Making it happen: national pathways to net zero

Long-term transformations in national pathways to net zero

LAND-USE SECTOR

The land use sector is instrumental in national pathways to net zero, serving as a key provider of carbon sinks up until and beyond 2050. Country-specific approaches are needed to ensure that mitigation compatible with the sector's other core functions.

The land use, land-use change and forestry (LULUCF) sector has an impact on the carbon fluxes between the atmosphere and terrestrial carbon pools, including biomass and soils. The sector's role in national pathways to net zero varies by country, depending on their starting points and potential (**Figure 10**). Some countries, including Brazil, Indonesia, India, and Nigeria focus on reducing the sector's net CO_2 emissions, while others, such as Mexico, South Africa, China and the US, maintain a relatively stable level of negative emissions. These aggregate results combine efforts to preserve existing carbon sinks by for instance halting deforestation, peat fires and land degradation, as observed in Brazil or Indonesia; and action to increase carbon sinks, for instance by afforestation/reforestation and increased adoption of agroforestry, such as in India. The below case studies further explore the actions taken in Brazil, India and Indonesia in greater detail.

However, beyond these differences, all national pathways to net zero include net negative CO_2 emissions in 2050 for the land use sector. Indeed, this sector is unique in its capacity to generate negative emissions without additional technologies, for instance through reforestation/afforestation and improved management of existing forests. Consequently, it serves as a crucial source of the negative emissions needed to compensate for hard-to-abate CO_2 emissions from the energy and industrial sectors and non-CO_2 emissions from agriculture.

The capacity of the LULUCF sector to act as a carbon sink in the coming decades is however uncertain. Climate change increases the risks for natural disturbances to terrestrial ecosystems, such as fires and droughts, which cause emissions of CO_2 from land-based carbon sinks. This supports diversified mitigation strategies that both drastically reduce CO_2 emissions in other sectors, and increase negative emissions in LULUCF.

The importance of the land use sector in national pathways to net zero can also be measured in its impact on cumulative CO_2 emissions. Despite significant variation across countries, the LULUCF sector is a net absorber of CO_2 emissions when considering its cumulative emissions and absorptions from 2020 to 2050 in all of the countries studied (as indicated by a positive percentage in **Figure 11**). However, the different national starting points and pathways lead to notable differences in the share of cumulative CO_2 emissions captured by LULUCF. In Brazil, the magnitude of emission reductions and annual CO_2 sequestration means that LULUCF captures nearly 80% of the country's total CO_2 emissions released between 2020 and 2050. This highlights the country's significant potential for negative emissions, which is being maximized in its national pathway to net zero, making action in the sector a priority mitigation strategy (see part 2.3). In Mexico, stable and relatively significant negative emissions from LULUCF between 2020 and 2050, combined with

Figure 10. CO_2 emissions from LULUCF in DDS ($MtCO_2$)

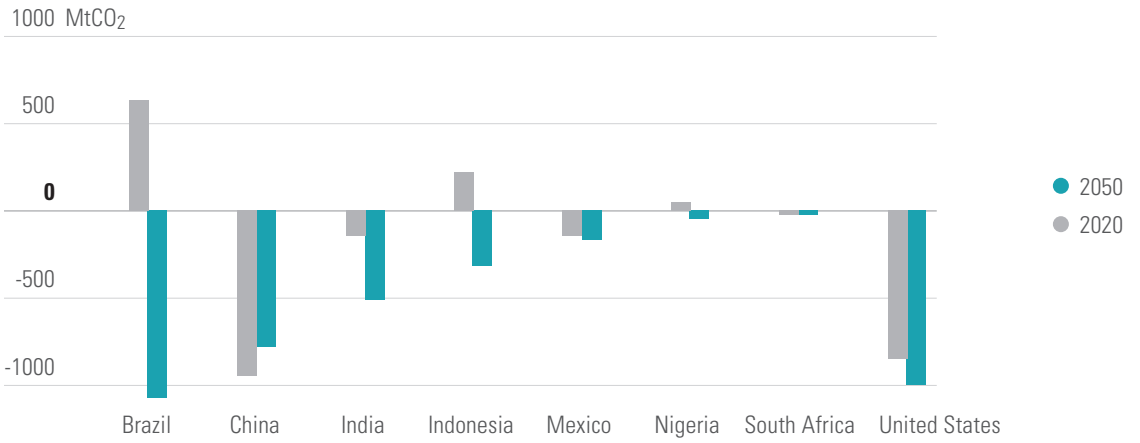
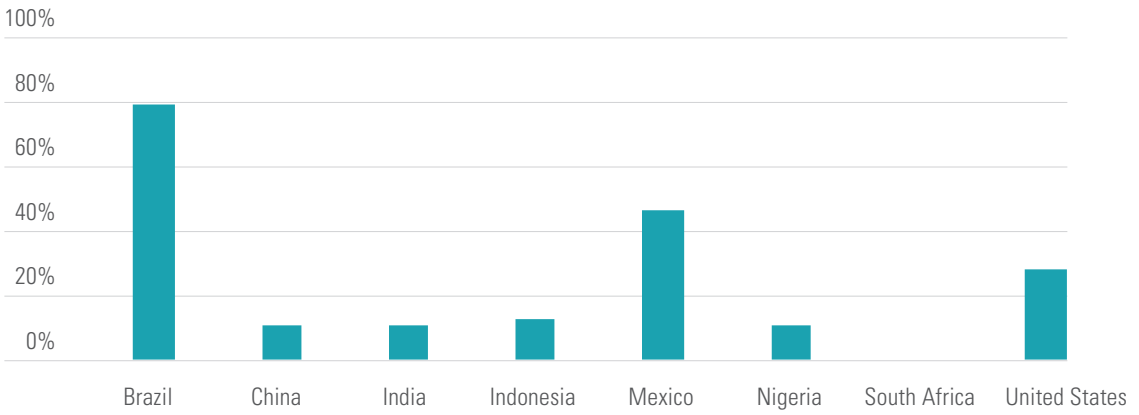


Figure 11. Share of cumulative CO_2 emissions (2020-2050) from all other sectors captured by LULUCF (except LULUCF)



Note: the LULUCF sector in Argentina has not been analysed in detail, and Argentina is therefore not included in this graph.

a robust mitigation strategy, are projected to capture about 45% of the country's CO_2 emissions released over the period. In contrast, India captures only 11% of its cumulative emissions from LULUCF, despite notable reductions in net emissions between 2020 and 2050. This is due to the fact that carbon neutrality will be reached after 2050, and CO_2 emissions from other sectors will remain significant until 2050. Similarly, in Indonesia, LULUCF absorbs only 12% of cumulative CO_2 emissions from other sectors between 2020 and 2050. This reflects both that Indonesia aims for carbon neutrality in 2060 and have significant CO_2 emissions in 2050, and that the LULUCF sector is a net emitter in 2020, which limits cumulative sequestration despite rapid net emission reductions.

The analysis of national pathways to net zero also highlights the need for country-specific approaches for transforming the LULUCF sector and the broader land use system, including agriculture. LULUCF's significant mitigation potential can only be realized if the sector also contributes to food security, rural employment, and resilient and biodiverse ecosystems, and other key functions of the sector. Given the locally specific character of eco-climatic and socio-economic systems, solutions that align these functions must be context specific. Examples of such country specific solutions include the restoration of degraded grasslands to drastically reduce deforestation without reducing agricultural production in Brazil, and increasing the support to farmers for adopting agroforestry to improve the quality of often degraded agricultural soils and providing farmers with alternative sources of revenues in India. The following case studies on Brazil, India and Indonesia illustrate how context-specific solutions can effectively provide the multiple functions that the land use system must play.

CASE STUDY

Context-specific solutions to balance increased absorption capacity with other core functions in the land use sector in Brazil, India and Indonesia

Brazil

In Brazil, the LULUCF sector will transition from emitting over 0.6 $GtCO_2$ in 2020 to absorbing more than 1 $GtCO_2$ in 2050. Halting deforestation is the single most important measure to reduce emissions and preserve climate-resilient, biodiverse ecosystems.

Achieving this level of mitigation requires balancing environmental conservation with the country's economic reliance on agricultural production. Agriculture, particularly extensive cattle rearing and soy production, is the primary driver of deforestation. However, the sector is also crucial for the country's economy, contributing signifi-

cantly to the balance of payments with important export revenues. To tackle this issue, Brazil is adopting strategies that align climate mitigation with economic resilience, aiming to both reduce deforestation and sustain agricultural productivity. One key strategy is the restoration of extensive degraded pasturelands. By rehabilitating these areas for agricultural expansion, Brazil can avoid deforestation while ensuring continued growth in food production and agri-business exports. This approach facilitates sustainable intensification, where advanced agricultural practices—such as integrated crop-livestock-forest systems (ICLFS)—enhance productivity per hectare, reducing the pressure to clear new areas of native forest.

Additionally, policies tailored to the national context—such as the enforcement of the Forest Code and the promotion of sustainable agriculture—are fundamental to ensuring that mitigation efforts do not compromise food security or economic growth. By incorporating local knowledge and aligning policy with the specific needs of different regions (such as the Amazon and Cerrado biomes), Brazil can create solutions that not only curb emissions but also support the livelihoods of rural communities, maintain biodiversity, and promote climate resilience.

This balance between climate action and land use is essential to ensure that Brazil meets its climate commitments while continuing to serve as a global leader in agricultural production.

India

In India, the annual net CO_2 absorption by the LULUCF sector is projected to increase from 112 to 518 $MtCO_2$ between 2020 and 2050. A key driver of this trend is the increased adoption of agroforestry on croplands. However, the large number of smallholders in India means there are challenges to accessing efficient farming practices and markets, which contributes to persistently low incomes for the majority of Indian farmers. Furthermore, Indian farmland faces significant challenges from soil degradation, which threatens to further reduce harvests and farmer revenues if not addressed. The agroforestry approach offers multiple benefits. In addition to its contribution to mitigation, it provides alternative sources of income for farmers, reducing their reliance on single crops. It also enhances soil structure and water retention in croplands, leading to improved resilience to the unpredictable impacts of climate-change related natural events.

Indonesia

In Indonesia, the LULUCF sector is projected to transition from emitting over 220 $MtCO_2$ in 2020 to sequestering more than 330 $MtCO_2$ by 2050. This significant shift from net emissions to a net annual carbon sink is primarily driven by reductions in deforestation and forest degradation, along with the restoration of degraded peatlands and mangroves and the expansion of forested land. To align the conservation of natural and semi-natural ecosystems with rural livelihoods, Indonesia is exploring sustainable forest and agricultural production systems that minimize damage to peatlands and forests, while also promoting incentives for ecosystem service benefits through market and non-market mechanisms.