Investment Leadership Programme

UN environment programme | finance initiative

PRI Principles for Responsible Investment

UN-convened Net-Zero Asset Owner Alliance

The Net in Net Zero:

The role of negative emissions in achieving climate alignment for asset owners

In partnership with:

WWF

GLOBAL OPTIMISM

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1. Introduction

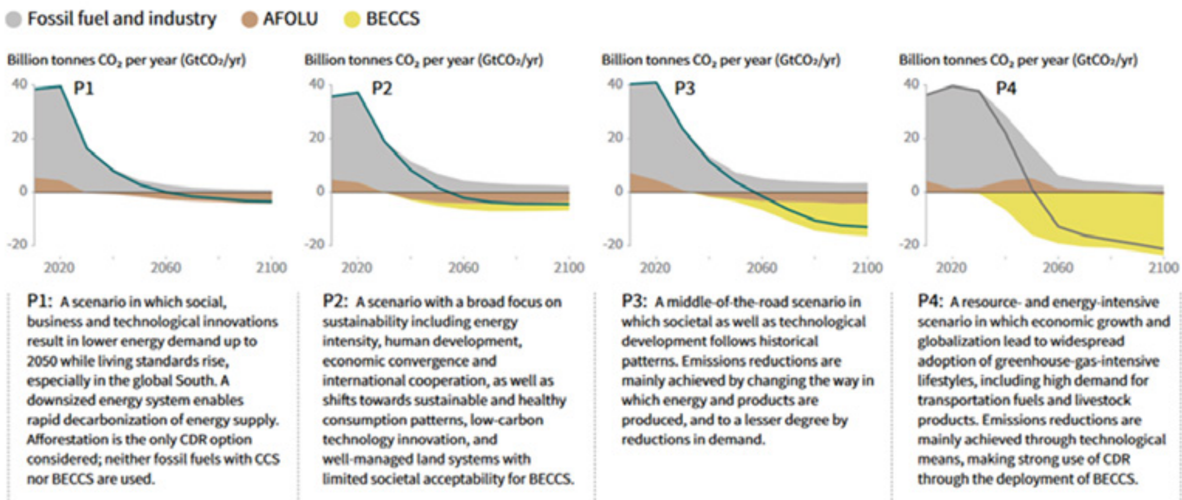
Members of the Net-Zero Asset Owner Alliance (AOA) are committed to supporting long-term investments aligned with net-zero emissions by 2050 or sooner, consistent with their fiduciary duties. Investments in companies and economies which are committed to reducing greenhouse gas (GHG) emissions, alongside advocating for changes in regulations, policies and carbon pricing for scaling clean energy and new technologies, will ensure that asset owners can align their portfolios to a 1.5°C pathway and help deliver the goals of the Paris Climate Change Agreement.

As illustrated by the Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C,[1] all scenarios that limit global warming to below a 1.5°C ceiling rely on accelerating action to cut GHG emissions, supplemented by at least some level of carbon dioxide removal (CDR) from the atmosphere using a mix of land-based carbon sinks and technological carbon removal approaches. Without CDR playing a role, it will be very difficult to meet the 1.5°C goal of the Paris Agreement.

This Alliance position aims to clarify the focus areas and prioritisation of actions that asset owners should take to align their portfolios to a global net-zero, 1.5°C pathway, including fostering rapid and deep cuts to GHG emissions within and outside of investee company value chains. The Alliance position recognizes that whilst the primary focus must remain on deep decarbonization in energy, urban, infrastructure and industrial systems, as well as reversing emissions growth from land use systems (broadly captured by scenarios P1 and P2 in Figure 1 below), investments in CDR and negative emissions technologies and solutions will also be complementary and necessary in order to accelerate progress and align to a 1.5°C pathway (scenarios P3 and P4).

1 ipcc.ch/sr15/

Figure 1: Breakdown of contributions to global net CO_2 emissions in four illustrative model pathways



Source: "Global Warming of 1.5°C." Intergovernmental Panel on Climate Change, 2018.

The importance of CDR through negative emissions technologies and nature-based solutions in addressing unabated emissions must not be underestimated. Avoiding all CO_2 emissions in the next three decades will be challenging, and emissions already accumulated in the atmosphere will continue to have impacts on the climate system for years to come. In addition, research indicates that for a given amount of CO_2 emissions, a larger amount of removals will be needed to achieve the same atmospheric CO_2 concentrations and mean temperature change into the future.[2] Whilst this asymmetric nature of emissions versus removals adds weight to the existing moral, economic, and physical science rationale for prioritizing abatement, it also underlines the crucial and complementary role of negative emissions to ensuring the sustainability of the 1.5°C ceiling over time.

It is estimated that in order to align with a 1.5°C pathway, CDR and negative emissions solutions must be scaled massively and rapidly to achieve global removal of 0.5 to 1.2 Gt of CO_2 per year by 2025 and as much as 6 to 10 Gt of CO_2 per year by 2050 (compared to global emissions of 42 Gt of CO_2 in 2020), alongside decarbonization efforts.[3]

The Alliance's target setting protocol (TSP) emphasizes that a deep and rapid decarbonization transition is needed across all sectors, particularly the carbon-intensive industries, which must more than halve emissions by 2030 to align with a 1.5°C pathway. It underlines that asset owners can facilitate this transition by investing capital into activities that drive deep decarbonization and investing in technologies and nature-based solutions that remove residual emissions (negative emissions technologies). In doing so, the measuring and reporting of generated emissions and emission removals will enable

2 Zickfeld, Kirsten, Deven Azevedo, Sabine Mathesius, and H. Damon Matthews. "Asymmetry in the Climate–carbon Cycle Response to Positive and Negative CO_2 Emissions." Nature Climate Change 11, no. 7 (July 2021): 613–17. doi.org/10.1038/s41558-021-01061-2.

3 The Case for Negative Emissions, a call for immediate action by the Coalition for Negative Emissions, supported by McKinsey & Company June 2021 coalitionfornegativeemissions.org/

asset owners to track progress against their net-zero goals and ensure accountability such that the employment of CDR does not deter or detract from decarbonization efforts and/or ambition on a wider scale.

Whilst the Alliance position supports both systemic decarbonization and CDR, it is important to underline that if investors and asset owners over-emphasize negative emissions when supporting net-zero, 1.5°C pathways, rather than prioritizing reducing emissions in and outside of value chains, they risk perpetuating a carbon intensive global economy with other societal, economic, and geopolitical implications, including:

- The impact of pollution (SOx and NOx and other pollutants) as well as the physical effects of climate change on vulnerable communities;
- The risk of not being able to continue to finance carbon dioxide removal later in the century;[4]
- The potential economic impacts of carbon taxes on poorer people; and
- Land use issues which would have to be balanced against the potential to create jobs, grow food, economic well-being as well as conserve nature and improve biodiversity and freshwater balances, through nature-based bio-sequestration approaches.

On the contrary, under-investment and failure to develop nascent CDR pathways now, risks them not being available as an important resource when needed at scale.

Economic and policy mechanisms including proposals to develop large scale voluntary carbon markets are in progress and will be complementary to how investors and asset owners support the transition to global net zero. To date, carbon credits, in the form of voluntary offsets, and permits in the form of regulated cap and trade schemes like the European Trading Scheme (ETS), have been two of the main economic mechanisms (along with carbon taxes and feed-in tariffs) to regulate and slow emissions growth in some sectors. Whilst compensating for emissions through purchasing carbon credits can have real world impacts, the Alliance target setting protocol (TSP) does not include them in accounting for or measuring net zero or portfolio alignment, and instead encourages rigorous accountability and stewardship of investee companies' compensation efforts (see section 3 'Engagement with Policymakers and other Stakeholders').

4 Bednar, J., Obersteiner, M. & Wagner, F. On the financial viability of negative emissions. *Nat Commun* 10, 1783 (2019). doi.org/10.1038/s41467-019-09782-x

2. The UN-convened Net-Zero Asset Owner Alliance Position

The Alliance believes that asset owners' immediate efforts must foster the rapid and deep cutting of GHG emissions as a priority, so that fewer emissions enter the atmosphere, requiring less CDR in the future. The focus must be on accelerated action to cut emissions through the reduction of scope 1, 2 and 3 emissions in line with science-based no/low overshoot scenario pathways to global net zero by 2050, or earlier if possible. This is aligned with climate science and initiatives such as the Science Based Targets Initiative (SBTi) and the Oxford Principles for Net Zero Aligned Carbon Offsetting.[5]

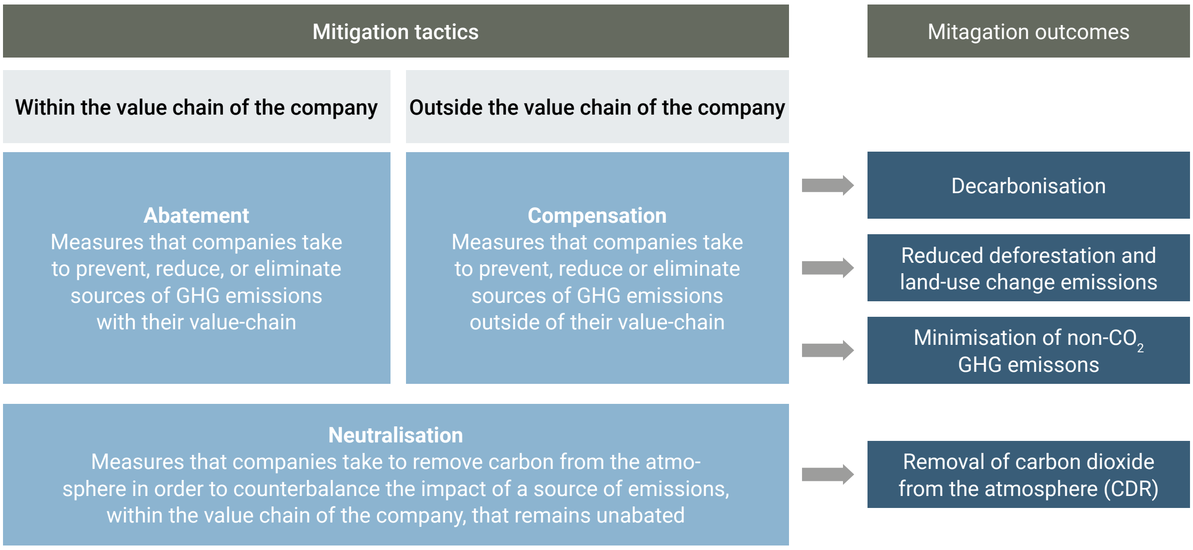
The Alliance supports a range of mitigation strategies and tactics, with a focus on abatement, compensation and neutralisation (see figure 2 below), with the following timing:

- The Alliance sees abatement as the top priority for the next 5–10 years.
- Compensation, including purchasing carbon credits, is a meaningful real-world impact key performance indicator (KPI), very important for the transition, but will not be used for measuring net zero or portfolio alignment as part of the Alliance target setting protocol (TSP).[6] Instead, Alliance members should develop separate metrics to track and understand the efficacy of their investee companies' compensation efforts, supporting efforts to enhance regulated schemes and accelerate meaningful action to reduce emissions at source, as well as supporting the scaling of voluntary carbon markets, ensuring that they are underpinned by assets, or projects that effectively avoid, reduce or remove carbon.
- Neutralisation via long-term carbon removal will be needed to reach net zero. The Alliance recognizes that CDR solutions, both nature-based and technological, will therefore need to be developed at scale. However, in the next 5–10 years, abatement should be the focus for technological solutions that are already feasible, like Carbon Capture, Use and Storage (CCUS).

5 Taxonomy of Carbon Offsets, in "The Oxford Principles for Net Zero Aligned Carbon Offsetting", Smith School of Enterprise and the Environment, Oxford University, September 2020

6 UNEP FI and PRI Net-Zero Asset Owners' Alliance "Inaugural 2025 Target Setting Protocol" unepfi.org/wordpress/wp-content/uploads/2021/01/Alliance-Target-Setting-Protocol-2021.pdf

Figure 2: Taxonomy of climate mitigation tactics and outcomes.



Source: Foundations for Science-Based Net Zero Target setting in the Corporate Sector, Developed by CDP, (Sept 2020)

The Alliance recognizes that CDR will be needed to limit global temperature rise to 1.5°C, to cancel out hard-to-mitigate residual emissions. Developing CDR capabilities provides the secondary benefit that, in the event of an undesirable temperature overshoot, we can still reduce atmospheric CO_2 concentrations to return to a 1.5°C pathway.

The robustness of any net-zero strategy reliant on negative emissions depends on the effectiveness of the underlying CO_2 removal and, especially, on the permanence of the stored carbon. It is essential that only CDR processes with long-lived, verifiable and certifiable sequestration mechanisms are supported. However, this transition must start today, and although carbon stored for decades is less valuable than carbon stored for millennia, it still has significant value. The world critically needs natural removals to be scaled over the next decades, but in the longer term, only CDR with long-term permanent storage should be part of corporate net-zero strategies.

A range of CDR approaches will be required to remove CO_2 at large scale, as each potential approach will have scale limitations, constraints and trade-offs—for example with land use, water conservation and biodiversity protection. The costs and benefits of each potential CO_2 removal approach, and their different institutional and economic contexts and geographies, will need to be scrutinized by investors.

It is important to also recognize the importance and trade-offs of nature-based solutions, related to incentives around indigenous forest protection. The more emphasis that is put on reductions, while under emphasizing the contributions that can be made through nature-based solutions or natural climate solutions (NCS), could ultimately translate to more removals being required.

The Alliance supports CDR approaches in two main categories:

- Nature-based solutions including enhancement of natural carbon stocks through ecologically sensitive design methods (e.g. having regard to indigenous species assemblages):
  - Restoration of ecological functioning of degraded landscapes—comprising peatlands, mangroves, coastal wetlands/ecosystems, aquatic ecosystems or low productive land—by promoting multifunctional landscapes, including reforestation and afforestation;
  - Natural regeneration of forests, assisted or otherwise;
  - Enhanced carbon sequestration in agricultural soils, which also enhances soil health, water holding capacity and productivity; and
  - Enhanced bio-sequestration techniques, replacing marginal agricultural land with managed indigenous flora, which is coppiced regularly and buried in anoxic, saline pits to avoid composting.

  The first three of these approaches to nature-based solutions have the associated risk of impermanence due to wildfires, deliberate deforestation or changed agricultural practices. Scientific modelling highlights the importance of keeping existing carbon sinks intact as the effectiveness of carbon sinks is likely to degrade with increasing CO_2 emissions.[7] Mechanisms to manage these risks are needed, like existing temporary Certified Emission Reduction credits (such as tCERs), or forest buffer zones, especially if these projects are the basis of financial products, such as carbon credits, or offsets.

- Technological solutions capturing CO_2 emissions from the atmosphere, such as Direct Air Carbon Capture and Sequestration (DACCS) or from Bio-Energy CCS, or from industrial processes which are biogenic such as fermentation, often collectively referred to as Biomass Carbon Removal & Storage (BicRS). This is defined as processes that use biomass to remove CO_2 from the atmosphere, store the CO_2 underground or in long-lived products, and do no damage to—and ideally promote—food security, rural livelihoods and biodiversity.[8]

  The transportation and storage of CO_2 at scale and permanently in geological reservoirs uses a set of technologies which are both feasible, and have been technically demonstrated. The Alliance position is that we should not rely solely on technical carbon removal solutions as they are still to be developed at the scale required to create efficiencies and reduce the cost to remove enough CO_2. Nevertheless, the further development of these technologies needs to be keenly pursued.

  There are some issues associated with these technical CDR approaches which need to be addressed in any future developments. Bio-Energy CCS (BECCS) is land and potentially water intensive, and limited in spatial suitability, but could, in appropriate

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7 IPCC Report: Climate Change 2021, The Physical Science Basis, Summary for Policymakers. Working Group, I contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Section B4.1 pg SPM25

8 ICEF 2020 Roadmap: Biomass Carbon Removal and Storage (BiCRS) icef.go.jp/roadmap/

circumstances and with adequate safeguards, provide CO_2 removal. However, the viability of BECCS for large scale emissions removals is questionable due to potential negative impacts on food security, rural livelihoods and biodiversity. The focus should now be on implementing BiRCS as an alternative CDR option.

DACCS is expensive and energy intensive but has large potential if cost-reductions occur with economies of scale. It also has fewer and less severe ecosystem-competition impacts than BECCS.

BECCS, BiRCS and DACCS will require storage sites and the costs of storage will be significantly reduced as more storage sites become available. Especially as CCUS schemes for abatement are implemented at scale to reduce emissions, their storage capacity can then also be accessed for CDR purposes.

3. Use of carbon credits as complementary instruments and engagement with policymakers

Carbon credits are complementary instruments

Achieving global net zero and aligning to a 1.5°C pathway requires following a robust decarbonization path alongside permanent neutralisation of residual emissions. Furthermore, the Alliance recognizes that compensating for all unabated emissions on the path to net zero will and must be embedded in the real economy but must only ever be complementary and additional to net-zero strategies and decarbonization efforts.

Retiring high-quality, certified carbon credits allows companies to neutralize (removal credits) or compensate (avoidance or reduction credits) for emissions.

The Alliance endorses the 'High Ambition Path to Net-Zero' statement made by the Principals of the Taskforce on Scaling Voluntary Carbon Markets (TSVCM), calling on firms to neutralize and compensate their emissions on the path to net zero, on top of their primary obligation to decarbonize.[9] Asset owners should not use carbon credits to meet their decarbonization targets at portfolio level and should report any offsets separately.

To this end, the Alliance supports scalable, transparent, liquid, reliable and high-quality carbon markets and therefore welcomes initiatives such as undertaken by the TSVCM.[10] Increased carbon credit quality will lead to higher carbon offsetting prices, which will in turn drive companies towards further decarbonization efforts in their operations. Current

9 Taskforce on Scaling Voluntary Carbon Markets news release May 21 2021 "Taskforce on Scaling Voluntary Carbon Markets Takes Steps Forward in Creation of High-Integrity Market for Carbon Trading with Launch of New Consultation" iif.com/tsvcm/Main-Page/Publications/ID/4429/Taskforce-on-Scaling-Voluntary-Carbon-Markets-Takes-Steps-Forward-in-Creation-of-High-Integrity-Market-for-Carbon-Trading-with-Launch-of-New-Consultation

10 Taskforce on Scaling Voluntary Carbon Markets, Final Report January 2021 iif.com/Portals/1/Files/TSVCM_Report.pdf

efforts to ensure and improve the quality of the voluntary carbon market require considerably more attention, requiring standards, protocols and methodologies developed by experts who are independent, non-conflicted and non-market participating.

When using carbon credits:

- **Prioritize removals/sequestration over reduction/avoidance:** Most of the offsets currently available are emissions reductions/avoidance, but carbon removals/sequestration should also be the focus towards net-zero goals. To do this, the underlying accounting methodology also needs to be improved. Currently removals accounting is not based on removal logic, but largely uses avoidance logic.
- **Permanence: Long-term vs short-term:** short-term impermanent storage can only serve as a bridge to implementing long-term permanent storage solutions;
- **Nature-based vs technology:** Nature already naturally removes around 41% of annual GHG emissions[11] so protecting the existing carbon sinks is vital, following approaches like Reducing Emissions from Deforestation and Forest Degradation (REDD+). This may be achieved through issuing avoidance credits (if meeting additionality requirements) and through other methods of managing the risks of deforestation whether accidental (wildfire) or deliberate (forest clearing/degradation). Nature-based solutions should be further developed in a manner that maximizes their potential complementary environmental and socioeconomic benefits. Mechanisms that incentivize carbon sequestration at the cost of other factors, such as biodiversity, water security or indigenous land rights, should be avoided. In case nature-based solutions are commercially used, sustainable and long-term utilization of the proceeds should be pursued. Sustainable management can mitigate climate risks and risk of CDR reversal. For example, the permanence of sustainably harvested timber when used as a construction material will play an important role in a low carbon economy.
- Technology based removal and storage solutions have been demonstrated as technically feasible, but they need to be implemented **at scale** in order to achieve scale economies and reduce costs to make them viable. When this happens, they will be an important additional tool on the path to decarbonization especially as the permanence of storage is high. Therefore, further research and development as well as financial support in exploring and expanding technological solutions is needed.
- To the extent **reduction and avoidance credits** are used, integrity of the projects is of paramount importance, especially: high-quality verification of existence; avoidance of double-counting; thorough additionality testing; avoidance of leakage; and credible baselines to avoid over-crediting.[12] A clear pathway towards phasing-out of these credits along the trajectory to achieve global net zero by 2050 is needed to ensure permanent GHG removals from the atmosphere to halt global warming sustainably.

11 Friedlingstein et al (2020), Global Carbon Budget 2020, Earth Syst. Sci. Data, 12, 3269–3340, 2020 and associated non-CO_2 budget papers.

12 leafcoalition.org/

- Companies employing any sort of credits are expected to **transparently disclose** both absolute emissions and emissions minus removals, as well as the type of credit used. Companies claiming to be on a 'net-zero' pathway cannot rely on avoidance and reduction credits. If claims based on these credits are to be made, companies should communicate that they have not yet eliminated all of their emissions, but are planning to compensate their emissions for a given period by having financed lower emissions elsewhere (subject to meeting all aforementioned quality criteria). These credits will finance much-needed climate mitigation action and support the global transition to a zero-carbon future and represent a temporary measure until the companies are able to undertake the steps needed to eliminate emissions entirely.

The carbon credit market, maturity, industrialisation and transparency

In the absence of a global carbon tax, carbon credits can act as a market proxy, growing, institutionalizing, formalizing and increasing the transparency and integrity of voluntary carbon markets. In this context, creating voluntary carbon markets plays a significant role in bringing the carbon price to adequate levels. However, given the voluntary nature, the carbon price will be self-imposed and not uniformly applied across industries or companies, and unless a company commits to a high shadow price, it will not be efficient in driving necessary decarbonization. Companies should therefore have an obligation to know, understand, and disclose elements of their marginal abatement cost curve, including the cheapest mitigation options available (in dollars per ton of CO_2), to avoid voluntary markets losing integrity and becoming ineffective strategies.

With CDR entering the markets, it will be possible to oblige emitters not only to offset their current emissions, but also to commit to paying for the removal of carbon equivalent emissions at a later stage.[13] The price for such carbon removal obligations will depend on how long the carbon remains in the atmosphere. Managing this carbon 'debt' and associated risks will require additional markets, policies and performance mandates.

Strong policy support will be crucial

Strong policy support will be crucial to developing and scaling up the negative emissions technologies outlined in this paper. Experience from policy implementation in other low-carbon sectors suggests that the effective policy formula is financial incentives + mandates for deployment or performance.

13 Bednar, J., Obersteiner, M., Baklanov, A. *et al.* Operationalizing the net-negative carbon economy. *Nature (2021).* doi.org/10.1038/s41586-021-03723-9

Financial incentives, through a price on carbon, subsidies or tax rebates have been vital to accelerating the deployment of renewables and electric vehicles, alongside the deployment of new mandates such as renewable portfolio standards and phase out commitments on internal combustion engine vehicles. This "incentives + mandate" approach could also be applied to the development of negative emissions technologies.

Other policy measures that the Alliance advocates for include:

- A near term focus on applications with low barriers to deployment, but also starting to define solutions to applications with higher barriers to deployment;
- A consistent long-term climate policy with national roadmaps, targets, industrial strategies and international commitments to develop investor and stakeholder confidence in long-term energy policy;
- A price on carbon that rises over time and other well thought out policy support mechanisms (e.g. payment for ecosystem services) that close the price gap and make projects investable; [14]
- Increased investment in research and development and strategic demonstration projects, through public procurement, to drive innovation, help address technical challenges and reduce deployment costs;
- The restoration of degraded land through the bolstering of existing enforcement authorities and dedicated environmental restoration programmes; and
- The promotion and uptake of soil carbon sequestration management practices.

Carbon pricing has been most effective in reducing emissions when a readily available substitute is already commercial (e.g., the EU ETS driving the switch from coal to renewables) and works less well where the alternative technology isn't yet commercially developed (e.g. aviation). This suggests that a policy response is necessary, which includes, and goes beyond carbon pricing. A rising price, rather than simply a price on carbon is, in the medium to long-term, the most effective economic measure that will drive the investment, substitution and behavioural changes required to achieve a net-zero, 1.5°C degree world.

14 See UNEP FI and PRI "Discussion paper on Governmental Carbon-Pricing" UN-Convened Net-Zero Asset Owner Alliance unepfi.org/wordpress/wp-content/uploads/2021/07/FINAL-AOA-Discussion-paper-on-governmental-carbon-pricing.pdf

4. Glossary

Abatement: Elimination of sources of emissions within a company's value-chain, for example some types of CCUS scheme. During a company's transition to net zero, compensation and neutralisation measures may supplement, but not substitute, reducing value chain emissions in line with science. At the time that net zero is reached, emissions that are not feasible for society to abate may be neutralized with equivalent measure of carbon dioxide removals (CDR).

Additionality: A term usually used in the context of carbon credits and their quality i.e. that the mitigation activity would not have taken place in the absence of the added incentive created by the carbon credits. Carbon finance decisions need to be carefully assessed on an individual basis as they can produce both co-benefits and collateral impacts that can affect other sustainable development goals.

Afforestation/reforestation (AR): Planting of forests on lands that have not historically contained forests or that have previously contained forests. AR is commonly depicted as the largest contributor to land-use related carbon sequestration, although active growth is required for net-negative capture of carbon dioxide. Mature forests tend to be in carbon equilibrium, as fixing of carbon dioxide by photosynthesis, is balanced by emissions of greenhouse gases through decay of older dead and composting plant material.

Avoided: Avoided emissions are emission reductions that occur outside of a product's life cycle or value chain, but as a result of the use of that product.[15] Avoided emissions refer to emissions that have been avoided thanks to activities such as conservation and protecting forests from deforestation, or the development of low carbon technology/product decreasing the amount of GHG emitted for the same service. Examples of avoided emissions could such as some types of products (goods and services) that avoid emissions include low-temperature detergents, fuel saving tires, energy-efficient ball bearings, and teleconferencing services. Other terms used to describe avoided emissions include, but are not limited to, climate positive and net-positive accounting.

15 Greenhouse Gas Protocol, (2014). GHG Protocol Standard on Quantifying and Avoided Emissions Summary of online survey results. ghgprotocol.org/sites/default/files/ghgp/Avoided%20emissions%20survey%20report_final%20draft.pdf

Carbon Capture Use and Storage (CCUS): CCUS is an abatement method of avoiding carbon dioxide emissions from industrial processes by capturing and using or storing the carbon dioxide, thereby preventing it from being released into the atmosphere. In some cases when a CCUS store is linked to a Direct Air Capture unit (DAC) or through the capture of emissions used in the production and use of bio-energy (BECCS), or BiRCS processes, then CCS can also be considered a carbon dioxide removals (CDR) process. A CCUS scheme for abatement, or carbon reduction, typically comprises three major processes;

- Capturing CO_2 from stationary emission sources (e.g. power plants, cement plants, iron & steel plants refinery plants, hydrogen production plants—steam methane reforming—"blue" hydrogen production),[16]
- Transporting CO_2 to a storage site (e.g. by pipeline, rail, or by ship), and
- Injecting CO_2 into geological formations deep underground (e.g. depleted oil and gas fields, saline aquifer formations, 1–3km beneath the earth's surface) for secure storage. In well-sited, regulated and permitted CCUS stores, the storage can be effectively permanent.[17]

Carbon Credit: An emissions unit that is issued by a carbon crediting program and represents an emission reduction or removal of greenhouse gases. Carbon credits are uniquely serialized, issued, tracked, and cancelled by means of an electronic registry.[18] The term can also be used as an umbrella term for voluntary offsets and various forms of compliance carbon credit, such as the EU Allowance (EUA) trading units under the EU Emissions Trading Scheme (ETS).

Carbon Dioxide Removal (CDR): The IPCC defines CDR as "anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products." Also known as **Negative Emissions.**

Carbon Offset: (See also Carbon Credit) A carbon offset is a reduction in emissions of carbon dioxide or other greenhouse gases made in order to compensate for emissions made elsewhere.[19] The term usually refers to voluntary carbon markets, not compliance-driven regimes like cap and trade schemes.

Compensate: Measurable climate mitigation outcomes resulting from actions outside of the value-chain of a company, compensating for emissions that remain unabated within the value-chain of a company.[20]

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16 Delivering Clean Growth: CCUS Cost Challenge Taskforce Report, July 2018 gov.uk/government/publications/delivering-clean-growth-ccus-cost-challenge-taskforce-report

17 "Estimating geological CO_2 storage security to deliver on climate mitigation" by Alcalde, J., Flude, S., Wilkinson, M. et al. Nat Commun 9, 2201 (2018). doi.org/10.1038/s41467-018-04423-1 nature.com/articles/s41467-018-04423-1

18 What makes a high-quality carbon credit? Phase 1 of the "Carbon Credit Guidance for Buyers" project: Definition of criteria for assessing the quality of carbon credits by Schneider et al 2020 (World Wildlife Fund (WWF-US), Environmental Defense Fund (EDF) and Oeko-Institut) c402277.ssl.cf1.rackcdn.com/publications/1342/files/original/What_Makes_a_High-quality_Carbon_Credit.pdf?1591405169

19 What are Offsets? In CORE, Carbon Offset research and Education by Stockholm Environment Institute and GHG Management Institute co2offsetresearch.org/consumer/index.html

20 A cross-sector guide for implementing the Mitigation Hierarchy. Cross Sector Biodiversity Initiative by Jon Ekstrom, Leon Bennun and Robin Mitchell, 2015. csbi.org.uk/wp-content/uploads/2017/10/CSBI-Mitigation-Hierarchy-Guide.pdf

Decarbonization: Measures that prevent the release of CO_2 emissions associated with electricity, industry and transport.

European Union Allowance (EUA): The tradable unit under the European Union Emissions Trading Scheme (EU ETS), giving the holder the right to emit one tonne of carbon dioxide (CO_2), or the equivalent amount of two more powerful greenhouse gases, nitrous oxide (N_2O) and perfluorocarbons (PFCs). Article 3(a) of the EU ETS Directive defines the emission allowance as being "an allowance to emit one tonne of carbon dioxide equivalent during a specified period, which shall be valid only for the purposes of meeting the requirements of this Directive and shall be transferable in accordance with the provisions of this Directive".[21]

GHG Emissions Reduction Targets: Goals set by an organisation or political actor, which aim to reduce the organisation, or political actor's direct or indirect emissions by a specified amount.

Greenwashing: Greenwashing is defined as is the overstating of the environmentally or socially conscious attributes of a firm's offering and/or the understating of the negative attributes for the firm's benefit.

Mitigation: The mechanism by which a corporation reduces its impact on the climate or contributes to societal transition to net zero. This includes abatement, neutralisation, and compensation.

Neutralisation: Halting the accumulation of emissions in the atmosphere. Neutralisation of unabated emissions can only occur through negative emissions.

Permanence: The robustness of a net-zero strategy that relies heavily on negative emissions depends on the effectiveness of the underlying CO2 removal and, especially, on the permanence of the stored carbon.

Reduction: Reducing an organisation's, or political actor's direct or indirect emissions (see also GHG Emissions Reduction Targets).

Residual emissions: GHG emissions that remain unabated in scenarios that limit warming to 1.5°C with low/no overshoot.

Value chain emissions: A company's scope 1, 2, and 3 emissions as defined by the GHG Protocol accounting standard.

21 Definition from the Emissions-EUETS.com emissions-euets.com/carbon-market-glossary/871-eua

5. Acronyms

AFOLU	Agriculture, Forestry, and Land-Use
AOA	Net-Zero Asset Owners' Alliance
BECCS	Bio-Energy Carbon Capture and Storage
BiCRS	Biomass Carbon Removal & Storage
CCUS	Carbon Capture Use and Storage
CDR	Carbon Dioxide Removal
DACCS	Direct Air Carbon Capture and Sequestration
EUA	European Union Allowance
ETS	EU Emissions Trading Scheme
GHG	Greenhouse Gas
IPCC	The Intergovernmental Panel on Climate Change
NCS	Natural Climate Solutions
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SBTi	Science Based Targets Initiative
tCER	temporary Certified Emission Reduction
TSP	Net-Zero Asset Owners' Alliance Target Setting Protocol
TSVCM	Taskforce for Scaling the Voluntary Carbon Markets

6. Appendix

A1. Pathways to Net Zero

Large-scale carbon dioxide removal (CDR) is a key component of most climate change mitigation pathways that limit global warming to 1.5°C. The Intergovernmental Panel on Climate Change (IPCC) states that:

> **"All analysed pathways limiting warming to 1.5°C… use CDR (Carbon Dioxide Removal) to some extent to neutralize emissions from sources for which no mitigation measures have been identified…. The longer the delay in reducing CO_2 emissions towards zero, the larger the likelihood of exceeding 1.5°C, and the heavier the implied reliance on net negative emissions after mid-century to return warming to 1.5°C."[22]**

Limiting global warming to staying within the well below 2°C Paris consensus therefore requires the prioritisation of either CDR or the shutting down of technologies without having a replacement for them within the next decades.

Three of the indicative pathways (P1 to P3) to 1.5°C from the IPCC's calculations shown in Figures 1 (see section 1 'Introduction') and 1A (below) are also represented in the Net-Zero Asset Owners Alliance Target Setting Protocol.

The first pathway (P1), although not entirely absent of offsets, comes closest to the vision for "real zero." For this scenario to work in practice, we would need global CO_2 emissions to peak around now, and then decline by about 8% per year for the next 30 years. By contrast, in 2020 during the pandemic and global lockdown, global emissions decreased by only about 7%[23] (with a global GDP of about -3.6%[24]). So, in order to

22 Rogelj, J., D. Shindell, K. Jiang, S. Fifita, P. Forster, V. Ginzburg, C. Handa, H. Kheshgi, S. Kobayashi, E. Kriegler, L. Mundaca, R. Séférian, and M.V.Vilariño, 2018: 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 the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press. "Global Warming of 1.5 Degree Celsius." IPCC.

23 https://www.nature.com/articles/s41558-020-0797-x

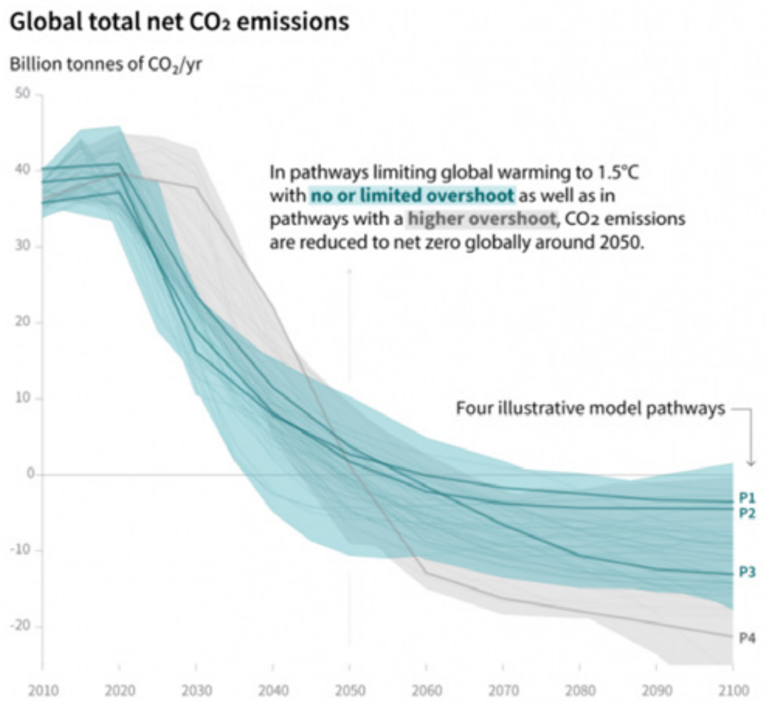
24 https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG

achieve the nearly "real zero" P1 pathway, we would need to do better than the global lockdown in every single year between now and 2050. Current trends very worrisomely indicate that that the likely outcome of pursing P1, but failing to achieve it, would be to exceed the 1.5°C temperature rise scenario.

The science indicates with a high level of confidence that offsets will be an important tool for achieving a 1.5°C scenario, and so should not be ignored or delayed. The Target Setting Protocol developed by the Net-Zero Asset Owner Alliance outlines the essential nature of not only decarbonizing but doing so rapidly. Scenario analysis on the extent of portfolio decarbonization required by certain milestones en route to net-zero emissions by 2050—especially the approximately 50% decline in anthropogenic CO_2 emissions required by 2030[25]—indicate the necessity of a timely transition. Interim target setting, a defining element of the Target Setting Protocol which has been referred to as the "gold standard" by UN Secretary-General António Guterres[26] is intended to safeguard the timeliness and rapid execution of the transition.

The timeline for implementation on Carbon Dioxide Removal (CDR) technologies will have a significant impact on not only the likelihood of achieving net zero by 2050, but on the ability to course correct in the event of those targets being missed. Larger overshoots will require greater amounts of CDR to remain on track, with the IPCC stating that "limitations on the speed, scale, and societal acceptability of CDR deployment hence determine the ability to return global warming to below 1.5°C following an overshoot."

Figure A1. Global total net emissions pathways.



Source: IPCC Special report on Understanding Global Warming of 1.5°C, Summary for Policymakers ipcc.ch/sr15/chapter/spm/

25 IPCC Special report on Understanding Global Warming of 1.5°C, Summary for Policymakers ipcc.ch/sr15/chapter/spm/

26 UN Secretary-General: Institutional Investors Crucial for Net Zero un.org/en/climate-action/sg-institutional-investors-crucial-net-zero

IPCC reports demonstrate that all pathways with limited or no overshoot will require the cumulative removal of 100–1000 $GtCO_2$ (gigatons of carbon dioxide) from the atmosphere (until 2100).[27] These pathways account for carbon removal in various forms (discussed below), but the common theme is that all of these sources of negative emissions will need time to be fully realized.

There is a wide variance in the maturity, cost, impact, and risk associated with these technologies. With risks and trade-offs associated with each, pathways to decarbonization recognize that none of these approaches are entirely predictable in terms of the scale of their usage or efficacy, and that multiple approaches to CDR will therefore be necessary if the solutions are to match the scale required. Like other forms of investment in the green economy, investments in CDR will require diversification.

A2. Negative Emissions Technologies and Nature-Based Solutions for CDR

As CDR solutions are capitalized and incorporated into portfolios of offset technologies, understanding the nature and trade-offs of each type of offset—especially given the perceptual differences in natural vs technological options—will be increasingly important.

Technological solutions

These involve capturing CO_2 emissions from the atmosphere and storing them in deep underground geologic reservoirs. There are two main categories of technological CDR solutions:

- **Biomass Carbon Removal & Storage (BiCRS)**. These are processes that use biomass to remove CO_2 from the atmosphere, this CO_2 is then stored underground or used in long-lived product. To avoid conflict with other sustainability goals, they need to be developed in a way that does not damage, and ideally promotes, food security, rural livelihoods, and biodiversity.
    - **A subset of BiCRS is Bioenergy with carbon capture and storage (BECCS). In this process, purpose-grown plants and trees are harvested as biomass then burned to generate heat or electricity.** The emissions are captured then stored. Alternatively, biomass is converted into liquid fuels—known as biofuels. CO_2 is released as part of the chemical process and is again captured and stored. In both cases, negative emissions are generated as biomass draws carbon from the atmosphere as it grows. A CCUS power station fueled by biomass or CCUS facilities that process biomass into biofuels would both be considered BECCS technology.

27 IPCC Special report on Understanding Global Warming of 1.5°C, Summary for Policymakers ipcc.ch/sr15/chapter/spm/

- BECCS was identified in the IPCC 1.5°C Report as the main CDR mechanism to comply with the Paris Agreement timeframe. Its role as a major CDR mechanism is constrained as it is land and potentially water intensive and limited in spatial suitability. Under appropriate circumstances and with adequate safeguards, BECCS it could still provide CO_2 removal, but the focus should now be on implementing BiCRS as an alternative CDR option.

- **Direct air carbon capture and storage (DACCS):** This involves removing CO_2 directly from the atmosphere using chemicals known as sorbents. A process called absorption dissolves CO_2 into the sorbent. A second process is adsorption, where CO_2 molecules adhere to the surface of the sorbent material. The sorbents are treated so that the CO_2 is released for sequestration.
    - The challenge with DACCS currently is that it is expensive and energy intensive, but it has large potential for cost-reductions, as scale economies reduce the costs, together with fewer and less severe ecosystem-competition impacts than BECCS.

The transportation and storage of CO_2 at scale, permanently in geological reservoirs, is a set of technologies that are both feasible, and technically demonstrated. BECCS, BiCRS and DACCS will require storage sites and the costs of storage will be significantly reduced as more sites become available. Especially as CCUS schemes, for abatement, are implemented at scale to reduce emissions and their storage capacity can then also be accessed for CDR purposes.

Nature-based solutions

- **Agriculture, Forestry, and Land-Use (AFOLU)**—refers to afforestation, reforestation, agricultural land management, and other practices for creating natural carbon sinks; however, permanency of current AFLOU practices is an open issue.

Agriculture, Forestry and Land Use (AFOLU) contributes to one third of global emissions,[28] making this basket of human activities a key target area for emission reduction efforts. However, conservation and land management also represent vital opportunities to improve the planet's carbon sequestration potential through the use of Natural Climate Solutions (NCS). These seek to use natural sinks and processes to sequester carbon, relying on ecosystem services like photosynthesis and decomposition to capture and store carbon. NCS tend to be significantly cheaper than the largely unscaled and unproven technologies used in CCUS approaches, costing around \$10–40 per tCO_2.

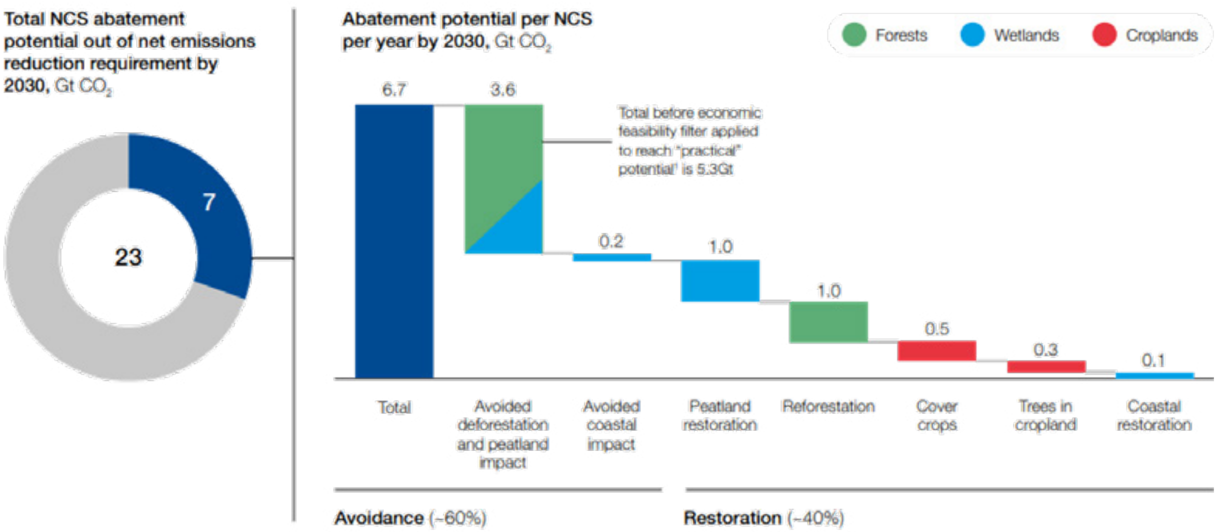
When implemented well, NCS have environmental and social benefits beyond carbon sequestration. These include sustainable economic opportunities for local communities, the preservation of indigenous rights, improved resilience to climate change, and enhanced biodiversity.

28 ipcc.ch/site/assets/uploads/2019/11/SRCCL-Full-Report-Compiled-191128.pdf

As demonstrated in Figure A2 below, NCS tend to take two main approaches: [29]

- "Avoidance" of emissions caused by the damage or removal of existing natural carbon sinks like tropical forests, peatlands and mangroves;
- "Restoration" of these natural sinks, for example through re-planting natural vegetation or re-flooding peat and wetlands, or by restoring soil and vegetation quality in agricultural areas.

Figure A2. The abatement potential of Natural Climate Solutions (NCS).



Notes: ¹ The "practical" potential is a portion of the total NCS abatement potential in recognition of the fact that it becomes progressively more difficult to secure carbon credits as the total potential of each source is approached. It filters out low-feasibility lands, which are more likely to be accessed by mechanisms other than voluntary carbon markets, such as philanthropic or governmental grants. The practical potential sized here is 6.7Gt CO_2 per year by 2030, which excludes 3.5Gt CO_2 that is low feasibility according to our filter. The total potential is therefore 10.2Gt CO_2. There are many economic, political and social lenses that can be used to determine feasibility. In reality, these lenses would not draw a neat boundary between lands that are "practical" or not for the voluntary carbon market; however, this analysis classifies low-feasibility lands, assessing their agricultural rent as an economic barrier and proxy for feasibility.

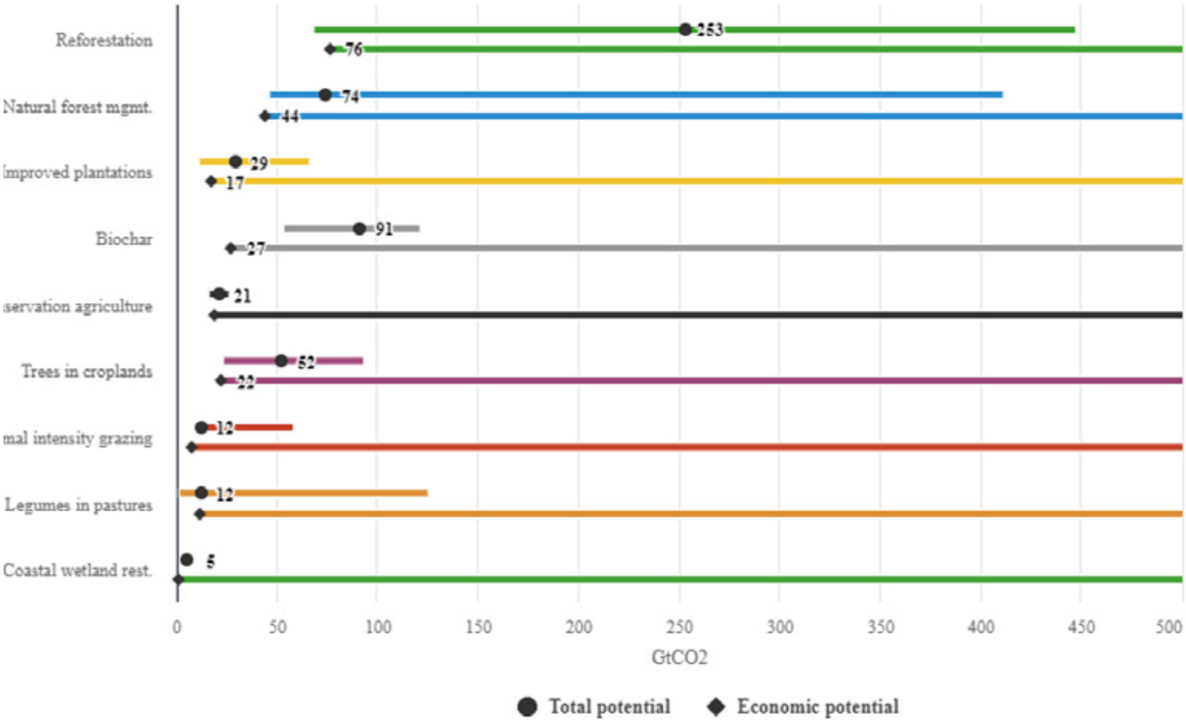
Source: McKinsey Nature Analytics

Source: Nature and Net Zero, May 2021, WEF WEF_Consultation_Nature_and_Net_Zero_2021.pdf (weforum.org)

The magnitude of the negative emissions potential of these approaches is shown in Figure A3 below.

29 WEF_Consultation_Nature_and_Net_Zero_2021.pdf (weforum.org)

Figure A3. Negative emissions potential of natural climate solutions.



Source: carbonbrief.org/analysis-how-natural-climate-solutions-can-reduce-the-need-for-beccs

Some of the most commonly seen NCS are detailed below, classified as agriculture, forest and wetland-based approaches.

Agriculture

Food production is both a major source of anthropogenic emissions (21–37% of global emissions come from pre- and post-production activities in the global food system[30]) and exposed to the physical impacts climate change may have on productivity. This complex relationship is compounded by a growing global population and corresponding increased demands for food, land and biofuels. If current practices are maintained emissions from livestock farming, application of nitrogen fertilizers, rice cultivation and energy use are expected to rise from 7 to 9 $GtCO_2$ p.a. by 2050.[31]

However, a change in our current agricultural system away from intensive, fossil fuel reliant and input-driven practices towards regenerative and conservation agriculture has the potential to not only avoid future emission increases but also increase carbon sequestration potential. These approaches also have the benefit of enhancing food production, rather than potentially competing with it. This transformation must also be accompanied by changes in consumer behaviour and consumption patterns.

30 ipcc.ch/site/assets/uploads/2019/11/SRCCL-Full-Report-Compiled-191128.pdf
31 How to Sustainably Feed 10 Billion People by 2050, in 21 Charts | World Resources Institute (wri.org)

Agroforestry: Combining both trees and crops or livestock on the same land has multiple benefits aside from the enhanced carbon sequestration in the trees themselves. These include the maintenance of soil structure and nutrient content and the provision of additional crops and habitats in landscapes otherwise dominated by monocultures.

Impacts vary across climates and with different combinations of crops and tree varieties. For example, in drier climates agroforestry may be unsuitable when combined with crops due to water shortages, however it may provide valuable shade for livestock.

Cover cropping: When soil is exposed between cash crops, such as cereals, more carbon is released into the atmosphere, as well as it being more prone to soil erosion and weed growth. Cover crops are planted in this off season between the growing periods of cash crops, extending the period of photosynthesis on the land, preventing soil erosion weed growth and moisture loss, and fixing nutrients like nitrogen in the soil. This reduces the need for carbon-intensive inputs as well as the cover crops themselves potentially being a source of revenue.

The carbon credits that can be generated, accompanied by the improved soil quality, higher output and lower input costs makes cover cropping an attractive financial and environmental proposition. Estimates vary depending on assumptions of crop types and agricultural returns among other factors, but cover cropping has the potential to sequester 0.2–0.5 $GtCO_2$ p.a.[32,33] and focuses on existing agricultural land that is only single cropped, making implementation less socio-politically challenging.

Biochar: When biomass is converted into charcoal through high temperature thermal decomposition it remains stable for extended periods. When this is added to soils as biochar around 80% of its carbon remains after 100 years[34] as well as increasing soil fertility.

There is significant interest in the use of biochar, however there are few long-term studies of its benefits and the infrastructure for producing it is limited. Care must also be taken to ensure biomass feedstocks are not produced purely for the production of biochar without careful consideration of land use.

Precision agriculture and agri-tech: Alongside enhancing the sequestration potential of agricultural land there are also significant opportunities to reduce emissions throughout the agricultural value chain. From advances in digital agriculture that enable more efficient fertilizer or pesticide application to the development of hardier or lower maintenance crop varieties, technology will play a vital role.

Management practices: Fortunately, not all solutions require technology that may be less accessible in emerging markets. Whilst new rice varieties can generate less methane, low-tech solutions to reduce the flooding duration of rice paddies also decrease the growth of methane-emitting bacteria, helping reduce rice production's significant methane footprint[35] by 90%[36] as well as saving water. Additionally, the rotation of livestock

32 nature4climate.org/science/n4c-pathways/grasslands-and-agricultural-lands/conservation-agriculture/
33 carbonbrief.org/analysis-how-natural-climate-solutions-can-reduce-the-need-for-beccs
34 pnas.org/content/114/44/11645
35 FAO - News Article: Agriculture's greenhouse gas emissions on the rise
36 How to Sustainably Feed 10 Billion People by 2050, in 21 Charts | World Resources Institute (wri.org)

between pastures allowing areas to naturally regenerate between productive periods, may potentially sequester 7 $GtCO_2$ up to 2100.[37]

The extent to which these approaches and efforts are classified as NCS projects that generate carbon credits varies according to how they are set up and the additionality of their emission reductions is proven and measured. However, whether they generate credits or not, they all have the potential to reduce emissions and provide additional financial and environmental benefits.

Forests

Avoided deforestation: Deforestation causes around 13% of global greenhouse gas emissions,[38] making avoided deforestation one of the most important mechanisms to reduce emissions. It must not be forgotten that growing forests actively sequester carbon, so this net percentage conceals forests' sequestration potential. In fact, reduced deforestation has the potential to mitigate the emissions from the entire land sector, about one-third of total global emissions.[39] Thus transforming the equation for this current net source of emissions into a net sequester is one of the most powerful NCS available.

The highest rates of deforestation occur in tropical forests, which also have higher comparative carbon sequestration and biodiversity benefits than temperate or boreal forests, amplifying the sequestration potential of avoided deforestation. Given that enhanced sequestration comes as a result of avoided activity, rather than the need to wait for habitats or infrastructure to develop, avoided tropical deforestation is also one of the most immediate and low input NCS.

Forest restoration: Forest-based solutions must be treated as part of the global climate system; they have complex interdependencies and impacts at a local and global level. The impact of deforestation or reforestation varies depending on location; in high latitudes reforestation may reduce snow cover and weaken the albedo effect of reflected sunlight, in tropical latitudes reforestation's cooling impact is more certain. Therefore reforestation (restoring areas previously covered by forests by planting trees) or afforestation projects (the establishment of a forest in an area that was not previously covered by forest) must be considered carefully. Schemes should also reflect local biodiversity and must not come at the cost of food security or community land ownership.

Taking into account the economic, social and political challenges that face any undertaking requiring significant areas of land, the World Economic Forum (WEF) estimates that reforestation has the "practical potential" to sequester 1.0Gt CO_2 p.a. by 2030,[40] with a further 1.1Gt CO_2 excluded as being unfeasible under current economic, regulatory and incentive conditions.

37 pnas.org/content/114/44/11645
38 ipcc.ch/site/assets/uploads/2019/11/SRCCL-Full-Report-Compiled-191128.pdf
39 wri.org/blog/2019/08/forests-ipcc-special-report-land-use-7-things-know
40 WEF_Consultation_Nature_and_Net_Zero_2021.pdf (weforum.org)

Wetlands

Avoided wetland impact: Peatlands are significant carbon sinks, sequestering 0.37 $GtCO_2e$ p.a.,[41] however their exploitation and damage as a result of draining, conversion to agricultural use or burning for fuel contribute around 10% of global emissions from land use. Whilst peatlands are found globally, some of the largest and most threatened are found in tropical forest regions already subject to significant deforestation. This means approaches to avoid deforestation and peatland damage often work in tandem, as evidenced by "No Peat, No Deforestation, No Exploitation" policies[42] encouraged in tropical commodity value chains.

In a similar manner to peatland, coastal habitats like mangroves, seagrass and marshes also sequester significant amounts of "blue carbon" through the growth of vegetation and accumulation of sediments. Mangroves in particular are highlighted for their co-benefits, storing 3–4[43] times more carbon in their soils than tropical forests, protecting coastlines from rising sea levels and storms, filtering water and capturing sediments that could smother nearby coral reefs.

The key drivers of coastal wetland destruction are property, agriculture and aquaculture, whilst development and deforestation can also have a knock-on impact. Given the high economic return of these activities, the WEF finds a practical abatement potential of only 0.2 Gt CO_2 p.a. by 2030 for avoided coastal impacts, however as their co-benefits are increasingly recognized and as carbon prices rise, more may become viable.

Wetland restoration: Restoring peatlands is a vital form of increasing carbon sequestration, with corresponding benefits for biodiversity, soil health, water quality and flood control. Despite peatlands containing carbon from organic matter decomposing over thousands of years, some studies indicate that restored peatlands can switch from being a carbon source to a sink within ten years with some initial management.[44] However, less intensive management may result in restoration taking between 50 and 500 years,[45] making selection, management and accurate monitoring a vital aspect of peat project planning and offset certification.

The restoration of coastal wetlands can be done by reducing pollution, replanting vegetation or restoring natural hydrology. However, given the opportunity cost for such restoration on previously developed land, these NCS were found by the WEF to have the lowest practical avoidance potential.

41 Peatlands and climate change | IUCN
42 spott.org/news/ndpe-policies-palm-oil-sector/
43 Mangrove Restoration: Offering two-for-one solutions to climate change | IUCN
44 nature.com/articles/d41586-020-00355-3#:~:text=These%20results%20mirror%20research%20in,recover%20following%20restoration%20efforts3.
45 iucn-uk-peatlandprogramme.org/sites/default/files/2019-05/11%20Peatland%20Restoration_FINAL.pdf

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