from GEF and OECD DAC. This report includes GCF data.		x	x	x
Forest and land use carbon markets	Combines transactions from both voluntary and compliance markets. Higher risk of double counting with public-sector funding.	Paulson Report does not disaggregate public and private investments into carbon markets. This report uses the Paulson approach for voluntary forest carbon markets and REDD+ only.		x	x
Water quality trading & offsets	Both reports use same data source (Bennett and Ruef 2016)	Report includes a broad “natural infrastructure” category encompassing watershed and coastal protection. It is unclear to what extent these are private sector investments in NbS.	x		
Payment for ecosystem services	Specifically, private-sector payments for watershed services.		x		

Note: OECD Report (2020). “Comprehensive Overview of Global Biodiversity Finance”.
Deutz et al. (2020). “Financing Nature: Closing the global Biodiversity Financing Gap”. The Paulson Institute, The Nature Conservancy, Cornell Atkinson Center for Sustainability.
Source: Vivid Economics.

The data was collated and checked against published reports and academic articles for both the private and public sectors. Cross-referencing and checking between sources reduced the potential for double counting, but this risk has not been totally eliminated, particularly within the public sector data from OECD and specific government budgets. The OECD recognizes that there may be some double counting in its dataset, for example in the case of biodiversity and forestry-related activities.

Step 3: Estimate NbS investment from public and private sources

Estimates of the amount of public money flowing into NbS-relevant sectors were obtained and the proportion of each directed towards NbS was extracted. As there is no existing classification and tagging of this data for NbS, this study employed multipliers (scaling factors) from existing literature, together with sectoral guidance from the OECD, to scale down the volume of investment within each sector on the basis of the proportion of activities within that sector that can more confidently be defined as NbS. All numbers were peer-reviewed.[22]

Table A 2. Scaling factors used to assess the proportion of investment categories related to the NbS framework used for domestic public spending

Sector	Scaling Factors
Agriculture, forestry, fishing and hunting	0.1
Waste water management	0.1
Pollution abatement	0.2
Protection of biodiversity and landscape	0.9
Environmental protection n.e.c.	0.2
Agriculture, forestry, fishing and hunting	0.1

Source: Vivid Economics based on expert assessments.

Table A 3. Scaling factors used to assess the proportion of investment categories related to the NbS framework used for ODA spending

Sector	Scaling Factors
14010: Water sector policy and administrative management	0.4
14015: Water resources conservation (including data collection)	0.7
14040: River basins development	1.0
31110: Agricultural policy and administrative management	0.1
31120: Agricultural development	0.1
31130: Agricultural land resources	0.9
31140: Agricultural water resources	0.1
31210: Forestry policy and administrative management	0.9
31220: Forestry development	1.0
32162: Forest industries	0.6
41010: Environmental policy and administrative management	0.5
41020: Biosphere protection	0.6
41030: Biodiversity	1.0
41040: Site preservation	0.1
41081: Environmental education/training	0.4
41082: Environmental research	0.4

Source: Vivid Economics based on expert assessments.

[22] List and resumé of reviewers available upon request.

Step 4: Aggregate and assess uncertainty

The confidence and reliability of NbS estimates depends on the granularity of the data. In order to account for data disparities, the data was classified by ranges of data estimates, with the upper bounds reflecting a more comprehensive list of NbS activities and the lower bounds reflecting a narrower definition of NbS. The final estimates are simply the midpoint between the upper and lower bounds. For example, the CRS dataset contains disaggregated categories for ODA related to the environment, as reported by donors to OECD. In this case, reliability is high, so the uncertainty range is low. In other sectors, confidence and reliability are low, such as agriculture, where both NbS-specific and non-NbS activities are recorded, so the uncertainty range is high.

Table A 4 below lays out the framework used to classify sectors, sub-sectors and activities, their relevance and their level of certainty or uncertainty. Uncertainty remains, as the inclusion of cross-sectoral data reduces granularity while providing the benefit of a more comprehensive and comparable dataset. Examining asset level data has helped build granularity, but at the expense of comparability.

Table A 4. **Methodological framework used to assess uncertainty based on the granularity of data provided**

Range	High uncertainty	Low uncertainty		
Relevance	Low	Medium	High	
Estimate of share of NbS	1-33 per cent	34-66 per cent	67-100 per cent	
Level	First-level data	Second-level data	Third-level data	
Source type	Fund/flow level	Expenditure level	Earmarked programme level	Asset level/project level
Example	Agriculture	Agricultural land resources, agricultural water resources	Regenerative agriculture, soil preservation, shade agriculture Water conservation measure and agricultural waste water reuse and repurposing	

Note: The level of the data (first, second or third level) is a statistical classification to characterize the granularity of the data. First level is less granular than second and third level.
Source: Vivid Economics.

Step 5: Filter and harmonize data to avoid double counting

The data is triangulated between sources and the definitions are assessed to exclude repeated transactions. The act of combining datasets can lead to double counting where categories overlap. Previous literature points to the risk of double counting, which arises when the same transaction is included multiple times. The emergence of new financial instruments means that the boundaries between private and public sector flows into NbS are increasingly blurred. In order to prevent double counting, the focus of the analysis is exclusively on expenditure figures, either through the COFOG database or country-specific annual budgets.

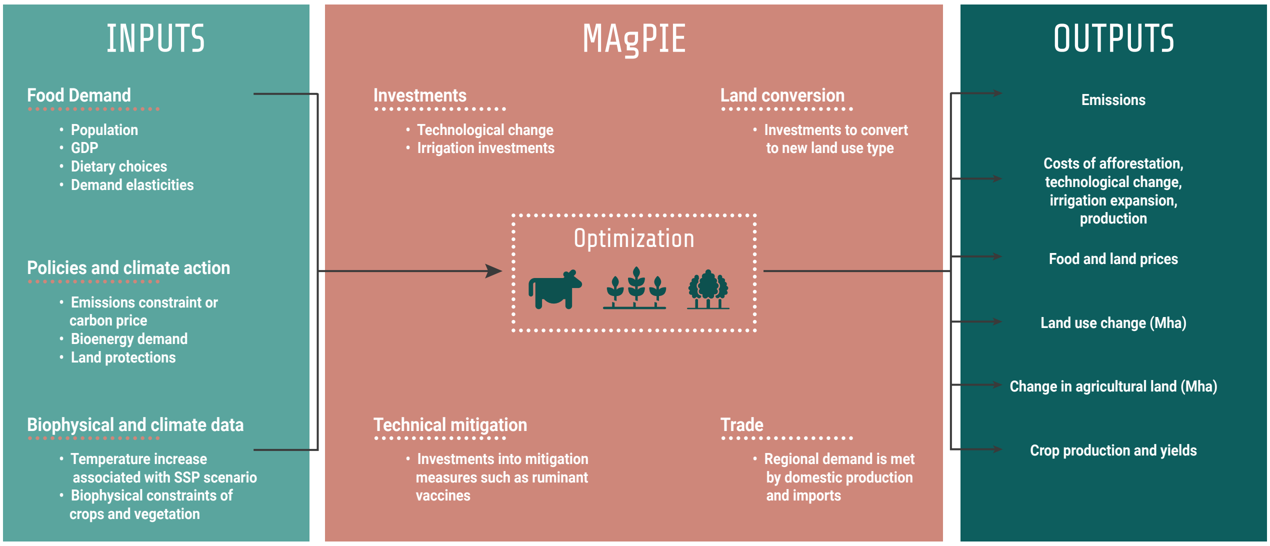
Step 6: Visualize and report results

The way in which the results are presented conveys the level of uncertainty in the estimates with error bars.

A.2 Future NbS investment needs

To determine future investment needs, estimates are modelled using MAgPIE[23] (Model of Agricultural Production and its Impact on the Environment), a global land use allocation model designed to explore land competition dynamics in the context of carbon policy. The model takes a set of policy input assumptions and estimates the least costly way in which the land use sector can meet demand for agricultural products. Key outputs from the model include cost of action and land use change (Figure A 2 describes the basic structure of the model).

Figure A 2. **MAgPIE: structure of the optimization process**



Source: Vivid Economics.

This work compared two sets of scenarios: the first set focuses on the additional costs needed to achieve international climate targets, and the second estimates the additional costs needed to achieve biodiversity targets. Each set includes at least two scenarios for comparison: a baseline and a policy scenario. The difference in costs between each policy scenario and the baseline scenario represents the additional investment needed to achieve the respective climate and biodiversity targets, such that for each time period, t:

$$\textbf{Investment Needs}_t = \textbf{Costs}_{t,\ \text{Policy Scenario}} - \textbf{Costs}_{t,\ \text{Baseline Scenario}}$$

The methodology behind the modelling exercise is laid out in the following sections. First, model assumptions are defined and an overview of the differences across the scenarios is provided for each set of scenarios. The model interactions and how key assumptions will affect results are then analyzed. Finally, how the modelled outputs fit into the analysis of future investment needs is described.

[23] Vivid Economics is currently using MAgPIE v4.1. The latest version, MAgPIE 4.3, models peatland restoration (see Humpenöder et al., 2020).

Climate targets: assumptions

The modelling exercise starts with the development of two scenarios, each characterized by a set of assumptions. Two scenarios developed by Vivid Economics for the United Nations Principles for Responsible Investment are compared in order to study the additional costs needed to achieve climate targets: the Inevitable Policy Response Forecast Policy Scenario and the corresponding Baseline Scenario. A list of assumptions is given below:

- **Population and GDP:** Growth projections align with SSP2 of the Shared Socioeconomic Pathways (SSP) (O'Neill et al. 2014; Riahi et al. 2017). This assumption implies a gradual increase in GDP, from about USD 130,000 billion in 2020 up to over USD 300,000 billion in 2050. Global population growth is moderate and levels off in the second half of the century, after reaching ~9.2 billion people in 2050.

- **Trade:** Trade liberalization will increase across the board, with crop products achieving higher levels of liberalization than livestock products.

- **Cost of investments:** Investment in technological change is aligned with historical trends.

- **Protected areas:** Both scenarios include strict nature reserves, wilderness area and natural parks (IUCN I and II categories).

The difference between the Forecast Policy Scenario and the Baseline Scenario is based on several policy assumptions:

1. **NDC commitments** involving the afforestation and regeneration of natural land. The Baseline Scenario only includes current nationally implemented policies, while the Forecast Policy Scenario integrates national NDC commitments. The NDC commitments are all the future sustainability policies and targets that a country publicly reported for the Paris Agreement.[24]

2. **2C-aligned carbon price trajectory.** A carbon price is introduced in the agriculture and forestry sectors in the Forecast Policy Scenario, but not in the Baseline Scenario.[25] The price applied to CO_2 is half that applied to all other gases to reflect challenges in regulating deforestation and rewarding afforestation.

3. **2C-aligned bioenergy trajectory.** In the Forecast Policy Scenario, bioenergy production in the land use system allows the energy sector to reduce its emissions using BECCS.[26]

4. **Ruminant meat fadeout.** In the Forecast Policy Scenario, global ruminant meat demand declines by 25 per cent by 2050 relative to the Baseline Scenario, where it remains constant.

[24] Information on NDC commitments has been extracted from country reports, while information on currently implemented policies refers to policies implemented before 2015.
[25] These trajectories are available as part of a database of integrated assessment modelling (IAM) exercises run by the Potsdam Institute for Climate Impact Research (PIK).
[26] Bioenergy with Carbon Capture and Storage (BECCS).

Table A 4. Key assumptions in the MAgPIE model

Variable	Description	Source	Baseline scenario	Policy scenario
1. GHG price trajectory	Defines global price trajectories for CO_2, N_2O, CH_4.	IIASA* database and PIK	No carbon price	Consistent with a carbon budget of 950 $GtCO_2e$ (<2C), 2030 phase-in
2. Reduction factor for CO_2 price	Lowers economic incentive for CO_2 emissions reduction from avoided deforestation and afforestation compared to carbon price level.	-	Not relevant	50 per cent
3. Bioenergy trajectory	Defines demand for second generation bioenergy crops (only used for fuel production, not for food).	IIASA database and PIK	Consistent with current commitments	Consistent with a carbon budget of 950 $GtCO_2e$ (<2C)
4. Population	Sets trajectories based on SSPs (Shared Socioeconomic Pathways).	SSP database	SSP2 - "middle-of-the-road" consistent pathways	
5. GDP	Sets trajectories based on SSPs.	SSP database	SSP2 - "middle-of-the-road" consistent pathways	
6. Protected areas	Level of area protection is based on IUCN categories. The default (WDPA) includes IUCN WDPA* categories I and II. The WDPA protection covers approximately 400 Mha of the terrestrial land surface. Alternatively, protection can be extended to include other areas, such as biodiversity hotspots.	(Leclère et al. 2018)*	IUCN categories I and II (no change from current levels)	
7. Ruminant meat fadeout	Defines decline in proportion of calories from ruminant meat in total meat demand relative to baseline scenario where it is treated as constant.	(Bodirsky et al. n.d)	Share of ruminant meat in diets remains constant.	Gradual global ruminant meat demand declines by 25 per cent by 2050
8. Trade liberalization	Defines change in current trade patterns. Traded goods can be allocated in one of two trade pools: one based on historical trends and another one where goods are traded based on comparative advantage. Trade liberalization implies a higher percentage on goods being traded in the "comparative advantage pool".	(Schmitz et al. 2012)	Historic self-sufficiency ratios maintained, trade with historic partners, limited free trade	
9. Future costs of investment	Selected options for the expected costs of future productivity improvement.	(Dietrich et al. 2014)	Trajectories for future investment costs in line with historical trends	

Notes: *shared socioeconomic pathways
*International Institute for Applied Systems Analysis (IIASA)

Source: Vivid Economics.

Biodiversity targets: assumptions

Two scenarios developed by Vivid Economics for the UK Treasury's Dasgupta Review of the Economics of Biodiversity are compared to study the additional costs needed to achieve biodiversity targets: the Immediate Action Scenario and the Baseline Scenario. As with the previous set of scenarios, assumptions of the population, GDP, trade and cost of investment remain unchanged across scenarios. Both scenarios include a diet shift of 25 per cent away from ruminant meat by 2050 (relative to a baseline in which it remains constant).

The Immediate Action Scenario differs from the Baseline Scenario in terms of policy and biodiversity ambition. As with the IPR scenarios, one (Immediate Action) is more ambitious and includes NDC commitments on the afforestation and regeneration of natural land, as well as 2C-aligned carbon prices and biodiversity supply pathways. Protected areas also expand under the Immediate Action Scenario to include ~21-24 per cent of global land area to cover all categories of protected areas under the World Database of Protected Areas (WDPA) as well as key biodiversity hotspots.

Table A 6. Immediate and delayed action scenarios differ in assumptions regarding scale of policy action

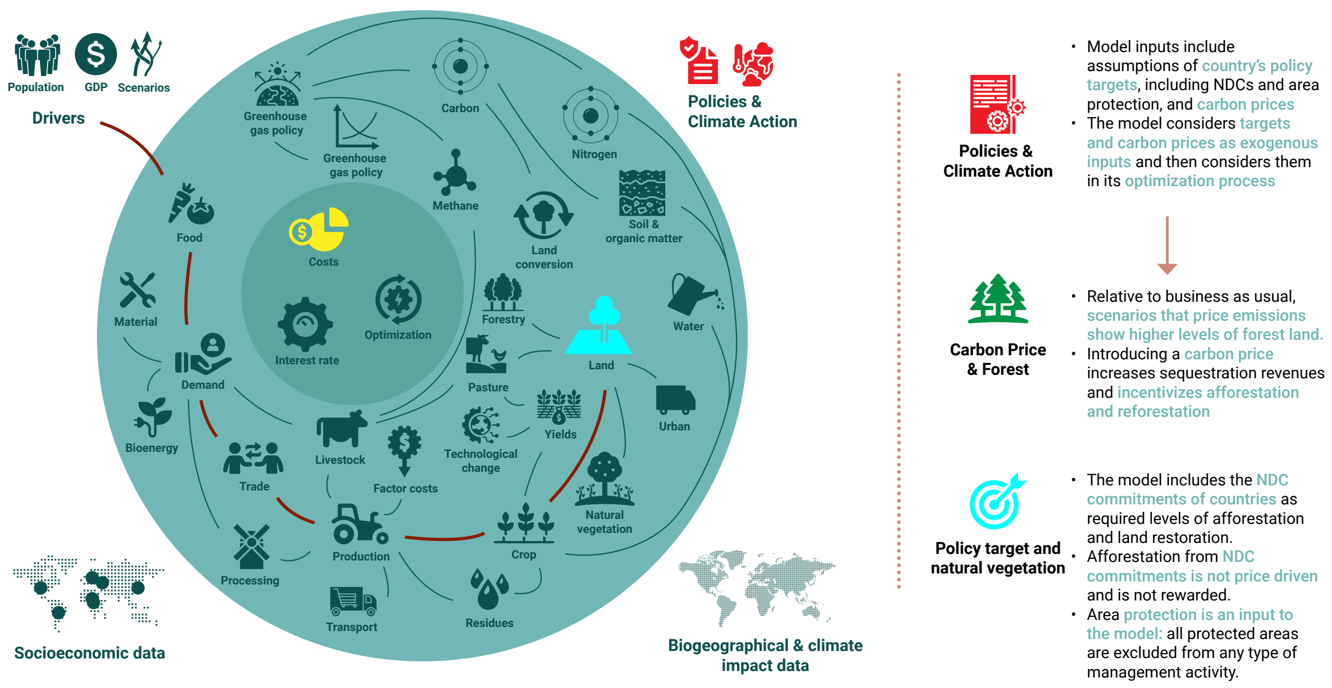
Variable	Description	Source	Immediate action (includes immediate high ambition)	Baseline scenario
1. GHG price trajectory	Defines global price trajectories for CO_2, N_2O, CH_4.	IIASA database and PIK integrated assessment modelling exercise	SSP2 RCP2.6 consistent trajectory with carbon prices phasing-in globally in 2020 (higher for immediate action)	No carbon price
2. Reduction factor for CO_2 price	Lowers economic incentive for CO_2 emissions reduction from avoided deforestation and afforestation compared to carbon price level.	-	0.5	-
3. Bioenergy trajectory	Defines demand for second generation bioenergy crops (only used for fuel production, not for food).	IIASA database and PIK integrated assessment modelling exercise	SSP2 RCP2.6 consistent trajectory	SSP2 NPi consistent trajectory
4. Population	Sets trajectories based on SSPs.	SSP database	SSP2 – "middle-of-the-road" consistent pathways	
5. GDP	Sets trajectories based on SSPs.	SSP database	SSP2 – "middle-of-the-road" consistent pathways	
6. Protected areas	WDPA categories plus all proposed areas and key biodiversity hotspots.	Leclère et al. 2018*	2708 Mha in 2020	351 Mha (no change from current levels)
7. Ruminant meat fadeout	Defines decline in proportion of calories from ruminant meat in total meat demand relative to baseline scenario where it is treated as constant.	Bodirsky et al., n.d	25 per cent reduction in ruminant meat share of diet by 2050	
8. Trade liberalization	Defines change in current trade patterns.	Schmitz et al. 2012	10 per cent trade liberalization for secondary and livestock products in 2030, 2050, 2100 and 20 per cent for crops	
9. Future costs of investment	Selected options for the expected costs of future productivity improvement.	Dietrich et al. 2014	Trajectories for future investment costs in line with historical trends	

Note: * The default protection in MAgPIE is defined by the WDPA protected areas. It includes IUCN WDPA categories I and II. The WDPA protection covers approximately 400 Mha of the terrestrial land surface. For a world with increased protection, this work follows a procedure similar to the Bending the Curve project, where a "potential protected area layer" is created, i.e. areas of the world that should be a priority to protect. Two criteria served for selection: (i) Expanding the WDPA protection from Cat I and II to cover all categories, and in addition to designated WDPA protected areas proposed PAs are also included (areas which are not protected, but deemed by WDPA to be prioritized for protection in the near or distant future, based on a variety of local factors). (ii) Key biodiversity hotspots, a similar layer as used in Bending the Curve. The created potential protected layer is named the WDPA+, which comes to around 2700 Mha, which is ~21-24 per cent of the terrestrial land surface and 600 per cent more than present WDPA protection. Source: Vivid Economics.

Model interactions

This sub-section explains how model assumptions affect system costs, focusing on the impact of climate action on transition costs. In MAgPIE, land is a limited resource which needs to be allocated to either agricultural production (food, feed and other materials) or carbon sequestration. This allocation process aims to minimize the costs incurred by the land use system in order to meet a specific demand for agricultural products. Demand for agricultural products is a function of both population and income. The former relationship is straightforward: more food and fiber will be needed to feed, clothe and supply a growing population. The latter refers to the fact that, as people become richer, their budget constraints loosen, allowing individuals to access more than enough to satisfy their essential wants. As both population and GDP are set to increase under SSP2,[27] demand will grow accordingly, and the agricultural sector will have to produce more using the same amount of land. This will intensify competition for land use, leading to investment in innovation, higher production efficiency and higher food prices.

Figure A 4. Examples of policy impacts on the land use sector



Source: Vivid Economics.

[27] Assumption that remains unvaried across scenarios.

The introduction of climate policies puts additional pressure on the land use sector, increasing the costs associated with meeting agricultural demand. Expanding area protection to include biodiversity hotspots as well as setting aside land to meet NDC commitments reduces the hectares of land available for agricultural production. The introduction of a price for greenhouse gases has two direct effects on the land use system: on the one hand, it increases production costs for emission-intensive activities, such as the production of beef and animal feed; on the other hand, it increases the benefits associated with non-productive activities, such as the regrowth of natural vegetation for carbon sequestration. The land use system faces substantial transition costs to meet demand under increasingly stringent land constraints and with cleaner/less-costly production systems, both in the form of investments to increase efficiency and of operational costs associated with more intensive production systems.

Model outputs and analysis of investment needs

As the model accounts for all costs in the land use sector, the direct and indirect costs of climate action are differentiated. The former category includes costs related to GHG emissions and mitigation actions. The latter category includes costs in the agricultural sector, either investments or recurring costs, which are likely to increase with policy ambition. In this case, the difference across scenarios is going to be driven by the additional pressure on the land use system due to climate action. This is because in order to reach climate and biodiversity targets, the land use sector allocates larger areas to the forestry and regrowth of natural vegetation, reducing the amount of land available for agricultural production. To "feed" an increasingly populous and rich world, agricultural producers need to become more efficient by investing in innovation and increasing spending on the overall production process. For example, firms trying to increase their crop yields will have to invest some capital in acquiring innovative machinery or developing new production systems, and to spend more money on skilled labor.

Table A 7. Costs from MAgPIE

Category	List of costs	Description
Indirect costs	1. Costs of input factors	The cost of input factors for producing food and materials includes labor, energy, physical inputs, non-land capital cost
Indirect costs	2. Investment in technical change and adoption	Investment in technical change and adoption includes R&D, adoption and irrigation expansion
Indirect costs	3. Costs of processing, transport and trade	Costs of processing, transport and trade includes all downstream costs to consumer
Indirect costs	4. Cost of land conversion	Cost of land conversion from one land use to another, including land clearing, land preparation, for agriculture or restoration
Indirect cost	5. Cost of forest management	Cost associated with forest management
Direct costs	6. Costs of climate policy	Split into a. Emissions costs associated with a Paris-aligned carbon pricing trajectory; and b. Rewards for negative emissions

Source: Vivid Economics.

The estimate examines the difference in the indirect costs of climate action to evaluate investment needs. Focusing on this category of cost allows the estimate to calculate the global spending needed to meet climate and biodiversity targets. Total investment needs between 2020 and 2050 are calculated as the difference in the cumulative discounted cashflows of the indirect costs of climate and biodiversity action between the policy and baseline scenario:

$$Total\ investment\ needs_{2020-2050} = \sum_{t=2020}^{2050} \Delta\ Costs_t$$

$$= \sum_{t=2020}^{2050} \Delta\ Costs_{t,\ Policy\ Scenario} - Costs_{t,\ Baseline\ Scenario}$$

Off-model analysis

This section provides an overview of the analysis of investment needs for NbS that are not included in the model. It starts with a discussion on the sources of data for the off-the-model analysis and concludes with an overview of the methodology and outputs.

The off-model analysis focuses on three types of NbS asset: mangroves, peatlands and agroforestry:

- **Mangroves** are dense coastal forests covering the planet's tropical and sub-tropical belt. Mangrove forests not only sequester close to 32 Mt CO_2 annually, but also protect coastal areas from extreme events, improve water and food security, and provide a safe breeding ground for marine biodiversity. This study includes the restoration of mangrove forests.[28]

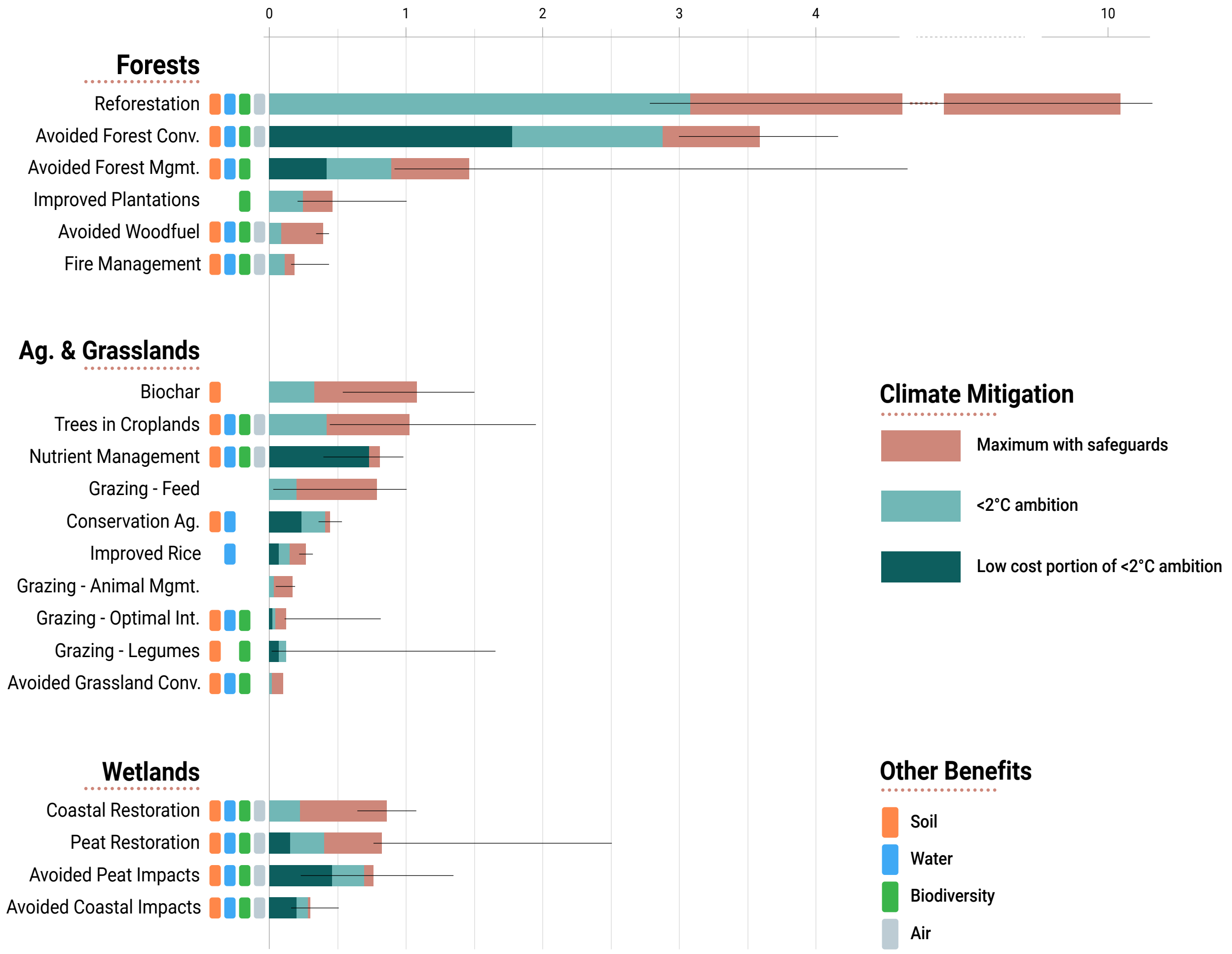
- **Peatlands** are terrestrial wetland ecosystems where 'year-round waterlogged conditions slow the process of plant decomposition to such an extent that dead plants accumulate to form peat.'[29] Peatlands provide the largest natural terrestrial carbon stock storage (550 Gt CO_2), but damaged peatlands contribute to approximately 5-6 per cent of GHG emissions from land use, and this can rise to 10 per cent if they are burned. This study looks at the costs related to restoring damaged and degraded peatlands, typically from overgrazing, drainage and fires.[30]

- **Agroforestry** involves 'land use systems in which trees are grown in combination with agriculture on the same land'.[31] It also includes: silvoarable agroforestry, the combination of trees and crops; forest farming, the cultivation of crops within a forest environment; and other systems that entail planting trees between fields, hedgerows, shelterbelts and riparian buffers.[32] This study focuses on silvopasture, which is the combination of trees and livestock.

The proposed focus on mangroves, peatlands and agroforestry in this study is due to their mitigation potential, data availability and compatibility with modelled results. Estimates collected from Griscom et al. (2020) ensure that solutions with high climate mitigation potential are included in the analysis. Table A 8 shows potential climate mitigation comparisons for different types of land. The second stage of the analysis includes data collection regarding both costs and potential future uptake for each solution. Solutions that could not be integrated into the modelled results are excluded. For instance, trees on croplands are not included in the analysis, while trees on pastureland are.[33] It is assumed in the case of silvopasture that trees are planted on grazing land, with no effects on yields or production.

[28] The Case for Mangroves as a Nature-based Climate Solution (Earth Security, 2020).
[29] IUCN Issues Briefs – Peatlands and Climate Change.
[30] Joosten, H. (2015) https://www.ramsar.org/sites/default/files/documents/library/ny_2._korrektur_anp_peatland.pdf, IPCC (2020). https://wedocs.unep.org/bitstream/handle/20.500.11822/29261/IPCCLand.pdf?sequence=1&isAllowed=y; Wetlands International (2015). https://www.wetlands.org/publications/saving-peat-less-heat-update/.
[31] European Union, Article 23 of Regulation 1305/2013.
[32] Mosquera-Losada MR et al. (2018).
[33] This is because a methodology to integrate on-model assumptions around increase in crop yields and monoculture agriculture with off-model assumptions around silvoarable agroforestry has not yet been developed.

Table A 8. Climate mitigation potential in 2030 ($PgCO_2e$/year)



Source: Griscom et al. (2020).

Because MAgPIE focuses on forests and innovation in the agricultural sector, the modelled results are integrated with some off-the-model analyses to include investment needs associated with NbS not covered by the model. This analysis is based on the available literature on capital costs and operating expenses associated with a subset of relevant NbS not covered in the modelling exercise. Table A 9 provides a list of sources, and details the type of information that is integrated into each in the analysis.

Table A 9. List of sources for NbS not covered by MAgPIE

Category	Source	Relevant Information
Mangroves protection	Adapt Now: A Global Call For Leadership On Climate Resilience. (Global Commissions on Adaptation 2019)	Cost-benefit analysis of mangroves protection: costs by 2030 are close to USD 167 billion (benefits USD 1 trillion, benefit to cost ratio 6:1)
Mangroves restoration	The Role of the Natural Environment in Adaptation, Background Paper for the Global Commission on Adaptation. (Kapos et al. 2019)	Median restoration costs for mangroves: $0.10/m^2 (between $0.05/m^2 and $6.50/m^2)
Mangroves restoration	Mapping Ocean Wealth Explorer and Mangrove Restoration Potential: A global map highlighting a critical opportunity (Worthington et al. 2018)	Restoration potential: 812,003 ha (regional information available in the paper)
Peatland restoration and protection	The Economics of Peatland Restoration (Glenk and Martin-Ortega 2018)	Capital costs associated with restoration: £200/ha to £10,000/ha Recurring costs: £25/ha to £400/ha per year
Peatland restoration	Peatland protection and restoration are key for climate change mitigation (Humpenöder et al. 2020)	Peatland rewetting: One-time costs: USD05 7000/ha Recurring costs: USD05 200/ha Also includes information on total peatland restored under three different policy scenarios
Agroforestry	Vivid Economics	Silvopasture: (all numbers in 2019 £/ha) Capital Expenditure 1298,47 Operating Expense 18,94

Source: Vivid Economics.

The objective of the off-model analysis is to estimate the direct costs of future restoration and the protection of mangroves and peatland. To this end, the associated cash flows as the sum of the capital investment and the cumulative operations expenditure between the initial investment period and 2050 are calculated for each ha of protection and restoration. For peatland, the timing of the investments follows the dynamics set out in Humpenöder et al. (2020); for mangrove protection and restoration a linear increase in land protected/restored between 2020 and 2050 is assumed. The direct costs of mangrove and peatland restoration are added to the value obtained from MAgPIE to obtain the total future investment needs. Because none of these options are considered by the model, the costs calculated on and off model are mutually exclusive.

A.3 Limitations

There are several limitations and notes regarding the estimates in this report.

- **Land-related NbS:** Like the global report, this report is limited to land-related NbS and focuses exclusively on disbursed investments, as opposed raised or pledged capital. To some extent this is due to the thematic focus of the organizations involved in issuing this report, however, another reason was data availability, especially in relation to private finance. Note that the aggregated nature of some data sets means that some marine spending might be included. The authors advise that future reports include marine NbS.

- **Geographic scope:** This report collects data from the G20 specifically for current NbS spending and future NbS spending need predictions. These estimates include comprehensive data, as G20 NbS spending data is much more comprehensive than worldwide public investment, however, some public finances will have been omitted for the future predictions on a global scale, as not every country publishes detailed data on public NbS finances and the data was aggregated by geographic region.

- **Double counting:** There is a risk of double counting, which arises because it is unclear in some cases whether entities are included in multiple categories within data sets. Data was triangulated between sources and definitions during the data analysis with the intent to reduce the amount of double counting, but some might remain.

- **Investment at the "asset level":** This report focuses on actual investment in assets rather than pledged or budgeted figures.

- **Data limitations and related issues:** Data in the NbS space is minimal. The methodology addresses a lack of comparable data, lack of data aggregation and limited disclosure of proprietary information, however, despite precautions, the selection and use of data for this report still risks double counting and the partial quantification of costs, benefits, and effects.

- **Nature-neutral or negative finance:** This report tracks nature-positive finance, although it might also include nature-neutral or negative finance to some extent.

    - 'Neutral finance' aligns conditionally with NbS activities, making sometimes negative and sometimes positive contributions depending on circumstances. Examples include agricultural intensification, bioenergy and timber harvesting.

    - 'Negative finance' harms ecosystems and the biosphere. Examples include the clearance of natural vegetation, and/or drainage of peatlands for commodity production, unsustainable forest management and infrastructure development.

- **Gender:** When tracking investments into NbS, it is crucial to recognize gender dimensions, like women's contribution to the conservation and growth of natural capital and the economic opportunities available to them in this area. To complement these linkages, national statistics should move towards gender-disaggregated data at the sector level, such as forestry and agriculture. Future reports will aim to utilize a gender lens and advocate for gender specific data to be collected across financial, economic, social, health and environment indicators. Currently, the limited availability of gender specific data is a key barrier to conduct a gender analysis.

List of Abbreviations

AFD	French Development Agency
BECCS	Bioenergy with Carbon Capture and Storage
BEIS	UK Department for Business, Energy and Industrial Strategy
BFFI	Biodiversity Footprint for Financial Institutions
CBD	Convention on Biological Diversity
COFOG	Classification of the Functions of Government
COP	Conference of the Parties
CPI	Climate Policy Initiative
CPIC	Coalition for Private Investment in Conservation
CRS	Creditor Reporting System
DAC	Development Assistance Committee
DCA	Development Credit Authority
DFI	Development Finance Institution
DNB	De Nederlandsche Bank
ESG	Environmental, Social and Governance
EU	European Union
EUR	Euro
FAO	Food and Agriculture Organization
FONAFIFO	National Forestry Financing Fund
FSC	Forest Stewardship Council
GBP	Great British Pound
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	Greenhouse Gas
GIIN	Global Impact Investing Network
GSI	Greenness of Stimulus Index
IATI	International Aid Transparency Initiative
IIASA	International Institute for Applied Systems Analysis
IISD	International Institute for Sustainable Development
IMF	International Monetary Fund
IPBES	Intergovernmental Panel on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IPR	Inevitable Policy Response
IUCN	International Union for Conservation of Nature

KPI	Key Performance Indicators
MDB	Multilateral Development Bank
NbS	Nature-Based Solutions
NCFA	Natural Capital Finance Alliance
NDC	Nationally Determined Contributions
NCS	Natural Climate Solutions
NYDF	New York Declaration on Forests
ODA	Official Development Assistance
OECD	Organization for Economic Co-operation and Development
OOF	Other Official Flows
PEFC	Programme for the Endorsement of Forest Certification
PES	Payment for Ecosystem Services
PIK	Potsdam Institute
P4F	Partnerships for Forests
REDD+	Reducing Emissions from Deforestation and Forest Degradation
RLU	Royal Lestari Utama
SAVi	Sustainable Asset Valuation
SOPIC	State of Private Investment in Conservation
SSP	Shared Socioeconomic Pathways
TLFF	Tropical Landscape Finance Facility
UK	United Kingdom
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USD	United Stated Dollar
WDPA	World Database of Protected Areas
WISE-UP	Water Infrastructure Solutions from Ecosystem Services
WRI	World Resources Institute
WWF	World-Wide Fund for Nature

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