FORESTS AND CLIMATE CHANGE

THE FACTS, SCIENCE AND POLITICS

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CENTRE FOR SCIENCE AND ENVIRONMENT

Authors: **Sunita Narain** and **Avantika Goswami**

Editor: **Akshat Jain**

Design and cover: **Ajit Bajaj**

Graphics: **Sanjit Kumar**

Production: **Rakesh Shrivastava** and **Gundhar Das**

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41, Tughlakabad Institutional Area
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Phones: 91-11-40616000
Fax: 91-11-29955879
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FORESTS AND LAND-BASED SINKS: GLOBAL SCENARIO

1. WHY ARE LAND AND FORESTS IMPORTANT FOR COMBATTING CLIMATE CHANGE?

It is now clear that forests will play a critical role in the world's desperate fight to combat climate change. Land—forests, trees and grasses—acts as a 'sink' for carbon dioxide (CO_2); which means that it removes a part of the CO_2 that is emitted through human activity.

There is more to this. The fact is that land is also a source of emissions—burning of forests, along with other disturbances, adds to CO_2 in the atmosphere. Therefore, scientists must estimate what is the amount sequestered by forests; and this estimation depends on a variety of complex factors. They must also estimate how much CO_2 is emitted from forests. This then provides the world with the 'net' contribution of forests to global greenhouse gases (GHGs). But these calculations are fraught with uncertainty and methodological issues.

This challenge is amplified by climate change—increased heat levels are adding to the moisture stress in forests and leading to widespread burning. Not only are forests being cut for different economic activities, they are also shrinking as temperatures increase—both of which are reducing their role as sinks for the CO_2 released from fossil fuel burning.

Research published in *Nature Climate Change* in 2021 found that the world's forests sequestered about twice as much carbon dioxide equivalent (CO_2e) as they emitted between 2001 and 2019. This study by Nancy Harris and her colleagues at the Washington-based World Resources Institute used a spatial resolution of 30 metres over the two decades. It estimated that global forests 'removed' some 15.6 giga tonnes (Gt) of CO_2e each year while emissions from deforestation and other disturbances were 8.1 $GtCO_2e$ each year on average. This meant that global forests were a net sink—soaking in some 7.6 $GtCO_2e$ each year—a little less than the total CO_2e emissions of China in 2020 (roughly 10 $GtCO_2e$) and more than the total annual CO_2e emissions of the US.[1]

In the two decades, therefore, the net removal from global forests would be 152 $GtCO_2e$—some 30 per cent of CO_2e emissions emitted in this period.

This is corroborated by the Intergovernmental Panel on Climate Change's (IPCC) Special Report on Climate Change and Land 2019 (SRCCL), which estimates that between 2007–2016, land use accounted for 13 per cent of anthropogenic CO_2 emissions. But it also provided a net sink of around 11.2 $GtCO_2$ per year, equivalent to 29 per cent of total CO_2 emissions in the same period.

In other words, some 29–30 per cent of human-driven CO_2 emissions have been soaked up by the world's forests during the past two decades. Without this, the world would have witnessed an even higher temperature rise, which is already bringing it to the brink of weather-related disasters.

It is for this reason that protecting land and growing forests is now back on the global agenda. The world is not on track to reduce GHG emissions at the scale needed to avert a temperature rise of 1.5 °C. The solution then is to find ways in which emissions can be removed from the atmosphere. Growing trees is part of this package. It is also clear that adding to forests and restoring land can benefit local people as environmental degradation impacts their livelihoods and impoverishes communities.

The question is how these forests will be grown—on whose lands? Who will benefit and who will pay the price? It is also important to understand the cost of protecting nature—particularly in the habitats of poor communities—and what this will mean for their future.

Before any of this becomes possible, it is important to understand the complexities in estimating the role of forests as sinks and to ensure that this accounting is credible. Without this, creative accounting of global GHG emissions will become a problem—where countries take credit for reducing CO_2 emissions that forests in their territories have naturally absorbed.

2. WHERE ARE THE MAJOR LAND-BASED SINKS?

So, just how big are the world's sinks? And where are they located? Forests contribute the largest fraction of the land-based carbon sinks. Other contributing biomes include grasslands, peatlands, tundra, and global drylands such as savannahs and shrublands. The UN's Food and Agriculture Organization (FAO) compiled data on the extent of carbon stock in the world and its status in its 2020 Global Forest Resource Assessment Report. It has estimated the global carbon stock in living biomass (trees), in dead wood and litter, and in soil. According to this, the world's forest area was roughly 4 billion hectares in 2020, which is some 30 per cent of the world's land area.

The world's carbon stock in forests was about 662 Gt in 2020, with almost half of this found in the soil organic matter in the forests (300 Gt), another 295 Gt in living biomass and the rest in dead trees. According to this estimate, each hectare of forests on an average provides 163 tonnes of carbon stock, but with variations based on geography and type of forests.

The report also finds that the carbon stock is going down—*the global forest carbon stock decreased between 1990 and 2020, from 668 Gt to 662 Gt, due to an overall decrease in forest area*. But, again, with variations. In Europe, North America and East Asia, the forest cover increased in the two decades; while it decreased in Africa, South America and South Asia (see *Table 1*).

Table 1: Changes in forest carbon stock between 1990–2020

Region	% Change in forest carbon stock (1990–2020)
Africa	-14%
South America	-10%
South and Southeast Asia	-9%
North America	+2%
Europe (excl. Russia)	+24%

Source: CSE, Compiled from FAO (2020), Global Forest Resources Assessment 2020: Main report. Rome. https://doi.org/10.4060/ca9825en

2.1 TROPICAL FORESTS STORE THE MOST CARBON, FOR NOW

Compared to temperate forests, the world's tropical forests are vastly superior in their ability to remove CO_2. The largest tropical rainforests are in the Amazon, Congo River Basin and Southeast Asia.

With deforestation, drought and changes in land use, the extent of removal is decreasing. Harris et al, in their study published in January 2021 in *Nature Climate Change*, report that tropical and sub-tropical forests have the highest emissions due to deforestation (78 per cent of gross emissions), even though they sequester more carbon (55 per cent of gross removal) than boreal and temperate forests combined.[2]

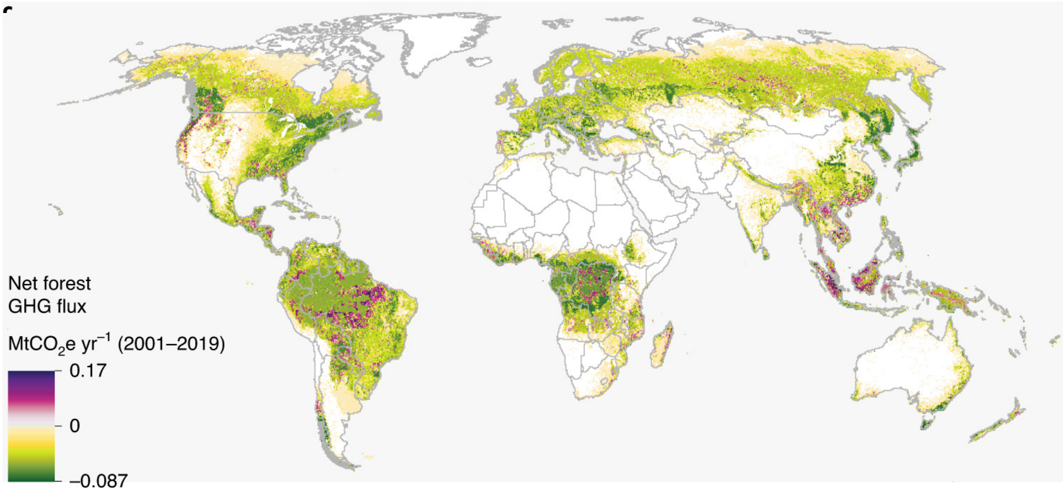
The FAO's data also points to this—the top three countries for average annual net loss of forest area between 2010–2020 are Brazil, Democratic Republic of the Congo and Indonesia.[3]

Consequently, the major global net sinks lie in temperate forests (47 per cent) and boreal forests (21 per cent) due to lower emissions compared to the tropics (31 per cent). Between 2001 and 2019, only six countries—Brazil, Canada, China, Democratic Republic of the Congo, Russia and the United States—accounted for 51 per cent of global gross emissions from forests, 56 per cent of global gross removals and 60 per cent of net flux[4] (see *Map 1*).

The real issue now is to track not just what forests absorb, but also what they emit and if these emissions are increasing over time.

A new tracking system, developed by scientist Sassan Saatchi of NASA's Jet Propulsion Laboratory, called "tropical forest vulnerability index (TFVI)" is being used to identify areas where rainforests are losing resilience because of disturbances and are reaching an irreversible state, or a "tipping point".[5] It is based on observations of forest cover, carbon and water fluxes. In their study published in *One Earth* in July 2021, they found that

Map 1: GHG flux from forests, net annual average (2001–2019)



Source: Harris et al. 2021

tree cover loss exhibited uneven patterns globally and across time. Forests in Africa show relatively higher resilience to climate change. In Asia, tropical forests appear more vulnerable to changing land use and fragmentation. The Amazon is significantly more vulnerable to climate and land-use stressors than forests in Africa and Asia. In fact, the net loss of tree cover was consistently higher in the Americas, with an average annual rate of 2.5 million hectares (mha) in the 1980s, 1.2 mha in the 1990s and 2.0 mha in the 2000s. This was somewhat reduced, because of the efforts made by the Brazilian government, to 1.6 mha in the 2010s.

In another study published in *Science Advances*, Saatchi and team found that tropical forests emitted and absorbed quadruple the total amount of carbon than forests in temperate and boreal regions, but that the ability of tropical forests to absorb massive amounts of carbon has waned in recent years. The decline in this ability was attributed to large-scale deforestation, habitat degradation and climate change effects, like more frequent droughts and fires.[6]

While most of the focus tends to be on forests, research has shown that better management in all major natural terrestrial

BOX 1: HAS THE AMAZON REACHED ITS "TIPPING POINT"?

The tipping point is defined as that moment when the rate of deforestation in the Amazon becomes so high that the forest loses the ability to rejuvenate and sustain itself, thus triggering the dieback of the entire rainforest.[1] Recent studies point to the fact that the Amazon may be close to this point—it is today a 'net' source of emissions and not a sink.

In July 2021, Luciana Gatti at the National Institute for Space Research in Brazil, along with other researchers, found that the Amazon rainforest, particularly the Southeastern section, is now emitting more CO_2 than it is absorbing. Its net emissions amount to 1 $GtCO_2$ per year, caused mainly by fires set deliberately to clear land for beef and soy production. These are made worse by hotter temperatures and droughts.[2] Gatti's research used small planes to measure CO_2 levels up to 4,500 m above the forest over the last decade and showed how the whole Amazon is changing.

Previous studies indicating the Amazon was becoming a source of CO_2 were based on satellite data (which can be hampered by cloud cover) or ground measurements of trees (which can cover only a tiny part of the vast region). Gatti's team found that fires produced about 1.5 $GtCO_2$ a year, with forest growth removing 0.5 $GtCO_2$. The worrying finding is that the Amazon is emitting carbon even without fires. Speaking to British daily, *The Guardian*, the researchers said that it was most likely the result of each year's deforestation and fires that were making adjacent forests more susceptible the next year. The trees produce much of the region's rain, so fewer trees mean more severe droughts and heatwaves and more tree deaths and fires.[3] In other words, a vicious cycle of destruction is unleashed.

habitats—including grasslands, wetlands and agricultural lands—could help provide up to 37 per cent of the CO_2 mitigation needed till 2030 for a greater than 66 per cent chance of keeping warming to less than 2°C.[7] This includes mangroves which have long-term carbon storing rates 45 times greater than forests and other ecosystems, peatlands which hold 25 per cent of the world's carbon despite covering only 2–3 per cent of land area, and grasslands which are more resilient to droughts and wildfires than forests.[8]

The agenda then is: to increase forest cover in countries; to do this in tropical regions where forests sequester higher amounts of

CO_2; to stop deforestation and other causes of forest degradation, particularly in tropical regions; and to regenerate biomass like peat and grasslands.

This agenda is still incomplete. The biggest question is—how can countries of the emerging and developing world, where the bulk of tropical forests are, grow their economies without depleting natural capital? What for instance can Brazil do to value the CO_2 sink ability of its forests and not cut them for pasture or wood? What role will forests play in the livelihoods and economies of the poor?

2.2 THE LINK BETWEEN COMMODITIES AND FORESTS

In many parts of the tropical world, forests are being cut to make room for commodities that are grown for export. According to Florence Pendrill at Chalmers University in Sweden, one-third of the world's tropical deforestation is driven by international trade, mainly that of beef and oilseeds.[9] In Brazil, one-third of the deforestation is driven primarily by the expansion of pastureland to raise cattle for beef production. This is followed by cropland expansion for soybean and palm oil, and tree plantations in native forests for paper and wood products. The annual forest loss rate in the Brazilian Amazon reached a 12-year high of 1.11 million hectares in 2019 and 2020.

In the wake of the major Amazon fires in 2019, the nonprofit Amazon Watch published a report titled *Complicity in Destruction,* in which they found that financiers in the Global North such as Vanguard, State Farm and BlackRock finance and profit from Amazonian exports. Banks such as BNP Paribas, JPMorgan Chase, Barclays, Bank of America and Citigroup provide lines of credit to agribusiness giants, while investment firm Blackstone has driven large-scale rainforest clearance for highway and port infrastructure projects. A July 2021 scorecard published by Amazon Watch, titled *Banking on Amazon Destruction,* highlighted banks who are still investing in oil expansion and large-scale forest extraction in the Amazon. Citigroup, JPMorgan Chase, Goldman Sachs, Deutsche Bank and HSBC were categorized as “very high” risk, describing their potential contribution to Amazon’s destruction. In October 2021, advocacy group Global Witness found that global banks and investment managers made roughly $1.74 billion in agribusiness deals linked to deforestation, despite voluntary commitments to eliminate deforestation from their businesses. Financial entities based in the US, UK, EU and China have made deals worth $157 billion since the Paris Agreement with firms accused of destroying tropical forests in Brazil, Southeast Asia and Africa.[10]

UK-based nonprofit Global Canopy published a report in January 2022 which asserted that 500 of the key companies and financial institutions that use or finance “forest risk” commodities, have not made commitments to stop deforestation, and those that have are doing very little to meet their goals. These companies are most closely linked to commodities that aid the destruction of the world’s forests—including beef, soy, palm oil and timber. They include 350 companies that most rely on commodities responsible for deforestation and the 150 banks and financial institutions that support them, including pension funds and asset managers. They found that roughly one-third of these 350 companies have no policies in place to stop deforestation and nearly three-quarters of them have only made commitments to stop deforestation connected to one or two commodities, often those they don’t rely on heavily.[11] An investigation by Bloomberg found that companies which have made commitments to rid their supply chains of animals born or raised on deforested land, like Brazil’s biggest beef producer JBS, use greenwashed supplier standards that do not reduce deforestation.[12] Moreover, the standards are applied ‘within a legal system so full of loopholes that prosecutors, environmentalists and even ranchers themselves consider it a farce.’

At COP 26, two announcements were made—the Glasgow Leaders Declaration to halt forest loss, and the FACT (Forest, Agriculture and Commodity Trade) Dialogue on sustainable trade. The Glasgow Declaration was endorsed by about 140 countries and includes $12 billion in public funding and $7.2 billion in private funding to restore forests. The FACT Dialogue provides a “roadmap for action” in four areas—trade and market development, smallholder support, traceability and transparency, and research, development and innovation. The 28 countries which signed it represent 75 per cent of global trade in key commodities like palm oil, cocoa and soy which contribute to deforestation.

Such voluntary commitments are unlikely to be effective, unless domestic policies to protect and restore forests are strengthened significantly. In Brazil, for example, environmental laws have been weakened by President Jair Bolsonaro, further encouraging illegal deforestation.[13]

3. WHERE IS THE RENEWED INTEREST IN SINKS STEMMING FROM?

3.1 GLOBAL CALLS TO ACTION ON FORESTS

Policy interest in using forest sinks to sequester carbon dates to the 1990s. The role of land (forests and agricultural land) as a mitigation pathway to reduce CO_2 emissions was recognized by the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. The Kyoto Protocol in 1997 endorsed the notion that not only should governments employ policies to enhance the land carbon sink capacities of their territories but also that such mitigation could be set against requirements for reductions in emissions from fossil fuel consumption.[14]

At the 2009 United Nations Conference of the Parties in Copenhagen (COP 15), a position paper by the International Union for Conservation of Nature (IUCN) advocated making 'full use of nature-based solutions in the post-2012 climate change regime'.[15] Subsequently in 2011, the IUCN launched the Bonn Challenge 'to restore 150 million hectares of the world's degraded and deforested lands by 2020 and 350 million hectares by 2030' wherein countries and organizations made pledges in "million hectares" of forested land to be restored.

More than 200 governments, companies, and civil society and indigenous organizations signed the New York Declaration on Forests in 2014, pledging to halve tropical deforestation by 2020 and end it by 2030.

The chorus of nature-based solutions for mitigating emissions has gathered speed in the past few years. In March 2019, the UN General Assembly declared 2021–30 as the "UN Decade on Ecosystem Restoration" to 'prevent, halt and reverse the degradation of ecosystems worldwide'.

In January 2020, business representatives from the world's major corporations signed on to the "1 trillion tree" initiative at the

World Economic Forum in Davos, Switzerland. Their aim is to plant a trillion trees by 2030 and 'accelerate nature-based solutions in support of the UN Decade on Ecosystem Restoration (2021–2030)'.

In May 2021, G7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom, the United States and the European Union) pledged their commitment to the goal of 'conserving or protecting at least 30 per cent of global land and at least 30 per cent of the global ocean by 2030 to halt and reverse biodiversity loss by 2030 and address climate change.'

In April 2021, at US President Joe Biden's Leader Summit, the LEAF (Lowering Emissions by Accelerating Forest Finance) Coalition was announced as a public-private effort led by the US, United Kingdom and Norway. It was supported by corporations like Unilever plc, Amazon.com, Nestle and Airbnb to mobilize at least $1 billion, a paltry sum, in financing to countries committed to protecting their tropical forests.

At the 26th Conference of Parties (COP 26) in Glasgow, about 140 countries endorsed the Glasgow Leaders' Declaration on Forests and Land Use 'to halt and reverse forest loss and land degradation by 2030.' A second announcement was the FACT (Forest, Agriculture and Commodity Trade) Dialogue "on sustainable land use and international trade". This was signed by 28 countries and aims to 'protect forests while promoting development and trade.'

The Glasgow Climate Pact highlighted the following under the mitigation banner: *The importance of protecting, conserving and restoring nature and ecosystems to achieve the Paris Agreement temperature goal, including through forests and other terrestrial and marine ecosystems acting as sinks and reservoirs of greenhouse gases and by protecting biodiversity, while ensuring social and environmental safeguards.*

The chorus is growing. The question is—can we get this business of growing trees right?

3.2 THE RACE TO NET ZERO IS BANKING ON FORESTS TO SOAK UP CO_2

The IPCC published the Special Report on Global Warming of 1.5°C (SR1.5) in 2018 stating that in order to limit warming to 1.5°C with "no or limited overshoot", net global CO_2 emissions need to fall by about 45 per cent from 2010 levels by 2030 and reach "net zero" by around 2050. This spurred the setting of net zero targets by countries and private companies.

At the 26th Conference of Partis (COP 26) summit in Glasgow in 2021, the slew of net zero pledges reached a crescendo, where even reluctant actors like India announced net zero targets. The private sector made its own announcements—financial firms with assets together worth over $130 trillion announced a commitment to 'transforming the economy for net zero'. While many of these pledges do not have sufficient plans detailing how they will be achieved, one thing is clear—they will depend in large part on the removal of CO_2 from the atmosphere after it has been emitted. This means that the success of "net zero" plans will be based on deploying technologies that will capture CO_2 and store it or on nature-based solutions, where land (in particular forests) will sequester emissions (see *Table 2*).

The term—nature-based solutions—may be new, but the role of forests—both as a source because of emissions from deforestation and as a sink—has been long in discussion. In climate change negotiations, Reducing Emissions from Deforestation and Forest Degradation (REDD)—with the addition of conservation of forests stocks (REDD+)—is the framework to address this issue. At COP 19 in 2013, the Warsaw Framework for REDD+ was adopted. In 2015, the Paris Agreement recognized this and included it in Article 5—parties reiterated their commitment to implement REDD+.

UNEP estimates that if the world is to meet its climate change goals, then it needs to close a $4.1 trillion financing gap in nature by 2050.[16] This could increase what the UNEP terms as "NBS assets" by 300 million hectares by 2050, relative to 2020.
In May 2021, the World Economic Forum published a report

Table 2: Role of land and nature in countries' net zero plans

Country	Target	Gases applicable	Role of land and nature	Source
UK	Net zero by 2050	GHG	Afforestation of 30,000 ha per year by 2025, and 50,000 ha by 2035 Restore approximately 280,000 ha of peat in England by 2050	Net Zero Strategy: Build Back Greener, October 2021
China	Carbon neutral by 2060	CO_2	36,000 km^2 of new forest a year till 2025	Comments by Li Chunliang, vice-chairman of the State Forestry and Grasslands Commission, report by Reuters
EU	Climate-neutral by 2050	GHG	According to the EU Climate Law, an estimated 2.2 per cent of emissions reduction, which amounts to 225 Mt CO_2e, will be achieved through forests and other natural sinks. If the EU relies on afforestation for carbon removal, this will require a minimum of 30 million ha and a maximum of 90 million ha of land	Tightening the Net, Oxfam Briefing Paper, August 2021
India	Net zero by 2070	Not clear	Additional carbon sink of 2.5–3 Gt from forests by 2030	India's first NDC
UAE	Net zero by 2050	GHG	Planting 100 million mangroves by 2030	Mariam Al Mheiri, Minister of Climate Change and Environment at COP 26 Report
US	Net zero by 2050	GHG	Up to 133 million ha of potential reforestation. Plus, 'avoided forest land conversion, longer harvest rotations or increased carbon storage in harvested wood products and substitution of more fossil-intensive construction materials with wood products'	Long term strategy, November 2021
Russia	Carbon neutrality / net zero by 2060	Not clear	'By aiming to build a carbon-neutral economy by no later than 2060, Russia is relying, among other things, on the unique resource of forest ecosystems available to us, and their significant capacity to absorb CO_2 and produce oxygen'	Vladimir Putin, video address on 2 Nov 2021, at COP 26
Colombia	Climate-neutral by 2050	GHG	'To reforest 1 million ha of land by 2030, which could sequester 10.5 Mt CO_2e, or roughly 6% of its total emissions reduction'	Tightening the Net, Oxfam Briefing Paper, August 2021
Ethiopia	Carbon neutral (without target date)	Not clear	220 MtCO_2e GHG reduction from land and forestry, 20 billion trees to be planted between 2020–2024	Tightening the Net, Oxfam Briefing Paper, August 2021

on *Nature and Net Zero* in collaboration with McKinsey and Company. According to this, nature-based solutions provide a 'potential of close to 7 Gt CO_2 per year, sufficient to deliver around one-third of the 2050 target (to cut emissions by 50 per cent over 2010 levels) and this is "lower cost than technological solutions".' The bulk of this will come from 'avoided emissions; deforestation, peatland restoration, reforestation and cover crops.' Cost is the key factor for this solution, says the business body. 'In most cases, costs are between US$ 10 and US$ 40 per tonne of CO_2 with variations between geographies and project types.' The report then says that this will also generate flow of funds to countries of the South as this is where the potential for reforestation really lies. Confidence in forest sinks has bolstered carbon offset markets, with a focus on forest-based offsets (see Section 2 on Carbon Offsets).

3.3 OPTIMISTIC SCIENTIFIC ESTIMATES OF POTENTIAL BOOSTS INTEREST IN SINKS

In parallel with the SR 1.5's statement on achieving net zero by 2050, several scientific studies have been published providing estimates of the CO_2 mitigation potential of land/forests.

We reviewed 14 such studies dated between 2017 and 2022 (see *Annexure 1)*. The studies vary widely in terms of:

1. the pathways analysed (reforestation, agroforestry, etc.)
2. the biomes selected (forests, wetlands, etc.)
3. time horizons that determine the resultant mitigation potential

Thus, their results are difficult to use to design a coherent land-based mitigation policy. But most agree that land and forests offer a low-cost solution to sequester CO_2. And many of them offer overly optimistic estimates of how much additional CO_2 land can capture.

3.4 ROLE OF FORESTS IN NATIONALLY DETERMINED CONTRIBUTIONS

Countries have also included the land sector (mainly forests) in their nationally determined contributions (NDCs) or their targets to reduce GHG emissions under the Paris Agreement. A 2017 estimate by Giacomo Grassi published in *Nature Climate Change* found that a quarter of the emissions reductions planned by countries in their INDCs (Intended Nationally Determined Contributions) came from forest-based climate mitigation.[17]

In 2019, researchers at the Potsdam Institute in Germany found that of 167 NDCs, the land sector is included in 121. Only 11 NDCs include a distinct and quantifiable LULUCF target, while 78 do not provide any kind of quantitative LULUCF target.[18]

They then chose a sub-set of 62 NDCs and estimated that implementing the land-based activities described in their LULUCF targets could result in a net sink of −2 $GtCO_2e$ per year in 2030. But this displayed a wide range of uncertainty, to the tune of 2.9 $GtCO_2e$ per year, due to ambiguity in the LULUCF targets.

Oxford scientist Nathalie Seddon, in a study for IUCN, found that at least 66 per cent of NDCs include “nature-based solutions” in some form, but once again, they lacked robust targets.[19] Although over 70 per cent of NDCs are estimated to contain references to efforts in the forest sector, only 20 per cent of these include quantifiable targets, and only 8 per cent include targets expressed in tonnes of CO_2 equivalent.

A progress report on the 2014 New York Declaration on Forests (NYDF), published in October 2021, highlighted that as of 1 May 2021, 47 out of 55 countries that submitted enhanced or updated NDCs to the UNFCCC mention forests.[20] But the issues remain—the targets either lack ambition, or they are not quantified in clear terms. Several targets are conditional on international climate finance. A lack of detail and absence of roadmaps for achieving the forest-related targets in NDCs are a recurring issue.

The World Wildlife Fund (WWF)-UK and Climate Focus reported in November 2021 that 96 of 114 enhanced NDCs include nature-based solutions for mitigation—this includes marine ecosystems in addition to land-based ecosystems like forests, agricultural lands, mangroves and wetlands.[21]

4. CHALLENGES WITH USING FORESTS FOR THE MITIGATION OF CO_2

4.1 COMPLEXITY IN THE ESTIMATION OF SINKS

The land sink is not easy to calculate. The factors influencing land CO_2 fluxes—exchange between emissions and absorption—are not fully understood even by climate scientists running global atmospheric models. And while models themselves are evolving and getting more accurate, they are hindered by the lack of observations to corroborate their results due to methodological difficulties associated with sampling in such complex ecosystems.

The methodologies need to account for differential rates of CO_2 absorption in different forest biomes. This is further complicated by the fact that growing forests have higher rates of absorption as compared to standing forests. Then there is the issue of removal of forests because of deforestation and how this will be accurately accounted for in the mathematics of forest as sinks. On the other hand, when a tree dies in the forest, its biomass carbon matter is transferred to the soil, where it can be stored for thousands of years. Or when a tree is cut and subsequently made into furniture, the carbon is stored for life in that product. So, how will it get accounted for?

According to a 2018 review titled *The Terrestrial Carbon Sink,* the uncertainties are exacerbated by the disagreements between models and methods themselves.[22] Taking the strength of sinks in tropical areas as an example, atmospheric measurements and models suggest that tropical sinks are strong and are increasing. Meanwhile, ground observations suggest that they are small or weakening, or may even have become carbon sources instead of sinks.

Initially, the land sink was estimated by a 'residual' accounting method—i.e., the balance left behind after accounting for anthropogenic CO_2 emissions from industrial and other sources and the oceanic sink was counted as the land sink. This method was used in the IPCC's Fifth Assessment Report (AR5) of 2014.

The most important estimation of the terrestrial sink has come from the Global Carbon Project (GCP), which since its inception in 2007 has improved the methodologies for estimating net emissions from land-based sources. In 2017, the Global Carbon Project changed its methodology to estimate the terrestrial sink based on Dynamic Global Vegetation Models (DGVMs). But even the estimation via DGVMs has errors and uncertainties—for example, DGVMs may underestimate the land sink following a volcanic eruption. Thus, this approach has also proven controversial as there is still huge uncertainty in the methodologies and the ability to estimate the flux. Even in the North American forests which have the densest network of atmospheric CO_2 concentration and flux sampling towers, the estimations of the role of forests as sinks vary.

In the paper titled *Global maps of twenty-first century forest carbon fluxes,* published in *Nature Climate Change,* there is a very high order of uncertainty. The estimate of net carbon sink of 7 $GtCO_2e$ per year from global forests in two decades includes uncertainty of ± 49 Gt CO_2e per year. Thus, the margin of uncertainty and error in estimating the actual emissions that are sequestered or released from forests and other land-based ecosystems is still huge.

While determining the future mitigation potential from the enhancement of these sinks, there are many optimistic estimates *(see Annexure 1).* But they are contradicted by equally assertive research which finds that even if the amount of vegetation all land in the world can hold is maximized, it would only sequester enough carbon to offset about ten years of GHG emissions at current rates. Beyond this there will be no additional carbon storage on land, according to Bonnie Waring, an ecologist at the Imperial College in London.[23]

The former NASA (and current Columbia University) scientist James Hansen estimated in a 2017 paper that the soil and biosphere can store a maximum additional limit of 100 Gt of carbon (367 $GtCO_2$) via improved agricultural and forestry practices, and no more.[24] Richard Houghton, a veteran ecologist at the Woodwell Climate Research Center and one of the leading experts in furthering understanding of the land sink, agrees but believes that the maximum could lie in a range between 100–250 Gt C.

"Several studies point to around 100 Gt C as the most plausible estimate for the land sink keeping in mind land rights and food security. But while plausible, this figure is also risky, since sinks are weakening and there is no guarantee carbon will stay in land and forests."

Kate Dooley, Research Fellow, Melbourne University's Climate & Energy College

Another major difference arises between the top-down global estimates from models, and the bottom-up estimates by countries from their GHG inventories calculated based on their forest area. This is where the big gap is showing up in the numbers, which can then cripple climate action. A paper published in 2021 in *Nature Climate Change* by Giacomo Grassi, a Senior Scientific Officer at the Joint Research Centre of the European Commission, finds that there is a missing gap of some 5.5 $GtCO_2$ per year between the land emissions estimates from global models and country inventories. This is equivalent to the annual emissions of the US—so, it is not trivial (*see Annexure 3*).

One of the main differences is an accounting technicality: Countries designate their land areas as "managed" or "unmanaged" as per IPCC guidelines. They are required to report only anthropogenic impacts that occur in their forests. Article 4 of the Paris Agreement refers to the goal of achieving a 'balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases.' This is reiterated in Article 13.

Separating anthropogenic impacts (such as logging or reforestation) from indirect impacts (such as tree growth due to CO_2 fertilization from higher atmospheric CO_2 levels) proves difficult. According to Dr. Grassi, when measuring the changes of forest biomass over time through direct observations—such as national forest inventories upon which Global Greenhouse Gas Information System (GHGIS) is typically based—one cannot say how much of the biomass change is due to better management and how much is due to environmental factors.[25]

‘National inventories measure biomass over time. In a certain time interval, you get a good estimate of the difference in carbon stock in tonnes of carbon,’ Dr Grassi said, in an interview with CSE in August 2021. ‘It is done by direct observation. But it does not distinguish what is anthropogenic or not—has the plant grown due to CO_2 fertilization or because you took good care and reduced density? It is hard to say.’

Thus, a compromise adopted in the IPCC’s guidelines allowed all impacts on managed land to be counted by countries. Global models, on the other hand, count the carbon uptake from indirect impacts in the RTS (indirect sink; *see Box 2*), and thus show higher land-related emissions in the anthropogenic net Land-use, Land-use Change and Forestry (LULUCF) component.

A second difference is the definition of “managed” land such as forests. In the Special Report on Climate Change and Land 2019 (SRCCL), the IPCC writes: *Global models consider as managed forest those lands that were subject to harvest whereas, consistent with IPCC guidelines, national GHG inventories define managed forest more broadly. On this larger area, inventories can also consider the natural response of land to human-induced environmental changes as anthropogenic, while the global model approach treats this response as part of the non-anthropogenic sink.*

Writing in the *Washington Post*, Chris Mooney and Brady Dennis explain this anomaly of “managed forests”. The UNFCCC defines “managed land,” as areas which humans use for production or where they perform ecological or social functions. In this way, countries say how much of their land area is under "managed forests" and then count all the carbon stock from there. ‘If large tracts of a country’s land are labelled as “managed”, then net sink

BOX 2: KEY ASPECTS OF THE CARBON CYCLE RELEVANT FOR UNDERSTANDING THE LAND SINK

The natural carbon cycle sees vast quantities of carbon exchanged between the oceans, atmosphere, land and living organisms. This cycle balances perfectly, until human beings introduce additional carbon, that was originally buried underground, through the burning of fossil fuels, production of cement and land-use changes such as deforestation. The excess carbon from human-driven or anthropogenic activities, that land or the oceans are unable to absorb, accumulates in the atmosphere leading to increasing concentrations of CO_2, which in turn causes global warming.

Accumulation of CO_2 in the atmosphere = Fossil fuel emissions – Ocean uptake – Land uptake

Direct and indirect land sink:

There are two exchanges of carbon between the land and the atmosphere:

- Carbon emissions caused by *direct anthropogenic activities* such as tropical deforestation, shifting cultivation and peatland drainage, and the subsequent absorption by anthropogenic activities such as afforestation/reforestation or the regrowth of forests following wood harvest or abandonment of agriculture. This is known as net LULUCF emissions, "fluxes attributed to AFOLU" as per the IPCC SRCCL; or ELUC (emissions from land-use change) as per the Global Carbon Project (GCP). This occurs on managed land.
- Carbon absorption caused by *indirect climate and environmental effects* such as CO_2 fertilization, aerosol-induced cooling, and changes in climate, such as longer growing seasons in northern extra-tropical regions. This is called the residual terrestrial sink (RTS), or "residual terrestrial flux" as per the IPCC Fifth Assessment Report (AR5), or "land sink" as per the IPCC SRCCL. This occurs on both managed and unmanaged land.

To balance the carbon budget, the GCP and IPCC include the following five fluxes in the carbon cycle:

Fossil fuel emissions + net LULUCF emissions (direct land sink) = Accumulation of CO_2 in the atmosphere + ocean sink + RTS (indirect land sink)

CO_2 fertilization:

Rising global atmospheric concentration of CO_2 due to the burning of fossil fuels increases the rate of photosynthesis in plants and can enhance carbon absorption by land-based sinks like forests and croplands. This is known as CO_2 fertilization. This effect is expected to grow due to climate change. According to the IPCC SRCCL, models estimate that between 1990–2009, CO_2 fertilization alone contributed a mean global CO_2 uptake of 10.54 $GtCO_2$ per year.

Carbon vs. carbon dioxide (C vs. CO_2)

Carbon dioxide (CO_2) is the chemical compound of two oxygen atoms and one carbon atom. Carbon is recycled in various forms throughout its lifetime, and is taken in as CO_2 during photosynthesis, stored in the plants as carbon, and emitted as CO_2 during respiration and decomposition. It is also emitted as CO_2 during the combustion of fossil fuels. One kilogram (kg) of carbon is equivalent to 3.67 kg of CO_2. Thus, converting carbon to CO_2 involves multiplying it by 3.67, for e.g., 1 gigatonne of carbon = 3.67 gigatonnes of CO_2.

could well be overestimated, since not all CO_2 uptake is caused by human-driven policy efforts such as stopping deforestation, replanting trees, or actively restoring degraded forest. The difference in managed land estimates between country reports and global models is an extra 9 million square miles and is contributing to the uncertainty.'[26]

This accounting discrepancy complicates efforts to determine how natural sinks can fit into mitigation plans, since countries claim large reductions to their annual emissions from the land use and forestry sector and get a free pass on their CO_2 emissions from fossil fuel use.

'This technicality is important since the Paris Agreement focuses on anthropogenic emissions and removals,' said Grassi. 'Net zero has to be reached by balancing anthropogenic emissions and removals. So, what you count as anthropogenic or natural, may affect whether you may reach net zero earlier or later. A country with a large amount of forest, will benefit by labelling a natural forest as managed land. Thus, they can show that our emissions are being balanced out by our forests, which are anthropogenically managed. But the emissions as per the global reporting standards are not balanced by the managed land but by natural mechanisms.'

4.2 NET ACCOUNTING DIMINISHES AMBITION TO REDUCE EMISSIONS

It is of concern that overestimating the role of forests as sinks could lead to inadequate steps to reduce GHG emissions in different countries. Russia, Canada, Brazil, the US and China that have large forests and happen to be large emitters of CO_2 have the most to gain from 'net accounting'—the deduction of CO_2 absorbed by a country's sinks from its total emissions to arrive at a possibly lower net figure.

In the US, of the 6.6 $GtCO_2e$ total emissions in 2019, some 0.789 $GtCO_2e$ was reduced by 'sinks', leaving net emissions of

5.8 $GtCO_2e$—roughly a 12 per cent reduction.[27] In 2021, the US government announced a plan to retain 30 per cent of its land for forests—details are not yet out on what and how this will be done (see *Box 3*).

BOX 3: US PLAN FOR FORESTS

US President Joe Biden unveiled a plan to conserve 30 per cent of US lands and waters by 2030 in May 2021, a goal that was echoed by the rest of the G7 countries—Canada, France, Germany, Italy, Japan and the United Kingdom—later that month. The conservation goal was developed by the US Departments of the Interior, Agriculture and Commerce, and the White House Council on Environmental Quality. It identifies six priority areas—parks for nature-deprived communities, tribal-involvement in conservation efforts, fish and wildlife habitats, outdoor recreation opportunities, rewards for voluntary conservation by fishers, farmers, etc., and job creation through restoration projects. Progress will be monitored in a federal atlas that will track, map and tally conserved areas.

Owing to the US' historical atrocities against and displacement of Native American Tribes from their own lands, the plan brings in language such as "tribally-led" and "collaborative conservation" to be more inclusive and bottom-up in its approach.

So far, it is mostly a broad set of goals, and specifics are yet to emerge. This includes clarifying the definition of "conservation" itself, to ensure that the thresholds are not too low and projects that do not restore biodiversity do not get counted in the atlas. New York University Professor of environmental studies and sociology Colin Jerolmack writes in the US-based magazine Slate that this creates the risk of greenwashing with no additionality.[1] He points to a history of conservation projects such as The Nature Conservancy's offset programmes, and payments by the United States Department of Agriculture (USDA) to farmers whose environmental restoration efforts were never monitored.

According to domestic authorities, Russia's forests can offset up to 38 per cent of its GHG emissions—i.e., about 0.55 $GtCO_2$ attributed to its sink in 2018—despite being the fourth highest GHG emitter. This obscures the actual need for Russia to enhance its NDC ambition and take meaningful measures to curb its fossil CO_2 emissions.

The world's current largest emitter, China, has become a strong advocate of nature-based solutions, and plans to use them to remove one-third of its carbon emissions, as stated ahead of the UN Climate Action Summit in New York in 2019. In its plan to become carbon neutral by 2060, China has included massive tree-planting efforts and the restoration of wetlands to absorb carbon.

Table 3: Net accounting of CO_2 emissions with LULUCF

Country	Total CO_2 emissions From Energy and Industry Not Including LULUCF (In $GtCO_2e$) 2018	Net CO_2 emissions from LULUCF (In $GtCO_2e$) 2018	Net LULUCF as % of total CO_2 Minus LULUCF 2018
Russia	1.61053	-0.5585	-35%
Canada	0.5744	0.03527	6%
Brazil	0.42771	0.38431	90%
USA	4.98121	-0.23173	-5%
China	10.312	-0.6501	-6%
European Union - 27	2.8	-0.23399	-8%

Source: Climate Watch

The EU responded to harsh criticism that its climate goal to reduce emissions by 55 per cent by 2030 compared to 1990 levels was over-dependent on removals from natural sinks. In July 2021, it revised its goal to clarify that 52.8 per cent of the 55 per cent goal would be attributed to actual emissions reductions—and that carbon removal from natural sinks would be capped at 0.225 $GtCO_2e$ per year in 2030 (see *Box 4*).

BOX 4: THE EU'S LULUCF PROBLEM

According to the European Commission, the EU's net sink expanded between 1990 to 2010 from around 250 $MtCO_2e$ to above 300 $MtCO_2e$. But it reduced to 263 $MtCO_2e$ in 2018 due to factors such as higher harvesting rates and ageing forests, and it is expected to decline further. The LULUCF sector in the EU showed a total net removal of -264 $MtCO_2e$ for EU-27 for 2019.[1]

In September 2020, the EU announced a new goal to cut GHG emissions by 55 per cent below 1990 levels by 2030, compared to 40 per cent earlier. It was submitted as a second NDC to the UNFCCC in December 2020. The plan was further announced as a legally binding goal in April 2021 and included the intent to 'invest further in "carbon sinks" such as forests, grasslands and wetlands.' The inclusion of sinks in its NDC target was criticized as an "accounting trick" to mask a more modest reduction of gross emissions, with environmental groups emphasizing that the previous NDC of 40 per cent did not include sinks. The EU then clarified that 52.8 per cent of its reduction would come from actual reduction of fossil fuel emissions in other sectors, and carbon removals from its sink would be capped at 225 $MtCO_2e$ per year in 2030.

In July 2021, the *Fit for 55* package of climate and energy proposals was unveiled, which would offer sectoral pathways to achieve the EU's 55 per cent goal. It committed to planting at least 3 billion additional trees in the EU by 2030. The package also included an update to the EU's LULUCF regulations—under existing rules of 2018, member states had to ensure that their LULUCF emissions are balanced by the equivalent volume of CO_2 removals between 2021–2030, as Carbon Brief explains.[2] This is referred to as the "no-debit rule". Member states with removals that exceed this obligation can use a limited volume—up to 280 $MtCO_2e$ across the entire EU—to cancel out emissions from other areas of their economies.

Ahead of the *Fit for 55* launch, groups such as the Climate Action Network Europe had called for a separate LULUCF sectoral target, and an increase in the contribution of sinks to 600 $MtCO_2e$. In the new package, the European Commission proposed a target of 310 $MtCO_2e$ of removals by 2030, which would be further divided up among member states. The proposed switch from the no-debit system to defined national targets is welcomed as a positive step since the earlier regulation did not incentivize member states to increase their sinks or prevent destruction of the same. But the 310 $MtCO_2e$ limit triggers fears that the sink can at most go back to its 2010 levels and no efforts will be made to enhance it further.

An additional aspect of the EU's LULUCF story is the use of bioenergy from wood pellets, which is counted as renewable energy despite its detrimental impacts. The burning of wood constitutes 35 per cent of the EU's renewable energy mix for heating and electricity generation, according to a report by Greenpeace Netherlands published in July 2021, which looked at Estonia's forests—one of the EU's top producers of wood pellets.[3]

Advocates cite that wood pellets can 'substitute fossil-based products and work on carbon storage at the same time,' as Finnish MEP Petri Sarvamaa said in an interview.[4] Scientists and environmental groups are skeptical however, especially since very often whole trees or large portions of stem wood are cut down for bioenergy, releasing carbon that would otherwise have stayed locked up in forests. In a letter in February 2021, more than 500 scientists wrote to the European Commission asking for an end to subsidies for wood burning. They said, 'Re-growing trees and displacement of fossil fuels may eventually pay off this carbon debt, but regrowth takes time the world does not have to solve climate change.'[5]

The Fit for 55 package includes some tweaks to regulations such as the need to "minimize" the use of whole trees. It reinforces the previously laid out "cascading principle"—that wood should first be used for long-lived products, such as building materials or furniture, and use of wood for bioenergy is ranked fifth in the list of uses. It also proposes to limit subsidies for bioenergy plants that only generate electricity.[6] While industry stakeholders will resist these changes, environmental groups believe that they are inadequate. The Greenpeace Netherlands report found that neither the EU's own sustainability criteria nor country-level regulations can prevent harmful logging practices, and yet the bioenergy produced qualifies for renewable energy subsidies (which incentivizes coal power producers to switch to wood) and gets counted towards European renewable energy targets. This is diminishing the sink potential of European forests, which is projected to decline further due to the massive demand for wood burning for energy.

Biomass energy from wood has been called a 'false solution that serves neither our climate nor our communities,' by Philip Duffy, President of the Woodwell Institute in the US. Burning wood for energy adds more carbon to the atmosphere, he says, than burning fossil fuels does (for a given amount of energy generated) and results in elevated levels of atmospheric CO_2 which last decades. Thus, to repair our climate, it is essential to let forests grow, not cut them down and burn them.[7]

Table: Proposed targets for each member state of the EU for net GHG emission removals

Member state	Value of the net greenhouse gas emissions reduction in kt of CO_2 equivalent in 2030
Belgium	-1,352
Bulgaria	-9,718
Czechia	-1,228
Denmark	5,338
Germany	-30,840
Estonia	-2,545
Ireland	3,728
Greece	-4,373
Spain	-43,635
France	-34,046
Croatia	-5,527
Italy	-35,758
Cyprus	-352
Latvia	-644
Lithuania	-4,633
Luxembourg	-403
Hungary	-5,724
Malta	2
Netherlands	4,523
Austria	-5,650
Poland	-38,098
Portugal	-1,358
Romania	-25,665
Slovenia	-146
Slovakia	-6,821
Finland	-17,754
Sweden	-47,321
EU-27	-310,000

Source: European Commission, Accessed at: https://ec.europa.eu/info/sites/default/files/revision-regulation-ghg-land-use-forestry_with-annex_en.pdf

4.3 WEAKENING OF FUTURE SINKS

Countries have formulated optimistic plans to bank on land sinks, but they are laid on shaky grounds. Scientists are uncertain about the ability of land sinks to continue to mitigate anthropogenic carbon emissions at the rate of ~30 per cent that they do today. If business-as-usual emissions continue, the strength of the global land sink could be cut by nearly 50 per cent by 2040.[28] In its first instalment of the Sixth Assessment Report (AR6) published in 2021, the IPCC stated that sinks are under threat from increasing cumulative CO_2 emissions:

While natural land and ocean carbon sinks are projected to take up, in absolute terms, a progressively larger amount of CO_2 compared to lower CO_2 emissions scenarios, they become less effective, that is, the proportion of emissions taken up by land and ocean decrease with increasing cumulative CO_2 emissions. This is projected to result in a higher proportion of emitted CO_2 remaining in the atmosphere.[29]

Data shows that the intact tropical forest carbon sink has saturated[30], while European forests may be heading towards carbon sink saturation as well.[31] According to the US' Fourth National Climate Assessment, assuming no policy intervention—and accounting for land-use change, management, disturbance and forest aging—US forests are projected to continue to store carbon but at declining rates, 35 per cent less than 2013 levels by 2037, because of both changes in land use and lower CO_2 uptake as forests grow older.[32] In fact, rising temperatures are already pushing old-growth forests in regions such as the Pacific Northwest past their brink due to more frequent and severe forest fires, more trees dying, and shifts in stream and land ecosystems due to rising temperatures.[33]

There is also the complicated question of "permanence"—carbon stored in the ground as fossil fuels is permanently locked away till it is burnt as coal. Carbon stored in the vegetation and soils can be released at any time due to fires or deforestation. A fundamental flaw in the current optimism of burying emissions from fossil fuels in sinks is that while restoration of natural sinks reduces atmospheric carbon, it simply parks the carbon in the active part of the land-atmosphere-ocean carbon cycle. The IPCC SRCCL 2019 mentions that any sequestration gains from afforestation or reforestation are ‘at risk from future loss (or sink reversal) triggered by disturbances such as floods, droughts, fires, or pest outbreaks, or future poor management.’[34]

Yet the chorus in favour of banking on land-based mitigation is growing. It is a fact that we must preserve land sinks for the carbon removal role they play, and the numerous biodiversity and other co-benefits they offer. But banking on them to mop up our fossil fuel emissions, while making little effort to reduce these emissions in the first place is a growing problem that threatens any possibility of limiting temperatures to 1.5 or even 2 °C.

4.4 OWNERSHIP OF FORESTS IS KEY TO MITIGATION

Carbon sequestration by land-based sinks is often assumed to be agnostic of geography and socio-political context. In this way, the existing users and dwellers of these lands are frequently disregarded. This could well lead to the appropriation of land and resources for planting trees and add to the marginalization of the poorest in the world.

Stephen Garnett of Charles Darwin University in Australia led a study published in the journal *Nature Sustainability* which found that indigenous people own 37 per cent of all remaining natural lands in the world, even though they account for 5 per cent of the global population.[35] Limited recognition of their tenure rights would continue to expose them to relocation and loss of livelihood from land-use schemes (including environmental schemes). This is even though at least 293 Gt C is stored in the collective forestlands of indigenous peoples and local communities, according to the Rights and Resources Initiative. In fact, deforestation rates are significantly lower in indigenous and tribal territories, where governments have formally recognized collective land rights.[36]

There is also the question of how the world will protect wild areas, which are also habitats of local communities. In the Amazon for instance, researchers estimate that some 54 per cent of the forests are protected areas, which also store some 56 per cent of the carbon of Amazon. Brazil has protected areas—under different regimes like strictly protected, for sustainable use and indigenous lands—which stretch over 190 million ha. Research conducted in 2010 led by Brazilian scientist Britaldo Soares-Filho found—well before the recent efforts of the current government to open these protected forests of Amazon—that the protection had stopped deforestation and increased the carbon sequestration from the Amazon between 2004 to 2009. The researchers however also noted that the cost of setting aside this land for protection needed to be understood in terms of its competing value for the developing country. In 2009, they calculated that the opportunity costs for the Brazilian Amazon protected network is $141 billion, averaging $5.4 per tonne of carbon.[37]

'Debates about the numbers—the sequestration potential of trees or any other solution—are not abstract mathematical games. They are the politics of the climate crisis, shaping who is burdened with the responsibility of change and who faces the risks of inaction,' wrote Stephen Woroniecki, a doctoral candidate working on sustainability and climate change at Lund University Centre for Sustainability Studies, in 2019.[38] 'Where relevant, Indigenous peoples' stewardship is the most effective means of keeping forest and soil carbon locked up, climate-resilient and biodiverse—but these people face the greatest risks and dangers to their rights.'

This then raises critical issues of how lands will be protected—particularly in the densely populated and poor tropical regions—and who will pay the opportunity cost of this protection and to whom?

2

FOREST CARBON OFFSETS: WHAT RULES WILL MAKE IT WORK?

5. CARBON OFFSETS: SIZE AND LOCATION

Before the world 'jumps' into the new-found language of nature-based solutions, it is important to examine the track-record of the past. Carbon offsets have been used extensively to write off or neutralize emissions—CO_2 emitted by a particular activity such as taking a trip on an airplane, is theoretically nullified by an equivalent volume of CO_2 absorbed by an activity such as planting a few trees elsewhere. Offsets exist within the larger framework of carbon markets, a process that turns CO_2 into a commodity which is then traded through a virtual marketplace in the form of units known as carbon credits. Each credit typically represents one metric tonne of CO_2 equivalent.

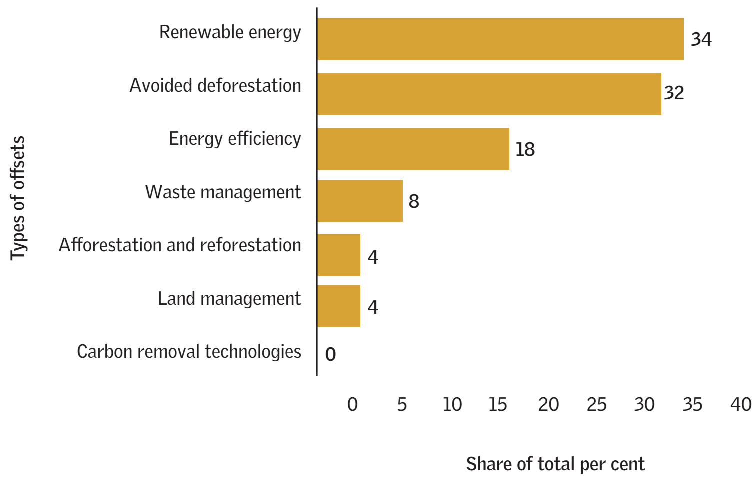
Purchasing an offset may fund a project that will reduce future CO_2 emissions by building a renewable energy facility or remove CO_2 emissions through a tree planting project. As a result, the original activity for which the offset is bought, is deemed "carbon neutral".

Trading of offsets may occur in a **voluntary** capacity—private companies or individuals can purchase an offset from a third-party provider to nullify the emissions of a particular activity or their entire operations across a certain time. Or they may be part of a **compliance** market such as companies subject to a government-regulated emissions trading system by the European Union or more recently China. While both components have proved to be largely ineffective for drastic cuts to CO_2 emissions, it is the former that is proving to be an ideal vehicle for corporate greenwashing, given that it is largely unregulated and difficult to scrutinize.

BOX 5: LESS THAN 5% OF OFFSETS ACTUALLY REMOVE CARBON

Offset credits are typically of two types: Avoidance/reduction credits such as avoided deforestation efforts, and removal/sequestration credits such as planting trees, restoring mangroves, or financing a bioenergy with carbon capture and storage (BECCS) project. Currently, only 5 per cent of offsets remove carbon, while the rest are focused on emissions avoidance or reduction.

Less than 5 per cent of offsets actually remove carbon dioxide from the atmosphere



Source: Bloomberg, via TSVCM inventory analysis for 2020

Table 4: Companies have used offsets to claim that they have successfully neutralized emissions

Company	Emissions (Year)	Offsets used
Google	12.5 million tonnes (2019)	Says it has eliminated its "entire carbon legacy" through the purchase of high-quality offsets
Total	386 million tonnes (2020)	Sold its first "carbon neutral" liquefied natural gas shipment in October 2020 using offset projects in China and Zimbabwe
Nestle	113.1 million tonnes (2018)	Ready Refresh bottled water brand claims to be carbon neutral, thanks to the purchase of offsets as well as emissions reductions

Source: Bloomberg, https://www.bloomberg.com/news/features/2021-06-02/carbon-offsets-new-100-billion-market-faces-disputes-over-trading-rules

There is currently no internationally recognized body for monitoring or oversight of the large voluntary market. And despite this, according to research group Ecosystem Marketplace (EM), the voluntary market for offsets has exploded in recent years. According to their data, between January to November 2021, the market value of carbon credits traded reached $1 billion.[39] The average price of each unit of carbon traded ranged between $3–4.73, which would mop up some 3 Gt of CO_2. In 2021, the world emitted some 51 Gt of CO_2. So, 3 Gt would constitute roughly 5 per cent of total emissions. According to EM, these credits were bought for offsetting carbon by planting trees (61 per cent) and installing renewable energy (38 per cent).

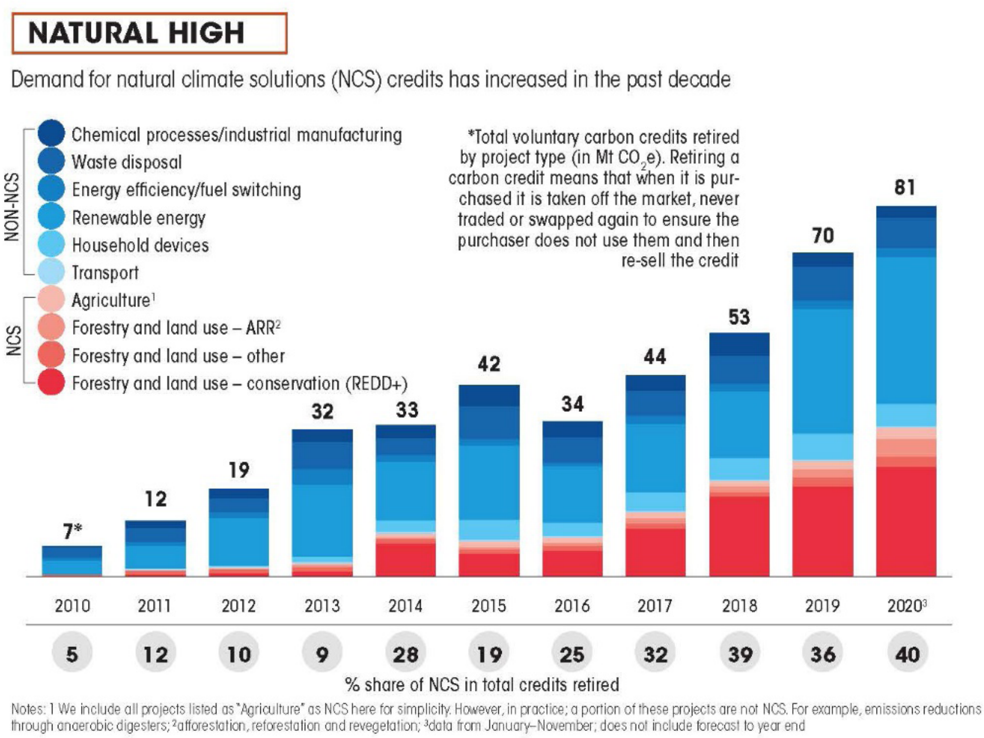
Purchasing offsets has also become a key part of the climate strategy of major oil companies like Shell and Total, who have no plans to scale down fossil fuel production but aim to achieve net zero emissions in the coming decades.

6. FOREST OFFSETS

In recent years, offsets have focused primarily on forests and land since they prove to be the lowest cost initiatives to fund. Research unit IHS Markit finds that a metric tonne of sequestered carbon for forest offsets is valued at an average of around \$4/tCO_2e but can reach up to \$50/tCO_2e, with costs increasing as potential for sequestration decreases with less land availability. For technological solutions like CCS, costs range from \$17–180, and up to \$800 if Direct Air Capture (DAC) is considered.[40]

Consulting firm McKinsey analysed transactions of credit-issuing parties like the American Carbon Registry, Climate Action Reserve, Gold Standard, Plan Vivo and Verified Carbon Standard, and found that credits based on "natural climate solutions" which encompass projects focused on land and forests, rose from 5 per cent of all credits in 2010 to 40 per cent in 2021.

Graph 1: Carbon credits for land and forests, i.e., natural climate solutions (NCS) went from 5% to 40% in the recent decade



Source: World Economic Forum January 2021. *Consultation: Nature and Net Zero*, in collaboration with McKinsey and Company. Accessed at https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/why%20investing%20in%20nature%20is%20key%20to%20climate%20mitigation/nature-and-net-zero-vf.pdf

Offset projects are disproportionately located in countries in the Global South, particularly Asia, Latin America, and Africa—the regions with the densest tropical forests and the poorest people. The reason is simple—the cost of growing trees is lowest in these parts of the world. Forestry and Land Use credits in Asia rose from 8.8 $MtCO_2e$ in 2020 to 59.9 $MtCO_2e$ in 2021, sourced mainly from Cambodia and Indonesia. In Latin America, 80 per cent of offsets in 2021 came from this category and were sourced mainly from Brazil and Peru.

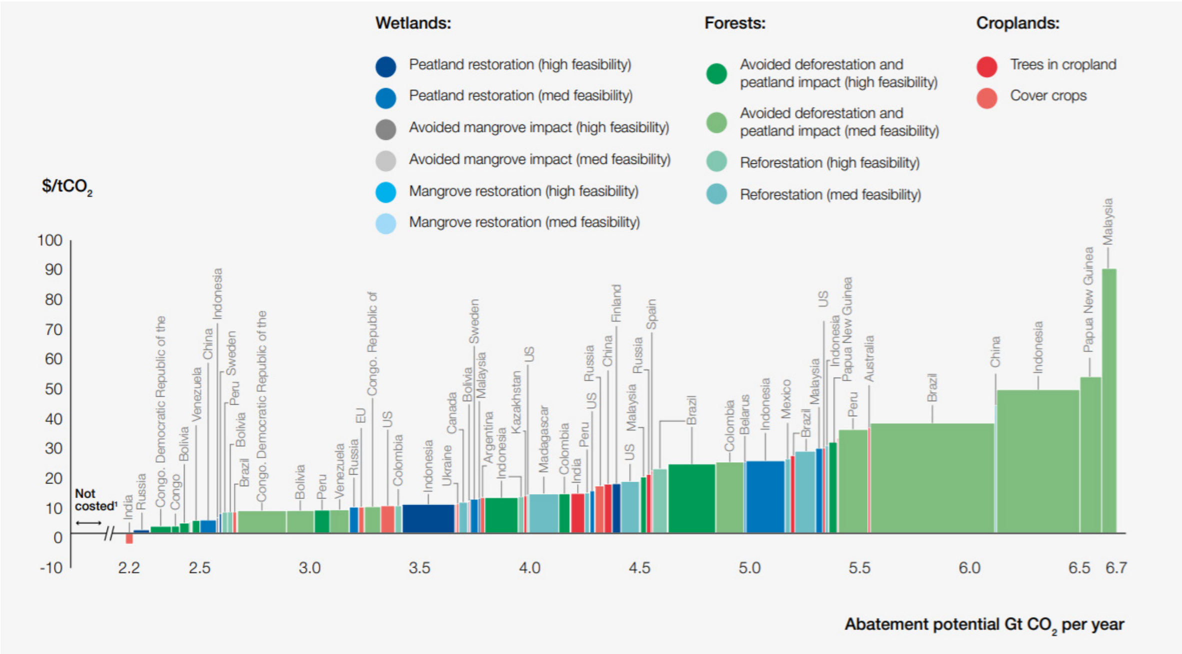
Table 5: Transacted voluntary carbon offset volume and average price by project region 2019–August 2021

	2019		2020		2021 (through August)	
	Volume ($MtCO_2e$)	Price (USD)	Volume (MtCO2e)	Price (USD)	Volume ($MtCO_2e$)	Price (USD)
Africa	16.1	3.94	14.9	4.24	23.9	5.52
Asia	45.6	1.80	63	1.60	91.8	3.34
Europe	1.1	2.92	1.7	9.47	0.8	2.96
Latin America & Caribbean	15.3	3.45	18.9	4.17	36.6	3.74
North America	15.5	3.51	11.6	6.31	10	5.13
Oceania	0.5	12.53	0.1	20.57	0.1	32.93

Source: Ecosystem Marketplace

McKinsey's 2021 consultation paper with the World Economic Forum also highlighted how natural climate solutions (NCS)—particularly in forestry conservation, restoration, and land-management actions—are a "low-cost measure". Costs are mainly driven by underlying land (opportunity) costs, so areas with competing land uses tend to involve higher costs, says the paper. They found that NCS projects cost between $10–40 per tonne of CO_2, with some variations between geographies and project types.[41]

Graph 2: The majority of NCS can be delivered at low cost, says McKinsey



Notes: [1] 2.2Gt total: avoided deforestation 0.95Gt; peatland restoration 0.21Gt; reforestation 0.36Gt; avoided coastal impact and restoration 0.30Gt; cover crops 0.22Gt; trees in cropland 0.11Gt.

Source: McKinsey Nature Analytics

Major corporations like Facebook, Delta Airlines, Eni and BP are investing in afforestation and reforestation projects worldwide through the purchasing of offsets to compensate emissions elsewhere in their value chains, reports IHS Markit. Oil companies like Total and Shell have established dedicated entities for direct investment in nature-based offset projects including afforestation and reforestation. As a result, forests are an attractive solution for polluting companies to offload their emissions reduction burden and gain popular approval for being climate conscious. By 2030, McKinsey estimates that more than half of carbon offsets will come from forest and other nature-based projects.

These bullish sentiments will more than likely lead to heightened demand for forest offsets. Offsets are, after all, a tool to commodify and financialize nature, and speculation is inherent to financial markets. The problem, however, is that nature does not behave like stock markets, and biodiversity, livelihoods, and land rights are tangible issues that will become collateral damage in the race to force trees to clean up our mess.

6.1 FOREST OFFSETS: THE FUTURE OUTLOOK

In 2020, the United Kingdom's Mark Carney, a former governor of the Bank of England, and Bill Winters, the chief executive of Standard Chartered Plc founded the *Taskforce on Scaling Voluntary Carbon Markets* (TSVCM) to establish a "large-scale, transparent carbon credit trading market", and for this they want to create a set of rules known as "Core Carbon Principles (CCPs), a threshold standard for defining high quality".[42]

The TSVCM published a "Phase 1" report in January 2021, and a "Phase 2" report in July 2021. They are also attempting to establish an independent governance body for voluntary carbon markets 'with the mandate to implement, host and curate the CCPs by evaluating which Standards and methodology types may issue CCP-labelled credits.'

Their hope is that the quality standards or CCPs will ensure that carbon credits have a meaningful impact on emissions. They also add that 'the creation of a CCP threshold standard will not exclude any credits from the market but will introduce new high-quality removal CCP credits and high-quality avoidance and reduction CCP credits that will be fungible and backed by accredited Standards.' This means that the CCP label will be added to offsets that meet its standards.

The TSVCM speculates that the voluntary market could be scaled up to $50 billion in 2030 and can contribute to the global goal of limiting temperatures to less than 1.5 °C above preindustrial levels.[43] The group also estimates that offsets can help in the race to net zero by removing 2 Gt of CO_2 per year by 2030, and that demand for carbon offsets could increase 15-fold by 2030.

Table 6: Core carbon principles for offset products

Real	Measured, monitored and verified ex-post to have actually occurred.
Additional	Beyond GHG reductions or removals that would otherwise occur. Projects demonstrate a conservative business-as-usual scenario and must be surplus to regulatory requirements. Jurisdictional programmes demonstrate additional reductions below the historical reference level.
Based on realistic and credible baselines	Credited only beyond performance against a defensible, conservative baseline estimate of emissions that assumes the BAU trajectory in the absence of the activity. Baselines should be recalculated on a regular, conservative timeframe.
Monitored, reported, and verified	Calculated in a conservative and transparent manner, based on accurate measurements and quantification methods. Must be verified by an accredited, third-party entity. MRV should be conducted at specified intervals.
Permanent	Only issued for GHG reductions or removals that are permanent or, if they have a reversal risk, must have requirements for a multi-decadal term and a comprehensive risk mitigation and compensation mechanism in place, with the means to replace any units lost.
Leakage accounted for and minimized	Assessed, mitigated, and calculated considering any potential increase in emissions outside of the boundary, including taking appropriate deductions.
Only counted once	Not double-issued or sold.
Do no net harm	The independent standard must have requirements to ensure that all projects and programmes consider related environmental and social risks and take actions to mitigate associated harm.

Source: TSVCM, Phase 1 Report, January 2021, https://www.iif.com/Portals/1/Files/TSVCM_Report.pdf

McKinsey, a key advisor to the TSVCM, recommends six guidelines to strengthen the voluntary carbon markets so that they can support climate action.[44]

- Standardized criteria to verify high quality credits
- Developing standardized contracts for carbon trading
- Developing post-trade infrastructure comprising clearing houses and meta-registries
- Common rules for companies to determine what would constitute an environmentally sound offsetting program, so that they make efforts to reduce emissions first and use offsets to neutralize only those emissions that they cannot reduce
- Fraud prevention methods like a common digital process by which projects are registered and credits are verified and issued, the implementation of anti-money-laundering and know-your-customer guidelines to stop fraud, and the creation of a governance body to ensure the eligibility of market participants, supervise their conduct, and oversee the market's functioning

- Demand signals that will help project developers increase supply of credits, such as commitments to reduce greenhouse-gas emissions or as up-front agreements with project developers to buy carbon credits from future projects

The TSVCM is comprised of 'hundreds of bankers, airline executives, sustainability experts, commodities traders, scientists and other business leaders', according to Akshat Rathi and Jess Shankleman at Bloomberg Green.[45] Their reports suggest that the TSVCM's closed-door deliberations dragged on for months with disagreements such as 'which companies can use offsets to reach their climate goals and whether credits based on avoiding emissions—the vast majority of offsets currently available—should be part of net-zero plans.'

Prominent US environmental non-profits are also some of the biggest advocates for offsets outside the private sector. Organizations like The Nature Conservancy (TNC) receive funding from corporations to issue offset projects. According to the 2021 report titled *Chasing Carbon Unicorns* by Friends of the Earth International (FOEI), TNC, along with Conservation International (CI), Environmental Defense Fund (EDF), and World Wildlife Fund (WWF) sit on the consultative group of the TSVCM.

BOX 6: WHERE IS THE LAND?

The exploding demand for offsets fuelled by the spate of net zero target announcements raises the issue of available land to accommodate this demand. The 2021 report titled *Chasing Carbon Unicorns* by Friends of the Earth International (FOEI) says, 'the geosphere cannot be stuffed into the biosphere.' The area of land required to sequester just 2 Gt CO_2 through ecosystem restoration is estimated at 678 million hectares—about twice the land area of India.

Shell's net-zero strategy alone includes offsetting 120 million tonnes of CO_2 per year through planting forests, estimated to require around 12 million hectares—three times the size of the Netherlands—according to ActionAid.

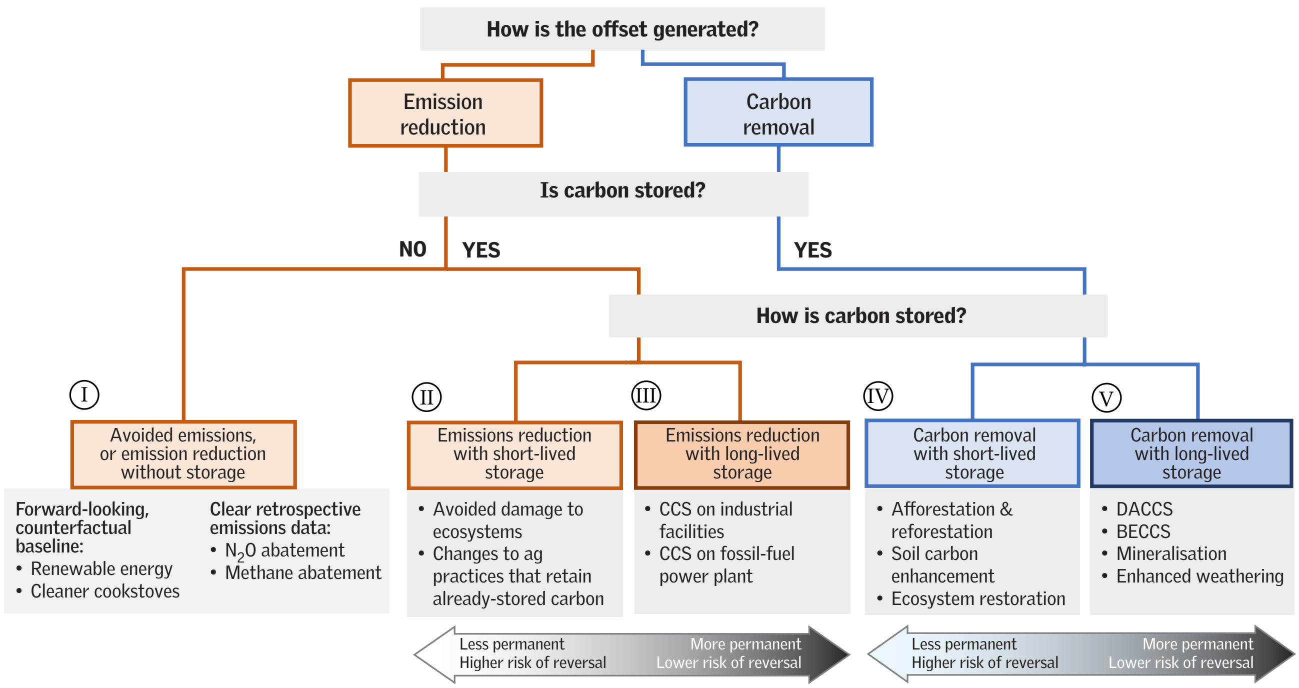
The TSVCM hosted an event at CoP26 in Glasgow, which was disrupted by activists from the Indigenous Environmental Network. Youth activist Greta Thunberg walked out of the event, saying: 'This Taskforce, and other schemes like it, are scams that could trash the goal of limiting global temperature rise to 1.5 °C. No more greenwashing.' In March 2022, reports emerged that the TSVCM was being "scaled back" amidst criticism that offsets would not reduce carbon emissions. Targets to increase the market have been abandoned, the focus instead would be on assuring the quality of offsets sold.[46]

If the rules for the new carbon market are not water-tight, companies will continue emitting while claiming to have lowered their net emissions. Narrowing in on some of the major risks, a multidisciplinary group of scholars at the University of Oxford, including climate attribution specialist Friederike Otto and nature-based solutions specialist Nathalie Seddon, published The Oxford Principles for Net Zero Aligned Carbon Offsetting in 2020.[47] They outlined four guidelines for offsetting that could help avoid greenwashing:

1. Prioritize reducing your own emissions and minimize the need for offsets in the first place. If offsets are used, they must be of a high quality.
2. Shift offsetting towards carbon removal, where offsets directly remove carbon from the atmosphere—such as planting trees for sequestration. Only 5 per cent of offsets today focus on carbon removal, while the majority focus on emissions avoidance/reduction through measures such as avoided deforestation. Users of offsets should increase the portion of their offsets that come from carbon removals, rather than from emission reductions, ultimately reaching 100 per cent carbon removals by mid-century to ensure compatibility with the Paris Agreement goals.
3. Shift offsetting towards long-lived storage, which removes carbon from the atmosphere permanently or almost permanently (such as storing CO_2 in geological reservoirs or mineralizing carbon into stable forms). Short-lived storage refers to methods of storing carbon which have an uncertain or higher risk of being reversed within decades—afforestation, reforestation and soil carbon enhancement.

4. Support the development of a market for net zero aligned offsets through measures such as long-term agreements to give certainty to offset project developers, and forming sector-specific alliances to work collaboratively with peers

Figure 1: Taxonomy of carbon offsets



Source: Myles Allen et al 2020. *The Oxford Principles for Net Zero Aligned Carbon Offsetting*, University of Oxford. Accessed at https://www.smithschool.ox.ac.uk/publications/reports/Oxford-Offsetting-Principles-2020.pdf

A stringent group of experts known as The Science-Based Targets initiative, or SBTi, that sets guidelines for companies to achieve net zero emissions, does not approve of using carbon offsets until a company has tried every available fix (such as installing wind turbines, boosting efficiency, or switching to cleaner fuel).[48] SBTi is open to considering offsets for only those emissions that are impossible to reduce, after all efforts are made. They have also called for regulation of the voluntary market, since there is no accountability mechanism to determine if the money being spent by companies is actually reducing emissions.

7. SINKS OR SCAMS

In recent years, even as the market for offsets has grown, there have been serious allegations raised on the effectiveness of this strategy in the real world.

According to San Francisco-based non-profit CarbonPlan, California's official forest carbon offsets programme was responsible for widespread crediting errors, such that 29 per cent of the offsets were over-credited, totalling 30 million tonnes CO_2e worth approximately $410 million.[49] The California Air Resources Board, the governing authority, estimated regional averages for carbon stored in large swathes of diverse forest that could contain a wide mix of trees. Landowners earn credits for activities that stimulate growth, such as logging or thinning out smaller trees. If their plot stores more carbon than the regional average, they earn credits for the difference which they can then sell. Due to regional averages being imprecise reflections of localized plots, landowners and developers earn far more credits than the actual carbon benefits they deliver. These are "ghost credits" which are then purchased by polluters, and ultimately lead to higher overall GHG emissions. Developers can then game the system by locating new plots near land with more carbon-rich trees than the regional average and earn millions in credits.[50]

In 2021, an investigation by journalist Ben Elgin at Bloomberg found that veteran environmental non-profit The Nature Conservancy (TNC) allowed corporations like JPMorgan, BlackRock and Disney to write off emissions by buying credits from projects where the land was never threatened to begin with, making the offsets more or less meaningless.[51] Similarly, a joint investigation by Greenpeace Unearthed and The Guardian in 2021 found that major players in the aviation sector such as British Airways, EasyJet and Delta, have turned to forest offset programmes to reduce their carbon footprint and present claims of carbon neutrality. An analysis of 10 reduced deforestation offsetting projects certified by Verra, the biggest issuer of carbon credits in the world, did not produce carbon savings as claimed.[52] The researchers found no evidence of claimed deforestation that was being avoided, but found exaggerated benefits calculated using simplistic and flawed methodologies. This directly points to the problem of "additionality", wherein companies are investing millions to make no dent in global net CO_2 emissions.

In October 2020, French energy company Total announced that it has 'delivered its first shipment of carbon neutral liquefied natural gas (LNG) to the Chinese National Offshore Oil Corporation.' They claimed that the carbon footprint of the LNG shipment was offset with VCS (Verified Carbon Standards) emissions certificates financing a wind power project in northern China, and a REDD+ project in Zimbabwe.[53] Subsequently, in May 2021, the US gas company Cheniere Energy said it had sold a "carbon-neutral" shipment of LNG to Royal Dutch Shell—also made possible by offsets. While these transactions look good on paper, they do not actually reduce accumulated CO_2 in the atmosphere—a vital part of lowering global temperatures. Thus, the term "carbon neutral" is nothing more than a marketing scam that lets polluters off the hook by paying a small monetary sum. The CO_2 and methane emissions, in this case, from the extraction, distribution, and use of natural gas, continue unabated.[54]

8. REDD+ AND OFFSETS

In 2005, a global mechanism called Reducing Emissions from Deforestation and Forest Degradation (REDD) was conceptualized to provide monetary incentives to forest communities for protecting forests, which are major carbon sinks.[55] It links forest protection with carbon markets. It was formally adopted during CoP 13 in Bali in 2007. In 2008, it graduated to REDD+ to include the sustainable management of forests, and the conservation and enhancement of forest carbon stocks. In 2013, CoP 19, held in Warsaw, Poland adopted seven decisions of the Warsaw Framework that provide the fundamental architecture for REDD+. REDD+ received a boost in CoP 21 when Article 5 the Paris Agreement explicitly stated that countries that are willing and able to reduce emissions from deforestation should be financially compensated for doing so.[56]

About 600 projects had been initiated as of early 2021, with some 400 still active.[57] REDD+ funding flows from bilateral and multilateral agencies, and REDD+ credits are also traded in the voluntary carbon markets. The programme has encountered numerous credibility issues such as questionable baselines and limited evidence that it has halted deforestation[58], as well as issues of land grabs from indigenous communities. REDD+ also focuses primarily on emissions “avoidance”, while the conversation is now shifting to credits that promote emissions “removal”. Despite this, REDD+ credits form a large component of forestry and land use credits, according to Ecosystem Marketplace.[59] One estimate suggests that they make up 80 per cent of forest-based offsets.[60]

From 2020 to 2021, REDD+ credits rose dramatically in volume, including a 166 per cent increase in the avoided unplanned deforestation project type and a 972 per cent increase in avoided planned deforestation. The average price was $4.4 in 2021. But despite the volumes, the total flow of funds has been low, with agribusiness and other deforestation drivers outspending efforts to curb deforestation.

Voluntary REDD+ schemes are most prevalent in Brazil, which has also been the largest recipient of funding for REDD+. It has also seen deforestation rates surge to a 12-year high in recent years. Projects are plagued by four major problems—leakage, additionality, permanence and measurement.[61]

Some standards like Gold Standard do not certify REDD+ offsets due to issues pertaining to baselines, but others such as the Verified Carbon Standard (VCS) do.

With project-based REDD+ interventions proving tedious, there have been calls for a "jurisdictional approach" on a larger scale, where governments can enforce forest and land-related laws and implement domestic policy reforms.[62] In simplest terms, the former refers to an independent, unregulated project typically managed by a non-governmental actor, while the latter refers to a larger programme overseen by the government.

Mark Carney's Taskforce supports the inclusion of REDD+ projects under its Core Carbon Principles, stating: *'Project based REDD+ is critical to finance deforestation avoidance and reforestation and should be allowed under the CCPs. However, to ensure full integrity of project-based REDD+, safeguards will be put in place, incl. requiring nesting where jurisdictional programs are available, requirements on buffers and leakage, and ability to select jurisdictional REDD+ if desired as additional attribute. Safeguards subject to regular review for need of further strengthening by future governance body.'* Carney did clarify later in November 2021, that in a broader sense, carbon offsets should be a last resort, that the best practice was that 'those offsets are at the end of a process of reducing absolute emissions.'[63]

At CoP 26 in Glasgow, rules for Article 6 of the Paris Agreement were finalized. Article 6 has two major mechanisms—Article 6.4 which is the proposed new centralized carbon market, and Article 6.2 or bilateral trades.

REDD+ was initially included in the draft text, supported by rainforest countries like Papua New Guinea, despite opposition from the EU. This referred to old credits generated during

BOX 7: REDD+: COMMONLY USED TERMS

- A "project" uses methodologies that have been specifically created at the scale of activities, usually implemented by non-state entities (private project developers and investors, often in cooperation with NGOs, communities or local (forest) authorities).
- A "jurisdictional program" denotes a mitigation activity at the sectoral level, such as large-scale REDD+ programs at national, subnational or jurisdictional scale. Such programmes are qualitatively different from projects as they look at performance over very large areas.
- "Nesting" refers to the integration of projects into jurisdictional programmes through harmonized GHG accounting rules.

Source: T. Chagas, H. Galt, D. Lee, T. Neeff and C. Streck 2020. A close look at the quality of REDD+ carbon credits. Accessed at https://www.climatefocus.com/sites/default/files/A%20close%20look%20at%20the%20quality%20of%20REDD%2B%20carbon%20credits%20%282020%29%20V2.0.pdf

2015–2021, and their inclusion in Article 6.2. Eventually, with the US proposing that the text be deleted, direct references to REDD+ were removed in the final drafts.[64] Countries opposing its inclusion hoped to avoid poor quality credits from REDD+. REDD+ credits generated from 2021 onwards could still be used, subject to meeting the wider Article 6 rules, reports analytics website Carbon Brief.[65]

Credits issued under 6.4 can be used by countries to achieve their climate goals, or even by private companies to meet their voluntary emissions reduction targets. According to Ecosystem Marketplace, REDD+ activities are eligible under 6.4 as well, 'provided that they comply with the respective international and national rules.'[66] This will most likely be fleshed out in the run-up to CoP 27 by the Subsidiary Body for Scientific and Technological Advice (SBSTA), since the Article 6 text asks the SBSTA to develop recommendations on 'the consideration of whether activities could include emissions avoidance and conservation enhancement activities.'[67,68]

3

INDIA'S FOREST CARBON SINK

9. IMPORTANCE OF FORESTS IN INDIA

More than 300 million people in India depend on forests for their livelihoods.[69] According to the Global Forest Resources Assessment 2020 published by the Food and Agriculture Organization (FAO) of the United Nations (UN), India's forests comprised 2 per cent of the world's forest area in 2020. Between 2010 and 2020, India ranked third in average annual net gain in forest area (0.38 per cent annual net change).[70]

Forests also feature in India's Nationally Determined Contribution (NDC) under the Paris Agreement, implying that they will play a vital role in India's plans for decarbonization. India has pledged to 'create an additional (cumulative) carbon sink of 2.5–3 gigatonnes of carbon dioxide equivalent ($GtCO_2e$) through additional forest and tree cover by 2030 . . . Government of India's long-term goal is to bring 33% of its geographical area under forest cover eventually.'[71]

10. STATE OF FORESTS AND GOVERNANCE

The Forest Survey of India (FSI) is the primary government agency, now under the Ministry of Environment, Forest and Climate Change (MoEF&CC), responsible for assessing the state of India's forests through a biennial report titled the India State of Forest Report (ISFR).[72]

The big picture from the State of Forest Report 2021 is:
India's forest cover has increased marginally since the last assessment in 2019. Total additional forests are a miniscule 0.1 million ha and the difference is a mere 0.2 per cent. Increase in forest cover has happened outside the area classfied in land records as "forests". It has also happened mainly in forests that are defined as "open"—with canopy cover between 10–40 per cent. This shows that forests are growing because people are planting trees on their individual lands, including plantations of rubber, coconut or eucalyptus—non-forest species—as there are huge restrictions on planting and cutting trees that are listed in the Indian Forest Act. These forest lands would also include plantations of tea or coffee, which have tree cover of more than 10 per cent in any hectare of land.

The area 'outside' the recorded forests is now a substantial portion of the green cover of the country. At 29.29 million ha, it adds up to as much as 40 per cent of the forest cover of the country. This land outside recorded forests also contributes to 38 per cent of the forest sinks in the country according to FSI.

Tree cover—scattered in individual plots—is close to 10 million ha, which is equivalent to the area under the very dense forests in the country. Mango, neem, mahua and tamarind are the most important trees, in that these species provide livelihood benefits to their growers.

Very dense forests—with canopy cover of over 70 per cent—are now a mere 14 per cent of the forest cover (only 3 per cent of the country's land area) and of this, more than 70 per cent are found in districts classified as tribal.

Most importantly, vast areas of the country's forest area—land recorded as forests—does not find any mention in the report. It is missing. This area is as much as 25.87 million ha—one-third of the land under the state forest department.

10.1 REINVENTING FORESTS FOR THE FUTURE

The 2021 State of Forest Report makes it clear that India needs to rework its forest strategies urgently. Forest management started in India with the colonial British government, which took away community lands and nationalized them. Forests were meant for extraction that could fuel the colonial government's economic exploitation of the country's resources. The first generation of forest management in post-British India continued this extractive system. The second generation started in the 1980s, when the Forest Conservation Act and, subsequently, its amendment was passed, centralizing the 'diversion' of forest land. The push for this was provided by growing awareness about the rate of deforestation and the deteriorating state of forests.

The third generation arrived with a focus on afforestation. At first, afforestation was done by growing trees outside forests, in wastelands that were thought to exist across the country. Soon, it became clear that the real wasteland was in the lands controlled by the forest department. It was also clear that making the planted trees survive required people to keep their livestock in check—villagers were needed to protect the land and to be partners in afforesation.

Joint Forest Management (JFM) began in order to make local communities part of the endeavour to save forests; they would get usufruct rights to the produce and would guard the land in return so that forests would grow. JFM did not succeed because it was a scheme in which state forest departments remained unwilling participants. They only showed up when the trees —protected over the years by villagers—were ready for harvest. As part of the agreement, money was to be transferred to the village community. But, as documented in village after village, the final cheque amount was so small that it was a affront to the community. The reason was that the department, while making the final payout, decided to substract all the costs it had incurred from it. People's trust was broken. This destroyed a movement to grow and then cut trees so that they could be grown again.

In the fourth generation, the 2006 Forest Rights Act (FRA) corrected a historical injustice and communities were given rights to the land they were living on. But scant attention was paid to the need to afforest these lands.

The Green India Mission and the funds collected through payments for compensatory afforestation need to be deployed for afforesation on these lands. In reply to a question asked in the parliament in 2020, MoEFCC said that the Compensatory Afforestation Fund Management and Planning Authority (CAMPA)—working under the ministry—has transferred close to Rs 50,000 crore to states for planting trees. There is no report card on the trees planted and their surivial rate.

It is time for reworking and reimagining forests for the fifth generation. On one hand, there is a need for enhanced protection of the remaining forests for ecological security; and on the other hand, there is a crucial need to build resilience of communities who live in these habitats. And all this has to be done in times of increased risk because of climate change.

The 5-G strategy should be based on the learning of the past—it must shed its reticience to plant trees that will be cut. The fact is that while the first generation of forest management in the country was extractive and exploitative, the fourth generation continues to be obsessed with conservation to the extent that planting trees has become a crime. Today, India has to rely on imports to satisfy much of its wood product needs—and according to a recent report by the International Tropical Timber Organisation (ITTO), this is often sourced from illegally cut forests in Africa and other places. This is happening when the country has set aside 23 per cent of its land area for forests!

Therefore, the future agenda for forests must be:

Agenda 1: Protection of the remaining very dense forests is critical—It is clear that we cannot afford to lose even a hectare of high quality and biodiverse forests. This would mean that forests which require highest level of protection should be identified and this data should be made available so that clearance for development projects is not granted in these areas.

Equally importantly, we must recognize that the bulk of these very dense and very rich forests are found in the habitats of the poorest people in the country. This means that much more has to be done to build strategies for enabling ecological payments to those communities which co-exist in these lands. They must benefit from this protection, not be worse off, because these lands are important for conservation.

The cartography of India—the map where the tigers roam, the dense forests exist, where minerals are found, where rivers come from, but also where the poorest, most marginalized live—must change. This can only happen if we make people partners in conservation and not dismiss them as "biotic pressure".

In 2002, the 12th Finance Commission set up an incentive-based grant to reward states for conserving forests—based on the land area of forests in the state. The 14th Finance Commission has made this "grant" unconditional—which means that states are free to use it as they want. There is no accountability for this grant and nobody really knows what the money is used for. And, frankly, the idea of ecosystem payment for conservation has been lost.

This payment needs to be given to communities that live near protected, high-value forests. This payment is for ecological services rendered because conservation is happening in their backyard and at their cost. It also means that we need to place real value on these forests—which are key for biodiversity conservation as well as carbon sequestration.

Agenda 2: Plant to cut and then plant again on forest land with communities—The reason why vast areas of land under the forest department remain degraded is that these are also habitats of people and their livestock. This is why planting trees requires the involvement of communities. The FRA has a provision for community forest management and it is time that states make this idea work. But, for this to happen, trees will need to be cut and then planted again—and this means making a business of the minor and major forest produce. Cutting of trees is not the problem, the problem is our inability to replant and regrow the trees. This needs to be fixed. It is time that we bring back the saw-mills so that wood can be used to replace cement, aluminium and steel in housing and furniture. We need a wood-based future. This is good for climate change and if we do this in ways in which the benefits go to communities then it is good for livelihoods and building local economies as well.

Agenda 3: End the license-raj in trees outside forests—ISFR 2021 shows that people are planting trees on their lands, but what is not said is that this plantation is happening against all odds. Under the restrictive conditions that operate in India today, it is literally a crime to plant a tree—people do not know if they will get permission to cut the tree they plant on their lands or even to transport it or sell it. Under the Indian Forest Act, timber or other produce derived from trees outside forests are treated as forest produce. This is not all. State governments have added to this through their own tree cutting acts, which govern tree felling and transit for different species. In this way, if you grow a tree on your land, you need permission to cut it and then permission to transport it or sell it. It is a task riddled with high transaction costs and harrasment. The fact is trees are like bank accounts. People plant in one generation to harvest for exigencies in another. But now, this bank account has been demonitized or nationalized.

Forests as carbon stock

In its Biennial Update Reports (BUR) that India is required to submit to the United Nations Framework Convention on Climate Change (UNFCCC), India reported that its share of greenhouse gas (GHG) emissions offset by the land use, land-use change, and forestry (LULUCF) sector has been increasing. The BUR 3 submitted in 2021, says that *'the LULUCF sector was a net sink of 307,820 Giga-gramme CO_2e [0.3 GtCO_2e] in 2016, registering an increase in the net sink activity by 39 per cent since 2000. Forest land, cropland and settlements categories were net sinks while grassland was a net source of CO_2. About 15 per cent of India's carbon dioxide emissions in 2016 were removed from the atmosphere by the LULUCF sector.'*

Table 7: Total GHG emissions and removals from sinks in India

Date of report	Based on	Total GHG emissions excluding LULUCF (GtCO_2e)	Total net LULUCF (GtCO_2e)	% Of Total GHG offset by Net LULUCF
June 2004, Initial National Communication	National Inventory 1984–1994	1.23	0.01	1%
May 2012, Second National Communication	National Inventory 1994–2004	1.52	-0.22	-15%
Dec 2015, BUR 1	National Inventory 2010	2.14	-0.25	-12%
Dec 2018, BUR 2	National Inventory 2014	2.61	-0.30	-12%
Feb 2021, BUR 3	National Inventory 2016	2.84	-0.31	-11%

Source: Compiled by CSE from India's official submissions to the UNFCCC

How will India achieve Its NDC goal to enhance carbon sinks?

While a quantified goal has been announced to enhance the forest carbon sink—additional 2.5–3 Gt of CO_2 by 2030—limited data is available on any progress made on this goal. India has not officially announced a baseline year from when this additional forest sink would be measured. But MoEF&CC officials say (off-record) that 2005 is the base year, while the carbon stock between 2005 and 2010 was used as a trend to arrive at the goal of 2.5–3 Gt by 2030.

The only publicly available official roadmap to achieve India's sink goal is the FSI's *Technical Information Series (Volume I, No 3, 2019)*[73], written by Dr Subhash Ashutosh and his colleagues. This paper reviews the carbon stock in the country, adding the tree carbon stock to forests. India's carbon stock in 'forest and tree cover' amounted to 8,063 million tonnes (or 8.063 Gt) as per the assessment in 2015 (equal to 29.59 $GtCO_2e$).

Table 8: Derivation of carbon in forest and tree cover of India

Year	Forest cover (sq km)	Forest carbon in forest cover (million tonnes)	Tree cover (sq km)	Carbon in tree cover (million tonnes)	Forest carbon from forest & tree cover (million tonnes)	Forest carbon from forest & tree cover CO_2e (billion tonnes)
2004	677,088	6,663	91,663	958	7,621	27.97
2011	697,898	6,941	91,266	953	7,894	28.97
2013	701,495	7,044	92,572	967	8,011	29.40
2015	708,273	7,083	93,815	980	8,063	29.59

Source: FSI Technical Information Series, Volume I, No 3, 2019

It then goes on to project carbon stock on a linear, log and exponential scale and estimates that this will increase to 31–32 $GtCo_2e$ by 2030. This would be an increase of 3.75 Gt from 2015 to 2030 and meet India's NDC commitment. It suggests that achieving the target requires protecting and improving existing forest cover while also extending tree cover in more than 25 to 30 million hectares.

The paper, however, says that there is uncertainty about India's stated NDC. Three questions are raised on the statement 'to create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030': Why is the term 'additional' occurring twice? What is the base year from when to measure the additional sink? And whether the additional sink is to be achieved within the business-as-usual (BAU) scenario or over and above it? The report treats the BAU scenario as the existing policies, acts, rules and programmes that can increase the carbon sink.

It then proceeds to project values of carbon stock in India's forest and tree cover from different (possible) baseline years: 2005 (the same base year as mentioned in GDP emission intensity target), 2015 (year of the Paris Agreement), or 2020 (year from which actions committed in NDC are to be implemented).

The researchers conclude that 'if the NDC target is not above the BAU level then the increase in carbon sink by 2030 to the target level can be achieved by just sustaining the existing policies and programmes (BAU).' However, if the NDC target is interpreted otherwise, then targeted programmes of forest restoration and tree planting on all available lands will have to be launched from 2020 onwards. In three different scenarios—depending on the target for increased sinks—the country would need to increase its tree and forest cover by 13–25 million ha to achieve increased sinks of 1.63–3.39 billion tonnes of CO_2e. In these scenarios, tree and forest cover would need to increase by 2.38–4.49 per cent by 2030.

The report also says that the most cost-effective answer would be restoration of degraded forest lands—lands under the forest department. These can contribute up to 60 per cent of the additional carbon sink to be achieved by 2030.

FSI in its 2019 technical paper recommended that 'MoEF&CC should issue clarification on these two critical questions without which strategy for achieving the NDC target cannot be developed.'

BOX 8: CARBON STOCK ACCORDING TO THE INDIA STATE OF FOREST REPORT 2021

Carbon stock is different from growing stock as it calculates the amount of carbon stored in biomass—in woody growing stock, vegetation, and leaf litter and soil. According to ISFR 2021, FSI had initially only calculated the woody growing stock and extrapolated the vegetation to estimate forest carbon. Then for India's Second Communication to the UNFCCC, it conducted a greenhouse gas inventory from 1954 to 2004. It estimated the greenhouse gas flux—net changes in carbon stock over time. Since the launch of the National Forest Inventory in 2003, FSI has been estimating growing stock and carbon stock in different carbon pools.

The carbon stock is estimated for vegetation—including soil and forest floor—in recorded forest and trees outside forests.

According to this, there has been a net increase of 79.4 million tonnes in carbon stock between 2019–2021. it is interesting to note that the biggest decrease in carbon stock has come from leaf litter and increase has come from above ground biomass. This would suggest that the carbon stock increase is in trees outside forests.

It is also important to note that according to this assessment the bulk of the carbon stock—56 per cent—is in the soil. The report (on page 249) also states Trees Outside Forest (TOF) are 8.94 per cent of the country's geographical area and contribute to nearly 38 per cent of the carbon sink.

Component	Carbon stock in 2019 (million tonnes)	Carbon stock in 2021 (million tonnes)	Net change in carbon stock (million tonnes)
Above ground biomass (tree stock)	2,256.5	2,319.9	63.4
Below ground biomass	700.8	718.9	18.1
Dead wood	35.8	47.7	11.9
Litter	127.9	107.3	-20.6
Soil	4,003.4	4,010.2	6.6
Total	7,124.6	7,204	79.4

Source: India State of Forest Report 2021, Forest Survey of India

II. CONCLUSION AND ISSUES FOR FURTHER DISCUSSIONS

The big picture of India's forest potential and future for carbon sequestration is as follows:

1. India has committed to create an additional (cumulative) carbon sink of 2.5–3 Gt of CO_2e through additional forest and tree cover by 2030.
2. Currently, as per India's BUR 2021, the LULUCF sector "offsets" roughly 15 per cent of the gross greenhouse emissions—0.32 GtCO_2e was the net sink of India. In other words, in 2016 (last estimate available in BUR 2021), the total GHG emissions were 2.84 GtCO_2e and after removal from forests and other land uses, they were 2.53 GtCO_2e.
3. According to the State of Forest Report 2021, India's carbon stock in forests increased from 7,124.6 million tonnes in 2019 to 7,204 million tonnes in 2021—an increase of 79.4 million tonnes between 2019 and 2021.
4. When tree and forest carbon stock is converted into CO_2e, it adds up to 29.59 billion tonnes in 2015. According to FSI's Technical Information Series (Volume I, No 3, 2019), India's forest and tree carbon stock in 2005 was 28.12 billion tonnes.
5. Taking the State of Forest 2021 tree and carbon stock (7,204 million tonnes), it would be equivalent to 26.44 billion tonnes of CO_2e.
6. The baseline year from when India will measure its improvement in carbon stock and sinks needs to be resolved.
7. The question remains: how is India's NDC to be estimated for the growth of carbon sink? Is it the increase in terms of the carbon stock in forests and trees or is it the increase in the 'sink'—the ability of the standing stock to sequester CO_2?
8. This is important as forests are both sources and sinks of emissions. It is also clear that with climate change and increasing heat levels, forest fires will increase in number. In this way, emissions from forests will also go up. According to the State of Forest Report, India's forests are seeing more fires. The government has a fire detection system in place, under which satellites MODIS and SNPP-VIIRS estimate these fires.

In 2019–2020, MODIS detected 22,447 hotspots; and in 2020–21, hotspots detected more than doubled to 52,785. The SNPP-VIIRS satellite detected 124,473 forest fires in different states of India in 2019–20. This went up to 345,989—more than triple—in 2020–21.

9. All this also matters because India's afforestation strategy will have to account for the needs of the poorest who live on these lands. The State of Forest Report clearly shows that the bulk of the forests in the country are "tribal" districts. Therefore, the issue is not just about accounting for sources and sinks, but to build a forest future for these communities. This will be the big question in India's nature-based solution strategy.

ANNEXURES

Annexure I: The potential—estimates of the amount of CO_2 land-based sinks can sequester

Estimates of mitigation potential from land-based sinks vary widely across fourteen studies reviewed for this paper.

Sr. no.	Study	Elements of land sink / pathways covered	Target year	Maximum mitigation potential
1	Griscom et al., 2017	Forests, wetlands, grasslands, agricultural lands	2030	23.8 $GtCO_2e$ / year
2	Grassi et al., 2017	Forests	2030	1.1 ± 0.5 $GtCO_2e$ / year
3	Hansen, 2017	Soil and biosphere	-	100 Gt C or 367 $GtCO_2$
4	Dooley et al., 2018	Forests, grasslands, savannahs, agricultural lands	2050	6.1 $GtCO_2e$ / year in avoided emissions 8.7 $GtCO_2e$ / year sequestered 7.5 $GtCO_2e$ / year avoided through agricultural practices
5	IPCC SRCCL, 2019	Reduced deforestation and forest degradation Afforestation	-	0.4–5.8 $GtCO_2e$ / year 0.5–8.9 $GtCO_2e$ / year
6	Bastin et al., 2019	Restoration of forested land and additional 0.9 billion hectares of forest canopy cover	-	752 $GtCO_2$
7	Busch et al., 2019	Tropical forests in 90 countries	2020–2050	Additional 5.7 $GtCO_2$ at carbon price of USD 20, or 15.1 $GtCO_2$ at USD 50
8	Austin et al., 2020	Avoided deforestation, forest management activities, increasing harvest rotations, and afforestation/reforestation	By 2055	0.6–6.0 $GtCO_2$ / year at a total annual cost of 2–393 billion USD / year
9	Griscom et al., 2020	Forest/savannah, agriculture, wetland in 79 tropical countries and territories	2030–2050	6.56 $GtCO_2e$ /year across 79 tropical countries and territories
10	Teske et al., 2021	Reforestation, forest ecosystem restoration, sustainable use of forests, and agroforestry	2050	117 $GtCO_2$ (3.9 / year 2020–2050)
11	Li et al., 2021	Land sink	2100	2.75 $GtCO_2$ / year
12	World Economic Forum, McKinsey & Company, 2021	Avoided deforestation and peatland impact, peatland restoration, reforestation, and cover crops	2030	7 $GtCO_2$ / year
13	Koch et al., 2021	Tropical forests and farmland	2100	Additional 124 Gt C or 455 $GtCO_2$
14	IPCC AR6 Working Group III Report, Chapter 7, 2022	AFOLU mitigation potential	2020-2050	8–14 $GtCO_2e$ per year with carbon prices up to USD100 tCO_2e

Source: Compiled by CSE

Note: The fourteen studies reviewed are as follows -

1. Griscom et al 2017. *Natural climate solutions*. Proceedings of the National Academy of Sciences, 114(44), 11645-11650.
2. G. Grassi, J. House, F. Dentener et al 2017. "The key role of forests in meeting climate targets requires science for credible mitigation." *Nature Clim Change* 7, 220–226.

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4. K. Dooley et al 2018. *Missing Pathways to 1.5°C: The role of the land sector in ambitious climate action,* Climate Land Ambition and Rights Alliance. Accessed at http://climatelandambitionrightsalliance.org/report
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The studies reviewed recognize the potential of natural sinks as low-cost options for mitigation compared to CO_2 removal technologies, with considerable co-benefits for communities and nature. There is near universal agreement that reforestation, i.e., the establishment of forest on land that had recent tree cover (IPCC), has one of the largest low-cost mitigation potentials among various pathways.

However, the studies vary widely in terms of the pathways analysed (reforestation, agroforestry, etc.), the biomes selected (forests, wetlands, etc.) and time horizons that determine the resultant mitigation potential.

The former NASA (and current Columbia University) scientist James Hansen estimated in his 2017 paper that the soil and biosphere can store a maximum additional 100 Gt C (367 $GtCO_2$) via improved agricultural and forestry practices, and no more. This is considered as an authoritative view of the maximum sequestration limit of the land sink. He also believes that 'this greater extraction, in combination with 6 per cent per year reduction of fossil fuel emissions, would return global temperatures close to the Holocene range by the end of this century.'

At least two studies (Griscom 2017 and WEF 2021) state that natural sinks can deliver up to 30 per cent of the mitigation required to limit temperature rise to 1.5 or 2 °C by 2030.

Three studies factor in costs per tonne of CO_2 removal for their pathways—US$ 10–100 (Griscom 2017), US$ 20–50 (Busch 2019), and US$ 10–40 (WEF 2021).

Overall, the variations in assumptions and estimates from published research makes the findings difficult to use in mitigation policy design, owing to large differences in geography, governance capacity and other context-specific factors for countries.

Moreover, the common fallouts from sink enhancement such as competition for land used for food production and threats to livelihoods of forest dwellers have been addressed only by a few studies—Griscom (2017) constrains mitigation potential by safeguards for meeting increasing human needs for food and fiber, while Teske (2021) avoids scenarios where methods like BECCS increase competition for land. One of the most comprehensive studies from this perspective is by Dooley (2018) which follows a rights-based and ecosystem restoration approach with a focus on community management of lands and agroecology. These constraints need to be systematically applied across all estimates to ensure a realistic picture of sequestration potential that presents minimal threats to livelihoods, food production and biodiversity.

Annexure 2: How is the land sink measured?

Several tools and databases measure CO_2 emissions and uptake from land:

- Models: Book-keeping/accounting models, process-based Dynamic Global Vegetation Models (DGVMs), Integrated Assessment Models (IAMs), Earth System Models (ESMs), atmospheric transport models
- Remote sensing: Satellite or near-surface remote sensing
- FAOSTAT and FAO Forest Resource Assessments
- Country reporting of GHG Inventories (GHGIs)

To estimate the land sink in relation to the rest of the carbon cycle, three methods are most frequently used:

1. By using models such as book-keeping or DGVMs—the latest iteration of the GCP's Global Carbon Budget 2020, for example, estimates the anthropogenic sink (i.e., net AFOLU emissions) from three book-keeping models and 17 DGVMs, while the indirect sink (RTS) is estimated from the mean of 17 DGVMs.
2. By calculating the difference from the other directly estimated fluxes in the carbon budget like the atmospheric concentration of CO_2, fossil CO_2 emissions and the ocean sink which are easier to measure—the RTS in the IPCC AR5 was calculated using this method.
3. Through national GHGIs, or country reports to the UNFCCC based on guidelines compiled by the IPCC and UNFCCC.[74]

Annexure 3: Difference between global models and national inventories

Anthropogenic land CO_2 fluxes (emissions and removals) are reported differently by countries and the scientific community:

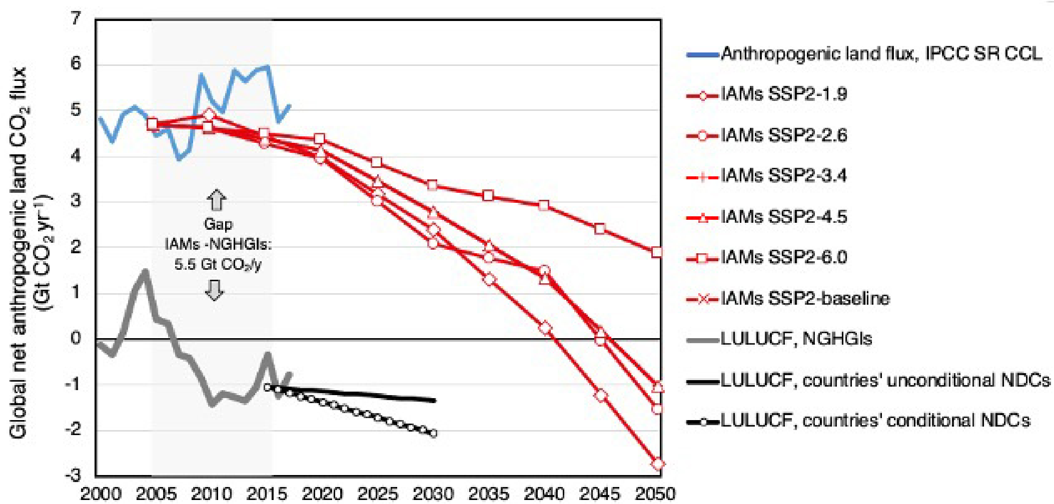
Data reported	Country level	Global scientific community
Historical land CO_2 flux (emissions and removals)	National GHGIs built in accordance with the IPCC's Guidelines, reported by countries to the UNFCCC periodically in the LULUCF component of their GHGIs	Book-keeping models, DGVMs
Future land CO_2 flux	Nationally Determined Contributions (NDCs)	IAMs (used by the IPCC particularly. IAMs also produce pathways of emissions consistent with the 1.5 and 2 °C temperature targets, to be compared with country reports to assess the emission gap for the Global Stocktake)

Source: CSE, Compiled from Grassi et al. (2018, 2021) [75, 76]

Country GHGIs differ from global models in their estimation of land CO_2 flux, such that they reported:

- About 3 $GtCO_2$ / year lower net land emissions than global models in the 2000s (compared to book-keeping models and DGVMs)
- About 4 $GtCO_2$ / year lower net land emissions than global models in the period between 2005–2014 (compared to book-keeping models and DGVMs)
- About 5.5 $GtCO_2$ / year lower net land emissions than global models in the period between 2005–2015 (compared to IAMs)

The graph below shows the mismatch between net land CO_2 exchanges (in $GtCO_2$ per year) between national inventories and global models (in this case, IAMs).



Source: Grassi et al (2021)

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Box 1: Has the Amazon reached its "tipping point"?

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It is clear that forests will play a critical role in the world's desperate fight to combat climate change. The question is how these forests will be grown—on whose lands? Who will benefit and who will pay the price? But before any of these questions are answered, it is important to understand the complexities in estimating the role of forests as sinks and to ensure that this accounting is credible.

Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi 110 062
Phones: 91-11-40616000 Fax: 91-11-29955879
Website: www.cseindia.org