ESG Report

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Treeprint

The ROE of a Tree

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Executive summary

"Treeprint: When emissions turn personal" and "The ROE of a tree" are the first in a series of reports that address the broader carbon cycle. In Treeprint, we addressed the importance that consumer behavior, including dietary habits, will have on achieving the goal of carbon reduction. This report argues that these changes could help accelerate reforestation efforts and outlines why we believe planting trees could be a profitable activity, not least for farmers. We hope you enjoy these two reports and those that will follow under the Treeprint banner.

Forests play a key role in fighting climate change

Forests play a key role in addressing climate change, as typical mature trees can capture c22 kg of CO_2 per year, according to sources such as the FAO. At present, the world's forests absorb c30% of CO_2 emissions; however, deforestation activity since 1990 has resulted in the loss of c420 million hectares of forest – an area equivalent to eight times the size of France or almost half of the US. The need to plant trees in order to help reduce emissions to net zero appears obvious, not just to us but also to intergovernmental bodies. For example, UN Sustainable Development Goal 15 ('Life on Land') is focused purely on protecting and restoring terrestrial ecosystems, including forests. Our review of work from the IPCC shows that reaching net zero by 2050 would require 3.3–6.2 m km^2 of land for bio-energy, carbon capture, and storage and forestry.

The ROE of a tree: Planting trees could make economic sense

Based on a carbon price of US$ 50 for each ton of CO_2 stored, we calculate that planting a tree could yield an internal rate of return (IRR) of over 11%. Assuming that governments pay farmers for planting trees, we show that these payments are not excessive and even after 30 years would only amount to c2.5% of GDP. If governments were to redirect current farming subsidies to help pay for this, we believe the net cost could be even less than 2% of GDP by 2051.

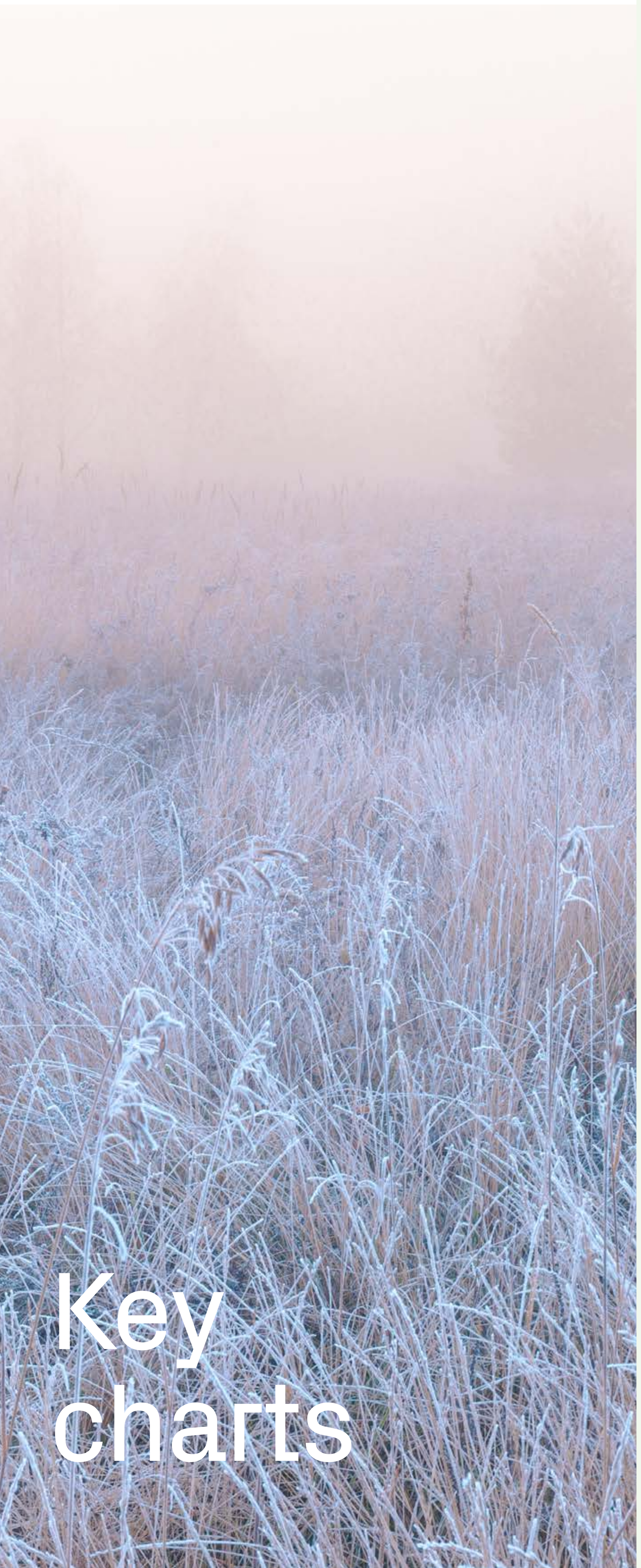
A change in lifestyle creates land needed for reforestation

Making land available for reforestation requires a rethink of the global food system given that current food production and consumption accounts for more than 25% of greenhouse gas (GHG) emissions and c50% of habitable land. We calculate that a reduction in meat consumption and increased intake of plant-based foods have the potential to make more than 20 m km^2 of land available that can be used for reforestation. The introduction of technologies such as cultivated meat and vertical farming could raise this to 27 m km^2, which could capture more than 80% of current anthropogenic emissions if it were used for reforestation.

A global carbon market remains a key hurdle

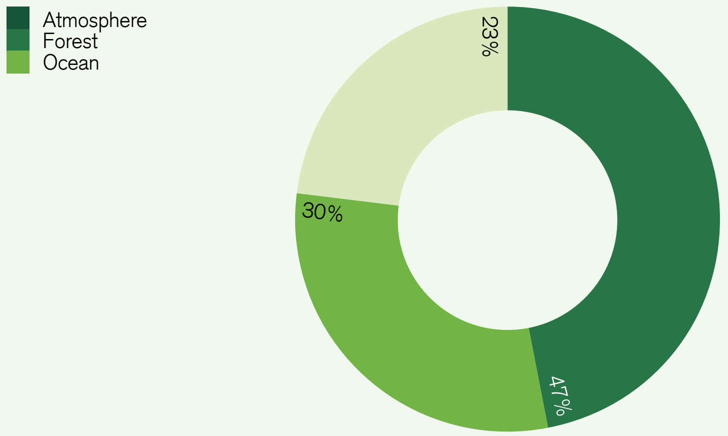
Currently, more than 20% of global emissions are covered by emissions trading schemes across a range of countries (see Figure 49 on page 58). The total traded value of these schemes increased by c20% in 2020 to a record € 229 bn. We believe that a more globally integrated carbon market might act as a catalyst for a shift towards reforestation. The G20 recently recognized the need for more coordinated carbon policies (G20 recognizes carbon pricing as a climate change tool for the first time). At present, these do not exist; however, the rapidly developing voluntary carbon market might help. A recent report by UCL and Trove Research, covered in our Global Weekly Report, suggested that the carbon price in the voluntary market could reach US$ 20-50/t CO_2e by 2030, from US$ 3/t CO_2 e currently, and could go as high as US$ 100/t CO_2e in certain scenarios. These prices do not seem out of line with modelling done by the IPCC and International Energy Association (IEA), which suggest that carbon prices could reach well over US$ 200/t CO_2 e by 2050. These prices would provide strong support for our claim that planting trees has the potential to be a very profitable exercise for farmers and one that helps achieve long-term emissions targets.

David Bleustein
Global Head of Securities Research



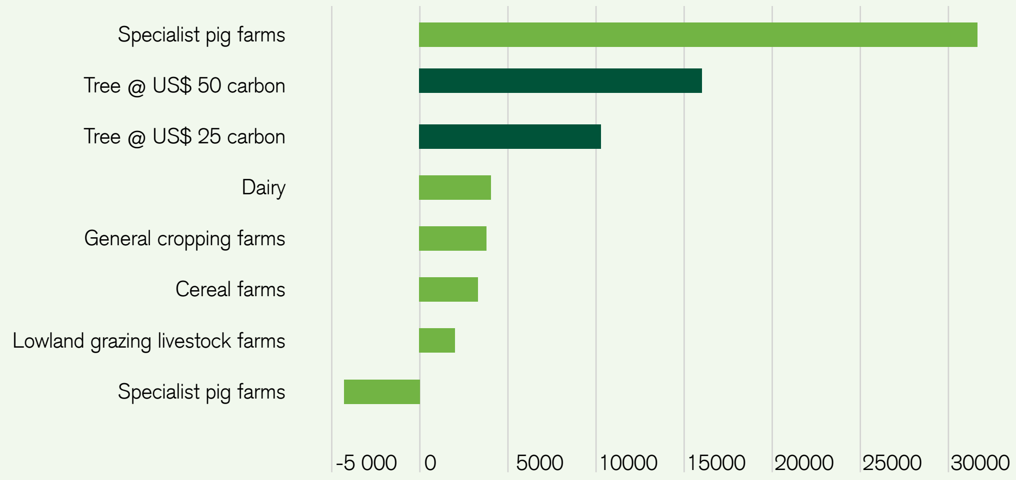
Key charts

Figure 1: Forests are highly relevant to fighting climate change: they absorb 30% of CO_2 emissions



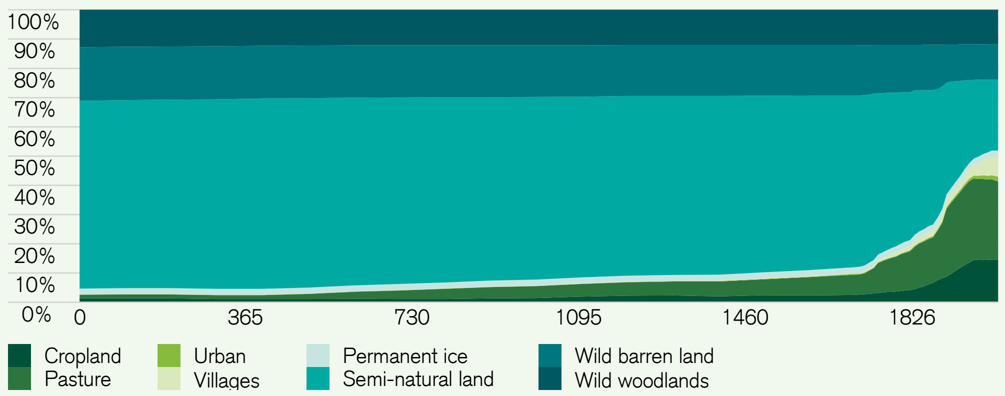
Source: World Resources Institute

Figure 4: Reforestation may provide farmers with a profitable new business line; we estimate that the NPV of planting trees is attractive compared to farming activities



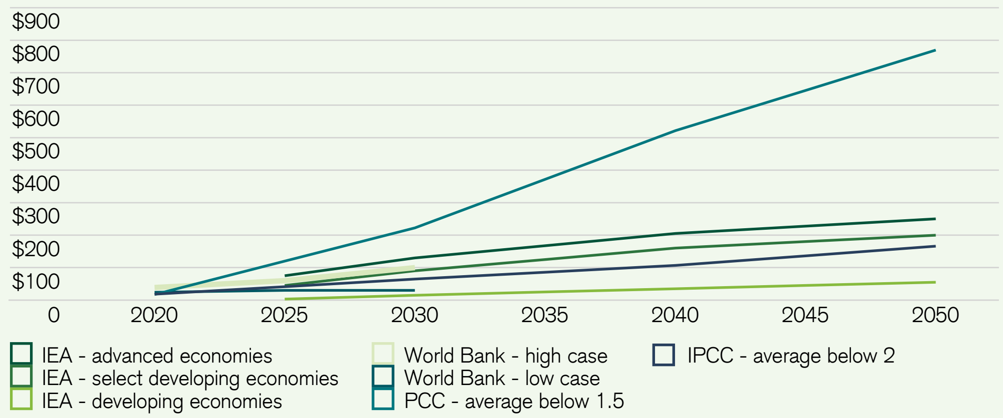
Source: Credit Suisse estimates

Figure 2: However, forested area globally has declined substantially; addressing climate change requires more trees



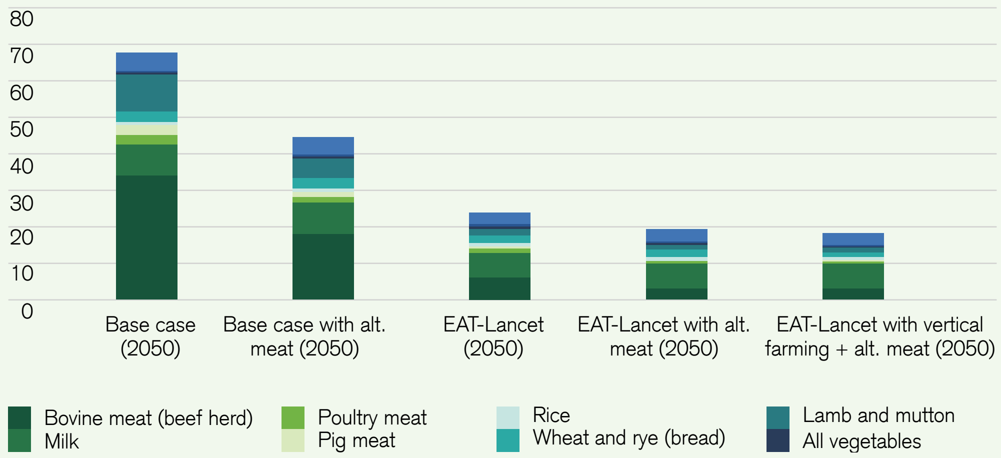
Source: Ellis, Beusen, Godewijk (2020)

Figure 5: A global carbon market is needed. Future carbon prices might be well in excess of the US$ 50/ton that we assumed for our NPV calculations (US$/ton CO_2 eq.)



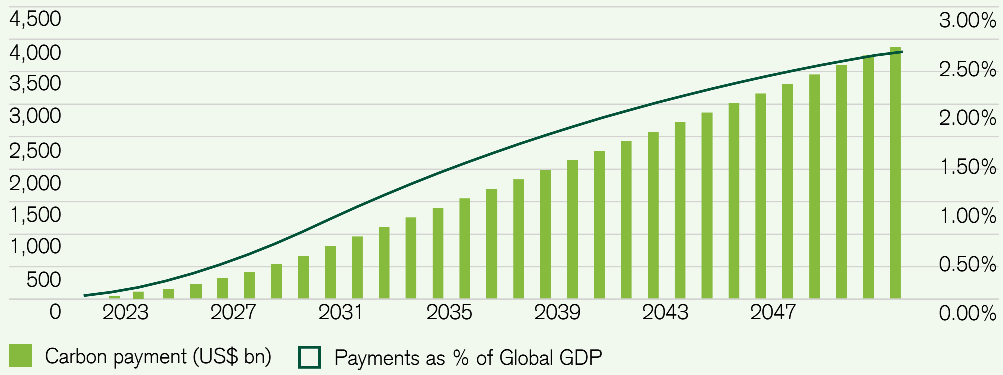
Source: IEA, World Bank IPCC, Credit Suisse research

Figure 3: Changing dietary habits and new food production technologies have the potential to free up a substantial amount of land that can be used for reforestation (m km²)



Source: Credit Suisse estimates

Figure 6: One way to achieve reforestation: Pay farmers so that they start planting trees and storing carbon; the cost of this appears low to us (farming subsidies could be used too)



Source: Credit Suisse estimates

Forests' role in combatting climate change

Forests play a key role when it comes to addressing climate change given that they currently absorb c30% of CO_2 emissions. However, deforestation activity since 1990 has resulted in the loss of c420 million hectares of forest. In this chapter, we outline how the forest carbon cycle works and highlight that tropical rain forests are crucial (particularly in countries such as Brazil, the Democratic Republic of the Congo, and Indonesia). We also estimate the carbon storage potential of a large-scale reforestation program.

Figure 7: Forests are key to addressing climate change as they currently absorb 30% of CO_2 emissions

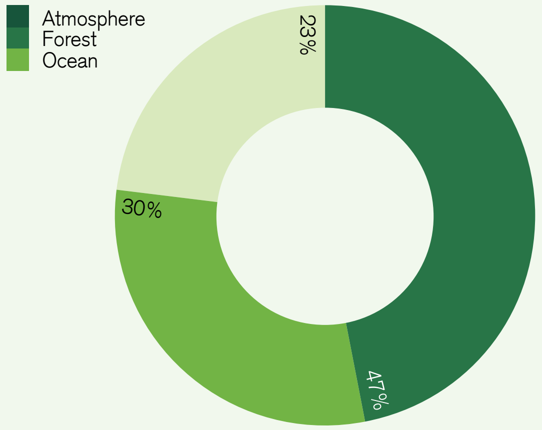
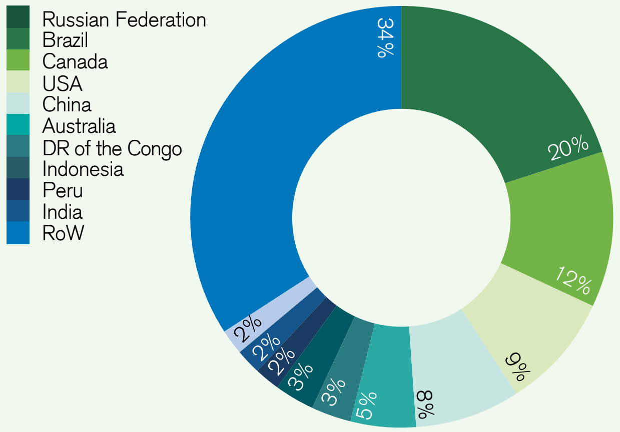


Figure 8: Global forest area by region: ten countries contain roughly two-thirds of all forests globally



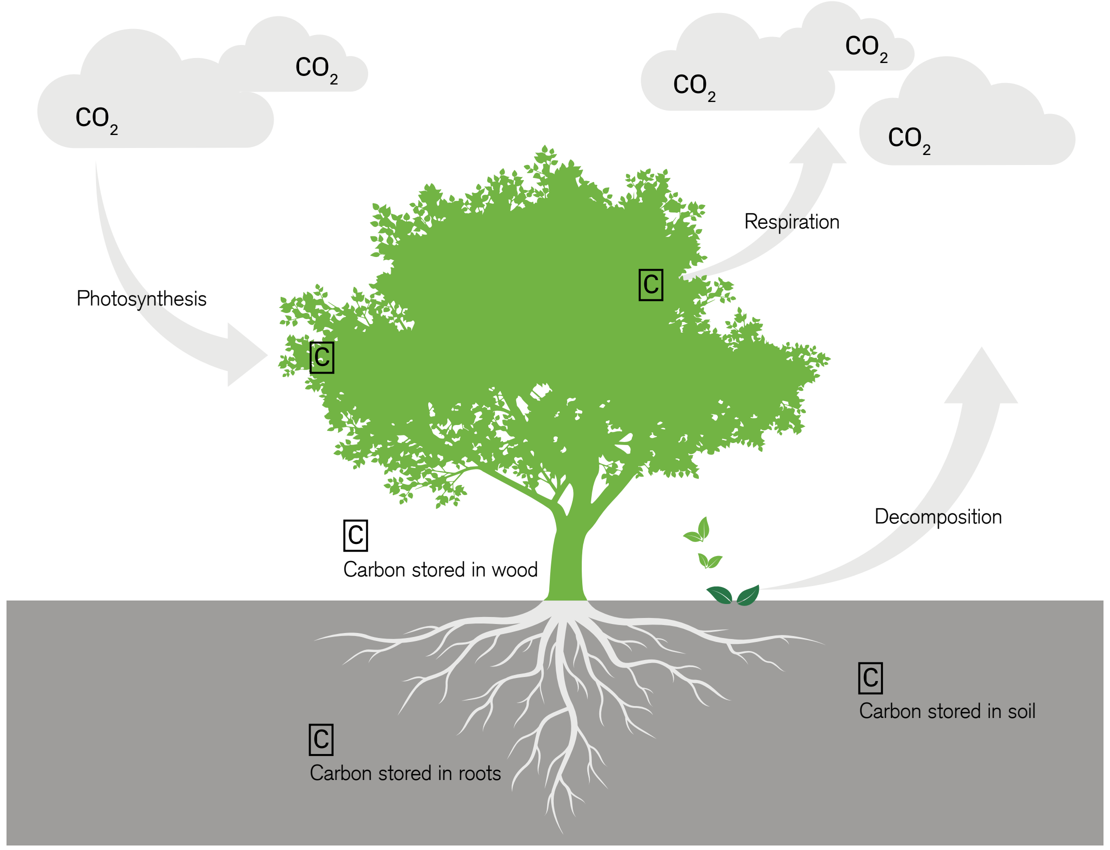
The forest carbon cycle

Forests and trees play a critical role in combatting climate change as they are natural "capturers" of carbon dioxide (CO_2), which is the primary culprit behind rising GHG emissions. Trees are able to absorb carbon through photosynthesis: the process of using a combination of energy from sunlight, water from roots, and CO_2 from the air to create sugar that is used to fuel the tree (i.e., build wood, branches, leaves, roots, etc.). While some of that carbon is used and returned to the atmosphere rather quickly (a process known as "respiration"), the carbon that is not respired gets stored throughout the tree, often for a long time. The tree keeps that carbon out of the atmosphere.

In fact, aside from water, wood is composed almost entirely of carbon and oxygen, making it an ideal "sink" for storing CO_2, which can continue for years after the tree dies. Leaves, on the other hand, release CO_2 more quickly after they have fallen off a tree. However, in both cases, the carbon ultimately breaks down and returns to the air as CO_2 (through a process known as "decomposition").

It is also worth noting that trees are not the only way forests capture and store CO_2. As carbon is found in all living organisms, CO_2 is also stored in soil, primarily through the remains of decomposing plant and animal tissue and other dissolved organic material – see Figure 9.

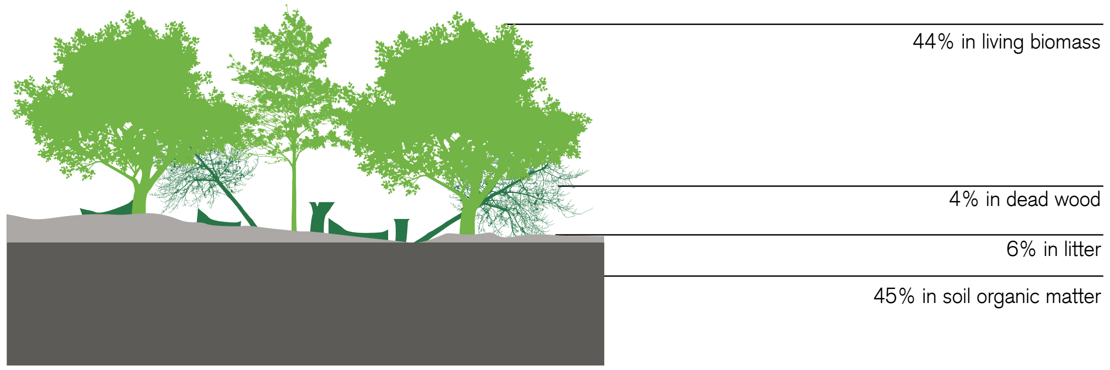
Figure 9: The forest carbon cycle



Source: Data Nuggets at Michigan State University - "Are forests helping in the fight against climate change?" by Fiona Jevon

Estimates of the amount of carbon stored in the world's forests vary significantly, ranging from ~550 Gt CO_2 (European Commission report) to ~1,100 Gt CO_2 (IPCC report). In its latest Global Forest Resources Assessment in 2020, FAO estimated the total carbon stock in forests to be 662 Gt CO_2. To put these figures in perspective, the amount of carbon added to the atmosphere as a consequence of human activities since 1870 is ~600 Gt CO_2, according to the Climate and Land Use Alliance. However, there does seem to be some consistency in terms of where the carbon in forests is found, with several studies (including FAO) estimating ~45% is in both biomass and soil organic matter and the remaining ~10% in dead wood and litter – see Figure 10.

Figure 10: Proportion of carbon stock in forest carbon pools, 2020



Source: Food and Agriculture Organization of the United Nations

There also seems to be some debate over how much carbon is stored in tropical vs boreal (arctic) forests, although the general view is that both store more than temperate (between tropical and boreal) forests. For example, a 2019 background analytical study prepared for the 14th session of the United Nations Forum on Forests cited a study from Science that found tropical and boreal forests are similar in terms of carbon stock density (242 and 239 tonnes of carbon per hectare, respectively), whereas temperate forests are ~40% lower (155 tonnes per hectare). Meanwhile, a report from the Canadian Boreal Initiative and the Boreal Songbird Initiative states that boreal forests store nearly twice as much carbon as tropical forests per hectare, and nearly seven times that of temperate forests. The discrepancies lie in the amount estimated to be in the soil beneath the ground, with an author of the latter study noting the amount and depth of carbon stored in and under the boreal forests is "greatly underestimated".

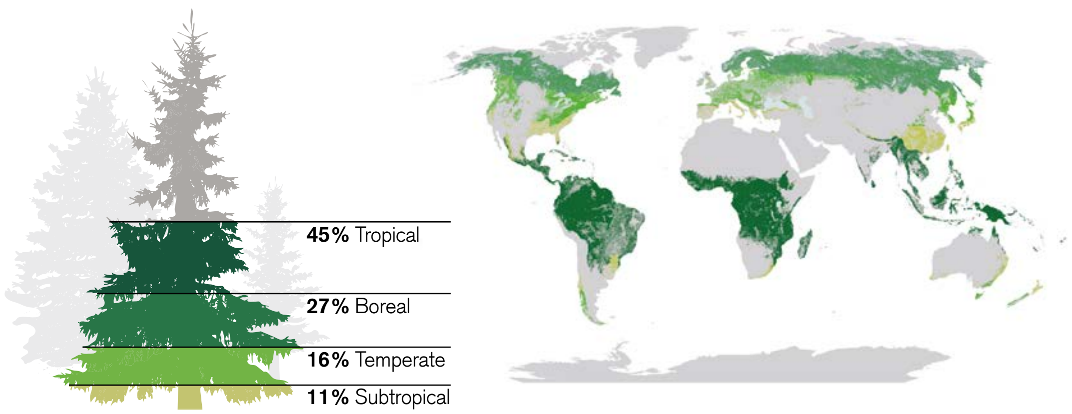
That said, it seems to be well understood that tropical forests store more carbon in biomass (~56% vs ~32% in soil, according to the Science study), whereas boreal forests store more carbon in soil (~60% vs ~20% in biomass). This intuitively makes sense, as tropical forests have more vegetation/trees/plants than boreal forests, while the latter's frozen conditions are more ideal for "storage" underground. From a climate change mitigation/environmental perspective, tropical forests also receive much more focus and attention than boreal forests as the majority of emissions due to deforestation (and thus the mitigation potential) and the world's biodiversity are from tropical regions.

Deforestation is a key challenge

According to the FAO, the world has a total forest area of c40 m km^2, which is ~37% of all habitable land. More than half (54%) of the world's forests are only in five countries – the Russian Federation, Brazil, Canada, the US, and China. Tropical forests represent the largest proportion of the world's forests (~45%), followed by boreal (~27%), temperate (~16%), and subtropical (~11%) – see Figure 11.

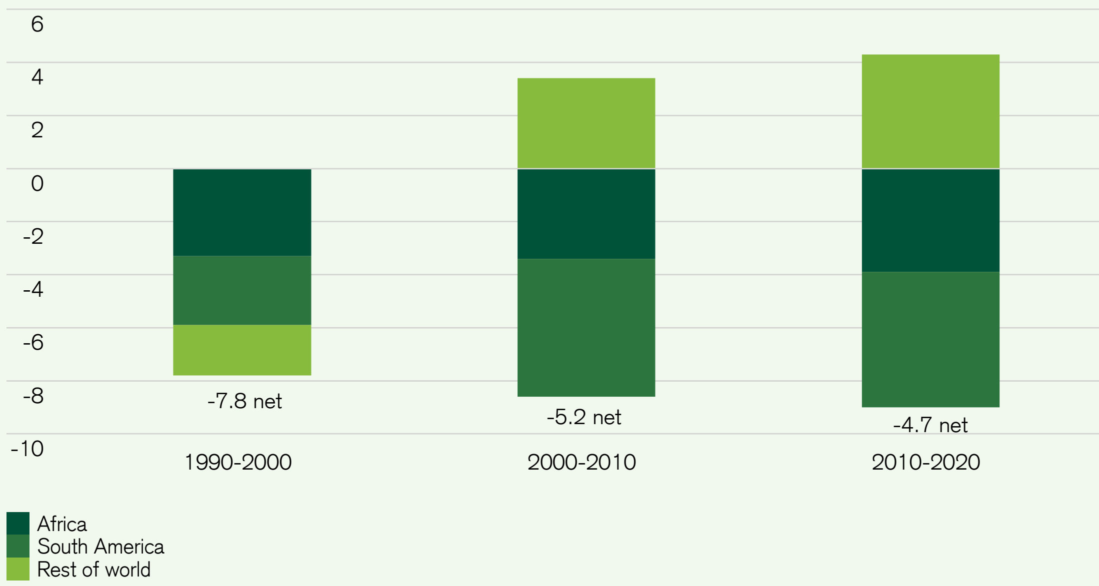
Data from the FAO suggest that the total area globally that is classified as forest has declined by c178 million hectares (1.78 m km^2) since 1990, or roughly the size of Libya. Somewhat positive, perhaps, is the fact that the rate of decline in forest area has decreased from c7.8 million hectares per year over 1990-2000 to c4.7 million hectares per year over 2010-2020. Nonetheless, two of the most important forest areas for carbon sequestration – Africa and South America – continue to experience reductions in forest areas (Figure 12).

Figure 11: Proportion and distribution of global forest area by climatic domain



Source: Food and Agriculture Organization of the United Nations

Figure 12: Global annual forest area net change by decade and region



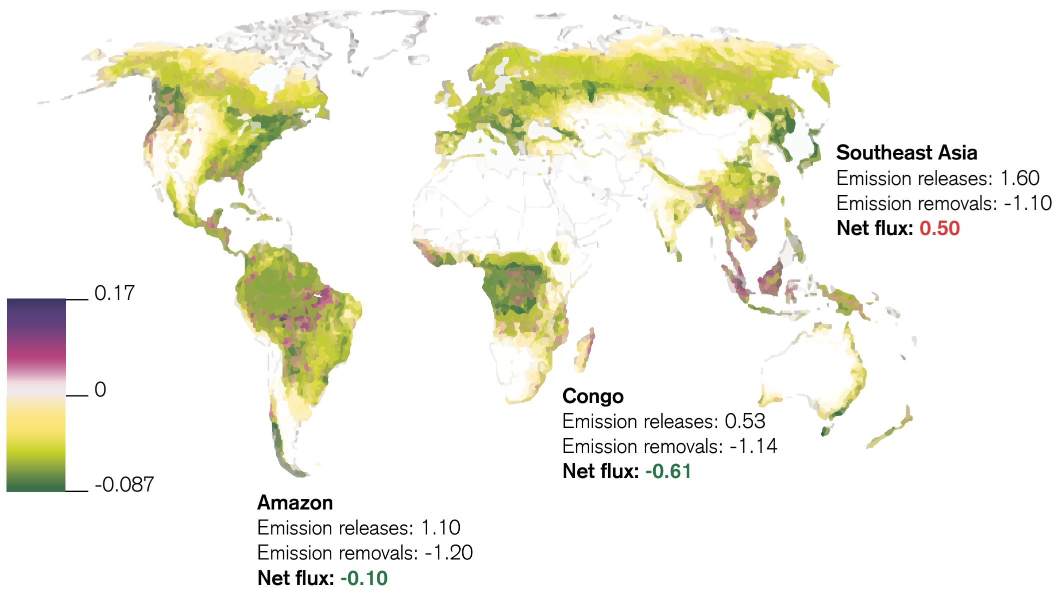
Source: Food and Agriculture Organization of the United Nations

The data shown in Figure 12 represent the net change in forest areas, or the difference between forest expansion and the area lost due to deforestation. Long-term data suggest that since the last ice age, about 2 billion hectares of forest land has been lost, which would be equivalent to roughly two times the size of the US. However, 75% of that loss took place during the past 300 years. Data from the FAO indicate that since 1990, a total of 420 million hectares of forest has been lost due to deforestation. This is roughly eight times the size of France, or almost half of the US. The rate of deforestation is declining, although at c10 million hectares annually per year during the past five years, it remains almost double the area of new forest created during the same period.

Given their relative size and carbon sequestration abilities, tropical forests are arguably the most important types of forests for mitigating climate change. This is also evident comparing Figure 11 with Figure 13. By far the world's two largest tropical rainforests are located in the Amazon (South America) and Congo River basin (Africa), which account for ~54% and ~17%, respectively, of the primary forests found across the tropics, according to the World Resources Institute. The majority of the remaining tropical rainforest coverage is a collection of forests across Southeast Asia.

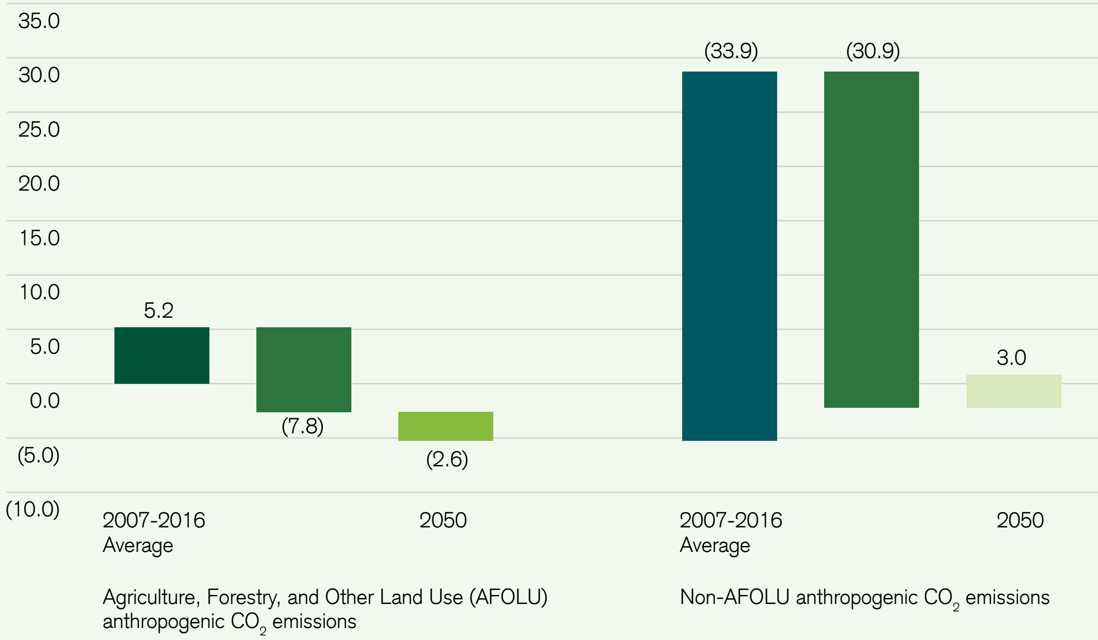
Figure 13 also shows that forests can be a net "source" (i.e., releasing) or a net "sink" (i.e., absorbing) of CO_2 depending on whether they are dying/being cleared or standing/regrowing, respectively. For example, a recent study published in Nature Climate Change also found that forests across Southeast Asia have collectively become a net source of carbon emissions over the past 20 years due to clearing for plantations, uncontrolled fires, and drainage of peat soils. While the Amazon remains a net carbon sink, the study suggests it is close to becoming a net source if forest loss continues at current rates. Meanwhile, despite relatively high levels of forest loss, the Congo's tropical forest remains a strong net carbon sink. This is why protecting and conserving such areas – particularly those that continue to absorb more carbon than they emit – is part of the fight against climate change conversation.

Figure 13: Net greenhouse gas fluxes from forests per year (2001–2019)



Source: Harris et al. 2021 / Global Forest Watch / Nature Climate Change / World Resources Institute

Figure 14: CO_2 emissions from AFOLU and Non-AFOLU sources – historical vs 2050 IPCC 1.5°C scenario



Source: IPCC, Credit Suisse research

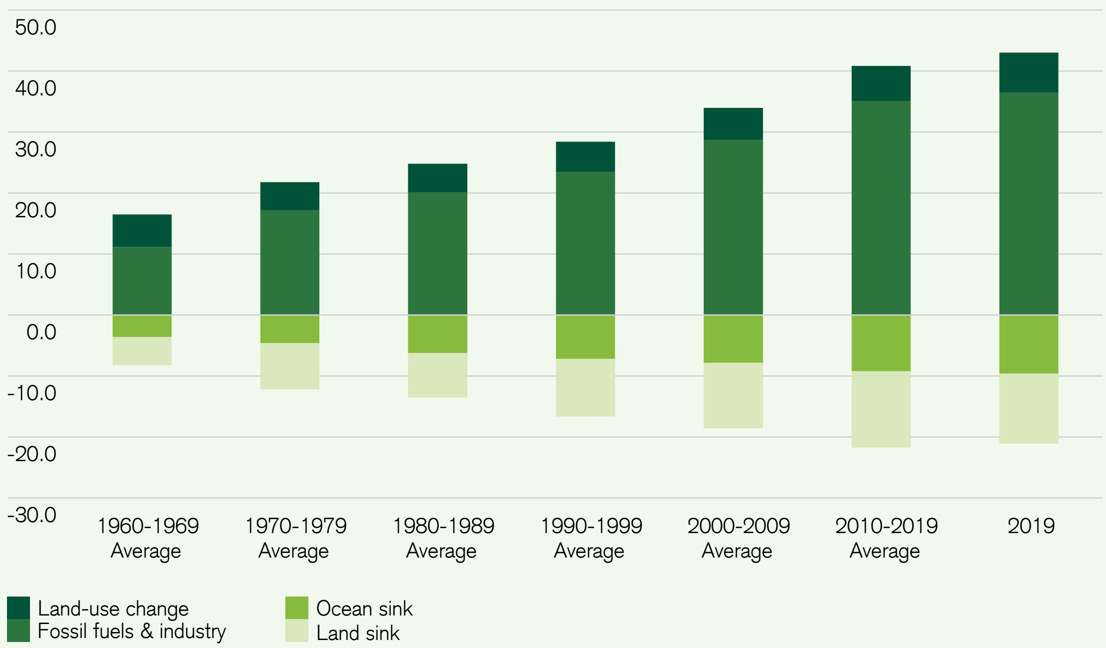
Carbon consumption of a tree

Typically when talking about emissions, investors are referring to greenhouse gas emissions, which are quoted in tons of CO_2 equivalent. While carbon dioxide makes up the majority of GHG emissions, we note that other gasses such as methane and nitrous oxide typically are included as well. In this note, we focus primarily on the carbon element, as this is what trees store. According to the Global Carbon Budget 2020, forests and trees currently sequester over 11 gigatonnes of carbon dioxide per year (Gt CO_2/year) which is equivalent to ~30% of anthropogenic global CO_2 emissions; this absorption process is known as the "land sink". Forests can also release CO_2 into the atmosphere when a tree dies and decomposes. This occurs naturally over time and as part of deforestation (i.e., "land-use change"). Overall, forests tend to absorb nearly twice the amount of carbon they emit, according to a study published in Nature Climate Change. Oceans also play a key role, absorbing on average ~20% of human-induced global CO_2 emissions – i.e., the "ocean sink". Combined, these two natural sinks currently absorb roughly half of anthropogenic CO_2 emissions, underscoring the critical role of nature in curbing climate change. We would note that the focus of the Paris Agreement is only on anthropogenic emissions and removals. As such, ocean sinks and unmanaged lands are excluded from measures of anthropogenic removals, though they are still important in global climate balances. From anthropogenic sources, absolute emissions (e.g., fossil fuels and deforestation) are far greater than anthropogenic removals (e.g., planting trees). A report from the IPCC estimated that anthropogenic CO_2 emissions averaged 39.1 Gt CO_2/year in 2007-2016, of which agriculture, forestry, and other land use (AFOLU) contributed a positive 5.2 Gt CO_2/year. Under the 1.5°C Paris-aligned scenario, AFOLU would need to reach a negative 2.6 Gt CO_2/year from mitigation measures such as livestock management, reduction of deforestation, afforestation, and reforestation efforts.

As can be seen in Figure 15, the land sink has increased from ~4.5 Gt CO_2/year during the 1960s to ~12.5 Gt CO_2/year in the most recent decade (2010-2019). Interestingly, this rise in the amount of CO_2 absorption is largely a function of the rise in human-induced CO_2 emissions. In this process (known as "carbon dioxide fertilization"), the higher human-induced CO_2 emissions increase the rate of photosynthesis in plants and thus increase their CO_2 intake. However, other climate impacts from increased CO_2 levels such as reduced precipitation/more droughts and higher temperatures can weaken the land sink, which appears to be happening.

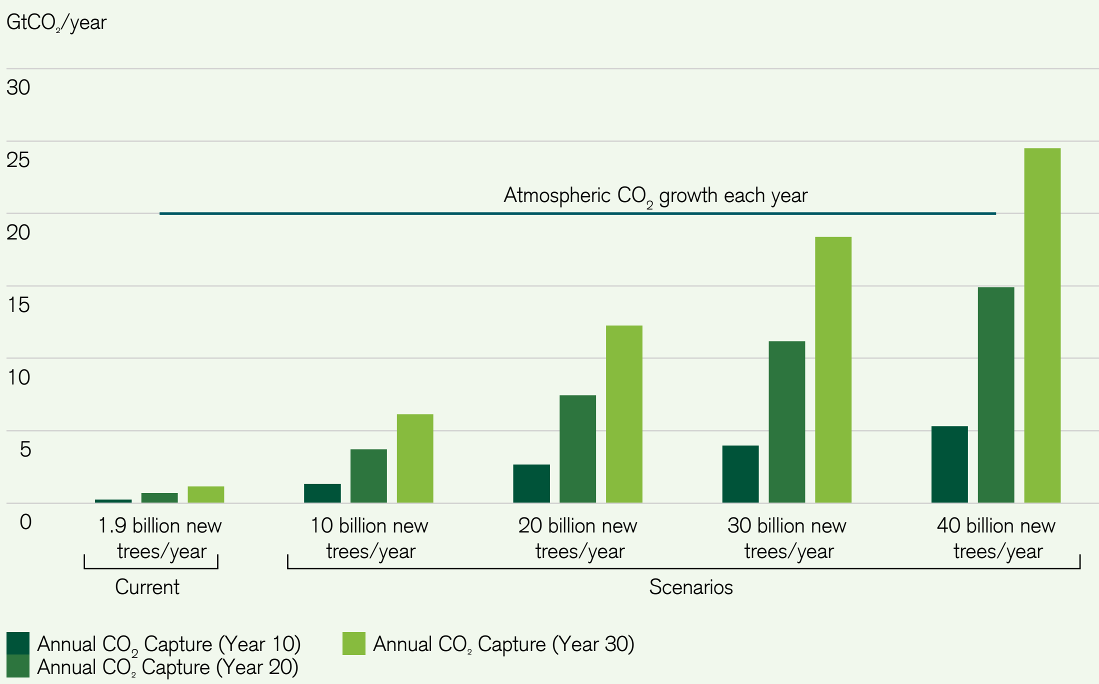
While the land sink does fluctuate from year to year, it is worth noting that for the first time since 1960, the land sink decreased for three consecutive years during 2017-2019. This was also confirmed in a recent study published in Science which found that as CO_2 in the atmosphere increases, the majority (~86%) of land ecosystems around the world are becoming progressively less efficient at absorbing it, which in turn could lead to a further reduction in the available "carbon budget" (i.e., remaining allowable emissions in order to limit global warming to <1.5°C or <2.0°C).

Figure 15: Average annual global CO_2 emissions by human sources (positive) and natural removals (negative) over time



Source: The Global Carbon Budget 2020

Figure 16: Hypothetical scenarios of incremental annual CO_2 capture based on new trees planted



Source: Credit Suisse research, The Global Carbon Budget 2020

With forests and trees having the natural ability to remove human-induced CO_2 from the atmosphere, the United Nations Environment Programme (UNEP) aims to plant one trillion new trees worldwide as part of the fight against the climate crisis. Other organizations and corporations have also committed to planting new trees as a way to "offset" their own carbon footprints. Thus, as part of our work, we sought to better understand the impact that planting new trees could have on mitigating additional carbon emissions and thus climate change.

On average, a "typical" young and mature (at ten years old) tree can absorb CO_2 at a rate of ~13 pounds (or ~5.9 kg) and ~48 pounds (or ~22 kg), respectively, per year. This is consistent with studies from the US Geological Survey (USGS) and University of Hamburg (UH), which have shown that in general the older the tree, the greater its potential to store CO_2. Notably, the latter study suggests that ~70% of all the CO_2 stored in trees accumulates in the back half of their lives. This could be because trees grow more quickly as they age and thus have a far greater number of leaves to absorb CO_2 (USGS study), and/or older trees are taller and reach the top of the canopy, thereby absorbing more sun/CO_2 from the atmosphere (UH study). Moreover, the UH study suggests younger trees are more sensitive to variations in rainfall and sunlight than older trees.

Using these figures, we have looked at hypothetical scenarios to get a sense for how much incremental CO_2 could be captured based on the number of new trees planted each year. According to the UNEP, around 1.9 billion new trees are planted each year around the world, which we hypothetically see capturing an incremental ~0.25 Gt of CO_2 per year after ten years, steadily increasing to ~1.16 Gt per year after 30 years. We would note this is consistent with data from the aforementioned study published in Nature Climate Change that showed forests/trees that have been planted in the last 19 years represent less than 5% of the current global forest carbon sink. Assuming the number of trees planted each year were to increase five-fold to ~10 billion new trees each year, hypothetically we could see the figures increase to ~1.3 billion tons of CO_2 per year after ten years and ~6.1 Gt of CO_2 per year after 30 years. These and the other scenarios we looked at can be seen in Figure 16.

We make several observations based on the figure above: 1) the annual CO_2 capture figures are (if anything) overstated, as they do not account for trees dying and the weakening impact global warming is having on the land carbon sink; 2) even if the rate of tree planting globally increased from the current run rate of ~1.9 billion per year to a staggering ~20-40 billion per year, it would take 20-30 years for these trees to start to have a meaningful impact on capturing human-induced CO_2 emissions; 3) even if the overstated annual capture figures are accurate, they imply planting ~30-40 billion new trees per year will only cancel out the increased CO_2 emissions we see today after ~30 years, while in the interim emissions will continue to build in the atmosphere (all else equal). For example, despite GHG emissions falling YoY in 2020 due to pandemic-driven shutdowns, atmospheric CO_2 levels (which ultimately need to fall to halt the rise in global temperatures) continue to rise, reaching their highest level in >4 million years during May at ~419 CO_2 molecules for every million molecules (i.e., parts per million), according to the Scripps Institution of Oceanography.

Thus, we come to the realization that while planting new trees is an important endeavor to protect the environment/biodiversity and help mitigate climate change (particularly in the long term), the urgency of reducing global emissions (which by some estimates need to halve this decade to be on a ~1.5-2.0°C pathway) requires a focus on reducing fossil fuel consumption and maintaining existing forests that are already maximizing the amount of carbon being sequestered. If the latter continues to deteriorate, it will simply accelerate the rise in global temperatures as atmospheric CO_2 levels continue to build (all else equal).

Forests and current net zero pathways

The previous section showed that forests play a vital role in decarbonizing the world to net zero emissions so as to mitigate the effects of climate change. In order to help guide policymakers in developing regulation aimed at achieving net zero emissions, so-called global emission pathways have been developed. These pathways reflect the fact that we are unable to reach absolute zero emissions. Therefore, forests and other carbon dioxide removal technologies are required to offset remaining anthropogenic emissions.

In this chapter we review how official bodies such as the IPCC incorporate the role of forests in their net zero pathways. Specifically this section looks at the volume of forests relied upon for carbon dioxide removal in IPCC net zero scenarios and in so doing raises questions as to the implications of the land use change.

Current land use and global emissions

The total land mass on Earth is 149 m km^2 and the ice-free land area is 130 m km^2. Humans use over 50% of global ice-free land as built-up land (which includes cities and urban areas), pastures, and cropland. Pastures, including permanent pastures, and meadows, are the single greatest land-use, accounting for 37% of total ice-free land. Cropland, defined as all land in food, feed, and fodder crops as well as arable land, accounts for 12% of total ice-free land. Forests, including both managed and unmanaged, account for under a third of total land, and natural land, including grassland, savannah and shrubland, accounts for 7%.

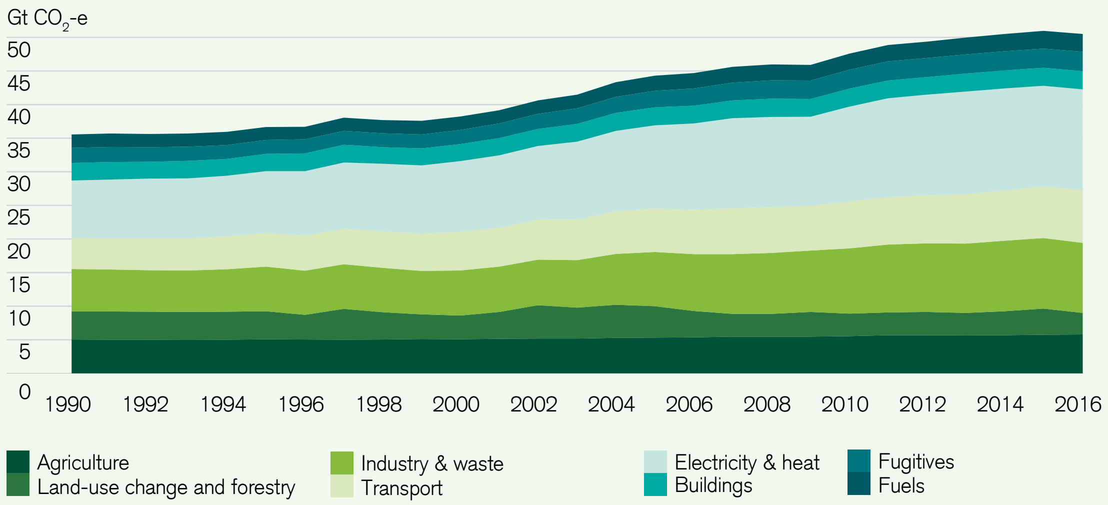
Global GHG emissions are just over 50 Gt CO_2e per year. Given current land use, Agriculture, Forestry and Other Land Use AFOLU activities account for 18% of anthropogenic emissions. Land is simultaneously a source and a sink of CO_2 due to both anthropogenic and natural drivers, making it hard to separate anthropogenic from natural fluxes.

Global models estimate land had net CO_2 emissions of 5.2 ± 2.6 Gt CO_2 per year from land use and land-use change during 2007–2016. These net emissions are mostly due to deforestation, partly offset by afforestation/reforestation, and emissions and removals by other land use activities.

Figure 17: Current global land use of ice-free land

Source: FAO, IPCC, Credit Suisse estimates

Figure 18: Current emissions and abatement gap



Source: IPCC, Credit Suisse research

IPCC net zero scenarios and land use

The IPCC is the United Nations body for assessing climate-related science and its research is the most authoritative for climate futures, mitigation, adaptation, and policies including carbon prices. In its Assessment Reports, the IPCC uses representative concentration pathways (RCPs) to describe different climate futures.

Each RCP represents a GHG concentration trajectory and each Assessment Report details the impacts, and required adaptation and mitigation for each RCP. Only two of the RCPs reach net zero by 2050. RCP2.6 provides a 66% chance of limiting a global mean temperature rise to below 2°C and RCP1.9 provides a 50-66% chance of limiting a rise to 1.5°C. We have chosen to demonstrate how land use changes under the RCP1.9.

In addition to its Assessment Reports, in 2019 the IPCC released a special report on Climate Change and Land, addressing both how land use needs to change to mitigate climate change under some scenarios and how it will be affected under different climate futures. We use the modelling completed as part of the special report into land to understand the implications of how land use needs to change by applying the modelled growth rates for emissions and subsequent land use change between 2020 and 2050 in each scenario to current actuals.

Using the IPCC land use report, we analyse how land use and emissions change under the IPCC RCP1.9 net zero pathway. One of the new frameworks used in conjunction with the RCPs in the IPCC Integrated Assessment Models are the Shared Socio-economic Pathways (SSPs). In scenarios under the SSP framework, each RCP can be modelled with the five SSPs, with each SSP describing distinct narratives about how societal choices, demographics, ideologies, and economics will affect emissions and climate action. There are over 100 climate models using the SSPs, so to illustrate how land use and emissions change under the different scenarios, we have selected two of the SSPs under the 1.5°C scenario.

1. **SSP1 is Sustainability – Taking the Green Road** describes a world that shifts towards sustainable practices, reducing inequality and respecting environmental boundaries, which is reached through global cooperation reducing challenges to mitigation and adaption.

2. **SSP5 is Fossil-fueled Development – Taking the Highway** is a resource-intensive pathway for economic and social development with a heavy-reliance on geo-engineering for climate action creating high challenges to mitigation but low challenges to adaptation.

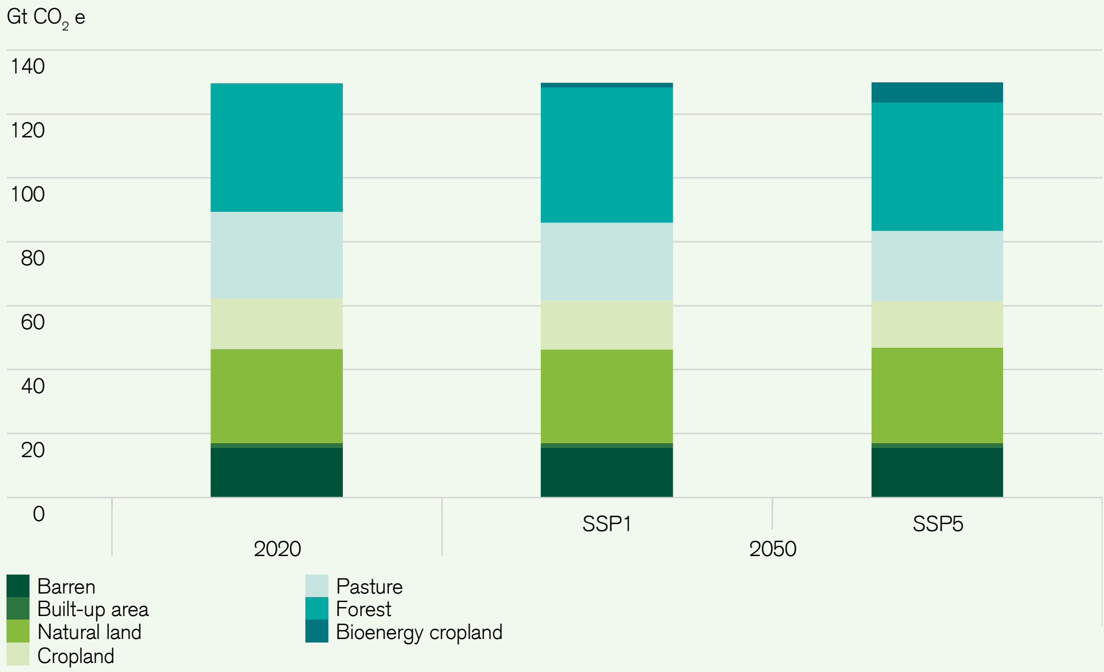
Land use

IPCC includes Bioenergy Cropland in its definition of land. Bioenergy Cropland refers to land dedicated to bioenergy crops including switchgrass, miscanthus, and fast-growing wood species. Traditional bioenergy crops like corn and sugarcane are included under Cropland.

To reach a net zero future under a 1.5°C pathway requires a decrease in anthropogenic usage of land and changing the use of natural land to make way for specific sequestration activities. The degree of land use change differs between the two SSP scenarios, with greater changes required under the resource-driven SSP5 compared with the SSP1.

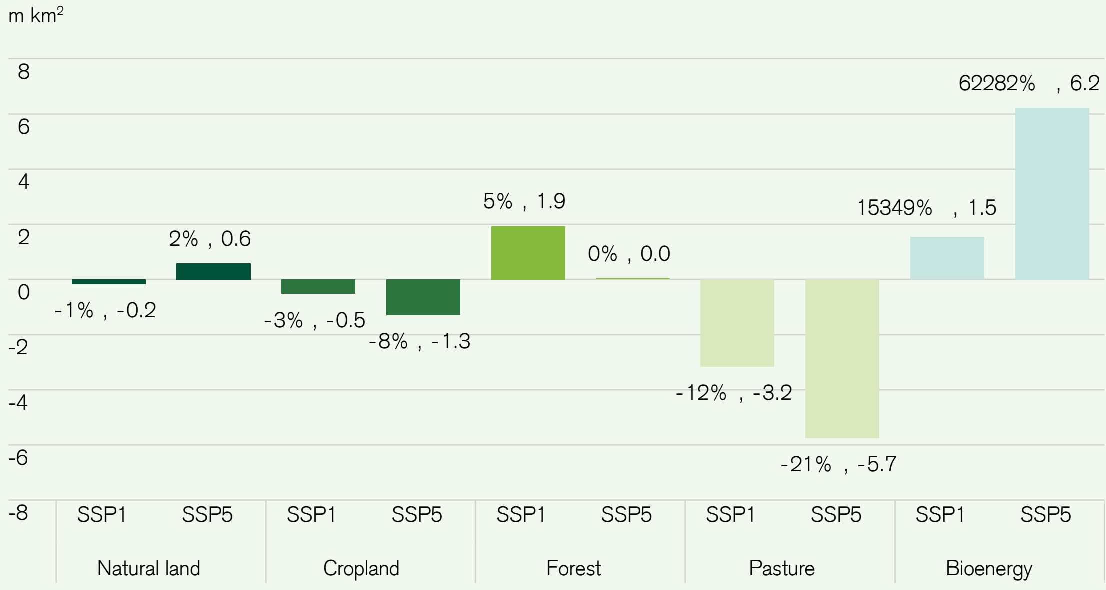
Under the SSP1, a 3% decrease in cropland and a 12% decrease in pasture are required to account for increases in forest cover and bioenergy cropland. Under SSP5, decreases are even greater, on top of an 8% reduction in cropland, a 21% reduction in pasture land is required to account for increases in bioenergy sequestration. In total, reaching net zero requires an additional 3.3 m km^2 of land for bioenergy, with carbon capture and storage (BECCS) and Forestry under SSP1 and 6.2 m km^2 under SSP5. The difference in the magnitude of required land change is related to the overreliance on fossil fuels under SSP5, which relies on measures to offset and sequester emissions rather than completely abate them through low-carbon technologies.

Figure 19: IPCC land use mix



Source: FAO, IPCC, Credit Suisse estimates

Figure 20: Change in land use types

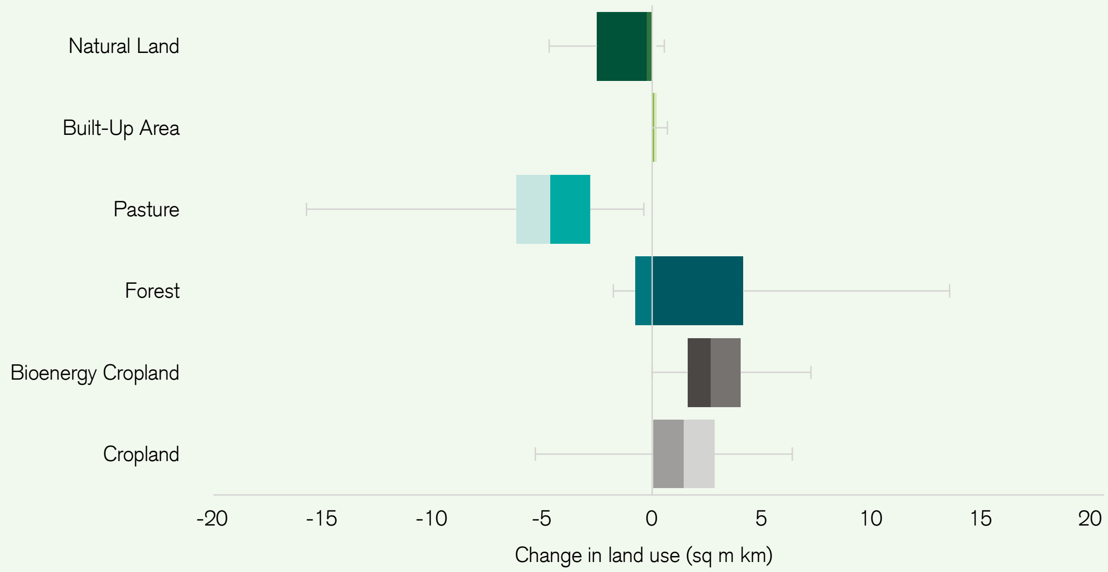


Source: FAO, IPCC, Credit Suisse estimates

The results above are only for two of the net zero pathways under the SSP framework. When we consider over a hundred net zero pathways under the IPCC land use report, the land use change estimates vary greatly. In Figure 21 below, we illustrate the scale to which the land use changes vary under different scenarios. The results echo the findings above in that the traditional forms of anthropogenic land use are affected by land demanding mitigation options such as bioenergy, avoided deforestation, or afforestation. At the extremes, pasture land can decrease by as much as 16 m km^2 while cropland can decline by 6 m km^2. Encroachment on natural land is in a range of 0-5 m km^2.

It is important to note that under the complete universe of scenarios, there are many models, variables, and assumptions that can differ and contribute to the diverse scenario outputs. The power of this analysis is that it enables us to visualize the spectrum and potential scale of the change that could take place, rather than predict or make judgements as to what is required.

Figure 21: The range of land use change estimates under the IPCC net zero pathways



Source: IPCC, Credit Suisse estimates. NB: Shaded boxes represent the interquartile range, and the whiskers represent the minimum and maximum values.

Emissions

Under SSP1, net zero is reached through a combination of bioenergy with carbon capture and storage (BECCS, 5 Gt CO_2e), carbon capture and storage solutions (CCS, 7 Gt CO_2) and land use sequestration (3 Gt CO_2e). Under SSP1, anthropogenic emissions reach 8 Gt CO_2e by 2050. In other words, between now and 2050, an increase of 1.6 m km^2 of land used for BECCS abates 5 Gt CO_2 per year by 2050, while an increase of 1.9 m km^2 of forestry land abates an additional 1.5 Gt CO_2 per year by then.

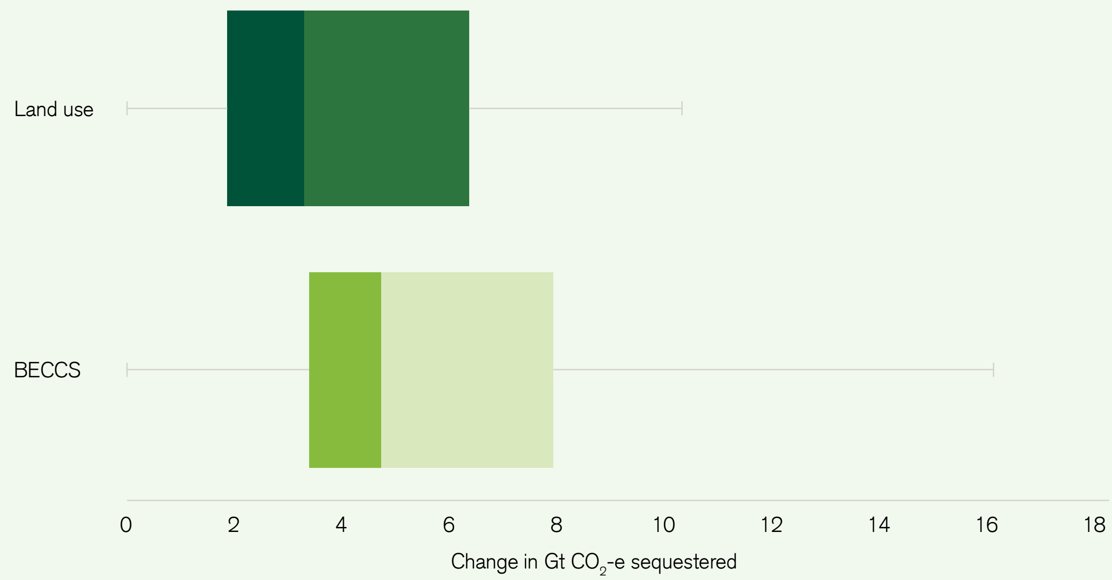
Under the resource-intensive SSP5, total emissions remain higher for longer, relying on steeper abatement through rapid deployment in BECCS. By 2050, BECCS is the primary sequestration method, abating 16 Gt CO_2 from the 6.2 m km^2 of land, or the equivalent of 25% of the current abatement gap.

Figure 22: Emissions and sequestration trajectory under 1.5 degree scenarios

Source: IPCC, Credit Suisse estimates

Repeating the approach for land use change, we analysed the range of BECCS and land use sequestration under net zero scenarios. For land use, the median abatement is 3 Gt CO_2 from current levels; however, the uncertainty around this appears high as abatement ranges from 0 to 10 Gt CO_2, or the equivalent to 20% of the current abatement gap to reach net zero. For BECCS the range is more varied, ranging from 0 to 16 Gt CO_2, with a median of just under 5 Gt CO_2, or roughly 10% of the current abatement gap.

Figure 23: Distribution of sequestration options under IPCC net zero scenarios



Source: IPCC, Credit Suisse estimates. NB: Shaded boxes represent the interquartile range, and the whiskers represent the minimum and maximum values.

The IPCC pathways assume that current land use will have to change in order to achieve long-term net zero targets. The question now is whether scenarios exist that imply an even greater decline in land use than currently assumed by the IPCC. If so, this would support a greater degree of carbon capture than is currently incorporated into the IPCC pathways. In the next section, we will outline such a scenario.

Changing land use aids carbon storage

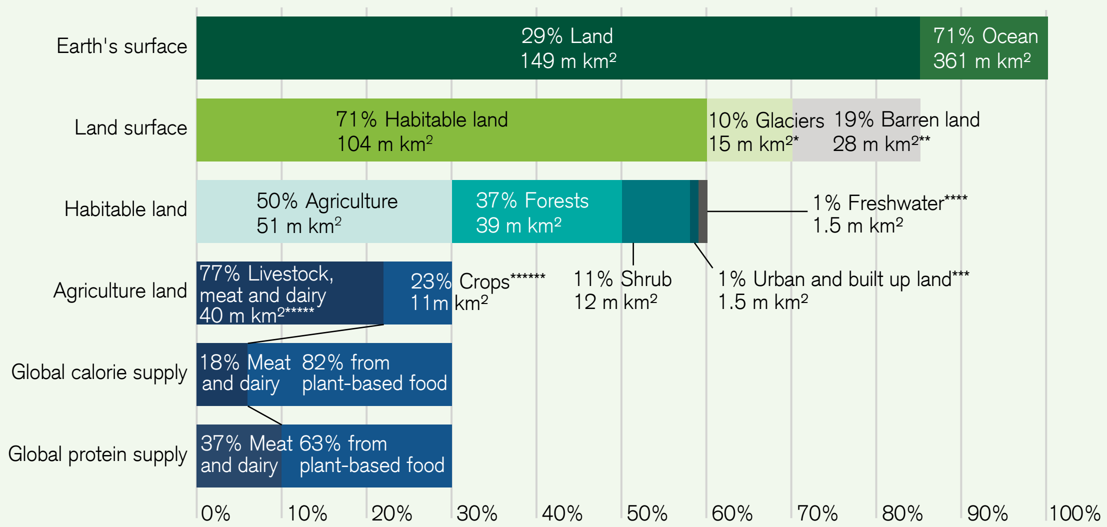
In the previous sections, we outlined that forests play a key role in the quest for carbon storage and reaching longer-term climate change targets. Although reforestation and change in land use are incorporated into existing net zero pathways such as those developed by the IPCC, it remains unclear whether and how the size of forests can be increased going forward in order to help increase carbon storage and meet long-term climate change targets.

The role that the global food system plays is key in this regard, given that current food production and consumption accounts for more than 20% of GHG emissions and c50% of habitable land. However, the world faces a number of existential challenges that increase the relevance of the food system for the topic of reforestation even more. These challenges include the prospect of having to substantially increase food production in order to eliminate undernourishment, which currently affects c700 million people, and feed a population that looks set to grow to c10 bn by 2050 from fewer than 8 bn currently. In this section we review the interplay among land-use, agriculture, and the potential for carbon sequestration.

The battle between forests and agriculture

The outlook for natural carbon sequestration looks challenging if history is to be a guide. Data from Ellis et al (2020) show the impact that the growth in agricultural land has had on the land mass available for natural areas. Figure 25 shows that total agricultural land use has grown exponentially during the past 150 years. In fact, since 1900 the expansion of agricultural land has been particularly strong in Asia (+167%) and Latin America (+210%). The combination of population growth and increased spending power suggests that agricultural land demand is unlikely to slow down unless changes are made to food consumption and production. Until then, further growth is likely to come at the expense of land mass occupied by forests and other nature-based, carbon-removing solutions.

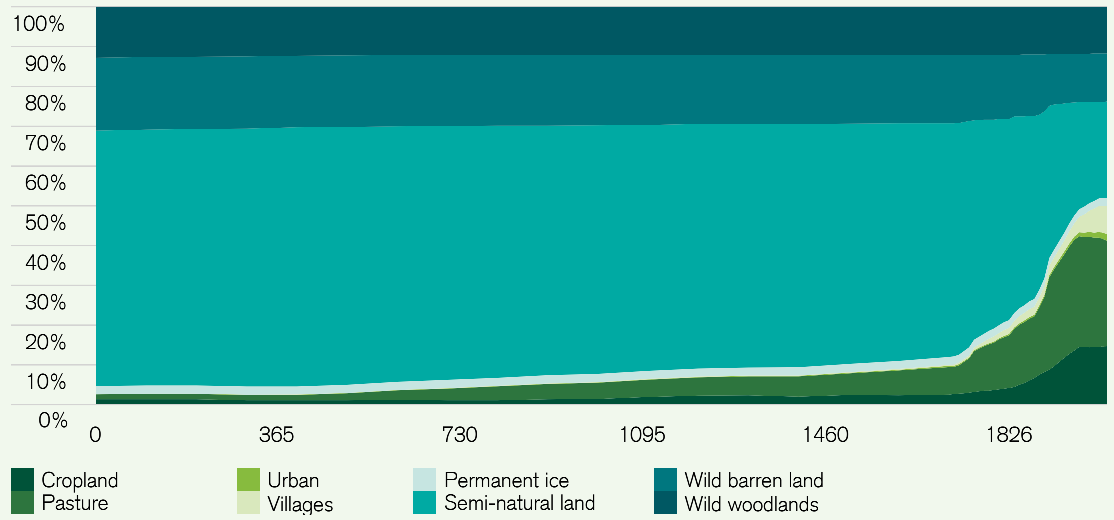
Figure 24: Agriculture makes up 50% of all habitable land



* 14 m km² of which is the land area of Antarctica
** This includes the world's deserts, salt flats, exposed rocks, beaches, and dunes
*** This includes settlements and infrastructure
**** Lakes and rivers
***** This includes grazing land for animals and arable land used for animal food production
****** Excluding feed

Source: FAO

Figure 25: The share of forests has declined through time

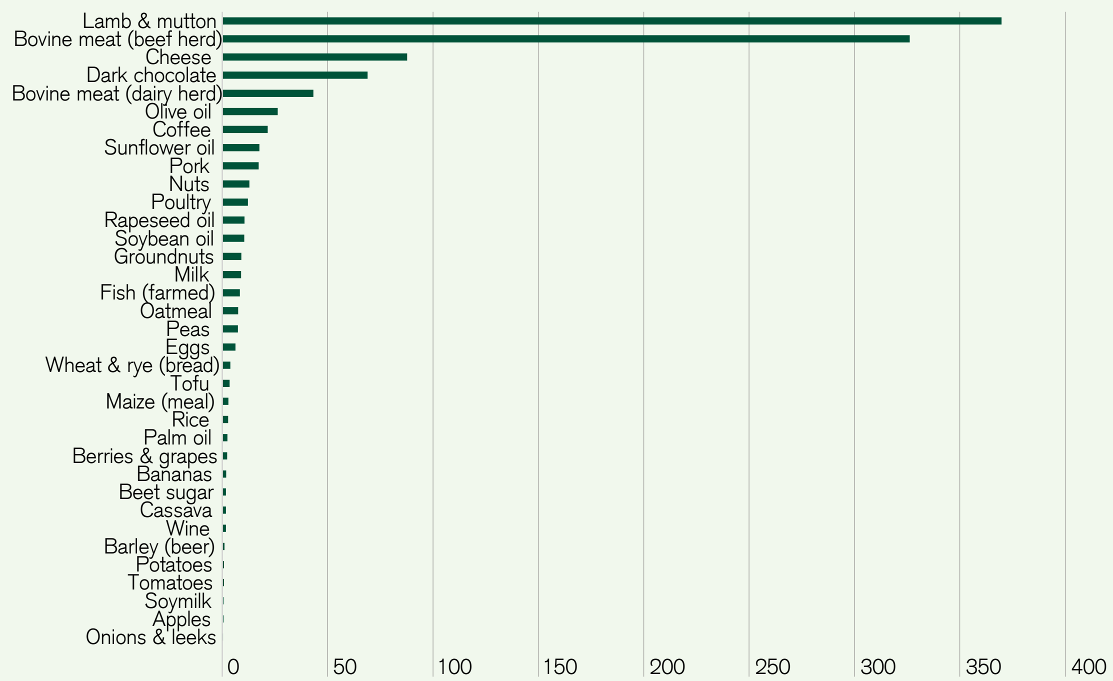


Source: Ellis, Beusen, Godewijk (2020)

What drives agricultural land demand

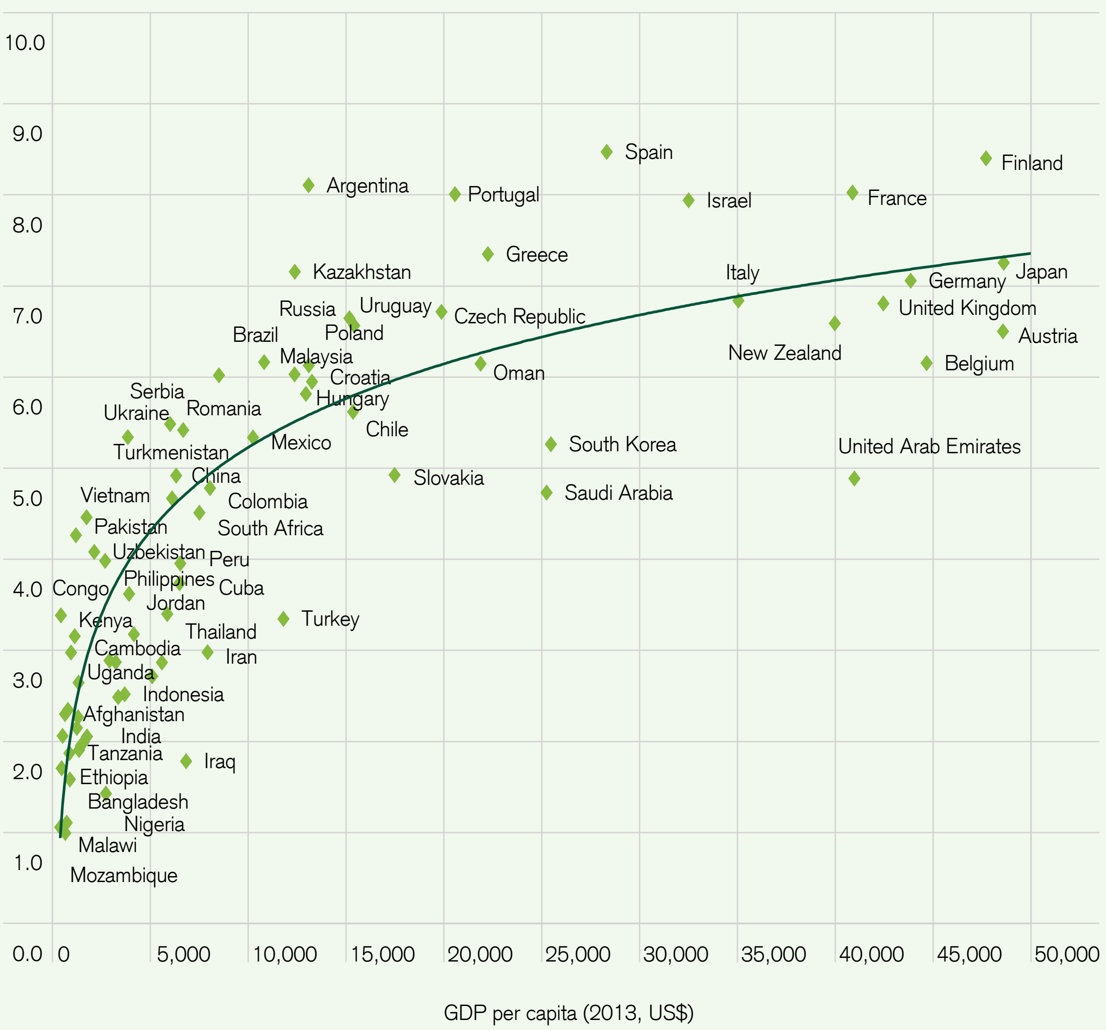
The rise in land mass used for agricultural purposes is related to global food consumption. Demand for food has increased as the world's population has increased from c1.6 bn in 1900 to c7.8 bn currently. In addition, average spending power across an increasing number of regions and countries has increased as well, enabling consumers to increase their spending on food, and particularly food items that require a lot of land. As Figures 26 and 27 show, an increase in income correlates with greater consumption of animal protein, which is the food group that has the highest land intensity per kilogram of produced product.

Figure 26: Land use (m²) per kilogram of product



Source: Poore and Nemecek (2018)

Figure 27: Animal-based protein consumption vs income



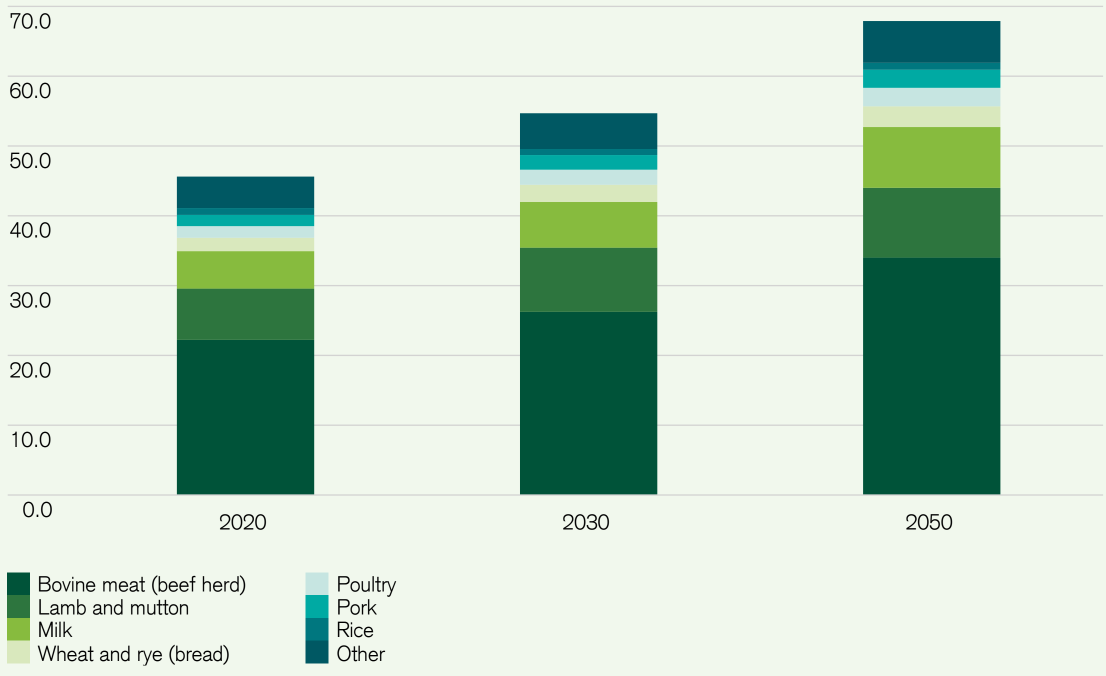
Source: Ellis, Beusen, Godewijk (2020)

Deforestation trends may worsen if no action is taken

Historically, deforestation trends have been damaging enough as far as their impact on carbon sequestration is concerned. However, these trends might actually worsen from here if no action is taken. The reason for this was outlined in our recent publication on sustainable food (see Credit Suisse Research Institute: The global food system - Identifying sustainable solutions).

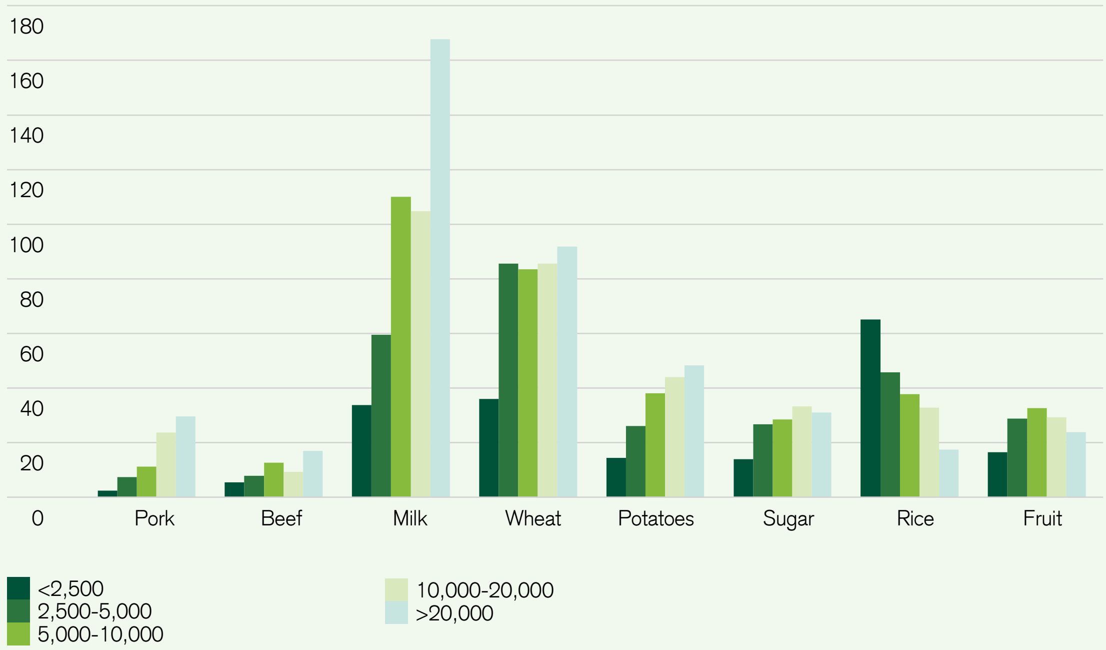
The global population is expected to increase to c10 bn by 2050 (United Nations estimate). In addition, we believe that the middle class across developing countries is likely to continue to expand. These two factors combined are likely to result in a strong increase in demand for food in general and especially for food for which a lot of agricultural land is needed. In our report on sustainable food, we outlined that an additional 22 m km^2 of agricultural land would be needed to produce the amount of food associated with this scenario. This is an increase of close to 50% from current levels and equates to 56% of the world's current forest coverage of 39 m km^2. This calculation shows that addressing deforestation and GHG emissions requires a change in consumption patterns.

Figure 28: Land demand to feed the global population (m km^2)



Source: Credit Suisse research

Figure 29: Per capita consumption (kg) of certain food items grouped by average GDP/capita (US$)

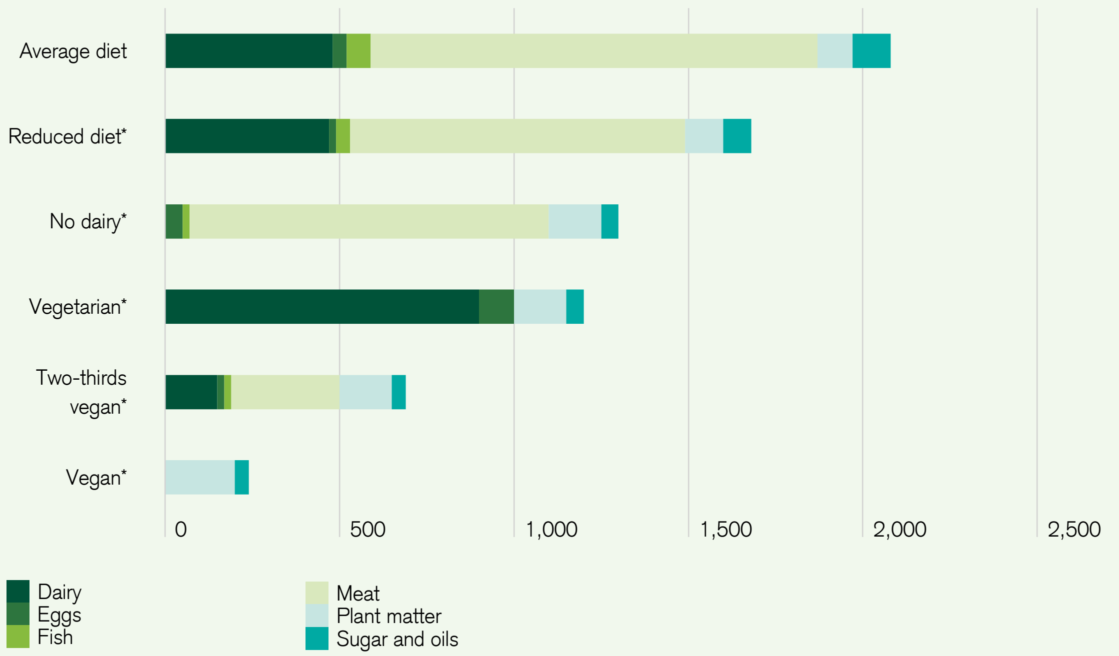


Source: World Bank, Poore and Nemecek (2018), Credit Suisse estimates

Healthy food consumption and reforestation potential

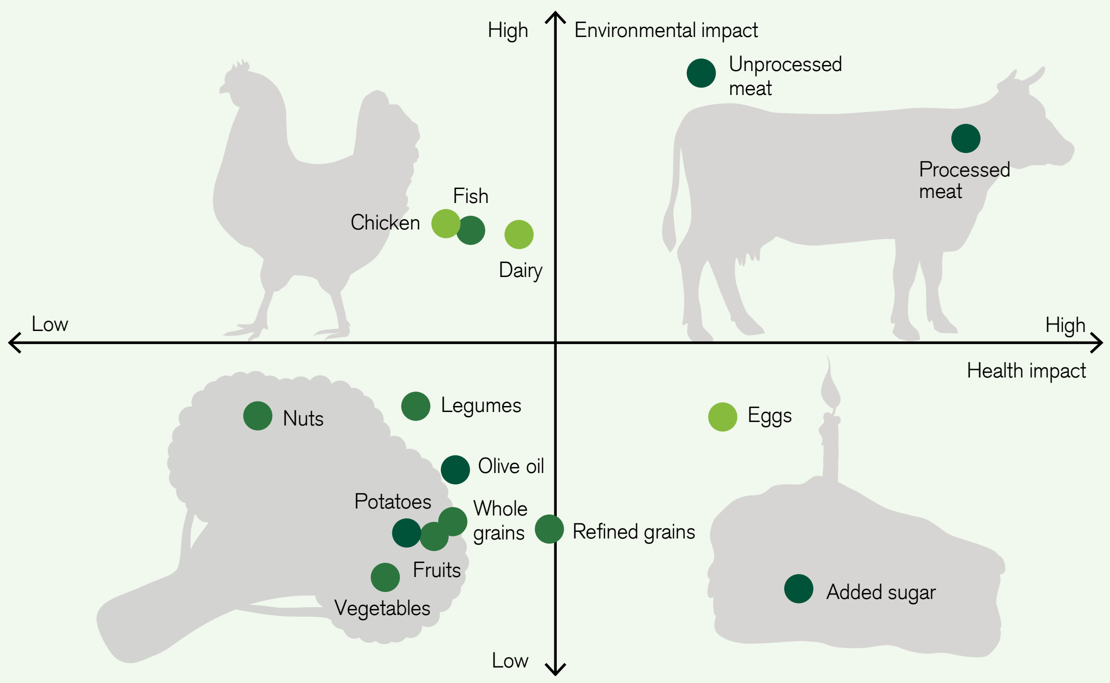
If increased consumption of land-intense food is likely to put more pressure on deforestation, then it stands to reason that a reduction in consumption of these items would help reduce that same pressure. In our report on sustainable food, we outlined that there is a significant need for the world's population to shift from a meat-based to a plant-based diet. This need is not only driven by the ecological footprint of a diet that is meat-rich, but also because current dietary patterns globally are unhealthy. Reducing the consumption of meat, processed food, and saturated fat and increasing the intake of fruit, vegetables, whole grains, and nuts and seeds would help lower the environmental burden of the global food system as well as the growth in the number of people who are overweight or obese.

Figure 30: Emissions intensity (kg CO_2 equivalent/person/year)



Source: Clark et al: "Multiple health and environmental impacts of foods"

Figure 31: The health and environmental benefits of moving to a plant-based diet



Source: Clark et al (2019), EAT: "Diets for a better future"

With this in mind, we wanted to know whether increased consumption of plant-based food would meaningfully reduce total agricultural land demand going forward. If so, this would free up land that can be used for reforestation and help reduce carbon emissions. In order to assess the impact of a change in diets on land demand, we ran the following scenarios:

1. **Consumers adopt healthy diets:** In 2019, the EAT-Lancet Commission published a diet that provides a healthy balance of macronutrients and micronutrients, limits calorie intake to 2,500 kilocalories (kcal) per day, and is sustainable from an ecological perspective. In our report on sustainable food, we outlined the structure of this diet and showed that if adopted it would result in a substantial reduction in meat consumption, while the consumption of healthier (and environmentally friendlier) products such as fruits and vegetables would rise. Figure 26 suggests that such a shift would reduce total land demand.

   Our first scenario assumes that the global population adopts the EAT-Lancet diet. In order to assess the potential impact of this on land demand, we incorporate footprint data for the relevant food groups that make up the EAT-Lancet diet. This, together with estimates on population sizes and average income for over 150 countries globally, allows us to calculate total land demand through time. We then compare these calculations with total land demand currently, as well as potential land demand going forward if dietary habits do not change. Data on the latter were included in our sustainable food report.

   Our calculations suggest that total land demand in 2020 would have been 17.7 m km^2 if the population across our universe of c150 countries had adopted the EAT-Lancet diet. This estimate is 61% lower than our 45.6 m km^2 estimate for land demand in 2020 based on actual dietary intakes that year. To put this into context, total land needed for agricultural production could have been almost 28 m km^2 less if people had decided to eat healthier. This land, if it had been used for reforestation, would have increased total forest land globally by c71%.

   The current food system is unsustainable, in our view; however, the challenges associated with it look set to increase rapidly going forward, driven by the combination of population growth and rising spending power, especially in developing countries. As outlined before, total land demand for agricultural activities could increase by almost 50% to 68 m km^2 in 2050 if dietary habits do not change. However, an adoption of the EAT-Lancet diet on our calculations would reduce this total land demand in 2050 by 64% to 24.1 m km^2 (Figure 32). The relevance of a dietary shift becomes obvious when one realizes that this 2050 estimate for land demand is 48% below current agricultural land demand despite the fact that we incorporate an increase in the global population between now and 2050 and an increase in per capita food consumption owing to rising incomes.

2. **Alternative meat replaces traditional meat:** It is clear to us that a shift towards a healthier and more environmentally friendly diet has the potential to strongly reduce demand for agricultural land and thereby make land available for reforestation. However, this is not the maximum that is achievable.

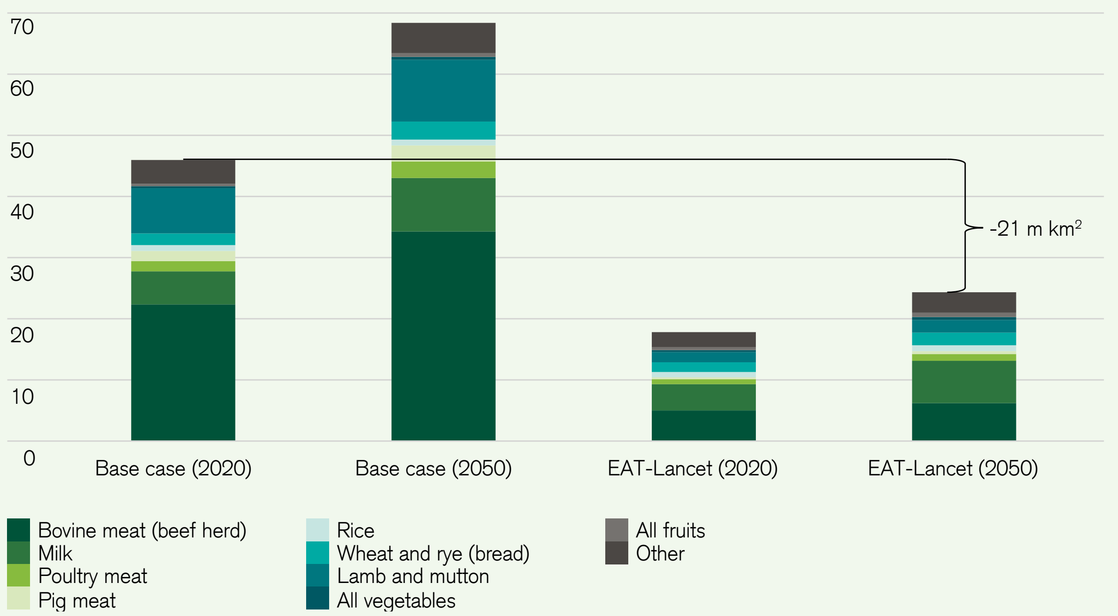
   Alternative meat products such as plant-based, cultivated, and fermentation-based proteins provide additional potential for a reduction in demand for agricultural land. For example, cultivated meat has an emissions and land use footprint that is more than 90% lower than that of traditional meat. For our second scenario, we assume that a share of the meat component of the EAT-Lancet diet will be provided by alternative meat producers.

   In a scenario in which the world adopts the EAT-Lancet diet and 50% of the meat component of it is provided through alternative protein, we estimate that total land demand by 2050 would reach 19.6 m km^2. This is 4.6 m km^2 (or 19%) less than what would be needed to feed the world on the EAT-Lancet diet assuming all meat is produced with traditional farming methods. As a reference, we note that a full replacement of traditional meat with alternative protein would have the potential to lower land demand to 15 m km^2. This compares with our base case land use estimate, assuming no adoption of the EAT-Lancet diet or the use of alternative meat products, of 68 m km^2.

3. **Aggressive adoption of vertical farming:** Finally, we assess how greater use of smart agricultural technologies might help release land that can be used for reforestation. Specifically, we look at the potential of vertical farming, which as described in our sustainable food report has an environmental footprint that is c99% lower than that of traditional crop farming and can be particularly relevant for providing produce in urban areas. Our third scenario assumes that by 2050, 50% of fruit, vegetables, wheat and rye consumed in urban areas is supplied through vertical farming. This reduces land demand by an additional 1 m km^2 from our Scenario 2 estimate.

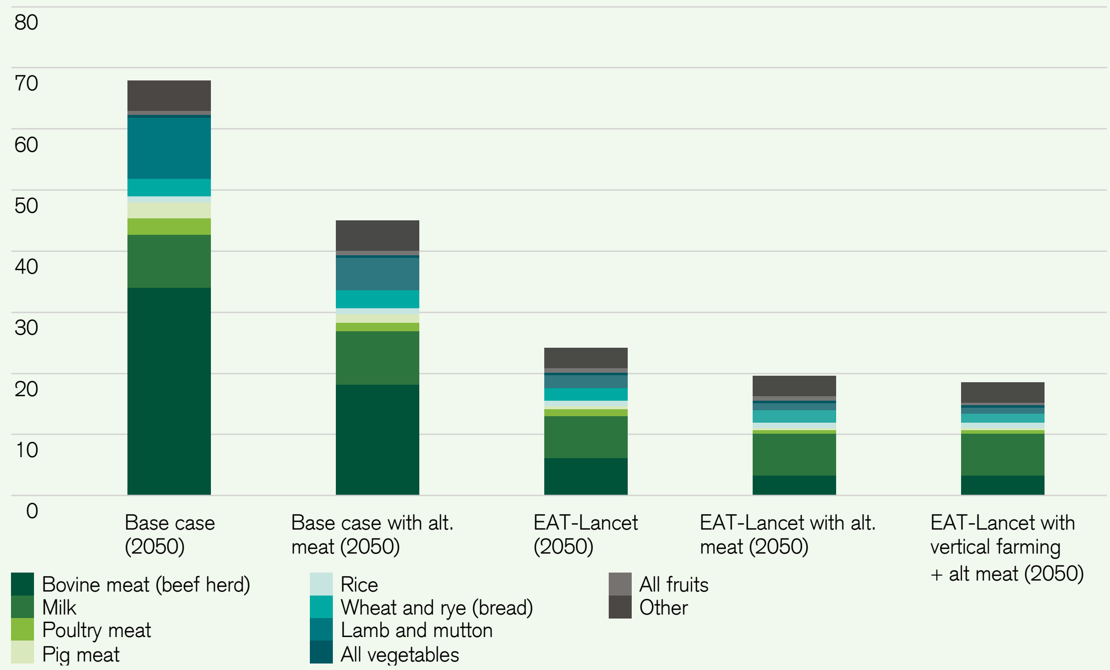
Figure 33 shows the impact of our assumptions on land demand for agricultural activities. The bottom line is that, relative to our 2020 estimates for land use across the range of countries in our database, we see potential for that to go down by 27 m km^2 in 2050. In our view, this is land that could be freed up to be used for reforestation and to store carbon. Key questions that remain are how much carbon can be stored if such a change in land use were to materialize and how this could be achieved.

Figure 32: Land demand: shifting to a healthier diet makes land available (m km²)



Source: Credit Suisse estimates

Figure 33: Land demand scenarios assuming the adoption of i) the EAT-Lancet diet, ii) alternative meat, and iii) vertical farming (m km²)



Source: Credit Suisse estimates

How much carbon can be captured?

In order to estimate the carbon storage potential that reforestation of agricultural land may provide, we have taken into consideration the following questions:

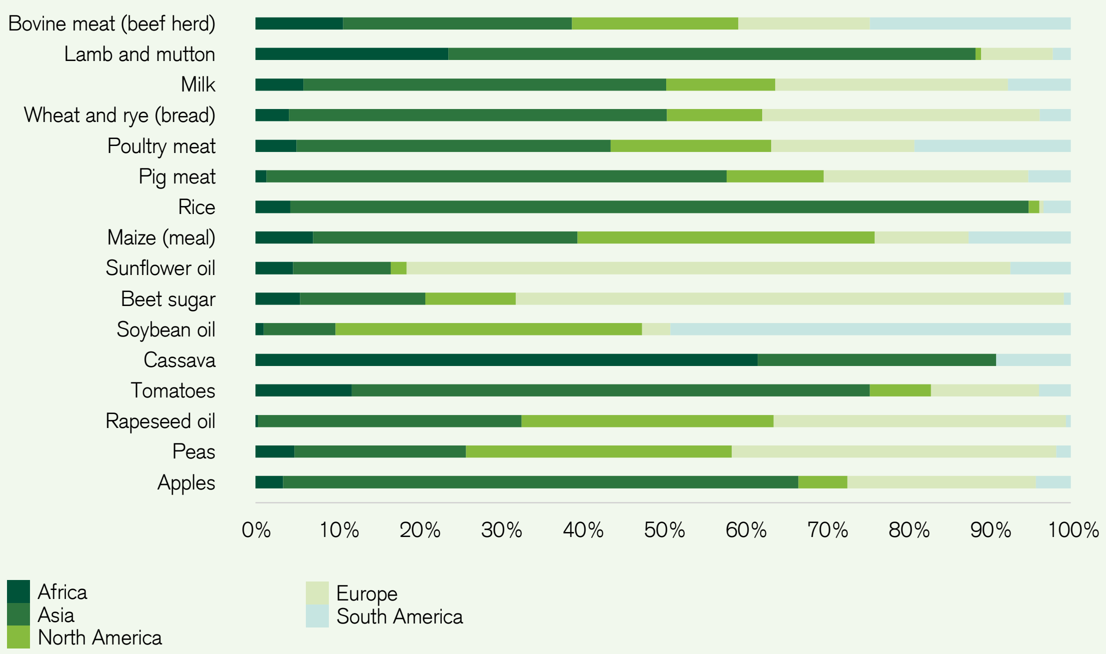
- **Where is agricultural land most likely to be freed up?** In order to calculate the carbon storage potential that might emerge because of a change in agricultural production, we need to estimate how much land might become available by region. This is relevant because different regions have different forest types (e.g., tropical forests in South America versus temperate forests in Europe and North America). We incorporate that a switch away from certain agricultural products (such as those indicated in Figure 33) affects certain regions more than others given that agricultural production differs by region (Figure 34).

For our calculations, we assume that the change in land requirement from a switch in agricultural production affects different regions on a pro rata basis.

By combining our regional estimates for the change in land use with the typical forest that exists across different regions, we can estimate how much additional tropical, temperate, or boreal forest might be planted. The table below shows this for the key food groups.

- **What is the carbon storage profile by tree and region?** Carbon storage for a tree increases with age and differs by tree type. Using data from the UN, we assume that carbon storage in tropical forests is higher than for temperate forests (Figure 36).

Figure 34: Annual agricultural production of key food groups by region



Source: FAO, Credit Suisse research

Figure 35: The potential additional size of forests that might emerge because of the reduction in consumption of key food groups (m km²)

	Tropical	Temperate	Boreal
Bovine meat (beef herd)	8.2	9.4	1
Poultry meat	0.4	0.6	0.1
Pig meat	0.2	1.1	0.1
Rice	0	0	0
Wheat and rye (bread)	0.1	0.3	0.1
Lamb and mutton	2	4	0.2

Source: Credit Suisse estimates

Figure 36: Key assumptions related to carbon storage of trees

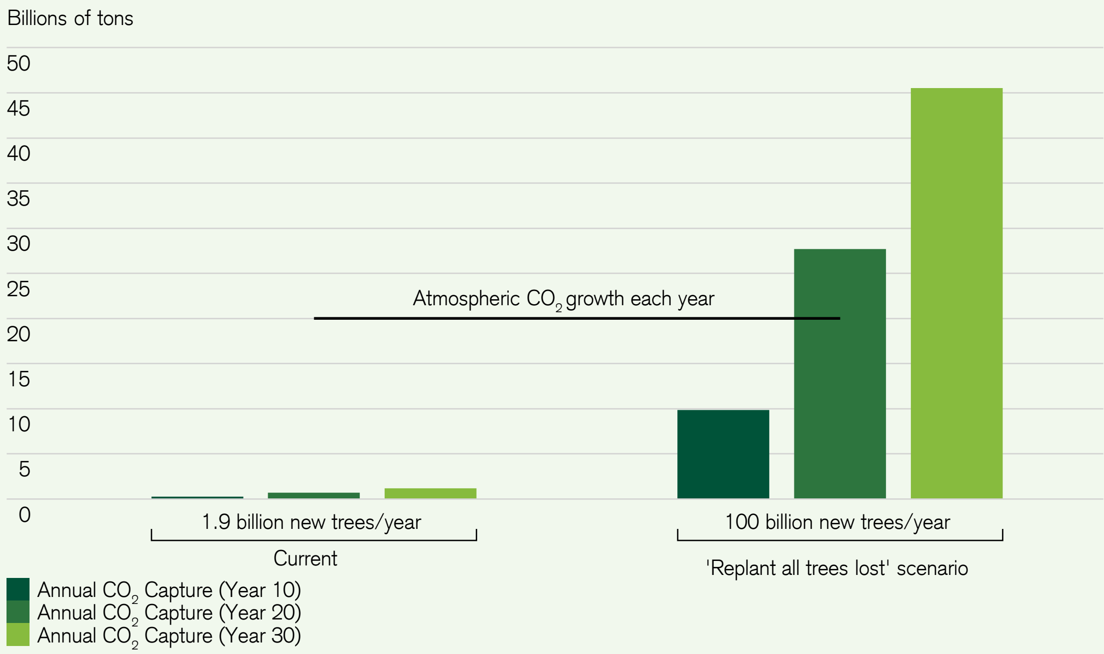
		Carbon storage per tree (lbs/y)	
Forest type	Share of new trees	Young tree	Year 10
Bovine meat (beef herd)	8.2	9.4	1
Poultry meat	0.4	0.6	0.1
Pig meat	0.2	1.1	0.1
Rice	0	0	0
Wheat and rye (bread)	0.1	0.3	0.1
Lamb and mutton	2	4	0.2

Source: United Nations, Credit Suisse estimates

Based on the assumptions above and our scenarios for agricultural land that might become available through a change in diet, greater adoption of alternative meat, and usage of smart agricultural technologies, we can estimate the carbon storage profile of reforested land through time. Figure 37 suggests that the long-term carbon storage potential is very significant in the event that all agricultural land that becomes available is used for reforestation. However, we see several reasons for thinking that a full capture of the potential is likely to be too optimistic:

1. First, there are unintended consequences of reforestation that in reality are likely to constrain how much land can be developed. Historically, the livelihoods of women, poorer households, or even entire communities were displaced by commercial plantations. Moreover, afforestation with "non-native" species can disrupt fragile ecosystems. For example, a report from the World Resources Institute highlights how South Africa continues to grapple with the legacy of afforestation decades ago as invasive exotic species that escaped from plantations dry up streams and threaten the country's unique biodiversity. The report also notes how past reforestation efforts have suffered low survival rates because they did not address the causes of forest loss in the first place, such as uncontrolled grazing or burning. Further, the IPCC Special Report on Climate Change and Land warned that large-scale reforestation and afforestation could increase competition for land, raise food prices, and threaten food security.

Figure 37: Carbon storage potential if all land made available from a more sustainable food system is used for reforestation (CO_2 equivalent)



Source: FAO, Credit Suisse research

2. Second, it is technically very unlikely that all land that might become available from a shift towards a more sustainable food system would be used for reforestation. The reason is that this would imply that a staggering 100 billion trees were planted each year. This is c50x the current run rate and implies 11 million new trees planted every hour.
3. Last, as shown in Figure 20, not all of the land reduction from pasture land and cropland might be converted into forest cover because of the likely need for bioenergy cropland.

The IRR of a tree

Our previous analysis shows that a shift towards a less environmentally intense diet would free up land that could be used for reforestation. In our sustainable food report, we outlined that the need to improve health conditions, the development of alternative meat products, greater use of smart-agriculture technologies, and tighter regulation were some of the drivers that might bring about this dietary shift. These drivers, however, largely depend on consumers' willingness to change their behavior, which may not necessarily be easy to achieve in the short term.

Another potential driver that might accelerate the change in land use and make land available for reforestation relates to the food producers. Farmers might proactively decide to switch from farming to forestry if financial conditions for the latter were superior to those associated with their current operations. In other words, if financial returns related to planting trees were better than those from farming animals, farmers might decide to switch and thereby help achieve climate-change-related targets. The key question, therefore, is: "What is the return of a tree"?

Cost of planting and managing trees

Cost estimates for planting and managing trees or forests are not easy to find; however, work done in relation to the Woodland Carbon Code in the UK provides some insight (see woodlandcarboncode). The cost of developing forests varies significantly and depends on the type of woodland, its location, and the operations needed to establish and manage it. Based on data from the Forestry Commission, the Woodland Carbon Code estimates that the initial investment cost related to the establishment of a new forest is between US$ 7,250 per hectare and US$ 10,780 per hectare, depending on the type of forest. These costs are typically incurred during the establishment phase, which can run for 15 years. In addition, the maintenance or operating costs associated with running the forests across the entire lifespan of the forest are estimated to be between US$ 9,660 and US$ 19,460 per hectare. This period can run for 55 years or more. The cost estimates include operations related to drainage, fencing, insurance, planning, planting, ground preparation, weeding, and general maintenance. For our calculations, we use the average of Woodland's estimates for lowland conifer and broadleaved woodland. This suggests that initial investments are US$ 8,600 per hectare, whereas lifetime costs (incurred over 55 years) are US$ 16,170 per hectare. This implies annual operating and depreciation costs of US$ 867 per hectare during the first 15 years of operation.

Figure 38: Key inputs for reforestation calculation/ha

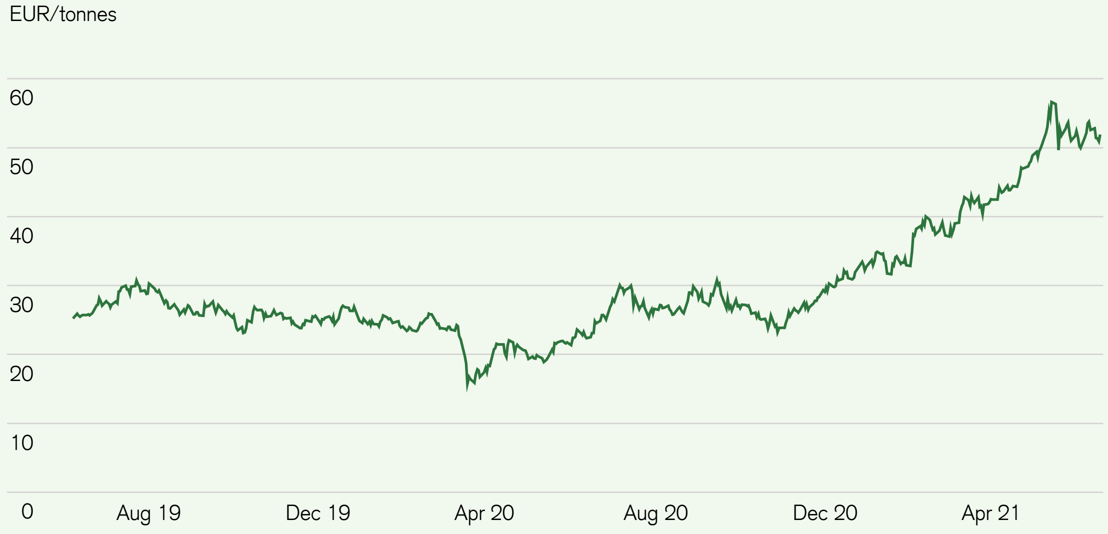
Key estimates for reforestation	Total	Per year
Planting and establishment cost (US$/ha/y)	8,600	573
Other lifetime costs incl maintenance (assuming 55-year rotation) (US$/ha/y)	16,170	294
Total Cost (US$/ha/y)	24,770	867
CO_2 sequestered per tree (kg/y)		
- Young (at planting)	2.5	
- Mature (from year 10)	22	
Trees per hectare	2000	

Source: Farm management handbook 2017/18, SRDP farm advisory service, Woodland Carbon Code, Credit Suisse research

Revenues from managing trees

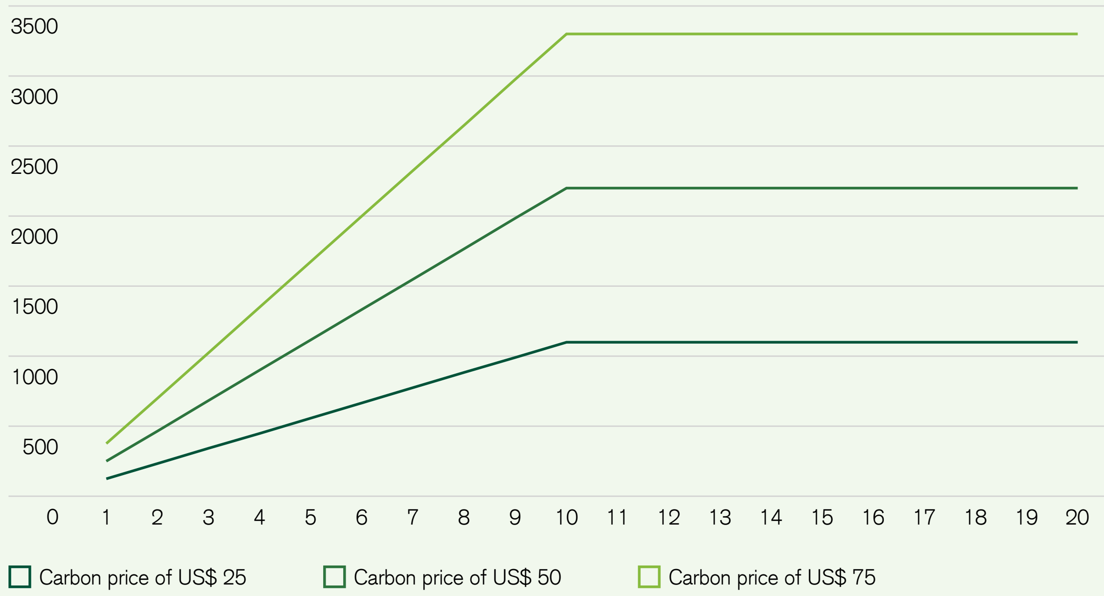
Historically, analysis of the revenue prospects from managing trees has included income from the sale of wood (e.g., timber). However, as we want to review whether carbon sequestration might be a profitable activity for existing farmers, we only incorporate the potential income that farmers would make from carbon sequestration. To do this, we calculate sequestration-related revenues using three carbon scenarios and assume that the amount of carbon sequestered by a tree increases during the first ten years after planting. The carbon prices used in our scenarios are US$ 25, US$ 50, and US$ 75 per ton of CO_2 stored. We note that carbon prices currently differ substantially across the world, but US$ 50 seems to be a reasonable average, given that in Europe carbon is currently priced around US$ 60 (€ 50 for the December 2021 EU Emissions Trading System (EU ETS) and £ 44 for the December 2021 UK ETS). Based on our estimates and assumption that trees reach their mature annual carbon intake rate after ten years, we calculate that revenues from carbon credits can reach US$ 1,100 per hectare by Year 10 using a carbon price of US$ 25 per ton of sequestered CO_2.

Figure 39: European carbon price



Source: Intercontinental Exchange, December 2021 Futures

Figure 40: Potential revenue by year (US$/hectare)



Source: Credit Suisse estimates

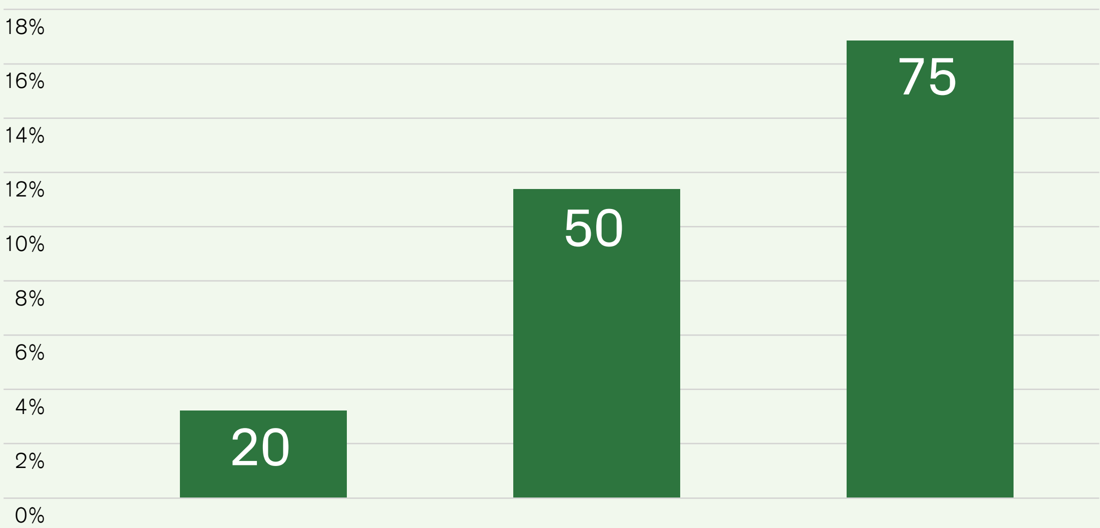
Planting trees could yield a return of more than 11%

In order to judge whether it makes sense for farmers to switch to planting trees, we have estimated the profitability of tree planting. To do this, we have calculated the return on equity of a tree as well as the internal rate of return that planting trees may achieve.

The ROE of a tree: Assuming no use of external funding, we find that carbon prices of cUS$ 50 per ton of CO_2 suggest that planting trees could yield a pre-tax profit of cUS$ 1,300 per hectare longer term. By comparison, pre-tax profit would stabilize at cUS$ 230 per hectare using a US$ 25 carbon price. In terms of profitability, we find that the ROE of a tree planting operation peaks after ten years at 10.9% when using a carbon price of US$ 50 per ton.

The IRR of a tree: In order to calculate the internal rate of return of a tree planting operation, we use our pre-tax profit calculations for the three carbon price scenarios as a starting point for cash flows. We add back depreciation related to the initial investment in order to calculate the free cash flows of a hectare of trees. When solving for the discount rate that equates the sum of discounted cash flows to the original investment needed, we find that the IRR of a tree is 3.2% if a carbon price of US$ 25 is used for each ton of CO_2 stored. This may not seem a high return, but we note that it is arguably higher than most bond yields and appears to compare well with the low profitability of traditional farming operations (see next section). A rise in the carbon price would have a significant impact on the returns of a tree. For example, a carbon price of US$ 50 per ton would already support an IRR of 11.4%, while a carbon price of US$ 75 per ton would lift the IRR to a very appealing 16.9%.

Figure 41: The IRR of a tree based on three carbon price scenarios (US$/ton)



Source: Credit Suisse estimates

To tree or not to tree?

The previous section showed that with some, in our view, moderate assumptions on future carbon prices, one finds that planting trees could yield appealing returns. The question that is relevant now is whether this return is attractive enough for farmers to change (some of) their activities. In this chapter, we argue that it does make sense for farmers to seriously consider shifting at least some of their focus from agricultural activities to planting trees.

Revenues and costs: farming vs. planting trees

There are obviously many reasons why a farmer might be engaged in keeping animals or growing crops. For the purposes of this note, we assume that only commercial reasons matter; therefore, we look at the question of whether, or rather when, it would make commercial sense for farmers to switch from growing crops or keeping animals to planting trees. To do this, we use farming income for UK farmers. We know that regional differences exist and are therefore reluctant to extrapolate too much; however, it may serve as an interesting discussion point.

Figure 42 shows gross income, costs and pre-tax income for different types of farming in the UK. The first observation we make is that farming income excluding the so-called Basic Payment Scheme (a subsidy scheme) and the so-called diversification surplus allowance is actually negative for all types of farming, excluding the specialty poultry farms. In other words, farming in the UK currently would be a loss-making enterprise were it not for government support programs.

Figure 42: Income and cost estimates for farms in the UK (£/farm)

Average (£/farm)	**Lowland grazing livestock farms**	**Dairy**	**Cereal farms**	**General cropping farms**	**Specialist pig farms**	**Specialist poultry farms**
OUTPUT	65,000	474,400	217,819	347,900	605,016	868,600
Livestock	48,100	428,800	12,200	13,600	543,000	819,100
Crops	8,300	33,200	176,600	305,100	50,400	39,300
Agri-environment	4,700	5,000	7,800	5,600	4,200	2,100
Other	3,900	7,400	21,219	23,600	7,416	8,100
Variable costs	32,079	281,784	106,500	155,193	436,176	560,819
Livestock specific costs	19,800	206,800	6,600	7,300	391,600	525,300
Crop specific costs	6,700	37,700	82,900	117,500	21,800	18,500
Contract costs	4,600	29,500	14,200	17,800	19,000	13,700
Casual labour	800	7,500	1,800	11,400	3,700	3,300
Sundry costs	179	284	1,000	1,193	76	19
Gross margin	32,921	192,616	111,319	192,707	168,840	307,781
Fixed costs	38,831	193,025	128,476	205,431	201,517	291,284
Labour	3,217	42,633	16,600	47,500	66,900	76,600
Power and machinery	14,217	59,217	48,300	67,231	52,717	63,508
Overheads	21,397	91,175	63,576	90,700	81,900	151,176
Farm business income incl BPS and diversification surplus	9,690	28,091	28,443	35,076	-13,377	73,697
Farm business income excl BPS and diversification surplus	-5,910	-409	-17,157	-12,724	-32,677	16,497
BPS	11,700	23,400	32,400	31,100	12,400	7,600
Diversification surplus	3,900	5,100	13,200	16,700	6,900	49,600
Farm business income per ha	**111**	**170**	**131**	**162**	**-157**	**1,249**
Number of farms in a sample	133	123	183	79	35	41
Average farm size (ha)	87	165	217	216	85	59

Source: Department for Environment, Food & Rural Affairs, Credit Suisse research

Figure 43: Income and cost estimates for farms in the UK (£/farm)

Farm income and expenses (per hectare)	**Lowland grazing livestock farms**	**Dairy**	**Cereal farms**	**General cropping farms**	**Specialist pig farms**	**Specialist poultry farms**
Current farm business income (incl. gov. support)	**156**	**238**	**184**	**227**	**-220**	**1,749**
Planting trees expenses	867	867	867	867	867	867
Required carbon-related revenues	**1,023**	**1,106**	**1,051**	**1,095**	**647**	**2,616**
Carbon break even price after						
1 year	**205**	**221**	**210**	**219**	**129**	**523**
3 years	**75**	**81**	**77**	**80**	**47**	**191**
5 years	**46**	**50**	**47**	**49**	**29**	**117**
Current farm business income (excl. gov. support)	-49	-2	-56	-42	-275	200
Planting trees expenses	867	867	867	867	867	867
Required carbon-related revenues	**819**	**866**	**811**	**825**	**593**	**1,067**
Carbon breakeven price after						
1 year	**164**	**173**	**162**	**165**	**119**	**213**
3 years	**60**	**63**	**59**	**60**	**43**	**78**
5 years	**37**	**39**	**36**	**37**	**27**	**48**

Source: Farm management handbook 2017/18, SRDP farm advisory service, Woodland Carbon Code, Credit Suisse estimates

In order to arrive at a more conservative estimate for the carbon breakeven point at which it makes commercial sense for farmers to switch to planting trees, we use farming income including government subsidies as a starting point. We note that even this is a negative number for specialist pig farms. Coupled with the fact that for health and environmental reasons moving away from meat-based diets is required, we would argue that specialist pig farmers stand to benefit from switching to planting trees irrespective of the carbon price we use in our analysis.

In Figure 43, we show what revenues from carbon sequestration are required for different farmers to generate a pre-tax income per hectare that is equal to what they currently make. We can then calculate the carbon price that drives such a revenue number, which gives us the carbon breakeven price above which it makes sense for farmers to start planting trees. We have calculated the carbon breakeven price for three different years, given that switching to a tree-based model would involve upfront capital cost, which delays the profitability profile of that business. Our calculations based on farming income including government support programs suggest that except for the specialty poultry farmers, all others are better off switching to planting trees when assuming a carbon price around the current level of cUS$ 50 per ton and a breakeven period of five years. When we exclude government subsidies, we find that the necessary carbon price on a five-year window drops to less than US$ 40 per ton.

The NPV of a tree (and of a farm)

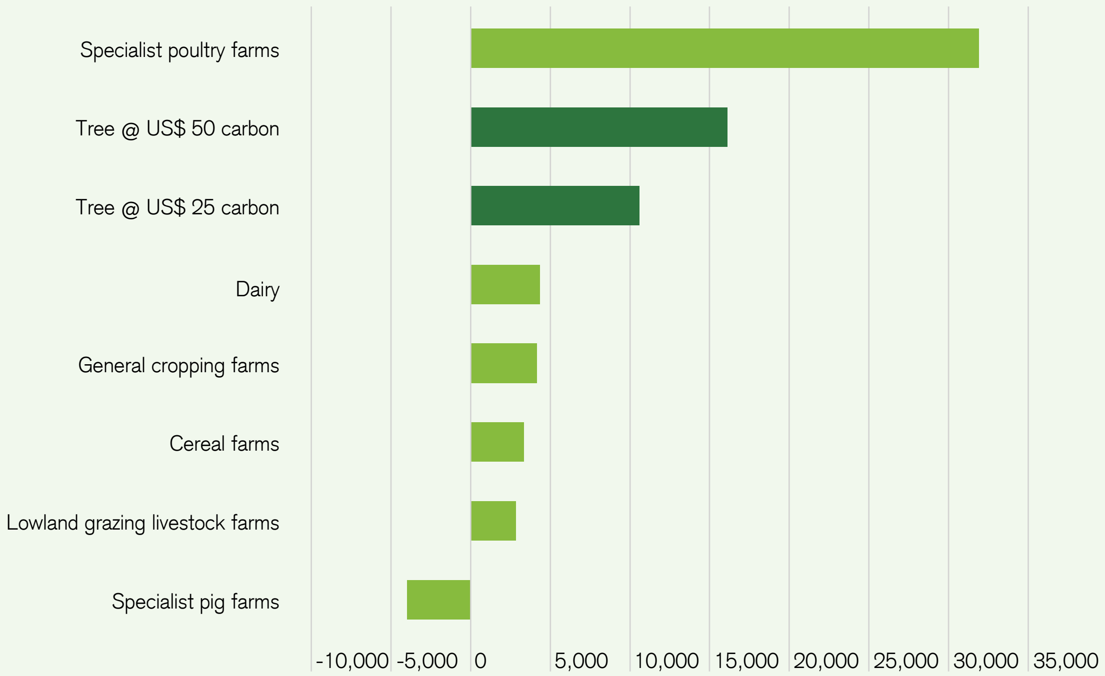
Comparing a current farming operation with that of a switch to planting trees on a shorter-term basis gives traditional farming an unfair advantage, in our view, as it compares a stable operation with one that is in a start-up phase during the initial years. Therefore, we have also calculated the NPV for the various farming operations and compared it to the NPV of a hectare of trees.

To do this, we use a 50-year window, which roughly equates to the turnover period of a forest. We calculate the cash flows for a 100% equity-funded tree operation based on a carbon price of US$ 50 and compare it to the NPV of the various farming operations assuming that their current pre-tax profits remain unchanged into the future, including government subsidies.

Using a 5% discount rate for all operations, we find that one hectare of trees is worth US$ 26,596. This is more than 7x the value of dairy, general cropping, cereal, and lowland grazing livestock farms. Only specialty poultry farm operations appear somewhat more valuable; however, we note that this is primarily due to the sizeable, so-called 'diversification' government subsidies.

Even a negative scenario of a carbon price of US$ 25 per ton would value a hectare of trees at over US$ 10,600, or a multiple of the value for most farms. The key conclusion therefore has to be that for most farmers in the UK it would make sense to start switching to planting trees.

Figure 44: The NPV of one hectare of trees and different farms (US$)



Source: Credit Suisse estimates

What about farming elsewhere?

Our ROE and NPV calculations were based on data for the UK and suggest that there is a convincing case for farmers to switch from traditional agriculture to planting trees. It is possible that the financial conditions elsewhere may be very different, which could result in different conclusions. With that in mind, we provide in the table below an overview of revenues per hectare for a range of farming activities in different countries. For each of these, we then calculate the breakeven period using a US$ 50 carbon price in order for carbon-sequestered revenue to be equal to that of traditional farming activities.

Data for European farmers (excluding the UK) suggest that revenues, including government support, ranges from US$ 1,164 per hectare to almost US$ 4,000 per hectare in the case of dairy farmers. Using a carbon price of US$ 50 would imply that dairy farmers, on revenue alone, are unlikely to switch to planting trees as carbon credits per hectare of planted trees are only ever going to reach US$ 2,200 per hectare. The breakeven period for the other activities is between six and seven years.

US farming activities generate revenues of between US$ 179 and US$ 600 per hectare. Figure 45 suggests that farmers in the US should definitely consider switching to planting trees if they can secure carbon credits at US$ 50 per ton of stored carbon on forested land. Revenues from managing trees would be higher than current activities within three years. We have used data for Indonesia as an indication of farming activities in emerging countries. On average, the conclusion appears to be similar to that for US farmers. With a relatively short revenue-based breakeven period, farmers in Indonesia may want to switch to planting trees.

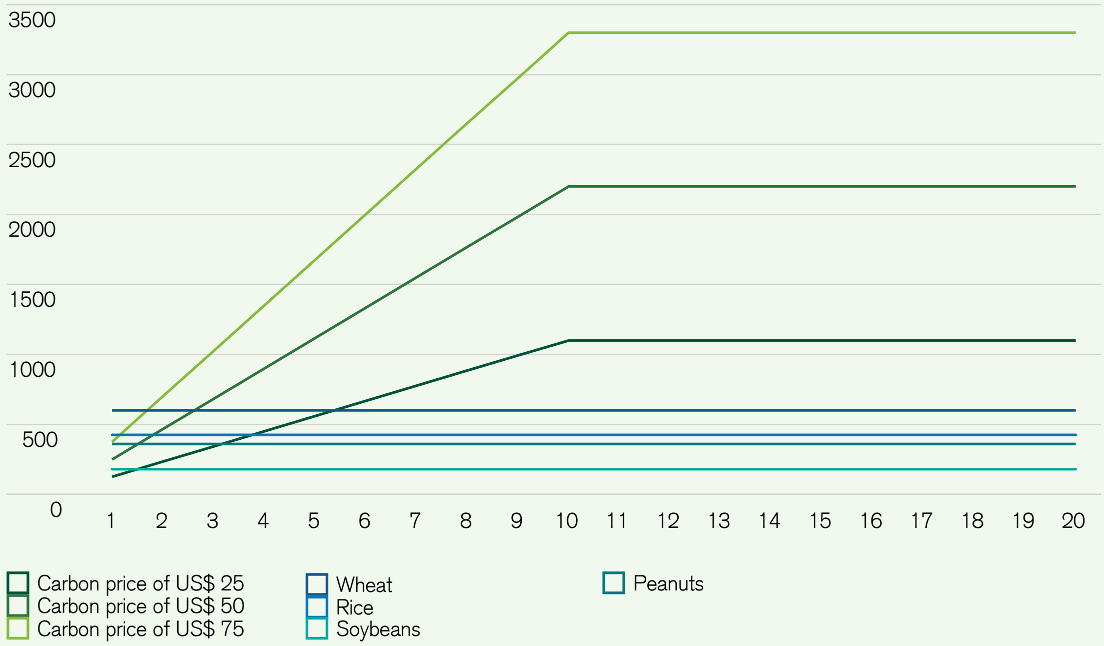
Figure 45: Farming revenue per hectare for traditional activities relative to potential carbon credit income through forestation

	"Farming revenue US$ per ha"	"Carbon revenue at carbon price of US$50"	Break-even year
Europe (ex-UK)			
Dairy	3,997	2,200	n.a.
Sheep and goats	1,458	1,550	7
Cattle	1,355	1,550	7
Fieldcrops	1,164	1,333	6
United States			
Wheat	600	683	3
Rice	425	467	2
Peanuts	360	467	2
Soybeans	179	250	1
Indonesia			
Rice	1,667	1,767	8
Soybean	1,098	1,117	5
Cocoa	826	900	4
Maize	709	900	4
Coffee	602	683	3

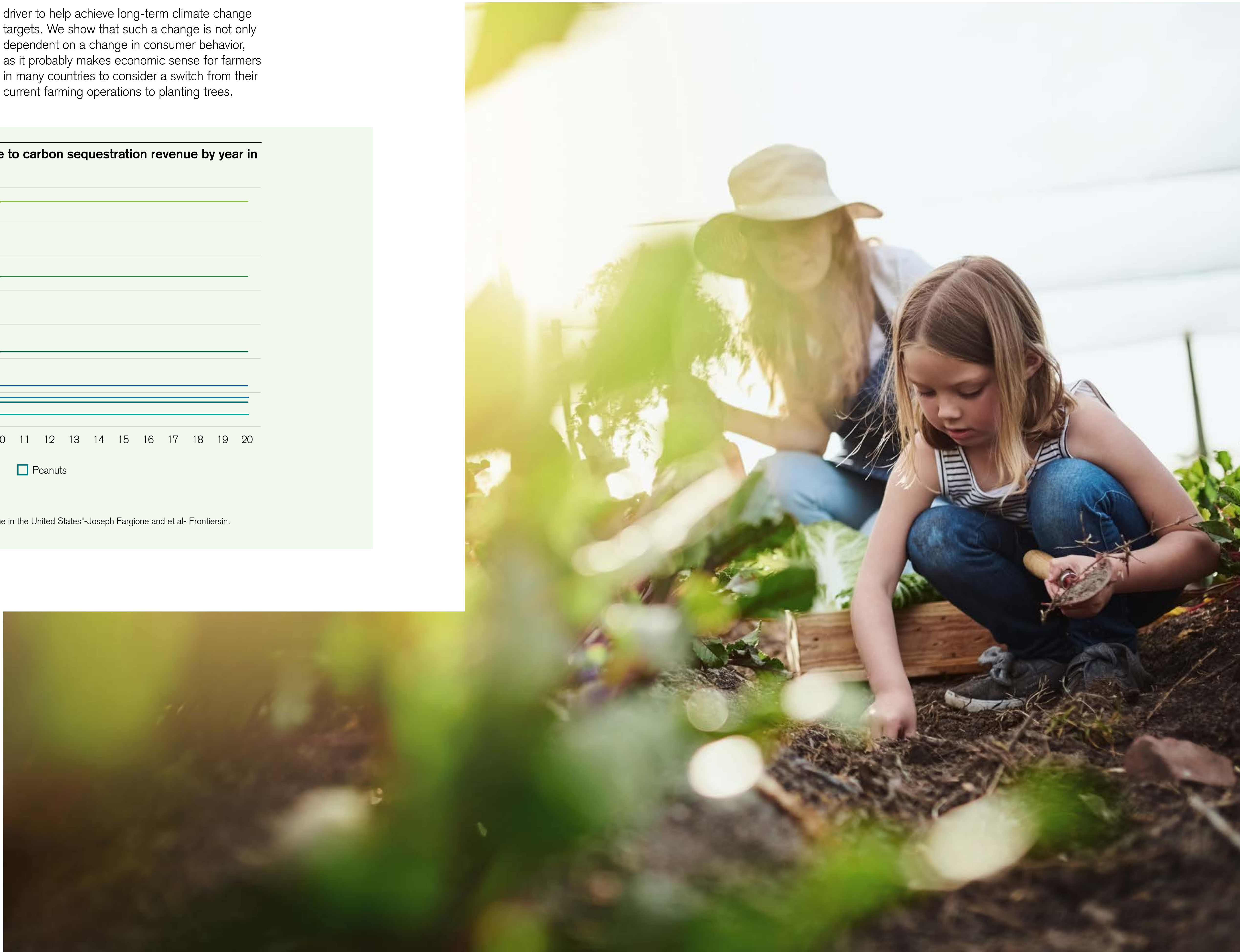
Source: US Department of Agriculture, "Challenges to reforestation Pipeline in the United States"-Joseph Fargione and et al- Frontiersin.org, "Profitability and Labour Productivity in Indonesian Agriculture"- Bustanul Arifin (University of Lampung) and et al, World Bank, EU Farm Accountancy Data Network, Credit Suisse estimates

Overall, our conclusion is straightforward. Improving the sustainability of the global food system through changing peoples' dietary habits has the significant benefit of substantially reducing the need for agricultural land. When this is used for reforestation, it would be a significant driver to help achieve long-term climate change targets. We show that such a change is not only dependent on a change in consumer behavior, as it probably makes economic sense for farmers in many countries to consider a switch from their current farming operations to planting trees.

Figure 46: Farming revenue per hectare relative to carbon sequestration revenue by year in case of forestation (US$)



Source: US Department of Agriculture, "Challenges to reforestation Pipeline in the United States"-Joseph Fargione and et al- Frontiersin.org, Credit Suisse estimates



A tree-transition might cost less than expected

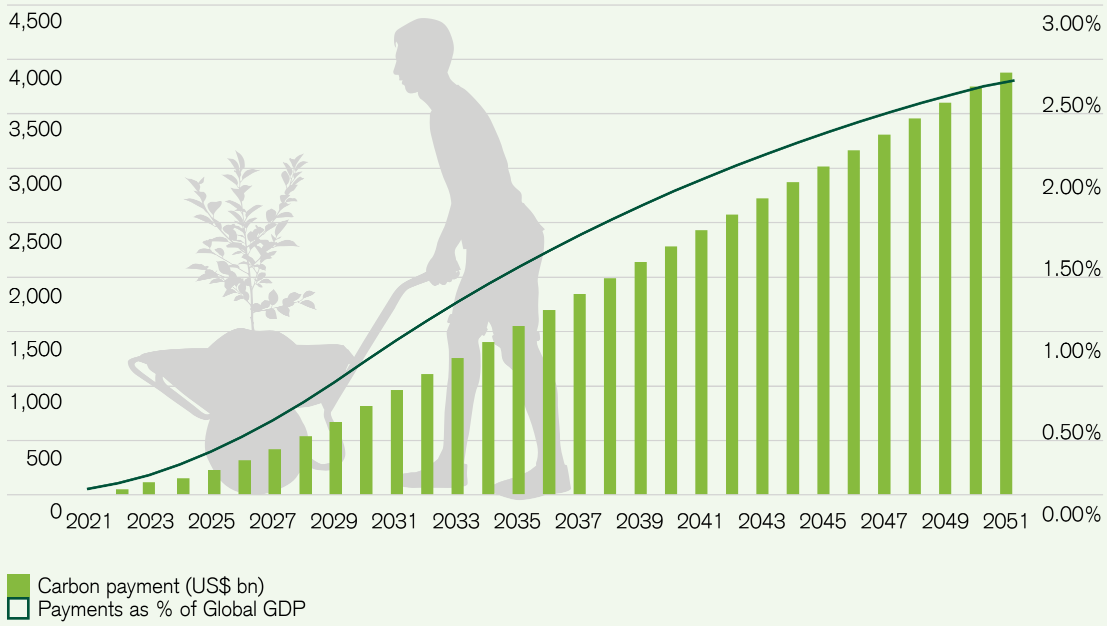
We have highlighted before that achieving full reforestation of all land that might become available presents a logistical challenge that is likely to be too high. Irrespective of these challenges, some investors might also wonder whether the costs associated with paying people to plant trees may not be too high. We have built a global tree planting model that aims to provide an estimate for the annual carbon-related payments that would have to be made to farmers or other workers planting trees based on total carbon stored. In order to calculate the annual payments associated with storing carbon through planting trees, we have made the following assumptions.

- First, we assume that the EAT-Lancet diet will be adopted fully by 2050, which will lead to a c.20 m km² decline in land needed for agriculture. This is the land that we assume will be used for reforestation.
- Second, we assume that reforestation takes place on a linear basis over a 30-year period and that trees need ten years before capturing 22 kg of CO_2 per year.
- Third, we do not allow for the increased carbon storage potential of forests in tropical regions. Equally, we apply a uniform US$ 50 carbon price payment per ton of CO_2 stored.

Based on our assumptions, we calculate that annual payments for carbon storage achieved by newly planted trees would grow from US$ 17bn in Year 1 to almost US$ 3.9trn by 2051. The increase and size of these payments may seem extraordinary to investors; however, we note that this is based on planting more than 130bn trees per year, which arguably is higher than is feasible. Nevertheless, even if this scenario were possible, the associated payments would still be low when compared with global GDP.

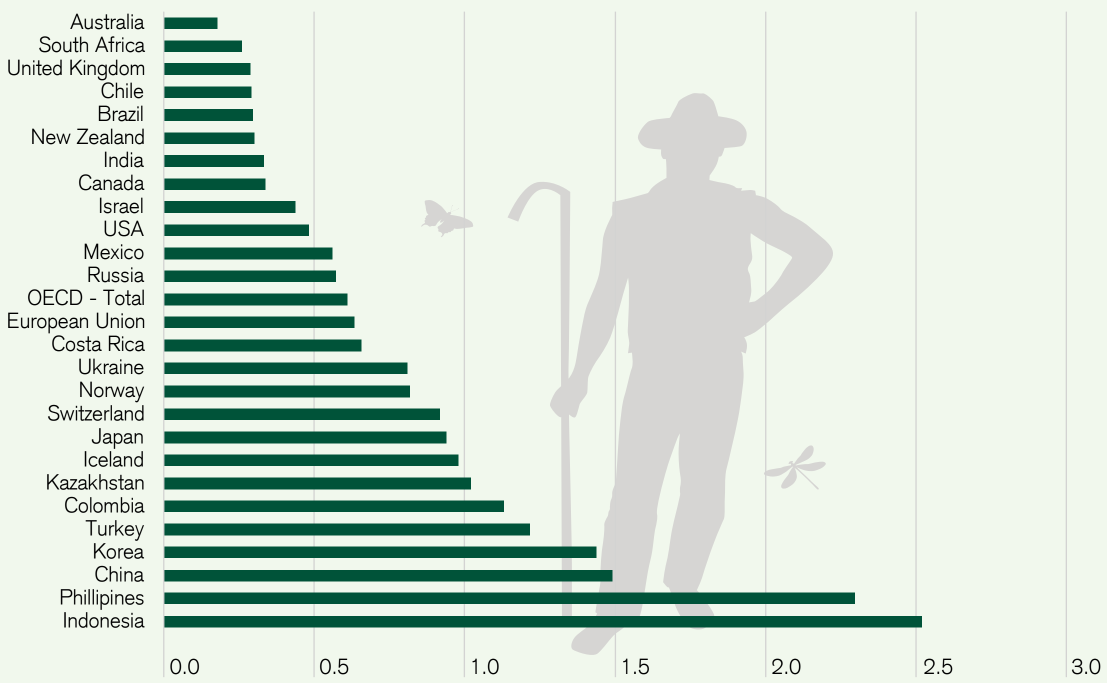
In 2020, global GDP reached US$ 84.5trn. A US$ 17bn payment in Year 1 would therefore represent just 0.02% of global GDP. Despite the strong growth to US$ 3.9trn by 2051, such a payment number then would, assuming that global GDP increases at 2% annually, still only represent 2.5% of GDP. Furthermore, if this approach were taken, we believe that the net cost would be lower than 2.5% of GDP given that government subsidies to agriculture would logically be able to fall. Across the OECD, farming subsidies are currently c0.6% of GDP. Therefore, the annual payments to farmers associated with planting trees on their reclaimed agricultural land are likely to be less than 2% of GDP. In our view, this appears to be a small price to pay if it helps secure climate sustainability in the long term. Furthermore, the cost could reduce further if it were funded by net polluters.

Figure 47: Paying farmers to plant trees would cost less than 2.5% of global GDP, in our view



Source: Credit Suisse estimates

Figure 48: Agriculture-related subsidies vary significantly; across the OECD they average c0.6% of GDP



Source: OECD, Credit Suisse research

A global carbon market is needed

Our analysis up until now suggests that it makes sense for farmers in various regions to change their focus to planting trees and managing forests if they can be rewarded for the carbon that these forests store. Land appears to be widely available, especially if consumers improve their diets, whereas the NPV of such an enterprise appears superior to most current farming activities. However, the reality is not so straightforward.

We have already outlined a number of the more logistical challenges associated with our planting scenarios. These challenges merely suggest that the pace of planting may be lower than some of our assumptions. A more fundamental challenge to such a large-scale global reforestation exercise relates to our assumptions i) that carbon prices everywhere will be US$ 50 per ton of CO_2 stored (or more), and ii) that governments will be paying these prices to farmers or anyone with reforested land for carbon sequestered.

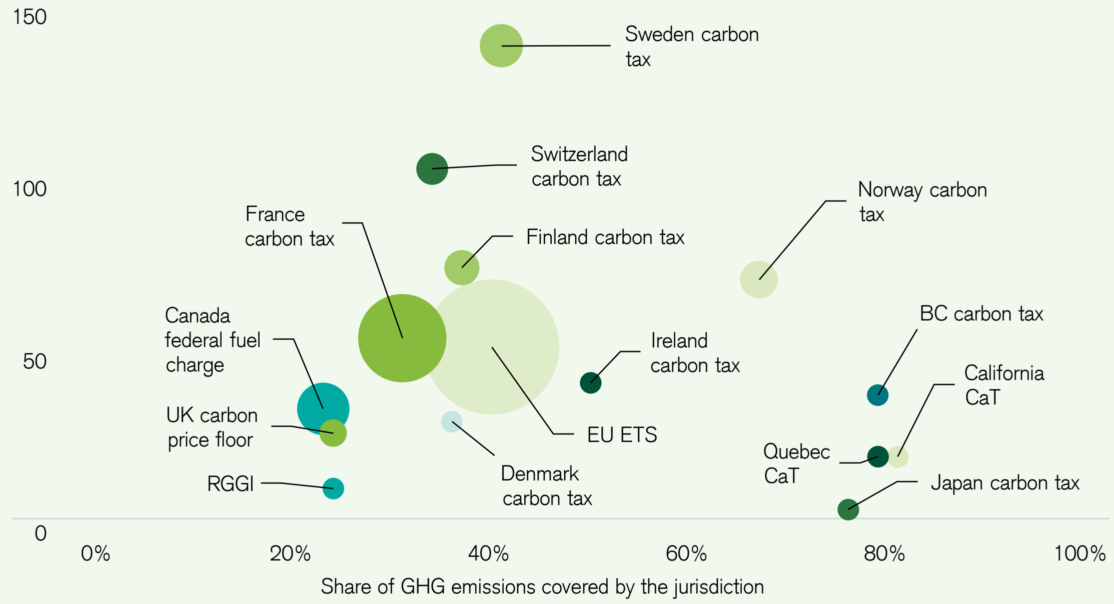
Currently there is no uniform carbon price globally or emissions trading mechanism. There are a range of carbon prices across different jurisdictions; however, these vary substantially. In addition, there are also a range of different emissions trading systems around the world. In addition to the EU ETS, there are systems operating in countries such as Canada, China, Japan, New Zealand, South Korea, Switzerland, and the United States. However, these carbon-trading mechanisms across regions do not necessarily match up with each other or have the same accounting rules.

Therefore, in order for our vision of planting trees to work, we believe that the adoption of a global carbon trading scheme would be needed for operators of forests to sell their carbon credits. An approach whereby governments pay farmers per ton of CO_2 sequestered would probably also be more likely if carbon prices and emissions trading schemes globally were to converge.

However, we do note the strong global growth in the voluntary carbon market. A recent report by UCL and Trove Research, covered in our Global Weekly Report, shows that demand for voluntary offsets is set to grow 5-10x over the next ten years, 8-20x by 2040, and 10-30x by 2050. This shows that while the carbon price is now around US$ 3-5/t CO_2e (in the voluntary market), it is expected to increase to US$ 20-50/t CO_2e by 2030 and could go as high as US$ 100/t CO_2e in certain scenarios. We also note the Taskforce on Scaling Voluntary Carbon Markets, now with over 250 member institutions, will enable greater uptick. The task-force is working to establish the infrastructure for a scaled and high-integrity voluntary market for the trading and exchange of carbon credits.

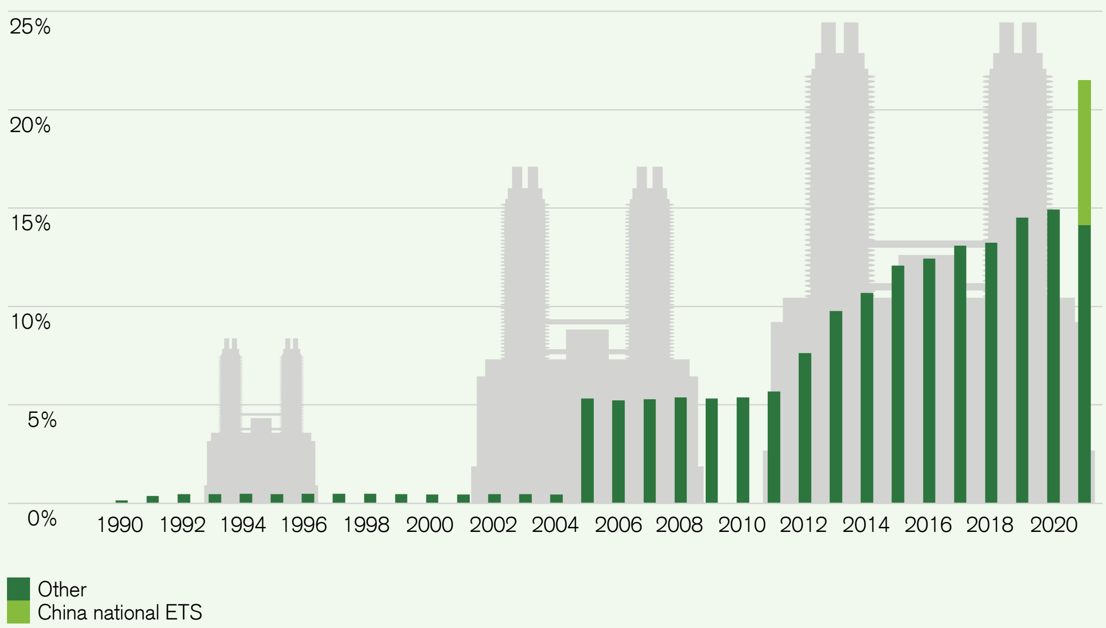
Notwithstanding these potential market development hurdles, the steps taken by the EU and US to set up a Carbon Border Adjustment Mechanism will in effect set a global carbon price for all exporters, so we see this as the first step in the creation of a global carbon price mechanism, whether formally or informally through the voluntary market. Modelling by the IPCC to estimate the necessary carbon prices to reach Net Zero are even starker. According to both the IPCC and International Energy Agency (IEA), between now and 2030, carbon prices under a 1.5 scenario could rise to a minimum of US$ 100 and could reach over US$ 200 by 2050.

Figure 50: Carbon price, share of emissions covered, and carbon pricing revenues of the 15 largest initiatives



Source: World Bank, Credit Suisse. NB: The China ETS is currently not included as it has not yet generated a full year of revenues

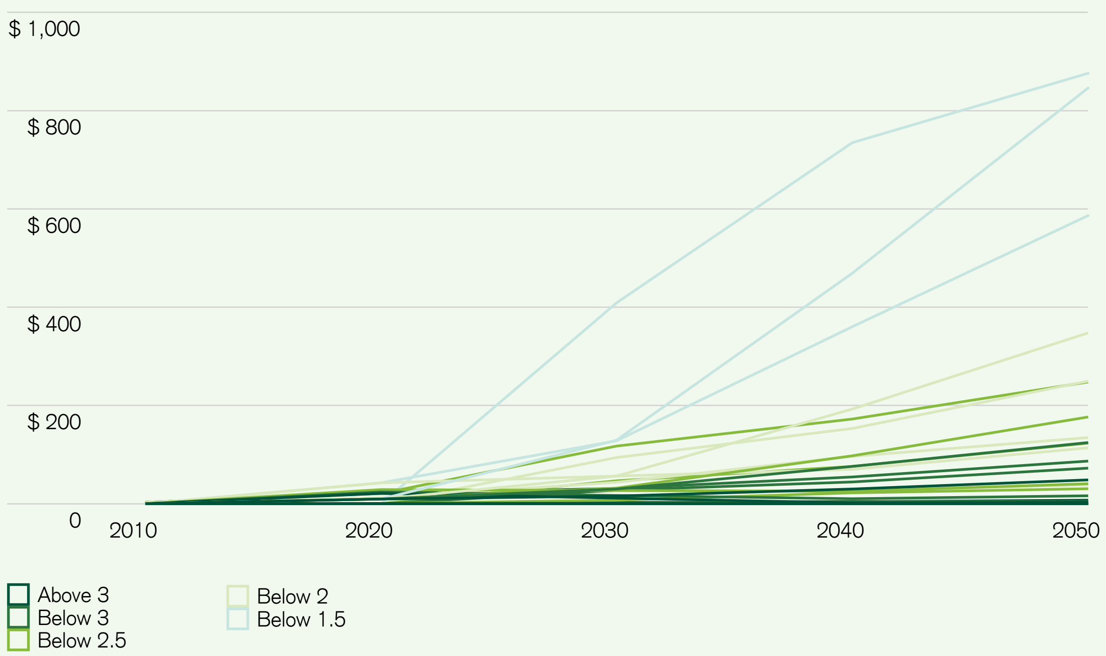
Figure 49: Share of global emissions covered by carbon schemes



Source: World Bank, Credit Suisse

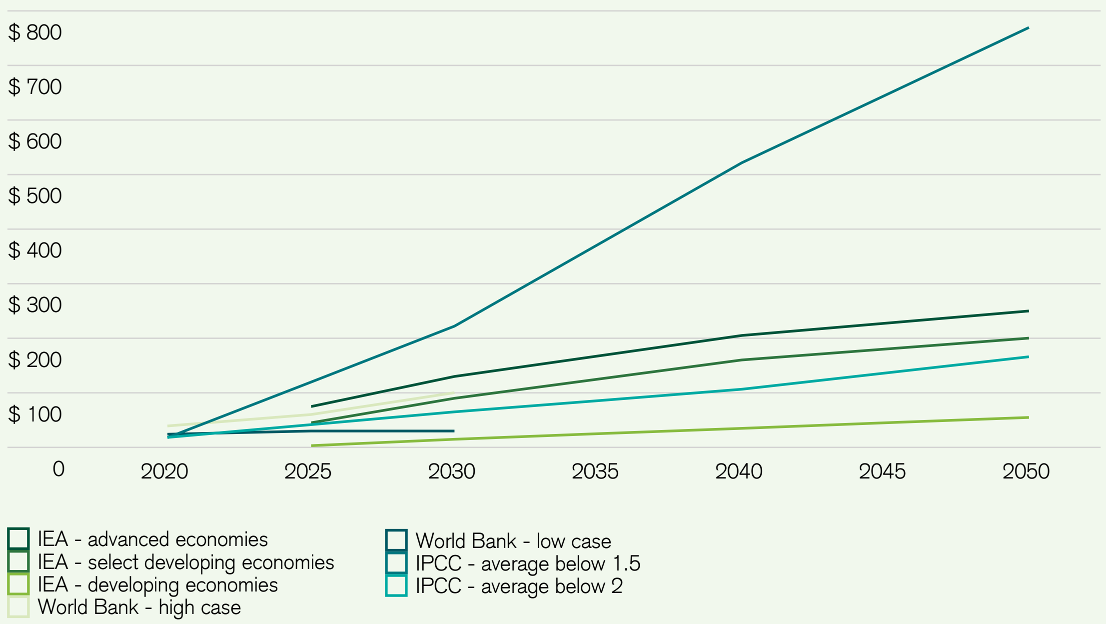
In conclusion, we would argue that governments should draw up plans that reward farmers for planting trees and storing carbon. This requires the implementation of more unified carbon trading schemes or carbon price-based subsidy schemes for farmers, something that we think is not impossible. Not only would this make farming a more profitable activity but it would also help achieve longer-term climate change targets. In order to achieve this, we also argue that much greater focus needs to be placed on persuading consumers to shift dietary habits towards plant-based food consumption. This not only helps to address the issue of consumers who are overweight or obese, something that we argued in our recent report on the global food system, but importantly it also naturally frees up land that can be used by farmers for reforestation. Planting trees is a TREEmendous opportunity.

Figure 51: IPCC range of carbon prices



Source: IPCC, Credit Suisse research

Figure 52: Key average carbon prices



Source: IEA, World Bank IPCC, Credit Suisse research

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