Agriculture, Forestry and Other Land Use (AFOLU)

For a sustainable future

Volume 2 – Carbon Emissions Management series

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This is an executive summary of the Kearney Energy Transition Institute's latest FactBook, **Agriculture, Forestry and Other Land Use (AFOLU): for a sustainable future.**

For the complete FactBook, please visit https://www.energy-transition-institute.com/insights.

Agriculture, Forestry and Other Land Use (AFOLU): for a sustainable future

Vol. 2 – Carbon Emissions Management series

This FactBook focuses on greenhouse gas (GHG) emissions (CO_2, CH_4, and N_2O) from the Agriculture, Forestry and Other Land Use (AFOLU) sector. It identifies key sources of emissions in the sector along with major trends and outlines key mitigation measures to address these emissions.

After energy systems and transportation, AFOLU is the third biggest contributor to global anthropogenic GHG emissions. In past decades, tree cover loss has been driven by increased forest fires and continuous deforestation, reducing forestland capacity to act as a sink. Emissions from the agricultural sector have increased mostly from livestock (enteric fermentation and manure management) and rice cultivation.

AFOLU also embeds climate change mitigation potential through sustainable agricultural practices, bioenergy use, ecosystems conservation, and dietary and behavioral shifts. Most of the mitigation solutions in AFOLU are mature and low cost and will play a key role in the energy transition. Regulatory and policy tools to enable these solutions at scale have gathered pace during recent years.

1

AFOLU GHG emissions account for 14 percent of global emissions, come from a variety of unique sources, and take place in complex land and food production systems.

2

AFOLU offers a substantial opportunity to reduce GHG emissions as well as enrich biodiversity and human well-being.

3

Various policy and regulatory tools have been designed and implemented to address AFOLU emissions and encourage mitigation efforts at global, national, and sub-national levels.

AFOLU and global GHG emissions

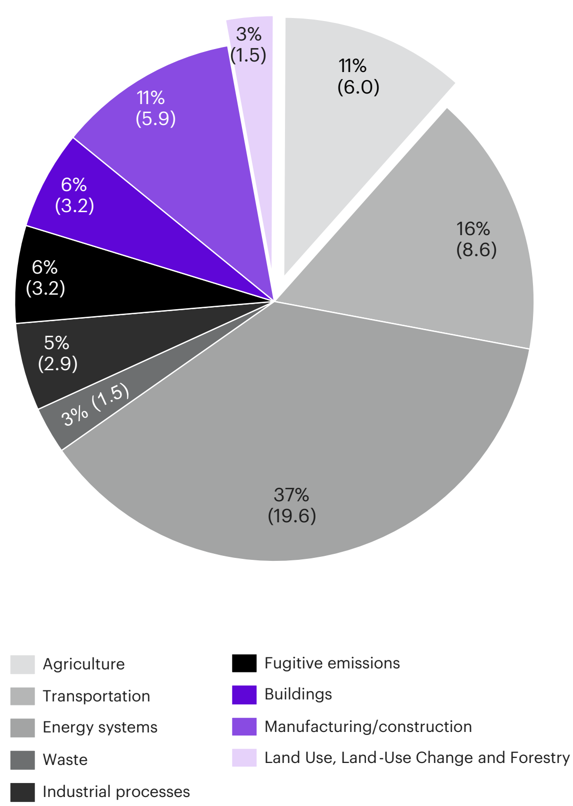
Anthropogenic greenhouse gas (GHG) emissions from AFOLU are defined as those occurring on managed lands. Managed land is land where human interventions and practices have been applied to perform production, ecological, or social functions.

AFOLU accounts annually for about 14 percent of global GHG emissions, with a total of approximately 7.6 $GtCO_2eq$ in 2020.

GHG emissions generated from natural unmanaged ecosystems, such as forests and wetlands, are not classified as anthropogenic in emission inventories/ sources (according to IPCC/FAO guidelines), and hence not included in the estimation of AFOLU emissions reported in this factbook. However, they have been explained and estimated along with their impacts on climate change in a dedicated section.

Global anthropogenic GHG emissions per sector

($GtCO_2eq$, % of total GHG, 2020)



Note: Graphic uses Global Carbon Project data for global carbon emissions for 2021 combined with EDGAR v6.0 split between sectors and uses, Global Methane Budget 2020 for methane emissions by sources and sectors, and EDGAR v6.0 data (2018) for global CH_4 (GWP-100 (AR6)), N_2O, and F-gases emissions. AFOLU data from FAOSTAT.
Sources: Global Carbon Budget 2021, International Energy Forum Methane Initiative (2021), FAO, UNFCCC, IPCC Chapter 11 Agriculture, Forestry, and Other Land Use (AFOLU); Kearney Energy Transition Institute analysis

AFOLU is divided into two categories...

— **Land Use, Land-Use Change and Forestry (LULUCF).** GHG emissions and removals resulting from direct human-induced land use such as urbanization, land-use change, and forestry activities.

— **Agriculture.** GHG emissions resulting from the practice of cultivating soils, producing crops, and raising livestock. Direct emissions are mostly from methane (CH_4) produced by anaerobic fermentation or nitrous oxide (N_2O) from extensive use of synthetic N-fertilizers, manure, and residues practices. Indirect emissions are the emission of precursor gases that will later transform into GHG in the atmosphere:

— Formation of NOx and NH_3 from crop and manure practices

— Formation of NH_{4+} and NO_{3-} from combustion gases deposition of biomass burning

...that are further split into various subcategories characterized by emission sources and types.

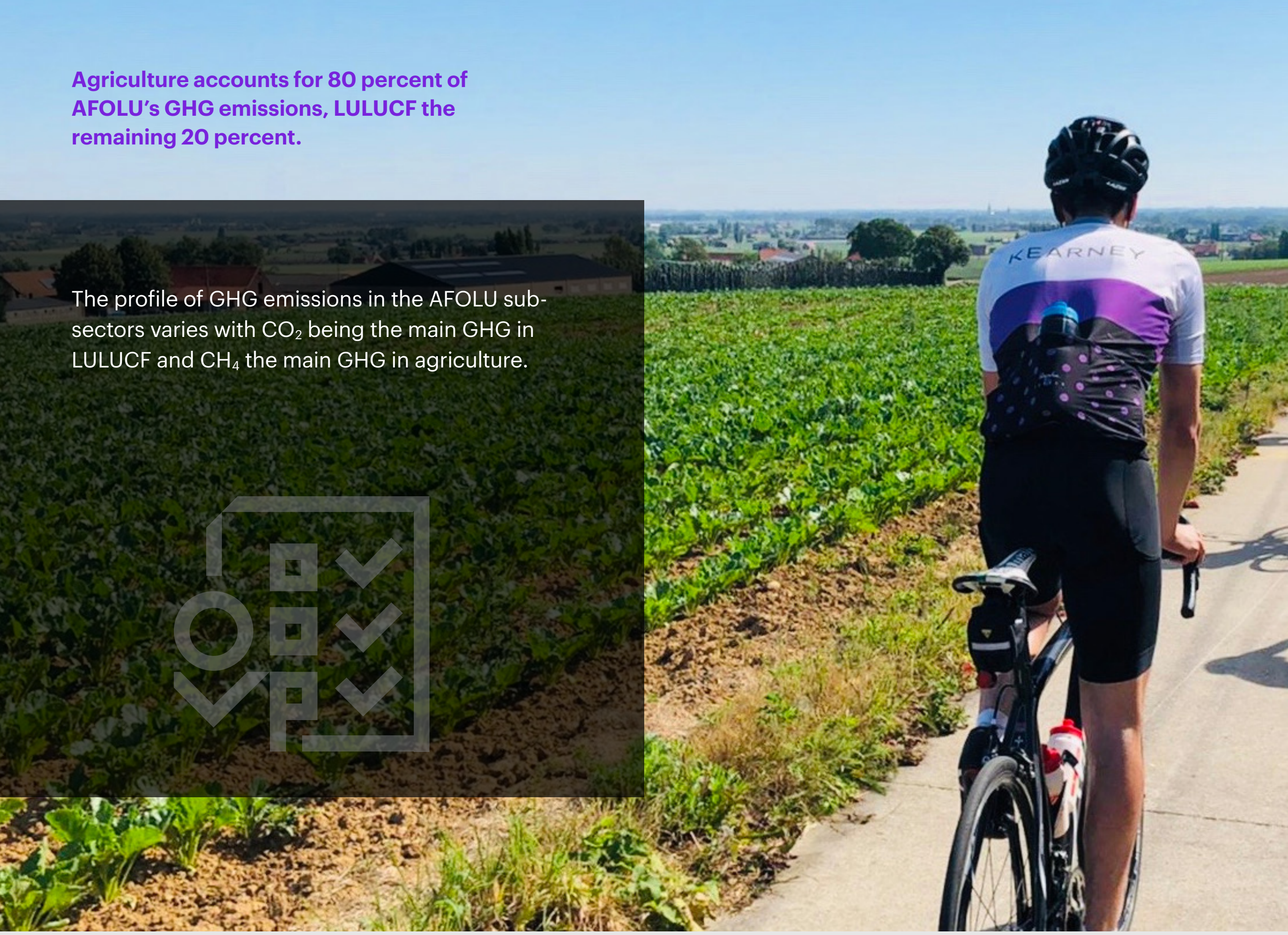
AFOLU categories and subcategories

(IPCC)		Subcategories (FAO)	GHG emission
AFOLU	LULUCF	L1 **Forestland**	CO_2 removals as a result of net carbon stock increase in the living biomass pool (above ground and below ground biomass) associated with forestland growth
		L2 **Net forest conversion**	CO_2 emissions from net carbon stock decrease in the living biomass pool (above ground and below ground biomass) associated with forestland converted to croplands or grasslands[1]
		L3 **Burning biomass (fires)**	CO_2, CH_4 and N_2O emissions produced by the burning of biomass. Subcategories included: organic soil fires (L3-a), forest fires (L3-b), and humid tropical forest fires (L3-c)
		L4 **Drained organic soils (CO_2)**	CO_2 emission following soil drainage due to the cultivation of organic soils for crop production or for livestock production (grasslands)
		L5 **Wetlands, settlements, and other land**	GHG emissions from underwater anaerobic decomposition of organic matter in wetlands (CH_4), developed lands converted to settlements, other land use change (bare soil, rock, ice)
	Agriculture	A1 **Enteric fermentation**	Digestive process by which carbohydrates are broken down by microorganisms into simple molecules for absorption. Methane emissions are produced as a by-product
		A2 **Manure left on pasture**	Nitrous oxide emissions produced by microbial processes of nitrification and de-nitrification from manure left by grazing livestock taking place on the deposition site
		A3 **Manure management**	Methane and nitrous oxide emissions from the decomposition of manure under low oxygen or anaerobic conditions
		A4 **Manure applied to soils**	Nitrous oxide emissions produced by nitrification and de-nitrification from manure added to agricultural soils by farmers as an organic fertilizer taking place on the application site
		A5 **Rice cultivation**	Methane emissions from decomposition of organic matter (mainly rice straw residue) under anaerobic conditions in paddy fields
		A6 **Synthetic fertilizers**	Nitrous oxide emissions produced by microbial processes of nitrification and de-nitrification from nitrogen added to agricultural soils by farmers taking place on the addition site
		A7 **Crop residues**	Nitrous oxide emissions from nitrification and de-nitrification of nitrogen in crop residues (above and below ground) and forage/pasture renewal left on agricultural fields by farmers
		A8 **Burning – crop residues**	CH_4 and N_2O gases produced from the burning of materials left in fields or orchards after crops have been harvested and/or processed (stalks and stubble (stems), leaves, seed pods)
		A9 **Savanna fires**	CH_4 and N_2O gases produced from the burning of biomass vegetation in the following five land cover types: savanna, woody savanna, open shrubland, closed shrubland, and grassland.
		A10 **Drained organic soils (non-CO_2)**	Nitrous oxide emissions produced by nitrification, de-nitrification after nitrogen mineralization associated with gain of soil organic matter resulting from drainage of organic soils
		A11 **Liming; urea application**	CO_2 and water produced from bicarbonate, resulting from lime stones dissolution or urea in the presence of water and urease enzymes

[1] Conversion to wood products is not included as this is considered a carbon transfer to another surface pool (harvested wood) and not a direct emission to the atmosphere. Sources: IPCC, FAO, European Commission; Kearney Energy Transition Institute

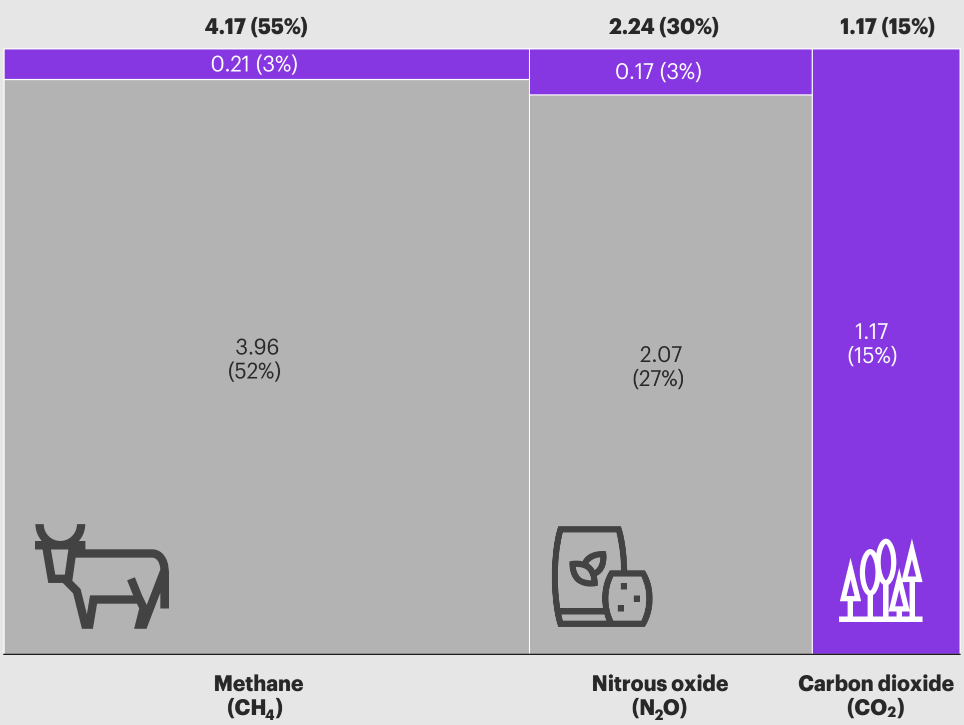
Agriculture accounts for 80 percent of AFOLU's GHG emissions, LULUCF the remaining 20 percent.

The profile of GHG emissions in the AFOLU sub-sectors varies with CO_2 being the main GHG in LULUCF and CH_4 the main GHG in agriculture.



Global AFOLU carbon emissions by source in 2020

($GtCO_2eq$, % of global AFOLU GHG emissions)



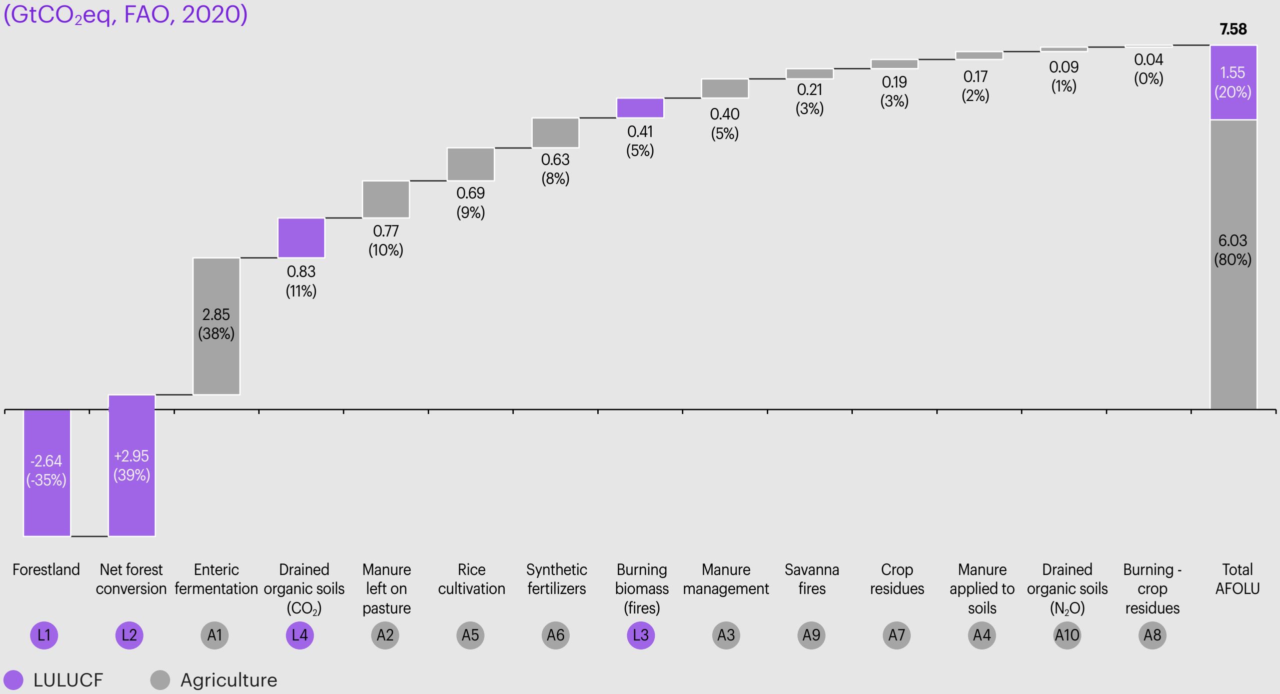
Land Use, Land-Use Change and Forestry (LULUCF)

Agriculture

Sources: FAO, 2015, Estimating Greenhouse Gas Emissions in Agriculture; Kearney Energy Transition Institute analysis

AFOLU global GHG emissions/removals per subcategory

($GtCO_2eq$, FAO, 2020)



Sources: FAO; Kearney Energy Transition Institute analysis

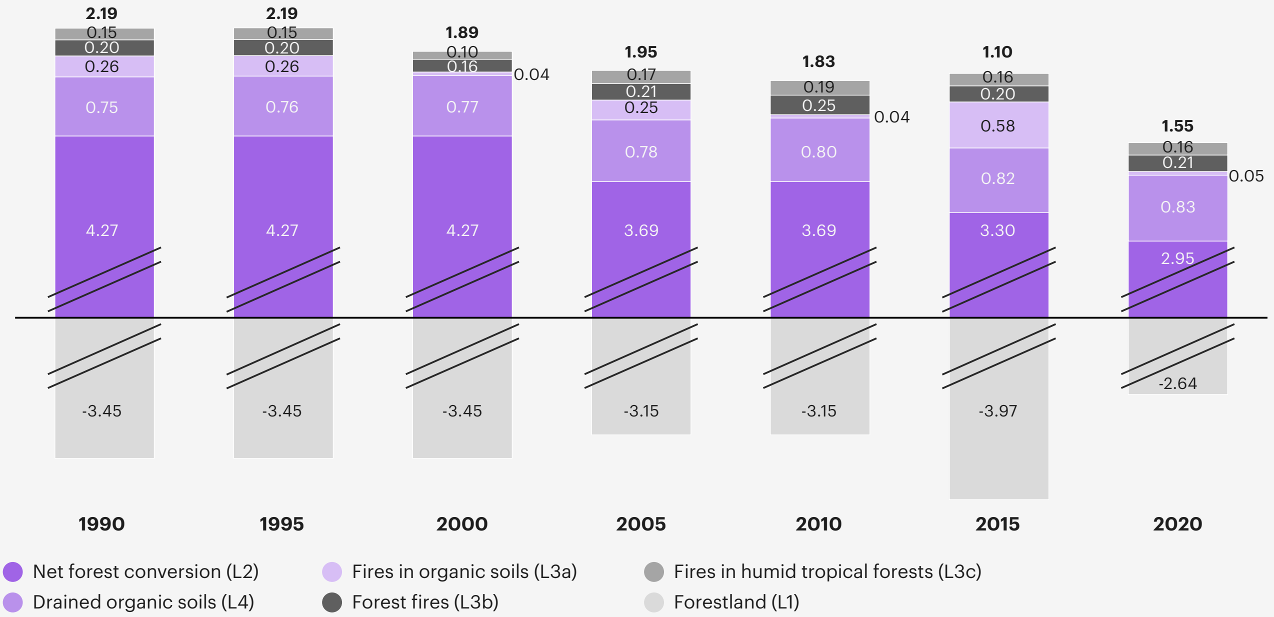
AFOLU GHG emissions are mainly from enteric fermentation and net forest conversion while removals are only from forestland.

Note: Data retrieved from FAO, 2021. FAOSTAT Climate Change, Emissions, Emissions Totals (fao.org/faostat/en/#data/GT). Negligible sources: Wetlands, Settlements, and Other Land (L5) and Liming; Urea Application (A11). 1 Subcategories included: Organic Soil fires (L3-a), Forest fires (L3-b) and Humid Tropical Forest fires (L3-c). Sources: FAO; Kearney Energy Transition Institute analysis

Net forest conversion (deforestation) is the major contributor to land use change and forestry emissions.

Land use change and forestry global emissions trend

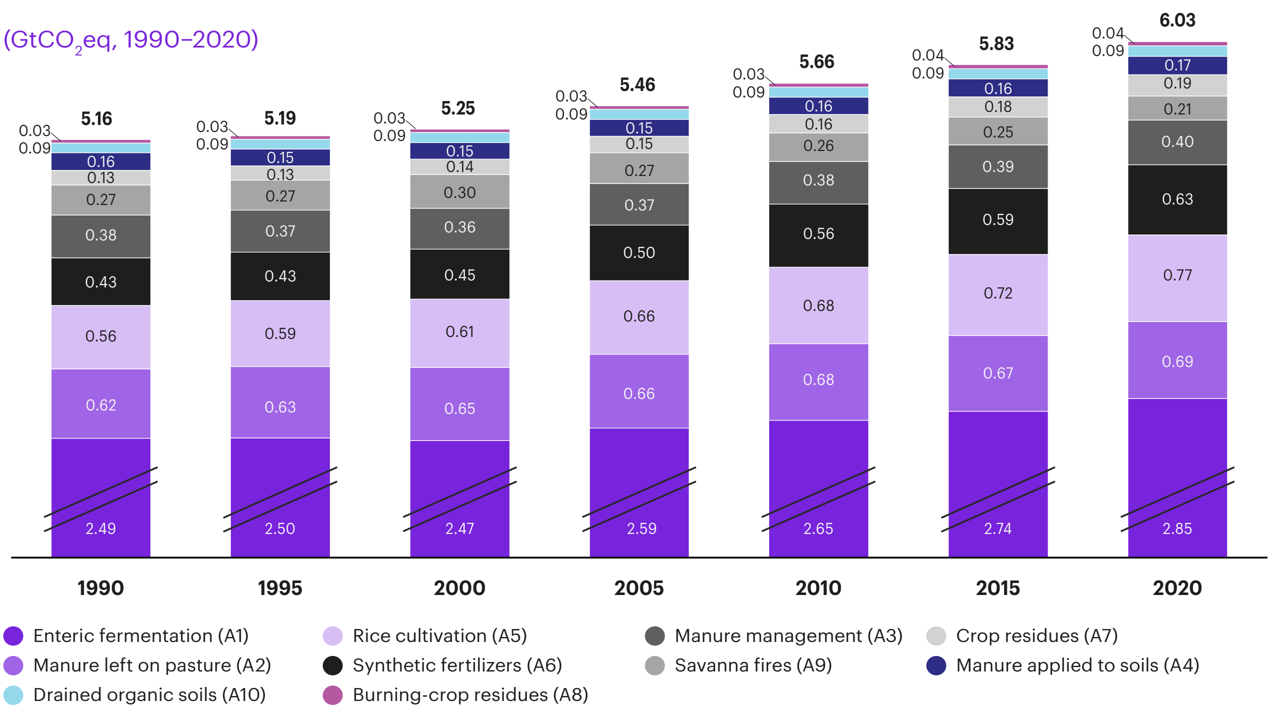
($GtCO_2eq$, 1990–2020)



Enteric fermentation, manure practices, and rice cultivation are major methane contributors in agriculture GHG emissions, accounting for 52 percent of the total agriculture GHG emissions.

Agriculture global direct emissions trend

($GtCO_2eq$, 1990–2020)

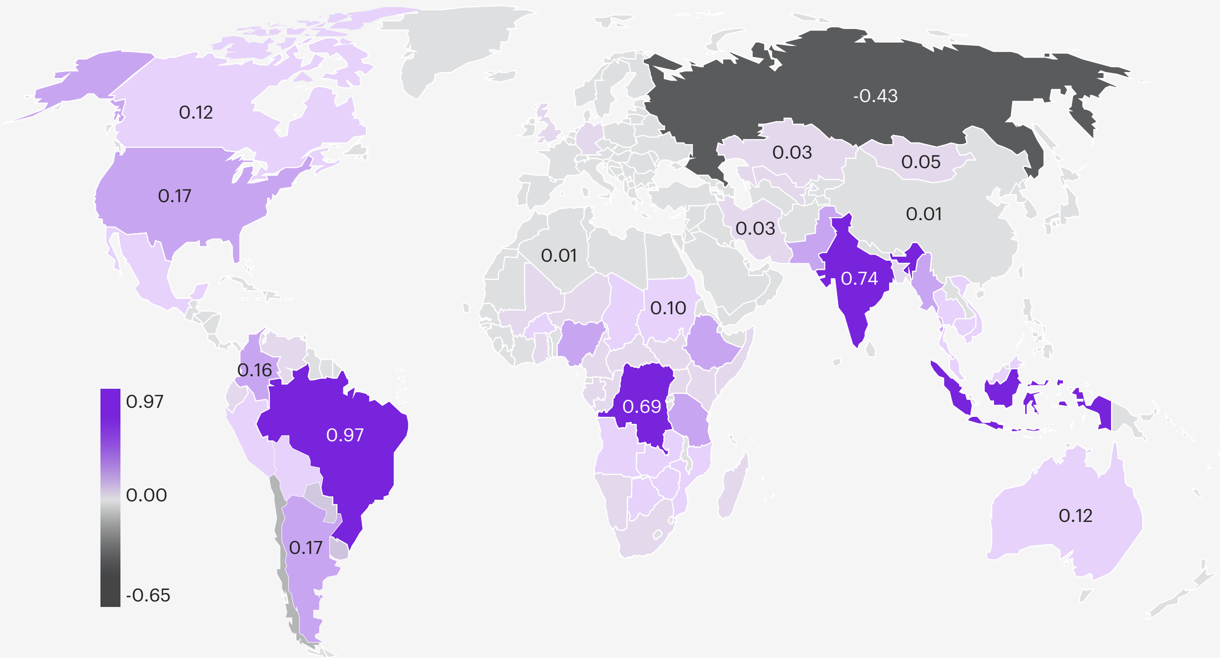


Note: Data retrieved from FAO, 2021. FAOSTAT Climate Change, Emissions, Emissions Totals (https://www.fao.org/faostat/en/#data/GT). 1 CO_2 emissions from this source are assumed to be zero in GHG inventories due to its recapture in regrowing vegetation and transfer to other carbon pools (for example, soils). Sources: FAO; Kearney Energy Transition Institute analysis

The largest GHG emissions from AFOLU occur in Brazil, India, Democratic Republic of Congo, and Indonesia due to forest conversion, enteric fermentation, and burning of biomass.

Global AFOLU carbon emissions by country

($GtCO_2eq$, 1990–2020)



Note: Non-exhaustive data retrieved from FAO, 2021. FAOSTAT Climate Change, Emissions, Emissions Totals (fao.org/faostat/en/#data/GT)
Sources: FAO; Kearney Energy Transition Institute analysis

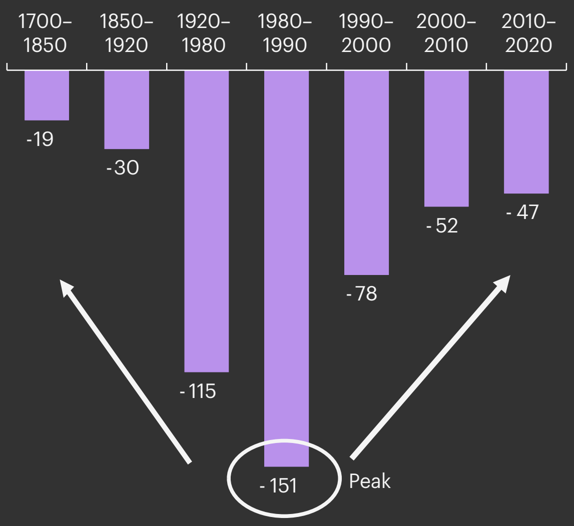
Land capacity to act as a sink, mostly from forestland, has been declining and is further threatened by climate change feedback loops.

Global forest cover continues to decline even though the deforestation rate has slowed down over the past 30 years. Forest loss is driven by natural (for example, fires, insects, diseases, and severe weather events) and anthropogenic (for example, deforestation, land conversion, and land degradation) factors.

The majority of forests are situated in the tropics (45 percent), followed by boreal (27 percent), temperate (16 percent), and subtropical (11 percent) domains. The ability of intact tropical forests to remove CO_2 from the atmosphere was at its highest level in the 1990s and has been in decline since then due to forest loss and reduced sink capacity per unit area.

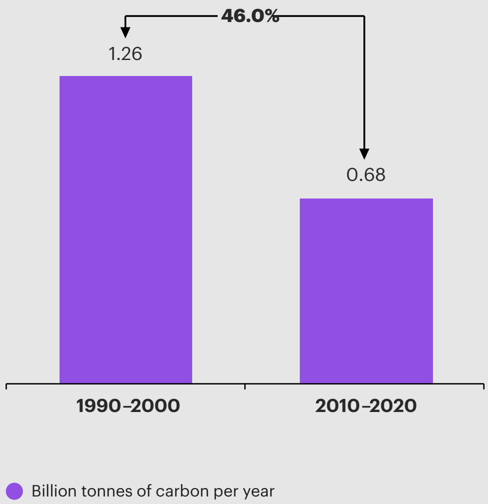
Global annual forest area net change rate (on average)

(1700–2020, million hectares per decade)



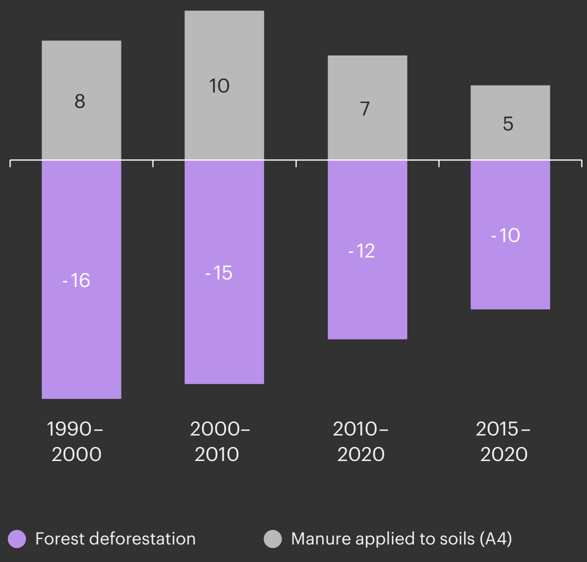
Carbon uptake ability

(tropical forests, cumulatively per year)



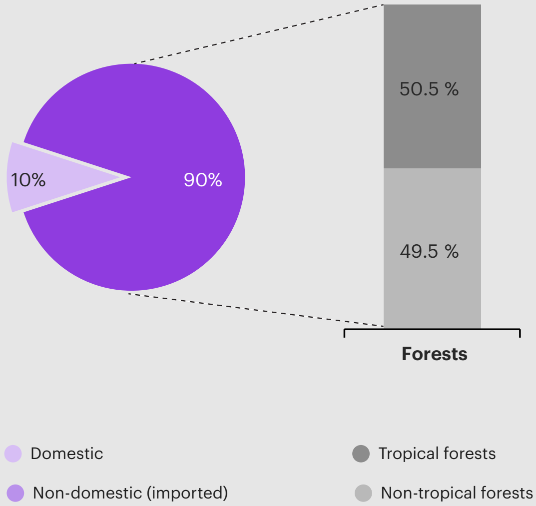
Global annual rate of forest expansion and deforestation (on average)

(1990–2020, million hectares per year)



Deforestation footprints of selected G7 countries[1]

(2015)



Sources: FAO (2020) "Global Forest Resources Assessment 2020," Williams, M. (2003) "Deforesting the earth: from prehistory to global crisis." ourworldindata.org; Kearney Energy Transition Institute analysis

[1] Japan, Germany, France, the UK, and Italy
Sources: Hoang, N.T. and K. Kanemoto, 2021: "Mapping the deforestation footprint of nations reveals growing threat to tropical forests." Nature Ecology & Evolution, Lewis et al., 2020, "Asynchronous carbon sink saturation in African and Amazonian tropical forests," Nature, cirad.fr

In the 1990s, the tropical forests were able to offset 17 percent of anthropogenic CO_2 emissions whereas this uptake dropped to 6 percent in the 2010s. When projecting high-emission scenarios, the proportion of CO_2 emissions stored by land and removed from the atmosphere is smaller despite the continuous expansion in sink capacities. Under these scenarios, land is expected to have an impaired ability to counteract atmospheric emission flux.

Traded agricultural and forestry products displace GHG emissions in foreign countries.

While global deforestation is decreasing, the imports of tropical deforestation-related commodities are on the rise:

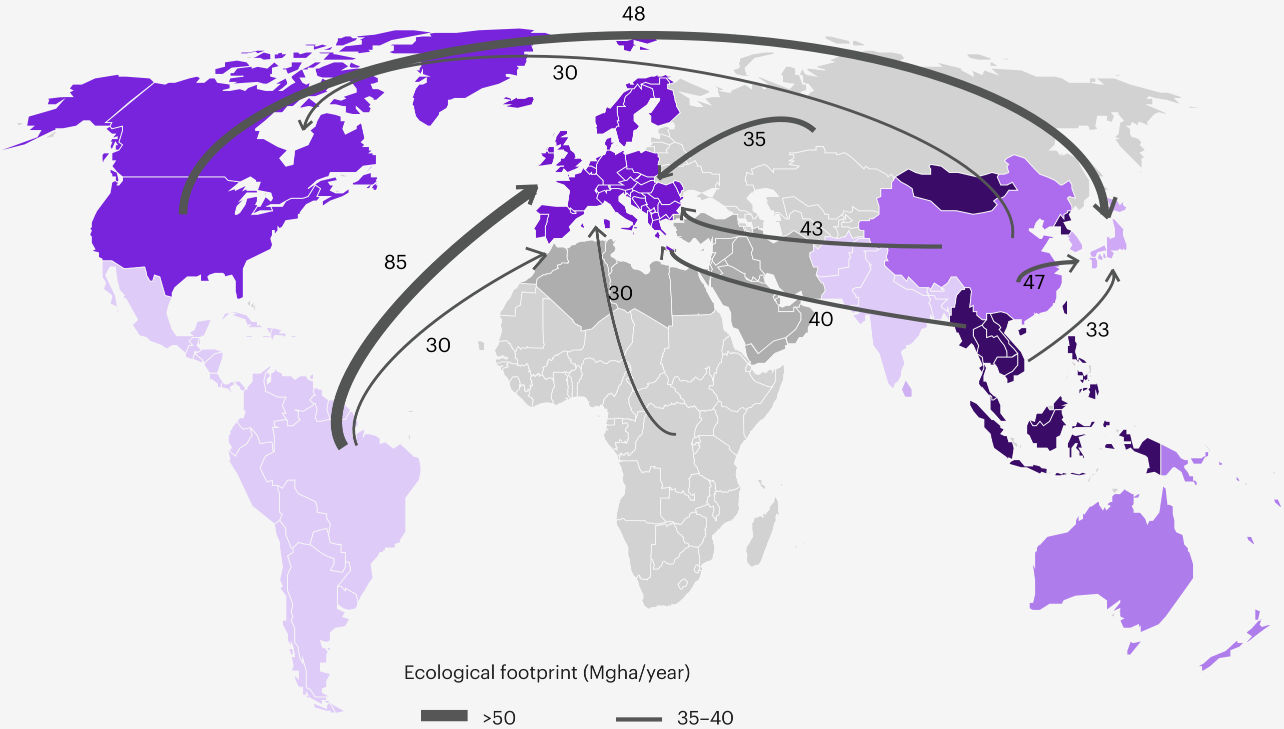
— China, some EU countries, and Japan have become major importers of tropical deforestation-related commodities, while developing countries such as Brazil are the main exporters.

— Key tropical deforestation-related commodities are **coffee, chocolate, cattle, soy, palm oil, and timber.**

— Many countries have achieved net forest gains domestically, but they have also increased the deforestation (mostly concentrated in the tropical areas) footprints of their imports.

Top net displacements of land use globally

(million global ha/year)



Note: Global hectare (gha) corresponds to the biologically productive hectare with world average biological productivity for a given year. Global Footprint Network (2023), Glossary. Sources: European Energy Agency (2019) Climate change adaptation in the agriculture sector in Europe; Kearney analysis

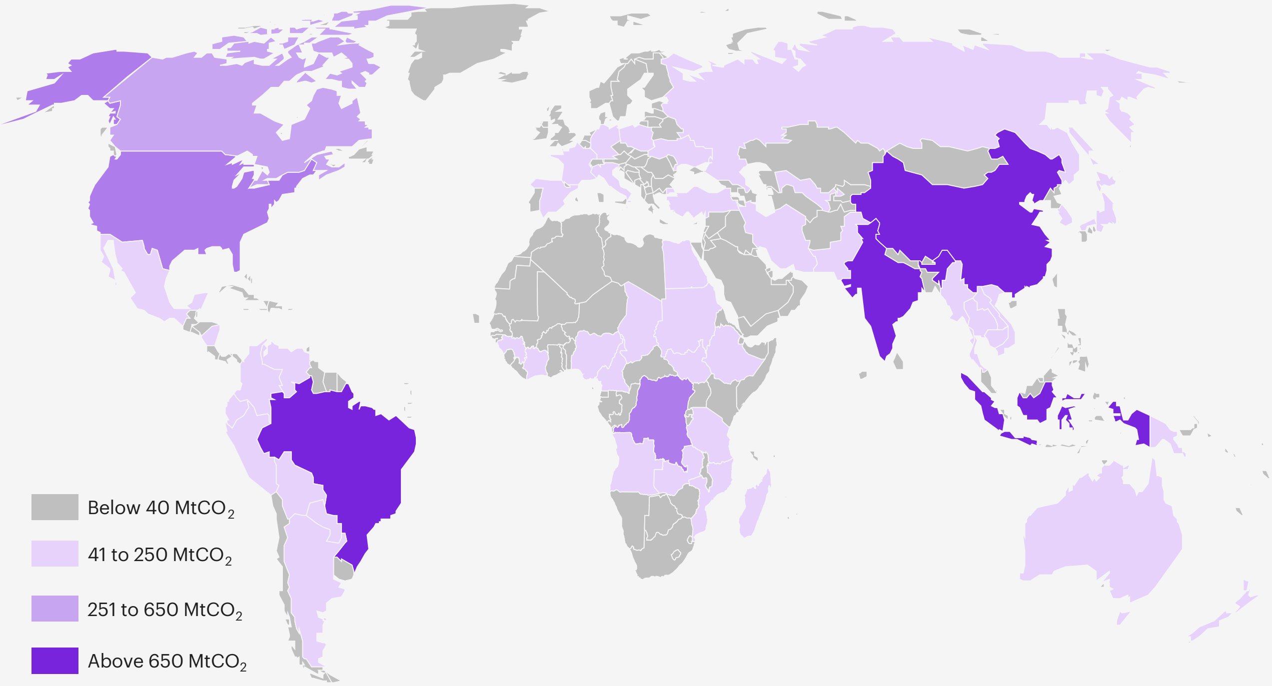
Food systems and value chains have the potential to reduce greenhouse gas emissions.

Food systems correspond to the stakeholders and added-value activities that are along the value chain which includes production, aggregation, processing, distribution, consumption, and disposal of agri-food products. Sustainable food systems are defined as those systems including the delivery of food security and nutrition through economic, social, and environmental sustainability.

There's a wide variation in food system-related emission imprints with emerging countries such as Brazil, China, and India having the highest share of global food system emissions, followed by Indonesia.

Total food systems CO_2 emissions by country

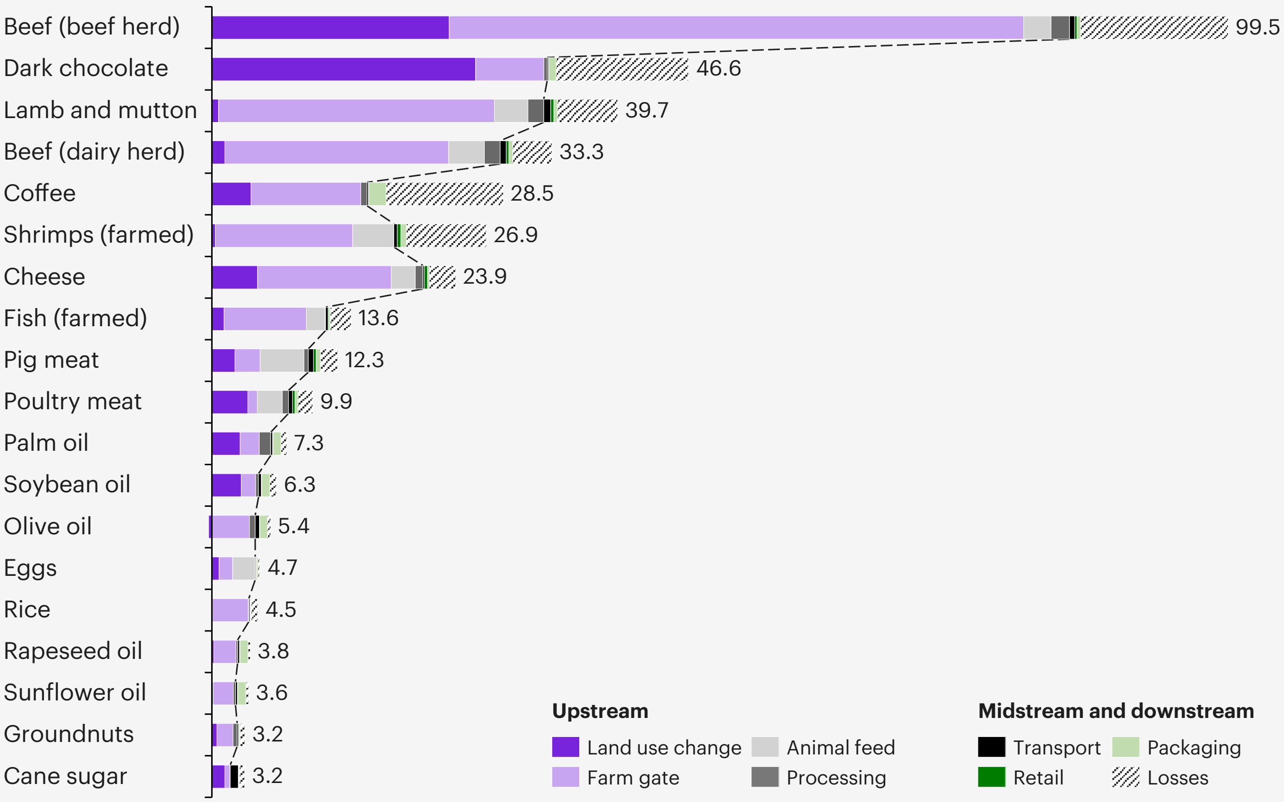
(Mt CO_2/year)



Note: CO_2 emissions from food systems include cropland, livestock, deforestation, and food loss and waste.
Sources: WWF (2020), Enhancing NDCs for Food Systems Recommendations for decision-makers; Kearney Energy Transition Institute analysis

GHG of food products per source in the value chain

(kg CO_2eq/kg of food, 2018, Our World in Data)



Emissions of food products vary across the phases of the value chain and are also dependent on the nature of the product. The highest emitters concentrate the bulk of their emissions in the upstream segment with land use change and farm gate as the activities with the largest footprint.

Mitigation options in food systems vary greatly from one region to another based on multiple drivers including eating habits, food preferences and production systems, urbanization, and infrastructure extent. Among the numerous options, reducing food loss and waste and shifting diets could decrease emissions by 1.8 $GtCO_2$eq per year.

Note: Data retrieved from Our World in Data site, which is based on an article from *Science Journal* (Vol 360, Issue 6392, pp. 987-992).
Sources: Our World in Data; Kearney Energy Transition Institute analysis

Non-anthropogenic emissions

Non-anthropogenic emissions from unmanaged wetlands and uplands are considered carbon neutral in the long term, as they are part of the natural carbon cycle.

Upland forests and vegetation store carbon from the atmosphere by photosynthesis. This storage is temporary and conditioned by the forest management. In fact, burning or natural decomposition of the organic matter returns the stored carbon to the atmosphere.

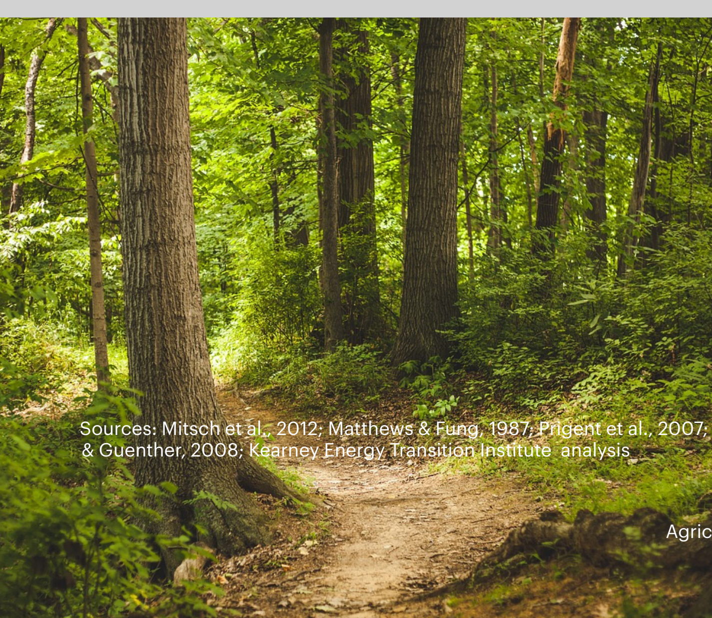
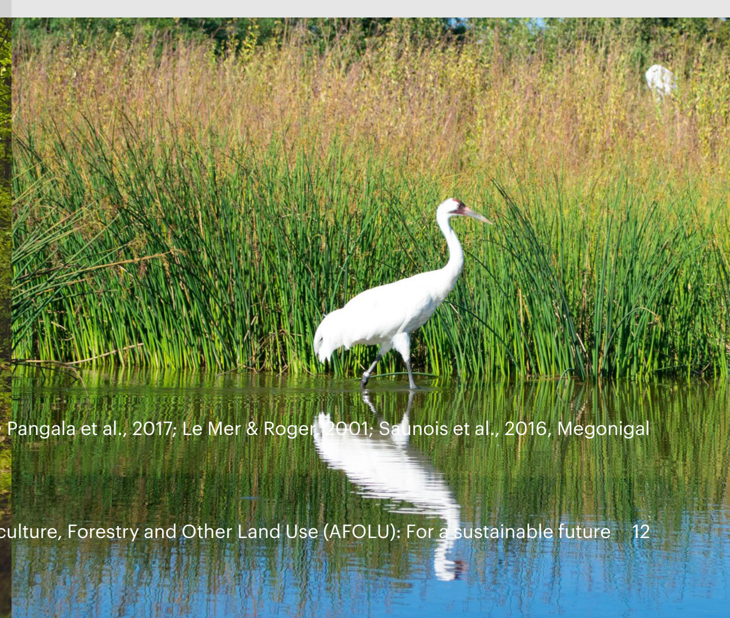
The impact of carbon storage from **wetlands** is balanced with their CH_4 emissions. Carbon fixation under wetland anaerobic soil conditions provides unique conditions for long-term storage of carbon into soil. However, this carbon sequestration process is intimately linked to methane emission from wetlands produced by methanogens under anaerobic conditions.

Uplands

- Uplands ecosystems include **forests, bushlands, tundra, grasslands, and desserts**
  - Forests cover about 31 percent of the world's total land surface with 46 M km^2. Unmanaged forests account for about 27 percent of total forest cover.
- Upland ecosystems on freely drained soils are **recognized as CH_4** sinks in global budgets and have been the focus of studies on CH_4 consumption by soils.
- Trees and vegetation store carbon from **photosynthesis** and release it through **respiration and decomposition** during natural degradation and death.

Wetlands

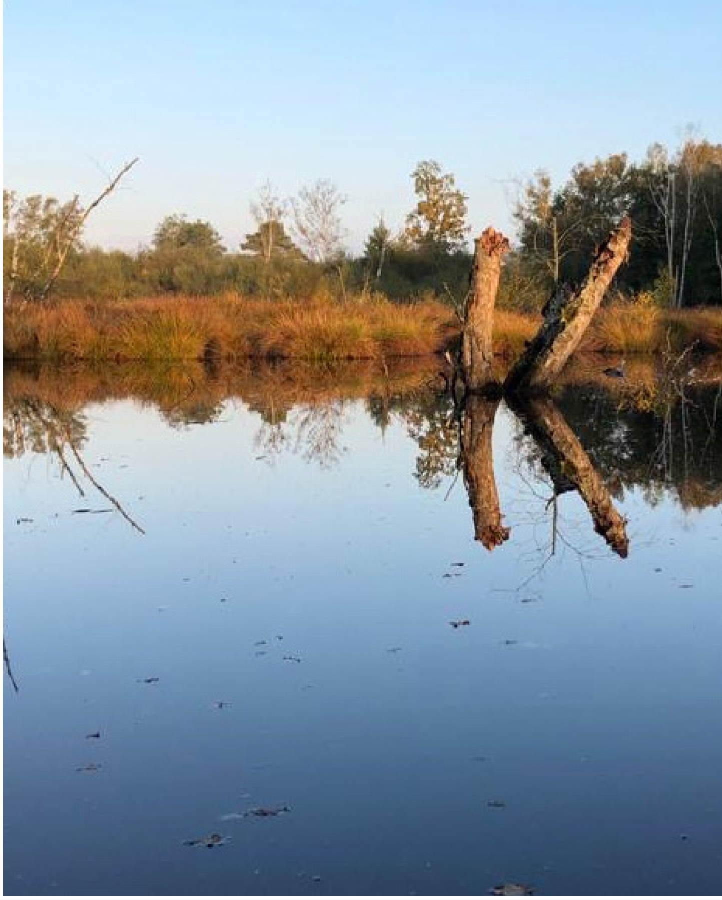
- Wetlands ecosystems include **marshes, swamps, and peatlands**
  - Wetlands cover about 5 percent of the world's total land surface.
  - Forested wetlands are about 60 percent of total global wetland areas.
- Wetland ecosystems are the **largest natural source of CH_4** globally (20–25 percent of global methane emissions from **underwater anaerobic decomposition** of organic matter).
- Vegetation stores carbon through **photosynthesis** and acid soil contributes to **peat formation** and long-term carbon storage.

Sources: Mitsch et al., 2012; Matthews & Fung, 1987; Prigent et al., 2007; Pangala et al., 2017; Le Mer & Roger, 2001; Saunois et al., 2016, Megonigal & Guenther, 2008; Kearney Energy Transition Institute analysis

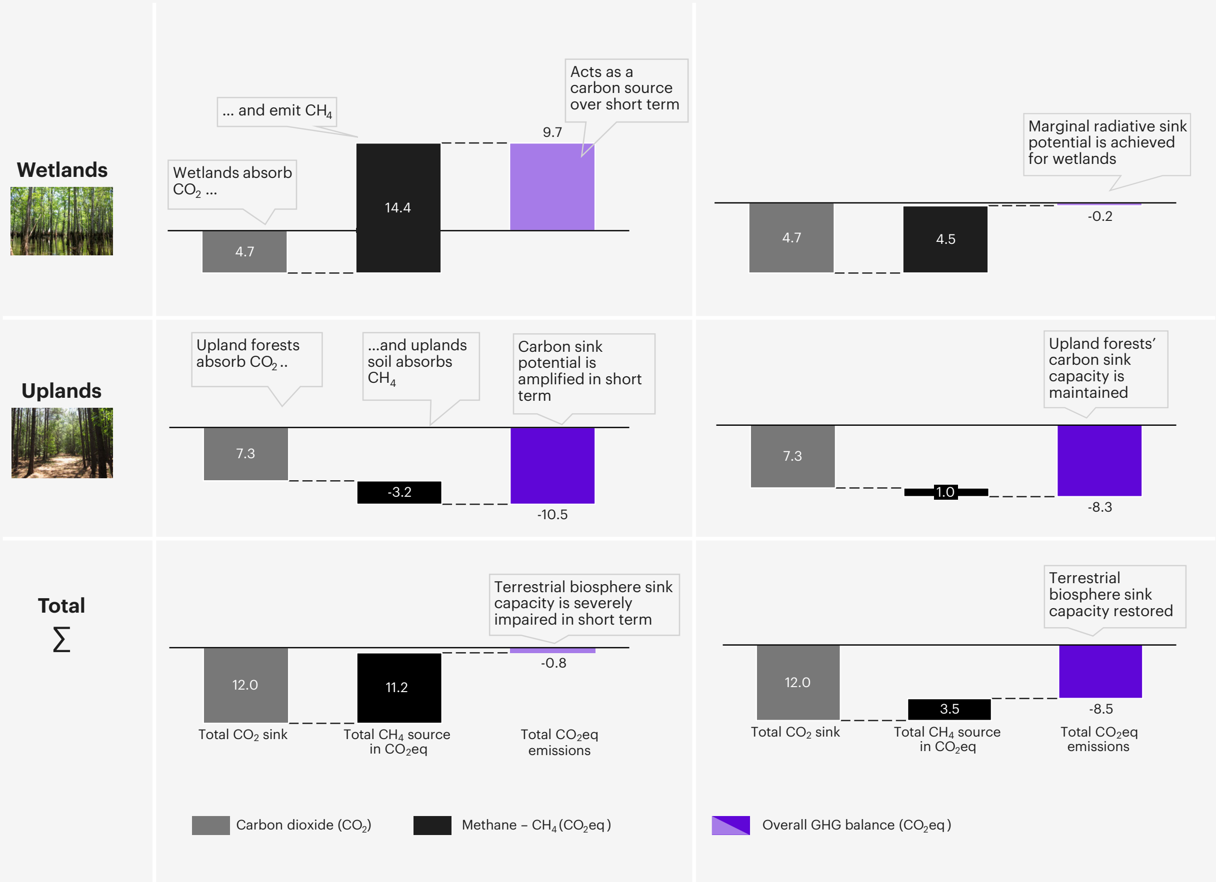
On a 20-year horizon, due to the impact of methane, the total sink capacity of uplands and wetlands suffers a big drop (in contrast to long term, for example 100 years).

This can have negative consequences (some of them irreversible, such as permafrost thaw) in the coming years. Hence, it is imperative to comprehensively analyze the impact of methane over the short term.



Radiative impact of uplands and wetlands GHG emissions

(million global ha/year)



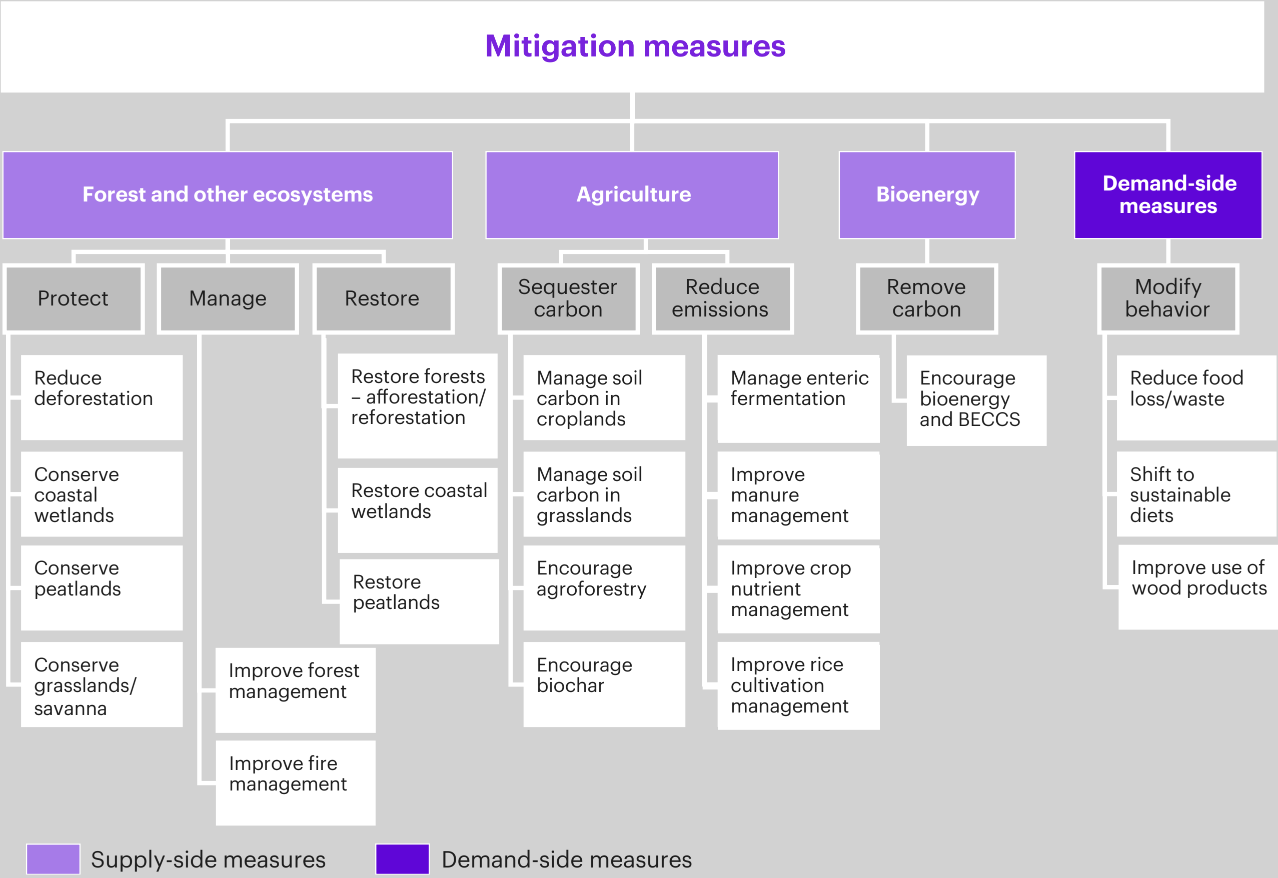
Sources: Global Carbon Budget; Global Methane Budget; Balcombe & al., 2018; Mitsch & al., 2012; Kearney Energy Transition Institute analysis

GHG emissions mitigation solutions in AFOLU

Measures are broadly categorized as to whether they intervene on the supply or demand side.

- **Forests and other ecosystems.** Protection, improved management, and restoration of forests, peatlands, coastal wetlands, savannas, and grasslands offer the highest mitigation potential.
- **Agriculture.** Agriculture-based measures such as cropland and grassland soil carbon management, agroforestry, use of biochar, improved rice cultivation, and livestock and nutrient management account for the second largest share of the mitigation potential.
- **Bioenergy and BECCS.** This area represents an important share of the total mitigation potential.
- **Demand-side measures.** These include reducing food waste, shifting to sustainable healthy diets, and improved use of wood products.

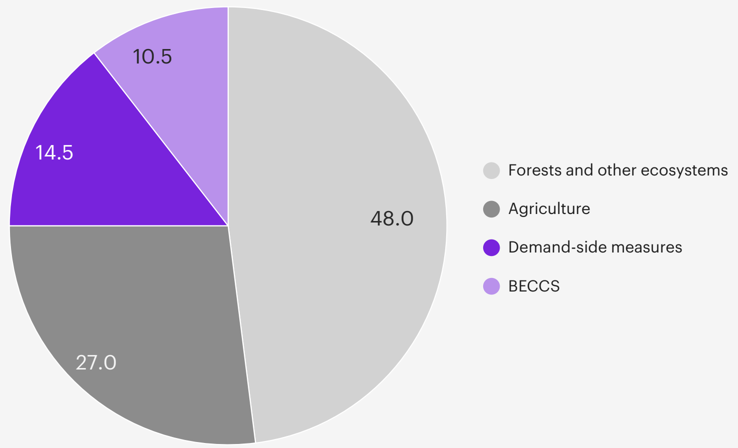
Classification of the key mitigation measures to address AFOLU GHG emissions



Sources: IPCC Sixth Assessment Report (Working Group III, Climate Change 2022: Mitigation of Climate Change, Chapter 7); Kearney Energy Transition Institute analysis

Contributions of different AFOLU mitigation options toward annual mitigation potential

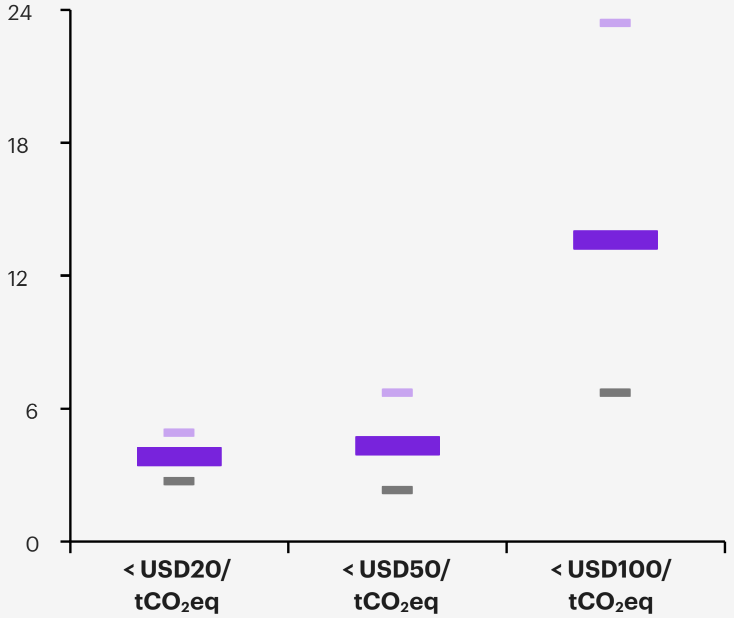
(in %, with carbon prices up to 100 USD/tCO_2eq)



Global AFOLU emission mitigation potential is approximately 14 $GtCO_2eq$/year (with carbon prices up to 100 USD/tCO_2eq).

Estimated annual mitigation potential of AFOLU options by carbon price

(2020–2050, $GtCO_2eq$/year)



Regionally, the mitigation potential from reducing deforestation is highest in tropical countries in Asia and developing Pacific, Latin America and the Caribbean, and Africa and the Middle East, whereas carbon sequestration in agricultural land and demand-side measures are critical in developed countries.

Sources: IPCC Sixth Assessment Report (Working Group III, Climate Change 2022: Mitigation of Climate Change, Chapter 7); Kearney Energy Transition Institute analysis

Each mitigation measure is characterized by its own set of benefits, risks, and challenges in implementation.

Mitigation measures, especially land-based interventions, should be evaluated for their impact on environmental and societal dimensions. Natural ecosystem protection, carbon sequestration in agriculture, sustainable healthy diets, and reduced food waste provide high co-benefits in the most effective way.

Mitigation measures' efficacy and scale of benefit/risk largely depends on the type of activity undertaken, deployment strategy (for example, scale, method), and context (for example, soil, biome, climate, food system, land ownership) that vary geographically and over time. Each mitigation measure should be carefully studied for its wider impact as negative consequences can be substantial in case of inappropriate implementation.

Mitigation measures' co-benefits and risks

Category	Mitigation measures	Biodiversity	Water	Soil	Air quality	Resilience	Livelihood	Food security
Forest and other ecosystem – protect	Reduce deforestation	●	●	●	●	●	○	○
	Conserve coastal wetlands	●	●	●	●	●	○	○
	Conserve peatlands	●	●	●	●	●	○	○
	Conserve grasslands and savanna	●	●	●	●	●	○	○
Forest and other ecosystem – manage	Improve forest management	○	●	●	●	●	○	○
	Improve fire management	○	●	●	●	●	●	●
Forest and other ecosystem – restore	Restore forests – afforestation/reforestation	○	○	●	●	○	○	○
	Restore coastal wetlands	●	●	●	●	●	○	○
	Restore peatlands	●	●	●	●	●	○	○
Agriculture – sequester carbon	Manage soil carbon – cropland	●	●	●	●	●	●	○
	Manage soil carbon – grassland	●	●	●	●	●	●	○
	Encourage agroforestry	●	●	●	●	●	○	○
	Encourage biochar	○	●	●	●	●	○	●
Agriculture – reduce emissions	Manage enteric fermentation	NA	NA	NA	●	NA	○	○
	Improve manure management	●	●	●	●	●	○	○
	Improve crop nutrient management	●	●	●	●	●	○	○
	Improve rice cultivation management	●	●	●	●	●	○	○
Bioenergy	Encourage bioenergy and BECCS	○	○	○	○	○	○	■
Demand-side measures	Reduce food loss and waste	●	●	●	●	●	●	●
	Shift to sustainable healthy diets	●	●	●	●	●	●	○
	Improve use of wood products	○	○	●	●	○	○	○

● Potential co-benefit only ○ Potential co-benefit and risks ■ Potential risks only

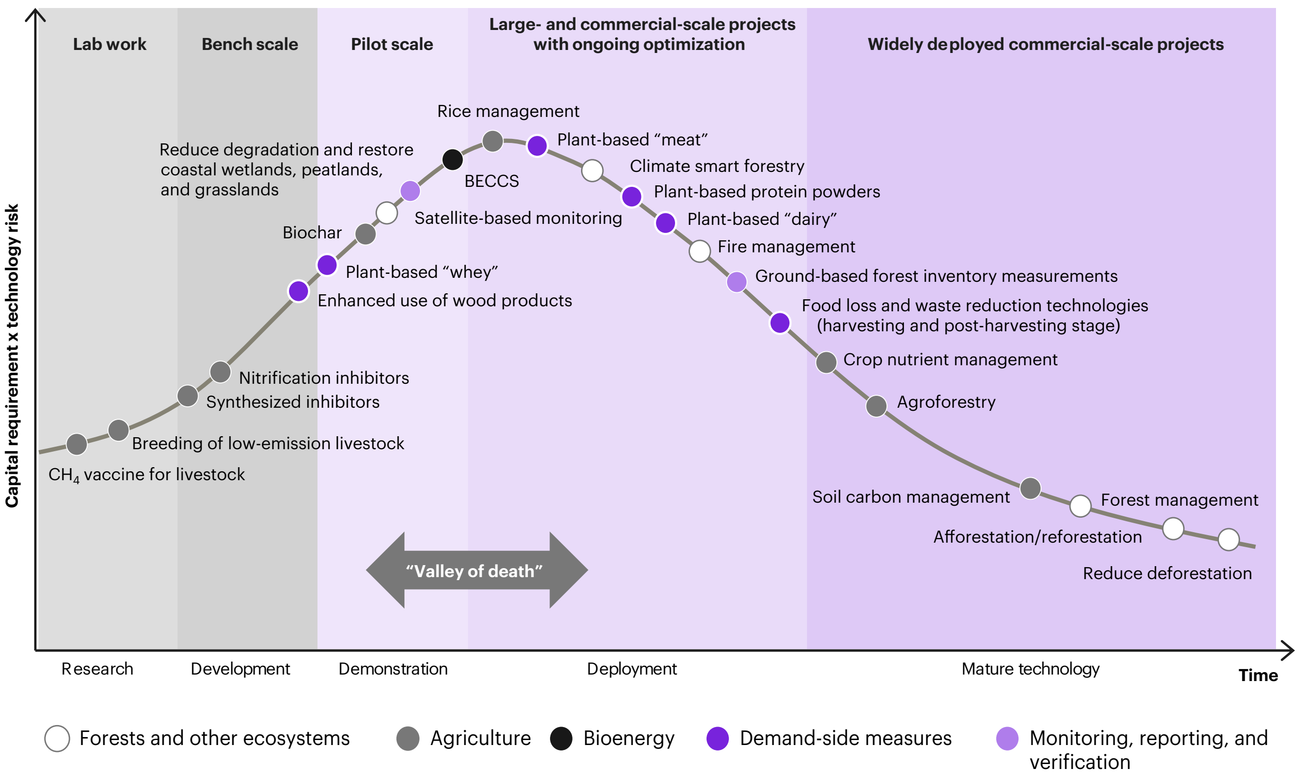
Sources: IPCC Sixth Assessment Report (Working Group III, Climate Change 2022: Mitigation of Climate Change, Chapter 7), Kearney Energy Transition Institute analysis

Most of the mitigation options are available and ready to deploy.

Significant near-term mitigation potential can be realized at relatively low cost and multiple new innovative solutions, such as CH_4 vaccines, inhibitors, and breeding of low-emission livestock, are being developed to complement traditional solutions.

Carbon removal solutions are essential in reaching net zero targets. AFOLU mitigation solutions can help support carbon removal efforts at scale by removing carbon emissions from the atmosphere and storing it in soils and forests.

Technology maturity curve



Sources: IPCC Sixth Assessment Report (Working Group III, Climate Change 2022: Mitigation of Climate Change, Chapter 7), Kearney Energy Transition Institute analysis

Regulation and policy scan

UNFCC has been at the forefront of the policy development of the AFOLU sector's emission mitigation since the early 1990s.

Global regulatory and policy efforts to mitigate AFOLU emissions continue to gather momentum. Multiple international initiatives and national policy instruments are in force. The past three decades have seen a constant push to formulate policies to facilitate and encourage GHG mitigation within AFOLU.

Milestones in policy development for AFOLU measures

Timeline	International agreements
1992	**UNFCC** — GHG inventory/comprehensive coverage of LULUCF and non-CO_2 emissions in agriculture
1997	**KYOTO protocol** — GHG inventory/comprehensive coverage of LULUCF and non-CO_2 emissions in agriculture — Clean development mechanism
2007	**COP13/REDD+** — Avoided deforestation levels — Result-based payments (reducing emissions from deforestation and forest degradation, for example REDD+)
2012	**COP18** — Nationally appropriate mitigation actions (NAMA) which may cover AFOLU emissions
2015	**PARIS Agreement** — Nationally determined contributions (NDC) which may cover AFOLU emissions
2022	**COP27** — Launch of the Forest and Climate Leaders' Partnership (FCLP), following announcements made at COP26 (Glasgow), which aims to unite concrete action by governments, businesses, and community leaders.

A wide variety of policy tools are utilized to encourage mitigation of AFOLU emissions:

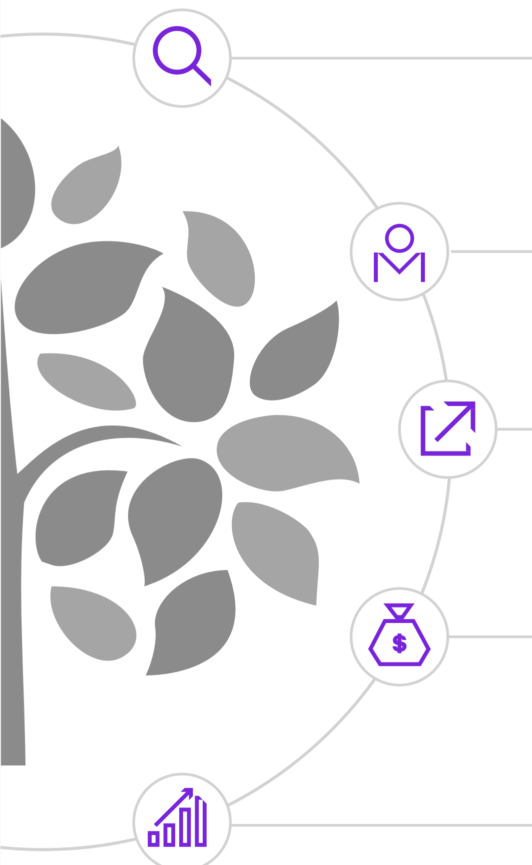
— **Financial incentives** such as low interest loans, subsidy programs, Payment for Ecosystem Services (PES), emission trading schemes, and carbon offsets, among others, have been utilized to encourage mitigation efforts at global, national, and sub-national levels.

— **Regulations** imply direct controls on how land is used, and zoning sets legal limits on converting land from one use to another to realize emission mitigation aims such as conserving forest resources or safeguarding protected land resources.

Out of all new/updated NDCs (nationally determined contributions), 95 percent include mitigation in the agriculture and/or Land Use, Land-Use Change and Forestry (LULUCF) sectors compared to previous NDCs where only 82 percent included some type of mitigation in AFOLU.

Various initiatives have been announced in the recent COP summits to address emissions from AFOLU.

Key initiatives have been launched at the recent COP summits



Forests and land use

— Declaration of forests and land use by 140 countries to commit to reforestation and restoration. Several new multi-country initiatives for tackling deforestation and restoring carbon-rich ecosystems

Global methane pledge

— To reduce human-caused methane emissions by 30 percent this decade from 2020 levels. Targeted methane abatement finance in AFOLU projects reached USD 4.2 billion in 2019–2020, making it the second largest tracked sector behind waste

Rainforest alliances

— Brazil, Indonesia, and the Democratic Republic of the Congo, which account for more than half of the world's tropical forests, launched an alliance for rainforest conservation

Financing

— Provide USD 12 billion for forest-related climate finance between 2021 and 2025

— Bezos Earth Fund has pledged to invest USD 1 billion by 2030 for the conservation of the most important carbon and biodiversity stores

Carbon market development

— Defining the use of internationally transferred mitigation outcomes (ITMOs)

— African Carbon Markets Initiative

Carbon regulations, including carbon pricing mechanisms that put a price on GHG emissions, are strengthening globally, providing further support to low carbon solutions. AFOLU projects have attracted investments and capital flows through emission trading markets and financing schemes. Forest and land use projects are a key driver for the growth of voluntary carbon markets which have seen a rapid increase in size in recent years, reaching USD 748 million in 2021.

Voluntary carbon markets and carbon offsets have been discussed in more detail in a separate section in the FactBook.

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The Kearney Energy Transition Institute is a nonprofit organization that provides leading insights on global trends in energy transition, technologies, and strategic implications for private-sector businesses and public-sector institutions. The Institute is dedicated to combining objective technological insights with economic perspectives to define the consequences and opportunities for decision-makers in a rapidly changing energy landscape. The independence of the Institute fosters unbiased primary insights and the ability to co-create new ideas with interested sponsors and relevant stakeholders.

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