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Sectoral Analysis of AFOLU

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Executive Summary

The contribution of the AFOLU sector for achieving net zero by mid-century is critical and few countries will rely on the sector to achieve the goal of the Paris Agreement. However, the sector faces significant economic, political and structural barriers across all levels of governance. To address these and materialize the potential of the sector, far-reaching and comprehensive public policies and support are needed.

This paper analyses the national policy frameworks of 10 countries where the AFOLU sector, in particular Forest, seem to be considered in their NDCs and will play a role for achieving net zero by mid-century. First, we identify general sectoral mitigation barriers, challenges and opportunities and analyse how these are manifested at national level, based on country case studies conducted or reviewed by national experts. Second, we consider if national policy frameworks are fit for purpose of the AFOLU sector to contribute to country LTS targets.

Our findings show that mitigation barriers differ significantly across countries, while economic (e.g. lack of investments for transformative actions) and structural barriers (e.g. weak land tenure regimes) are identified as the most crucial common challenges. At the same time, the analysis indicates that key high forest countries identified the sector as a mean to increase their NDC ambition. To exploit this potential and increase mitigation ambition support (blend comprehensive context-specific sectoral policies are needed.

However, national policy frameworks vary significantly, both in terms of existing policies and approaches for the AFOLU sector. While many countries have some form of sector or subsector specific mitigation targets and foreseen support for their actions (both domestic and international), enforcement of existing policies have so far failed to trigger sustained over time mitigation efforts. However, developing and emerging economies seem to be unable to provide the needed support measures due to a lack of financial means at domestic level. The lack of means and capacity in many developing countries regarding the AFOLU sector points out the need for better orchestration of the existing international cooperation, with more focus on transformative investments. The article concludes by providing policy recommendations to advance national climate policy frameworks, as well as general lessons learned for the AFOLU sector, in particular for forest.

Content

1 Introduction

In contrast to other sectors, the Agriculture, Forestry and Other Land Use (AFOLU) sector has the capacity to facilitate mitigation in several different ways. Specifically, AFOLU can (i) reduce emissions as a sector in its own right, (ii) remove meaningful quantities of carbon from the atmosphere at a relatively low cost, and (iii) provide raw materials to enable mitigation in other sectors, such as energy, industry or the built environment.

The AFOLU[1] sector encompasses managed ecosystems and offers significant mitigation opportunities while providing food, wood and other renewable resources as well as biodiversity conservation. Nonetheless, the sector must effectively adapt to climate change to provide these benefits (Nabuurs et al 2022). Land-based mitigation is increasingly recognised as a key strategy to reach the Paris Agreement's aim to "achieve a balance between anthropogenic emissions by sources and removals by sinks" by 2050. However, estimating its potential continues to be a challenge, despite the ongoing efforts to reconcile top down and bottom up estimates (Grassi et al 2023). Carbon fluxes from land are associated with complex and highly dynamic biological systems, characterised by a marked spatial and temporal variability. Estimating these fluxes in a complete, accurate, and consistent manner present significant challenges, as different approaches may capture different natural and anthropogenic drivers. Recent efforts to construct global time series with all available data (Grassi et al 2022) show that land remains a global sink. Results indicate a mean net global sink of -1.6 GtCO2 yr-1 over the period 2000–2020, largely determined by a sink on forest land (-6.4 GtCO2 yr-1), followed by source from deforestation (+4.4 GtCO2 yr-1) (Nabuurs et al 2022). Smaller fluxes are observed from organic soils (+0.9 GtCO2 yr-1) and other land uses (-0.6 GtCO2 yr-1). While the data from the UNFCCC GHG data interface[2], once gap filled by Grassi et al (2022), shows a net sink of -5.4 GtCO2 yr-1 and the FAOSTAT -1.1 GtCO2 yr-1 (Tubiello et al 2020). In all cases, forests seem to be the larger gross emitters and gross sink globally, especially in the tropical regions. These regions account for the majority of global land-based mitigation potential and experience the highest rates of both forest loss and gain (Griscom et al 2017).

Looking forward, all pathways that limit global warming to 1.5°C include a rapid deployment of AFOLU measures and ambitious targets for the sector. Measures to protect natural carbon sinks are relevant in both land and marine ecosystems. The latter has received comparatively little attention and will not be considered in this assessment (Gattuso et al. 2018). While large potentials are estimated globally for the land mitigation (Griscom et al 2017; Roe et al 2019), the AFOLU sector faces significant barriers and challenges that hamper the sectoral transformations needed to achieve them. This includes policy, regulation, finance, innovation and even behaviour. However, these transformations will not be easy to achieve, given the currently fragmented policy frameworks that are often marked by conflicting interests. In addition, presenting targets themselves as the end goals of transformation, obscures both the means of achieving them and the social and environmental values that legitimate them (McDermott et al 2022). For example, food and land use systems incur hidden costs arising from their

[1] AFOLU is a sector in the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2019). AFOLU anthropogenic greenhouse gas emissions and removals by sinks reported
governments under the UNFCCC are defined as all those occurring on 'managed land'. Managed land is land where human interventions and practices have been applied to perform production,
ecological or social functions.

[2] https://unfccc.int/topics/mitigation/resources/registry-and-data/ghg-data-from-unfccc.

impact on health, nutrition, the natural environment and inclusion. These hidden costs have been estimated at $12 trillion a year compared to a market value of the global food system of $10-$16 trillion a year by 2050 (The Food and Land Use Coalition, 2019).

By end of 2021, 84% of revised NDCs included the protection or restoration of ecosystems, or agroforestry, in their mitigation and/or adaptation plans[3] which represents an increase from 78% in the first round (Sebbon et al 2019). The challenge is therefore to meet growing demand for goods and food, while protecting existing carbon stocks in forest and soils, restoring and expanding forest, and improving management. This is possible but contingent on substantial financial support and public policies, including enforcement of policies in place.

This paper analyses the national policy frameworks of 10 countries with large forest potential to assess whether they are fit for achieving their land mitigation NDC goals and beyond for the sector. The analysis is based on the overall review of relevant literature and analysis. It includes 10 country case studies, some reviewed by national experts, including the European Union (EU), Australia, Russia, Mexico, Brazil, Colombia, Ecuador, Indonesia, Morocco and Vietnam. To this end, the analysis identifies mitigation barriers, challenges, opportunities and enablers to achieve the land mitigation potential, in particular from forest-based measures. Next, it maps national policy mixes and assesses if they are fit for purpose to enable a sectoral transformation by comparing them to best-practice identified in the general literature. Based on this analysis, we provide policy recommendations to advance national climate policy frameworks, as well as general lessons learned to enhance mitigation in the sector.

[3] https://www.naturebasedsolutionsinitiative.org/news/nbs-policy-platform-ndc-submissions/

2 Methodology

This analysis focusses of the AFOLU sector as defined by IPCC with particular emphasis on forest giving the larger potential of its single mitigation measures (see Table 1 below). It refers specifically to the management, conservation, and use of forest resources. Thus, it does not introduce elements beyond land-based mitigation actions, meaning, it does not include demand side actions, such as changes in consumer behaviour and diets. However, it recognizes that changes in the demand side are likewise critical for enabling supply measures and indicate them although it does not assess them.

This study aims to assess and compare national mitigation barriers and enablers as well as policies and measures relevant to unfold the mitigation potential of the sector. To allow for the comparison across the different countries studied and further facilitate the comparison with the analysis of other sectors conducted as part of the NDC ASPECTS project a common typology of mitigation barriers and enablers was applied. We thereby distinguish between six categories:

(1) Structural context captures societal, geographical and environmental conditions that are outside the socio-technical system in question but influence the options, preferences and behaviour of relevant actors.

(2) Paradigms & discourses captures explicit and implicit informal rules, cognitive schemes, routines, values and norms affecting the way actors view and respond to issues.

(3) Polity captures the general setup and political system and bureaucratic institutions in general.

(4) Politics captures the composition, sub-national and international relationships, power structures and vested interests of the actors involved in maintaining and changing the system.

(5) Policy captures formalised (i.e. codified and explicit) rules and principles that guide behaviour such as policies, standards, formal contracts, roadmaps, commitments and formalised governance mechanisms.

(6) Economy captures conditions, restrictions and incentives affecting the ability of economic actors to adopt more climate-friendly solutions.

The analysis of national policy frameworks is based on a comprehensive mapping of relevant national policies and measures, that resulted of the specific country studies. In the mapping we included governance and planning instruments, economic instruments, regulatory instruments and educational instruments, as well as voluntary agreements (such as international initiatives as the Bonn Challenge or New York Forest Declaration).

This analysis builds on 10 case studies where the AFOLU sector or some subsectors are highlighted for mitigation, in particular Forest. The case studies aim at analysing national mitigation enablers and barriers and mapping national policy frameworks. They are based existing relevant literature here cited, official documents i.e. country NDCs, national strategies, policy databases, grey literature i.e. UNFCCC reports, Global climate risk index, Climate Change Performance Index, International Carbon Action Partnership, and specialised news reporting i.e. Climate Transparency analyses, Climate Target Update Tracker analyses, Climate Funds Update, Climate Watch Data, , Emissions Trading Worldwide. The case studies were reviewed by sectoral experts in some cases.

The country selection was based on the respective relevance of the AFOLU, in particular the forest, in terms of emissions and/or removals of GHGs according to the latest Biennial Reports (BRs) and Biennial

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Update Reports (BURs) submitted to the UNFCCC[4]. Additionally, geographical diversity was considered to allow for a broader consideration of research findings. Selected countries as clustered by World Bank country classification by income level (World Bank, 2022): high-income (European Union (EU)[5], Australia (AUS)); upper-middle income (Russia (RU), Mexico (ME), Colombia (CO), Ecuador (EC)); other-middle income (Morocco (MO), Viet Nam (VI), Indonesia (IN)).

[4] Countries clustered by 2022 BRs and BURs

- High levels of emissions and/or removals: European Union (EU), Russia (RU)
- Medium levels, with heavy reliance on industry/fossil fuels: Australia (AUS), Mexico (ME), Colombia (CO), Ecuador (EC)
- Lower levels, with weaker national wealth: Morocco (MO), Vietnam (VI), Indonesia (IN)

[5] For the purpose of this study the European Union (EU) is considered as one jurisdiction.

3 Key mitigation strategies from the AFOLU sector

The SRCCL-Special Report on Climate Change and Land (Jia et al. 2019) assessed the full range of technical, economic and sustainability mitigation potentials in AFOLU for the period 2030–2050. The report identified reduced deforestation and forest degradation to have greatest potential for reducing supply-side emissions (0.4 to 5.8 GtCO2-eq yr–1) followed by combined agriculture measures (0.3 to 3.4 GtCO2-eq yr–1). Measures with greatest potential for sinks (Carbon Dioxide Removal_ CDR) were afforestation/reforestation (0.5 to 10.1 GtCO2-eq yr–1), soil carbon sequestration in croplands and grasslands (0.4 to 8.6 GtCO2-eq yr–1) and BECCS- Bioenergy with Carbon Capture and Storage (0.4 to 11.3 GtCO2-eq yr–1). Scenarios that limit warming to 2°C (>67%) or lower by 2100 commonly involve extensive mitigation efforts in the agriculture, forestry and other land use sector. Thus AFOLU plays a dual role in reducing emissions and in providing biomass for mitigation in other sectors (Babiker et al 2022). Similar to the SRCCL, the IPCC AR6-Sixth Assessment Report (Nabuurs et al 2022) assesses the mitigation potential of several measures within the AFOLU sector. Among a total of 20 assessed measures as supply-side activities in forests and other ecosystems, agriculture, bioenergy and other land-based energy technologies, the protection, improved management, and restoration of forests and other ecosystems (wetlands, savannas and grasslands) show the largest potential to reduce emissions and/or sequester carbon at 7.3 (3.9–13.1) GtCO2-eq yr–1 (up to USD100 tCO2-eq–1). Within these measures, the ones that focus on ‘protection’ exhibit the single highest total mitigation and mitigation densities (mitigation per area) within the AFOLU sector. Agriculture measures provide the second largest share of mitigation with 4.1 (1.7–6.7) GtCO2-eq yr–1 potential (up to USD100 tCO2-eq–1), from soil carbon management in croplands and grasslands, agroforestry, biochar, rice cultivation, and livestock and nutrient management.

While the SRCCL does not provide detailed analysis of costs, AR6 Analysis are based on recent numerous current global assessments of sectoral land-based mitigation potential (Fuss et al. 2018; Griscom et al. 2017; Roe et al. 2019; Jia et al. 2019; Griscom et al. 2020; Roe et al. 2021) as well as IAM-Integrated Assessment Model estimates of mitigation potential (Riahi et al. 2017; Popp et al. 2017; Rogelj et al. 2018a; Frank et al. 2019; Johnston and Radeloff 2019; Baker et al. 2019), expande the scope of AFOLU mitigation measures included and improved the robustness and spatial resolution of mitigation estimates. According to the report, global sectoral studies indicate that the economic mitigation potential of supply-side measures in AFOLU for the period 2020–2050 is 11.4 (5.6–19.8 full range) GtCO2-eq yr–1 at a cost up to USD100 tCO2-eq–1. This represents about 50% of the technical potential of 24.2 (4.9–58) GtCO2-eq yr–1. The total land-based mitigation potential up to USD100 tCO2-eq–1 is 13.6 (6.7–23.4) GtCO2-eq yr–1. A recent development of the AR6 analysis by Roe et al. (2021) assessed technical and economic mitigation potential for 20 AFOLU measures at the country level, including previously unestimated aspects like demand-side and soil organic carbon sequestration in croplands and grasslands. In agreement with AR6 calculations, Roe et al. (2021 found the aggregate global mitigation potential of supply and demand-side measures to be 13.8 ± 3.1 GtCO2-eq yr–1 up to USD100 tCO2-eq–1 for the period 2020–2050. Across IAMs, the economic potential for land-based mitigation (Agriculture, LULUCF and BECCS) for USD100 tCO2-eq–1 is 7.9 mean (4.1–17.3 range) GtCO2-eq yr–1 in 2050. This results in a range 7.9–13.6 GtCO2-eq yr–1 up to USD100 tCO2-eq–1 between 2020–2050. Considering the sectoral economic potential estimates, land-based mitigation measures in the AFOLU sector could have the capacity to turn it into a net negative GHG emitter from 2036 on (Nabuurs et al 2022). Recent analysis (Grassi et al. 2023, Friedlingstein et al. 2022) reconciling

global estimates for the LULUCF sector (equal to FOLU) indicate a net sink on average for 2000-2020 of approximately -2 GtCO2 yr-1. While agriculture emissions[6] are estimated approximately as 5 GtCO2eq ye-1 (Tubiello et al. 2021). Which results in approximately a net source for the AFOLU of 3 GtCO2 yr-1.

Overall, economic potential estimates, which reflects a public willingness to pay, may be more relevant for policy making compared with technical potentials, which reflect a theoretical maximum that may not be practically feasible or sustainable. It is worth keeping in mind that, although economic potentials provide more realistic, near-term climate mitigation compared to technical potentials, they still do not account for feasibility barriers and enabling conditions that vary by region and country.

Developing more refined sustainable potentials at a country-level will be of most importance and will require the close collaboration with country experts. Currently, the impacts of future climate change are not/poorly incorporated in the estimated potentials, despite the growing evidence of the impacts in efficiency and high risk of non-permanence due to extreme events triggered by climate change (e.g. fires, droughts, heat waves, pests and diseases). Identifying the drivers of emissions can help to constrain specific pathways for different regions and countries. Drivers are divided into direct drivers resulting from human decisions and actions concerning land use and land-use change, and indirect drivers that operate by altering the level of one or more direct drivers. Although drivers of emissions in agriculture and FOLU are assessed and presented separately, they are often interlinked, operating in many complex ways at different temporal and spatial scales, with outcomes depending on their interactions.

Carbon Dioxide Removal (CDR) is a necessary element to achieve net zero CO2 and greenhouse gas (GHG) emissions both globally and nationally, counterbalancing residual emissions from hard-to-transition sectors. Land-based biological CDR (primarily afforestation/reforestation (A/R)) are expected to play a key role (Babiker et al 2022). Gross Zero emissions in the AFOLU sector are some hard-to-abate activities will still have positive emissions, but for the sector as a whole, net negative emissions are possible through carbon sequestration in agriculture and forestry although permanence of the sequestered stocks are threatened by the increasing climate change impacts (in particular if adaptation measures are not considered).

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[6] Agriculture sector in GHG inventories activities.

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Table 1: Potential mitigation measures for AFOLU by 2030

Measures	Potential GHG reduction/sink (GtCO2/yr)	TRL(1)	Cost per tonne CO2-eq (USD)	Risk and impacts	Co-benefits
Reducing emissions from deforestation (Reduce forest conversion to OLUs) (Protect)	0.41-5.8	8-9	1.9-250	Limit land used for farming and food production Restrict the rights and access of local people to forest resources; increase dependence to insecure external funding	Improves air quality and reduces pollution Preserves ecosystem services and biodiversity Increases yields and land availability Enhances adaptation capacity Reduces soil erosion, enhances water retention Regulates hydrological cycle Enhances employment, incomes, and livelihoods
Improved sustainable forest management (Manage)	0.44-2.1	8-9		Affect albedo and evapotranspiration Decrease in biodiversity in case improved management is seen as short rotations Decrease resilience to natural disasters in case improved management is seen as short rotations."	Improves air quality and reduces pollution Conserves biodiversity and ecosystem services Improves crop productivity Enhances adaptation, microclimatic regulation Reduces soil erosion, enhances coastal protection Regulates hydrological cycle Enhances employment, incomes, local livelihoods"
Afforestation and reforestation	0.5-10.12	8-9	0-240	Reversal of carbon removal through wildfire, disease, pests. Reduced catchment water yield and lower groundwater level if species and biome are inappropriate.	Enhanced employment and local livelihoods, improved biodiversity, improved renewable wood products provision, soil carbon and nutrient cycling. Possibly less pressure on primary forest.
Carbon sequestration in croplands and grasslands (soil)	0.38-9.34	8-9	-45 - 200	Risk of increased N2o emissions due to higher levels of organic nitrogen in the soil. Risk of reversal of carbon sequestration.	Improved soil quality, resilience and agricultural productivity.

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Measures	Potential GHG reduction/sink (GtCO2/yr)	TRL(1)	Cost per tonne CO2-eq (USD)	Risk and impacts	Co-benefits
Ecosystem restauration (peatland and coastal wetland)	0.35-1.65	8-9		Increase in nitrogen input offsetting soil organic carbon sequestration Difficulty in monitoring and verification	Improves air quality and reduces pollutions Improves biodiversity Increases yields and available land Enhances adaptation capacity Improves soil quality and function Regulates hydrological cycle Enhances employment and incomes
Reduce CH4 and N2O emission in agriculture	0.1 – 3.3	8-9		**Enteric fermentation** High technology, capacity and financial needs of farmers to implement Toxicity and animal welfare issues Land use change from increased production of feed **Manure and nutrient management** Reduce yields High technology, capacity and financial needs of farmers to implement	**Enteric fermentation**: Improves air quality and reduces pollution Improved animal welfare Increased animal productivity **Manure and nutrient management** Improves air quality and reduces pollution Improves yields, land availability, water efficiency use Enhances adaptation capacity Improves soil quality and reduces erosion Reduce water pollution and eutrophication Enhances employment and incomes

Note: (1) NASA TRL; (2) Year 2030 or 2050 depending on the study. Source: Pathak et al 2022, Roe et al 2021, Fuss et al 2018.

4 Main enablers and barriers

Following the typology introduced in Section 2, this section explores the main mitigation barriers and challenges as well as enablers and drivers for enhancing the mitigation potential within the AFOLU sector. Moreover, it synthesises how the findings materialise through the examination of case studies. The analysis is based on existing global literature, i.e. Jia et al (2019) and Nabuurs et al (2022), and the information gathered through the analysis of the 10 countries. Table 2 summarises the main enablers and barriers identified.

4.1 Structural context

The structural context captures societal, geographical and environmental conditions that influence or constrain options, preferences and behaviour of relevant actors. This concerns the overall structure of the economy and availability of public resources, the availability of technical/institutional capacities, regulations and land tenure frameworks.

Regarding the **structure of the economy**, for countries where the economy relies on the opportunity cost of agriculture commodities with respect to other land uses (such as intensive agriculture production, mining etc.) represent often a barrier for forest protection (e.g. reducing emissions from deforestation) and restoration.

L**and tenure rights** represent key enablers but also key barriers for the implementation of land base mitigations measures, depending on the development of the country's tenure system. Land-based mitigation can have adverse effects including lack of recognition of customary rights, loss of tenure or possession rights, and even displacement of social groups (Bustamante et al. 2014). Enhanced legal frameworks, enforcement capacities, monitoring and traceability, land tenure data, and preferential public procurement measures for free deforestation and sustainable produced commodities are vital steps towards enabling tenure system implementation at the national and subnational levels. Securing land tenure, especially for the poor and marginalised populations, can empower them to sustainably manage land (Chigbu et al. 2022).

The AFOLU sector presents **unique trade-offs, such as food security.** For example, large-scale A/R projects may negatively affect food security since they can lead to higher food prices as a result of intensified land competition (Kreidenweis et al. 2016).

Over the last few decades, low- and middle-income countries including Brazil and Mexico, have experienced such **rapid dietary changes** reflecting this trade-off (Lamb et al 2021).

Thus, while measures in the AFOLU sector are uniquely **positioned to deliver substantial co-benefits,** the inappropriate or misguided design and implementation of these measures may lead to considerably negative consequences. These consequences may include risk to mitigation permanence, longevity, and leakage, impacts on biodiversity, wider ecosystem functioning, local livelihoods and food security) (Nabuurs et al 2022).

Furthermore, the majority of these positive and negative impacts within the AFOLU sector are highly **context-specific**. This specificity makes it challenging to make generic statements about which AFOLU mitigation measures hold the most promise on a global scale. Due to the diverse socio-economic, ecological, and policy landscapes across different countries and regions, the effectiveness and feasibility of mitigation measures can vary significantly (Bustamante et al. 2014).

The reversibility of measures that increase terrestrial carbon stock (**risk of non-permanence**), either through increased soil carbon or changes in land cover (e.g., reforestation, afforestation) is a significant concern as future changes in climate or land cover could result in reduced carbon storage, undermining their effectiveness (Jia et al 2019).

Moreover, i**mpacts of climate change** are felt worldwide as treats for the technical and economic mitigation potential of the sector while they are poorly or not at all incorporated in global and national mitigation pathways. Forests as natural climate solutions in particular face fundamental limits and underappreciated risks, including wildlife, biotic agents, human disturbances and climate stress. These risks have the potential to compromise the current land carbon sink and the success of forest-based mitigation measures (Anderegg et al. 2020). The consideration of vulnerabilities and adaptation needs will allow for more realistic mitigation pathways at national level and achievement of the foreseen NDCs- Nationally Determined Contributions targets.

4.2 Paradigms and discourses

The emerging discourse around **residual emissions by 2050, which have to be compensated by** Carbon Dioxide Removals (CDR), is placing greater emphasis on the land-based mitigation measures as the most prominent means in the short term (e.g. afforestation and reforestation, ecosystem restoration). This perception is reinforced by the often-simplistic paradigm that CDR biological measures cost is very low and CCS-carbon capture and storage or CDR technologies are still at early stages of development (low TRLs) and far from being competitive. In addition, as indicated in the section 3 above, it is unlikely that emissions from agriculture will be eliminated and therefore **biological carbon dioxide removal methods such as re/afforestation or soil sequestration** would be required to compensate emissions within the AFOLU sector itself and not only to compensate other sectors residual emissions to meet stringent climate targets, further putting pressure on global land resources (Allen et al 2018). However, the success of such practices depends on the quality of the soils and the climatic conditions were implemented. Evidence suggests that land sinks will become less effective over time (Dow et al. 2022, Jiang et al. 2020, IPCC, 2021) and shifts in forest dynamics are already occurring, both due to climate change (McDowell et al 2020). It is therefore important to caution against excessive reliance on land sinks as a strategy to slow down or avoid decarbonisation in other sectors with the aim of achieving net zero emissions by 2050. It is likewise essential to incorporate these feedbacks into the projections. In addition, concerns related to the permanence of sequestered carbon have important consequences for emission trading and carbon credit/offset systems in the FOLU sector, which are marked with a range of permanence requirements (Nabuurs et al. 2022).

Reducing emissions from deforestation, often focused on the protection of primary forest in the tropics, is seen as the less costly and more effective measure in the AFOLU sector for the short term. Reducing deforestation and forest degradation, i.e. conserving existing carbon pools in forest vegetation and soil by avoiding tree cover loss and disturbance, implies protecting forests. In this context, the Land Use, Land Use Change and Forestry (LULUCF) within the AFOLU sector is expected to have significant relevance in achieving the NDCs and mitigation agreements of various countries, such as Viet Nam, Brazil, Indonesia or the EU. For instance, Viet Nam targets LULUCF to reduce 70% of emissions and increase 20% of carbon absorption with a total sink capacity of 95 MtCO2e by 2030. Furthermore, protecting primary forest remains a vital measure in countries such as Australia and Colombia, where the AFOLU sector constitutes a source of emissions despite its mitigation potential.

Forest protection involves controlling complex and diverse drivers of land use change (i.e. deforestation) across countries and regions. These drivers include commercial and subsistence

agriculture, mining, urban expansion, etc. At the same time, forest degradation practices such as overharvesting including fuelwood collection, poor harvesting, overgrazing, pest outbreaks, and extreme wildfires, require to be addressed (Kissinger et al 2012, Barber et al 2014,). Achieving effective forest protection also includes establishing well designed, managing and funding protected areas (Barber et al. 2014), improving law enforcement, implementing forest governance and land tenure, supporting community forest management and introducing forest certification (Smith et al. 2019). Potential side effects of these conservation measures include reducing the potential for agriculture land expansion, restricting the rights and access of local people to forest resources, or increasing the dependence of local people to insecure external funding. Barriers to implementation include unclear land tenure, weak environmental governance, insufficient funds, and increasing pressures associated with agriculture conversion, resource exploitation and infrastructure development.

4.3 Polity

Public sector action is crucial in setting the enabling conditions necessary to reduce deforestation and associated carbon emissions, particularly in removing deforestation from agricultural value chains. Such action can aim to improve policy and regulatory coherence, better law enforcement and enhanced governance. These dimensions of reform are vital to agri-food systems transformation (DeValue et al 2022). Sufficient **public sectoral capacity and expertise** is essential to enable and ensure a stable and predicative investment. The absence of public sectoral capacity, expertise and action can be an important driver for deforestation and a barrier to protect ecosystems, which is often the case in many developing countries. Similarly, general **political instability or prevalent corruption** limit public sector capacity and undermine the enforcement of policies on the ground hindering their impact, this is particularly evident in the context of illegal logging control in some of the countries assessed[7].

Often the implementation of measures in the AFOLU sector is hampered by the competences **dispersion across different departments of the government and the lack of coordination** among them. Ecuador serves as an example in this regard, showcasing a high level of national planning and intergovernmental coordination on their NDC process. The conflicting and sometimes overlapping responsibilities between ministries and agencies within the government can prevent a holistic approach and adaptive management of the sector due to the institutional rigidity and “silos” mentality of public administrations.

AFOLU sectorial decentralised authorities, primarily at the sub-national level, often have key competencies in land-use policy development and planning. These authorities are well positioned to catalyse action and promote a more integrated approach to align subnational and national policies (often fragmented). By doing so, they can facilitate the effective implementation of measures while meeting the multiple objectives of diverse stakeholders. However, it is important to acknowledge that subnational authorities also can become barriers that slow down implementation, often due to lack of resources and capacities. To address these challenges, it is key to enhance coordination mechanisms and equip subnational departments with sufficient budget, competences, adequate expertise and capacity.

[7] https://www.worldwildlife.org/pages/tnrc-blog-understanding-how-corruption-is-accelerating-illegal-logging-and-deforestation-during-the-covid-19-pandemic
https://www.transparency.org/en/blog/corruption-and-illegal-deforestation-go-hand-in-hand

4.4 Politics

Climate change is increasingly becoming a centre topic in domestic political debates. For example, it is evident with the EU Green Deal, which is at the centre of the political debate in Europe. In this context, public awareness, perception of the risk due to impacts and engagement in emerging climate action is an important enabler for innovative and transformative policies (e.g. the wave of Citizens Climate Assemblies at national, regional and city levels).

International politics, including multilateral agreements, play a dual role in shaping the overall mitigation ambition in the AFOLU sector. On the one hand, international climate politics and the adoption of the Paris Agreement are important enablers driving the development of domestic climate ambition and highlighting the need for the sector in achieving net-zero emissions by mid-century. On the other hand, while relevant multilateral commitments – for example the 2021 Glasgow Leaders Declaration on Forests and Land Use, the Forest, Agriculture and Commodity Trade (FACT) Dialogue roadmap, and the Policy Action Agenda for the Transition to Sustainable Food and Agriculture – have engaged a range of countries and initiatives across "consumer" and "producer" sides, these countries lack sufficient coordination and alignment to enhance impact and manage trade-offs between agriculture and forests (DeValue et al 2022), overall hampering their mitigation ambition.

4.5 Policy

Similar to other sectors, policies, formalised rules and principles, are essential to drive and enable the transformation of the AFOLU sector. To effectively mitigate climate change, they have to be designed in a way that they enable the solutions chosen in the sector, guide and constrain the behaviour and decisions of relevant actors during implementation, and incentivise good practices.

The increasing number of national policies on agriculture and forest land-uses aiming to raise the mitigation contribution of the AFOLU sector signals an increasing emphasis on enhancing the mitigation efforts of the sector. This is evident in their inclusion within their NDCs (i.e. Indonesia, Brazil, EU, Ecuador). Similarly, the EU introduced LULUCF-Land Use, Land Use Change, and Forestry regulations, carbon farming initiatives, and proposed a Nature Restauration Law. In Indonesia forest and peatland moratorium, the multi permit scheme, palm oil certification (ISPO), and the sustainable jurisdiction agenda are likewise aimed at increasing mitigation efforts. Comparably, Ecuador developed the REDD+ Action Plan and implemented the Climate Smart Livestock Project. Agri-food commodity "consumer" countries are enhancing regulatory frameworks with due diligence measures and trade standards for agricultural goods. These measures aim to reduce deforestation embodied in imported products, as exemplified by the EU free deforestation commodities regulation. Instead, "producer" countries are implementing a range of strategies according to their national circumstances to increase mitigation efforts from the AFOLU sector. These strategies include land use regulations, such as the Forest and peatlands moratoria, to supporting programs like payments for ecosystem services, smart agriculture, and the re-investment of REDD+ result-based payments.

There has been an increase in AFOLU and climate change mitigation related policies in the last decades in all the 10 countries analysed (see section 6 below). The broader environmental and sustainability policy context seems to be key to guide agriculture and land use policies aiming to support enhanced mitigation of climate change. Despite the existence of specific policies to protect ecosystems in several countries, i.e. EU, Brazil, Indonesia, Ecuador, Colombia , such as limiting or forgiven forest conversions in to other land uses, often their impact is limited due to the weak or lack of enforcement in some countries, i.e. Colombia, Brasil, Indonesia, Ecuador. For example, for many years Brazil was

successfully slowing and halting this process by efficient investments in enforcement of policies in the Legal Amazon. However, once these policies were weakened or removed, the process of deforestation resumed (Fritz et al 2022). In Indonesia, despite the forest cover loss has been declining in the last years and although a national forest-related policy demonstrates a paradigm shift, the layering process through which the new policy was created allows for interpretable flexibility, which enables continued forest cover loss (Erbaugh & Nurrochmatc, 2019). In high-income countries, where policies and regulations are more effective due to stronger enforcement, the emissions from the forest sector are mainly driven by disturbances, including large fires in Australia and extreme weather events, droughts and fires in the EU. However, across all countries assessed, the policies and regulations in the AFOLU sector often lack coherence and include conflicting policies that hamper the mitigation deployment of action. In many of the assessed countries, including high-income (i.e. EU and Australia) and middle-low income (i.e. Russia, Brazil, Indonesia) impacts of climate change are emerging as a threat to the mitigation efforts in the FOLU sector, in particular for high potential measures in the forest sector. To enable more successful mitigation, adaptation and mitigation strategies will need to be aligned within the sector and adaptive adjustments over time should be incorporated to enable needed corrections and enhance program sustainability and effectiveness (Hurlbert et al., 2019; Smith et al., 2020).

4.6 Economy

The AFOLU sector and its emissions are closely tied to global supply chains and trade flows. For example, countries like Brazil use about half or more of their cropland and grassland for products exported to other countries (Yu et al 2013, Arto comms. pers. 2023). Difficulties in tracking supply chains and limited corporate accountability result in such exports often being associated with illegal deforestation (Vasconcelos et al 2020). In South-East Asia and particularly in Indonesia, the expansion of cropland is largely driven by an international demand for palm oil, rubber, and plantation products (Austin et al 2019, Xin et al 2021). At the same time, efforts to promote environmental sustainability in regions like the EU, US, and fast-growing emerging economies such as China, can take place at the cost of increasing land displacement elsewhere to meet their own demands (Lamb et al 2021). Creutzig et al (2019) emphasise these global connections through different country ‘archetypes’ that explain co-occurring land use changes. ‘Consumers’ such as the EU, feature stagnating population, agricultural intensification, and a high reliance on imports. ‘Producers’ are regions with high biocapacity and low institutional capacity such as South American countries, Russia, and Indonesia, where exports play a large role for land-use trends. Other regions of Asia and Africa belong to the ‘movers’, where high population growth is the main driver leading to a stronger domestic consumption of some commodities previously exported.

AFOLU emissions were rather constant between 1990 and the early 2000s, despite continuous population growth and higher agricultural production globally. They kept quite stable from 1990 to 2000 mostly due to agricultural intensification requiring less land per unit of agricultural production. However, AFOLU emissions increased from the 2000’s onward (and in some cases from the late 90s) due to the clearing of pristine, carbon-dense forests (Lamb et al 2021). Tropical regions across all continents cause the majority of AFOLU emissions, with increasing emissions in Latin America and Southeast Asia, both directly linked to global supply chains. These trends, in particular for forest, do not appear to be stabilising but rather fluctuate (i.e. Brazil), slowly decrease (i.e. Indonesia), or even increase in low and middle-income countries (i.e. Ecuador, Colombia, Viet Nam), overall underlining the urgency of interventions at all scales. Thus, despite many interventions aimed at financially supporting forest protection and enhancement, as well as to other co-benefits (i.e. Ecuador payment-

for-ecosystem services program Socio-Bosque, Amazon Fund, etc), there are still challenges to overcome.

The cost of the response options varies substantially, from low (e.g. the cost of agroforestry is less than 10 USD tCO2e–1) to much higher costs (e.g. the cost of BECCS could be as much as 250 USD tCO2e–1) (Jia et al 2019). Nonetheless, for example, the implementation of agroforestry, which is considered a low-cost option, can be hindered by a lack of reliable financial support (Hernandez- Morcillo et al. 2018). Additionally, there are a number of reasons why no-cost options are not adopted, including risk aversion, lack of information, market structure, externalities, and policies (Jaffe 2019).

The integration of global commodity markets often leads to embedded emissions and carbon leakage, particularly for large agricultural importers, making it difficult for some countries to collectively address AFOLU emissions, particularly where agricultural demand and economic opportunity act as drivers of deforestation (Pendrill et al., 2019).

Global cooperation and tailored assistance could help address feasibility barriers in developing countries, particularly to increase economic and institutional capacity and to help develop country-specific plans to start implementation.

Box 1. Gender: enablers and barriers in the AFOLU sector

(Extracts from the IPCC Special Report on Climate Change and Land, Chapter 7)

Structural context: Due to engrained patriarchal social structures and gendered ideologies, women may face multiple barriers to participation and decision-making in land-based adaptation and mitigation actions in response to climate change (Quisumbing et al. 2014). Disproportionate responsibility for unpaid domestic work, including care-giving and provision of water and firewood, remains a key challenge to women empowerment (UNEP, 2016). These patriarchal structures also affect women's control over land in developed countries (Carter 2017). Recognition of the household level, including men's roles and power relations, can help avoid the de-contextualised and individualistic portrayal of women as purely instrumental actors (Rao 2017b).

Paradigms: Land-based mitigation measures may lead to land alienation, either through market or appropriation (acquisition) by the government, and it may interfere with traditional livelihoods in rural areas and lead to decline in women's livelihoods (Hunsberger et al. 2017). If land alienation is not prevented, existing inequities and social exclusions may be reinforced (Poudyal et al. 2016). Cumulative effects of land-based mitigation measures may put families at risk of poverty. In certain contexts, they lead to increases in conflicting situations where women become more exposed to personal violence (UNEP, 2016).

Polity: The integration of a gender equality perspective across the public administration is a strategy that can help governments to make better decisions to achieve gender equality including as they relate to policy and decision-making. It can facilitate gender mainstreaming in public planning and sectoral policy as one of the most effective ways that governments can support and promote gender equality.

Politics: Gender is at the centre of the political debates in high-income countries, including on the rural population, yet it needs to be more prominent in middle and low-income countries. Women's empowerment, decision-making power, and voice are a necessity in land use decisions (Mello and Schmink 2017a; Theriault et al. 2017b).

Policy: Women often phase constraints to land access not only from state policies, but also customary laws (Bayisenge 2018). In only 37% of 161 developing and developed countries do men and women have equal rights to use and control land, and in 59% customary, traditional, and religious practices discriminate against women (OECD 2014), even if the law formally grants equal rights. Thus, longstanding gender inequality in land rights, security of tenure, and decision-making may constrict women's lands adaptation and mitigation options. Secure land title and/or land access and control for women increases SLM by increasing women's conservation efforts,

Box 1. Gender: enablers and barriers in the AFOLU sector (cont.)

increasing their productive and environmentally beneficial agricultural investments, such as willingness to engage in tree planting and sustainable soil management (high confidence) as well as improving cash incomes (Higgins et al. 2018; Agarwal 2010; Namubiru- Mwaura 2014b; Doss et al. 2015b; Van Koppen et al. 2013b; Theriault et al. 2017b; Jagger and Pender 2006). Many of the barriers women face can be overcome by integrating, or mainstreaming, gender into land and climate change policy through gender-inclusive approaches. Policies to increase women's access to land could occur through three main avenues of land acquisition: inheritance/family (Theriault et al. 2017b), state policy, and the market (Agarwal 2018). Rao (2017) recommends framing land rights as entitlements rather than as instrumental means to sustainability. Policies that address barriers include: gender considerations as qualifying criteria for funding programmes or access to financing for initiatives; government transfers to women under the auspices of anti-poverty programmes; spending on health and education; and public subsidised credit for women (Jagger and Pender 2006; Van Koppen et al. 2013a; Theriault et al. 2017b; Agarwal 2018b). Training and extension for women to facilitate sustainable practices is also important (Mello and Schmink 2017b; Theriault et al. 2017b).

Economy: Women play a significant role in agriculture, food security and rural economies globally, forming 43% of the agricultural labour force in developing countries (FAO, IFAD, UNICEF, & WHO, 2018), ranging from 25% in Latin America to nearly 50% in Eastern Asia and Central and South Europe and 47% in Sub-Saharan Africa (FAO, 2017). However, women often have restrictions on mobility for capacity-building activities and productive work outside the home. They often lack organisational social capital, which may help in accessing credit (Jost et al. 2016), as well as a lack of ownership of productive assets and resources (Kristjanson et al., 2014), including land. Collective action and agency of women in farming households, including widows, have led to the prevention of crop failure, reduced workload, increased nutritional intake, increased sustainable water management, diversified and increased income and improved strategic planning (Andersson and Gabrielsson 2012).

Table 2: Summary of Barriers and Enablers identified and overserved in the country studies

	Barriers & Challenges	Enablers & Drivers
Structural Context	▪ Lack of clarity of land tenure rights. ▪ Large reliance of the economy on intensive agriculture sector linked to main drivers of deforestation. ▪ Negative effects on food security, land use competition. ▪ Shift in diets in emerging economies (shift in demand of agri-food commodities), that often lead to increased pressure on natural ecosystems (e.g. increasing forest conversion to other land uses). ▪ Increase in climate change impacts on the AFOLU sector.	• Improved legal frameworks. • Enhanced enforcement capacities. • Enhanced monitoring and traceability of policy impacts. • Improved land tenure systems. • Enhance co-benefits, such as biodiversity and other ecosystem services, rural population incomes (local communities, IPs). • Consideration of vulnerabilities and adaptation needs when designing AFOLU contributions to mitigation at national level.
Paradigms	▪ Residual emissions by 2050 to be compensated by Carbon Dioxide Removals (CDR) increasingly relying on land-based mitigation measures. ▪ Reducing emissions from deforestation is seen as a low costly and more effective measure.	• Better understanding of the climate change impacts in the projections of land base mitigation solutions • Consider adaptation needs when designing mitigation solutions in the land sector. • Minimise the compensation through CDR land-based solutions as alternatives to decarbonize other sectors.
Polity	▪ Limited public sector capacity. ▪ Multi-level competences on Agriculture, Forest and other land uses. ▪ Political instability, corruption.	• Public sector capacity and expertise enhanced. • Enhance coordination across government departments at national, subnational and local level.
Politics	▪ Climate change and nature protection at the centre of national political debates. ▪ International climate politics drive the development of domestic climate ambition.	• Public awareness and engagement on climate action and nature protection enhanced. • International agreements, promoting coordination and alignment to enhance impact and manage trade-offs between agriculture and forests.
Policies	▪ Lack of policy and regulation enforcement. ▪ Conflicting policies (e.g. Agriculture subsidies vs forest protection) ▪ Lack of coordination across ministries and with regional and local administrations with distributed competencies. ▪ Climate change impacts are increasing as a treat to land ecosystems	• Law and regulation enforcement strengthened. • Efforts to align policies • Government departments at national and subnational levels enhanced coordination. • Integration of mitigation and adaptation policies.
Economic	▪ Underestimation of investment costs ▪ Low carbon price for FOLU sector ▪ High opportunity cost of deforestation driving commodities ▪ High monitoring cost	• Private/public innovative investments promoted. • Public support for investments, domestic and international, aligned towards common objectives. • MRV systems are enhanced with the objective to serve for multiple reporting objectives and to inform and improve agriculture land management actions.

The analysis is based on the case studies, available in the supplementary material on the NDC ASPECTS website.

4.7 Main takeaways

The analysis presented above shows that barriers and enablers for the AFOLU sector differ significantly across countries and within the sector itself (Agriculture and FOLU).

In high-income countries, mitigation efforts in the sector are mainly hampered by sometimes conflicting policies, lack of coordination across national, regional and local administration with distributed competencies and different capacities. Middle-income and especially low-income countries, face greater challenges due to less evolved policy frameworks for land planning, less access to finance and the lack of governance capacity and policy enforcement.

Overall, there is significant heterogeneity among countries in terms of the relative scale of mitigation potential, the types of land-based measures available, the potential co-benefits and risks associated with the measures, and the feasibility of implementing them.

What, where, when, and how mitigation measures are implemented will therefore vary significantly by country, as demonstrated in the analysis of the 10 countries. Implementing mitigation measures that maximise co-benefits including adaptation and biodiversity while limiting risks, requires strategies that consider mitigation costs and opportunities in other sectors, evaluate environmental and socio-economic consequences across different sectoral stakeholders (in particular distributional impacts), consider trade-offs and synergies among mitigation actions and with other policy goals, as well as cost efficiency. It will be therefore necessary to look at individual country plans and lessons learned from experiences in implementing land-based mitigation measures and policies within and across countries.

In implementing and scaling-up land-based mitigation the following main messages have emerged:

- AFOLU mitigation strategies are more successful when part of long-term strategies and policies that have a holistic view of emissions and decarbonization options from other sectors, of various land-use needs and challenges, and of sustainable economic development;
- Allowing for adaptive adjustments and moving towards more coherent policies across food systems over time could enable the necessary corrections and enhance sustainability and effectiveness;
- Large trade flows are responsible for large land use changes in particular in the tropics, and revert them will require attention to demand-side measures (i.e. changes in consumer behaviour), particularly where agricultural demand and economic opportunity act as drivers of deforestation;
- Global cooperation and tailored assistance could help address feasibility barriers in developing countries, particularly to increase economic and institutional capacity and to help develop country-specific plans to start implementation;
- Women’s empowerment, decision-making power and voice in rural areas is a necessity in agriculture and land use decisions. A true integration between women’s economic empowerment and low-carbon transitions in the AFOLU sector is still to be more widely and deeply adopted.
- Certain emissions reductions in the AFOLU sector are contingent on energy sector decarbonisation. Such as, substitution of fossil fuel for energy (bioenergy), substitution of GHG intensive materials or in urban natural based solutions (i.e. trees and green roofs planted to counter urban heat islands reduce the demand for energy for air conditioning and simultaneously sequester carbon).

5 Sustainable development

This section explores trade-offs and co-benefits between mitigation of climate change through AFOLU interventions and the achievement of sustainable development, i.e. the Sustainable Development Goals (SDGs). Although SDGs are intended to be comprehensive and interconnected, presenting them as separate entities can lead to a fragmented approach in implementing policies, which mirrors conventional strategies employed by government institutions (Moreno et al. 2023).

The IPCC Special Report on Climate Change and Land (SRCCL) provided an overview of the impact of integrated response measures to multiple land challenges, including but not limited to climate change mitigation (Jia et la 2019). Several response measures have co-benefits across 10 or more SDGs without any adverse side effects on other SDGs. These include increased food production, improved grazing land management, agroforestry, integrated water management, reduced post-harvest losses, sustainable sourcing, livelihood diversification and disaster risk management. Other response options may have synergies with some SDGs but do imply trade-offs with others. For example, use of local seeds brings many positive benefits for poverty and hunger reduction, but may reduce international trade (SDG 17). Other response options like enhanced urban food systems, management of urban sprawl, or management of supply chains are generally positive for many SDGs but may imply trade-offs with clean water (SDG 6) or decent work (SDG 8), as they may increase water use or slow economic growth. Several response options, including avoidance of grassland conversion, reduced deforestation and forest degradation, reforestation and afforestation, biochar, restoration and avoided conversion of peatlands and coastlands, have trade-offs across multiple SDGs, primarily as they prioritise land health over food production and poverty eradication. Several response options such as bioenergy and BECCS and some risk-sharing instruments, such as crop insurance, trade-off over multiple SDGs with potentially significant adverse consequences.

Conservation of biodiversity and ecosystem services is part of the larger objective of regulating climate, building climate resilience and promoting good quality of life, human well-being and sustainable development. While two of the 17 SDGs directly relate to nature, covering marine (SDG 14) and terrestrial ecosystems and biodiversity (SDG 15), most other SDGs relate to poverty, hunger, inequality, health and wellbeing, clean sanitation and water, energy, are directly or indirectly linked to nature (Blicharska et al. 2019) and therefore, to AFOLU sector interventions. Conservation of biodiversity and ecosystem services is critical to sustaining the well-being and livelihoods of poor and marginalised people, and indigenous communities who depend on natural resources (Nabuurs et al 2022). Land-based measures can thus provide a broad array of goods and services that are critical to good quality of life and human well-being, including but not limited to climate change mitigation. For example, healthy and diverse ecosystems can play an important role in reducing vulnerability and building resilience to disasters and extreme weather events (Ninan and Inoue 2017). Current negative trends in biodiversity and ecosystem services will undermine progress towards achieving 80% (35 out of 44) of the assessed targets of SDGs related to poverty, hunger, health, water, cities, climate, oceans and land (IPBES 2019).

Despite this potential for synergies between land challenges, trade-offs between climate policies aiming to enhance ecosystem services and human well-being are multiple. For instance, Kirchner et al. (2015) noted that although policy interventions and incentives to enhance supply of provisioning services (e.g., agricultural production) have led to higher GDP, it may have an adverse effect on the regulatory services of ecosystems, including climate. Such trade-offs are particularly identified in

relation to the use of land for bioenergy crops, water and food access, and competition for land between forest or food production (Denton et al 2022). The trade-offs of the sectoral mitigation options can become barriers to implementation, as exposed in Section 4 of this report.

Nevertheless, even in the absence of additional mitigation policies, achieving the SDGs would provide up to 25% of the expected greenhouse gas abatement from land use required to stay on track with the 1.5 ◦C target until 2050 (Frank et al 2021). Future land use mitigation policies should consider and take advantage of these synergies across SDGs while minimising trade-offs. In many of the country's studies it was observed that the transformations in the AFOLU sector is increasingly seen as an opportunity to foster sustainable economic development and growth in line with the SDGs. These win-win strategies and sustainable development pathways can be achieved by promoting a nexus approach to decision-making where the interactions between water, land, food and climate systems are accounted for jointly since development in each component affects and is affected by the other components (Doelman et al. 2022). Nexus approaches coupled with modelling efforts can identify optimal combinations, or portfolios, of AFOLU mitigation strategies that increase co-benefits for SDGs while minimising trade-offs (Prudhomme et al. 2020).

Table 3. Assessment of the impacts on SDGs arising from the prioritized mitigation options.

SDG Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Reducing emissions from deforestation	±																
Improved sustainable forest management																	
Afforestation																	
Reforestation	±																
Carbon sequestration in croplands and grasslands																	
Ecosystem restauration																	
Reduce CH4 and N2O emission in agriculture*	±	±	±		±	±	±	±	±	±	±	±		±	±	±	±

Large positive impacts, strong evidence
Medium positive impacts, some evidence
Small positive impacts or low evidence
Low negative impacts or low evidence

Table based on Jia et al 2019 and own assessment. *Too aggregated to asses properly the SDGs impacts.

A portfolio of mitigation strategies tailored to the local context allows both, reducing side-effects on biodiversity and food security compared to siloed strategies, and achieving several SDGs simultaneously. Such a portfolio can combine supply-side and demand-side measures to counter-balance identified trade-offs. For instance, dietary shifts towards plant consumption associated with reforestation efforts can minimise the effects of increased pressure on cropland and pastureland on agricultural commodity production and ultimately, on food security (Prudhomme et al. 2020). Other studies have shown how trade-offs from bioenergy production could be reduced through a combination of initiatives for protecting forests and water resources, enhancing fertilisation efficiency, and intensifying agriculture (Humpenöder et al. 2018). Particularly in the AFOLU sector, it is thus crucial to anticipate potential adverse consequences of mitigation efforts and carefully design policies that not only address these challenges but also capitalise on the opportunities to create synergies across several SDGs and reinforce positive outcomes.

6 Policies and Measures

This section analyses if the 10 countries studied national policy frameworks are fit for purpose to make effective the contribution of the AFOLU sector, in particular for forest, to achieve their NDC goals and increase their commitments ambition by mid-century in line with the net-zero global goal. We did a synthesis of what policies and measures academic literature and technical reports identify to get the AFOLU sector on track to effectively contribute to the goal of near-zero emissions by mid-century. And an assessment of the extent to which previously identified policies are reflected in national policies instruments. Base of the analysis general recommendations on how to improve policy frameworks are provided.

6.1 Policy mixes for the AFOLU mitigation ambition

Based on the Nilsson et al. (2021) policy framework building on several topics for other sector as a guidance, we classified the AFOLU policy instruments identified across the literature reviewed. These topics as adapted for our sector are: (1) instruments that provide directionality and stable frameworks for actions and sustained finance, (2) technology and innovation in ways systems of practices are deployed to accelerate implementation, (3) (re-)shaping markets for key commodity chains, (4) policy coherence and integration within the subsectors and international coherence, and, (5) public capacity and knowledge to enable the transition and reduce the risk and potential social and environmental impacts. An additional topic, linkages to adaptation is included given the increasing threat that climate change represents for the AFOLU sector mitigation. Each of these topics fulfils certain policy functions that aim to address specific barriers or provide enabling conditions, the summary of the options and instruments for each policy function within the topics above can be found in the table 4 below.

On instruments that provide directionality and stable frameworks for actions encompasses the provision of clarity and guidance on the direction of the change and long-term finance national instruments. This can be provided through land and agriculture related regulation and planning instruments that can include mitigation targets in laws, plans/strategies outlining overall decarbonisation visions and sectoral interdependencies, nature protection and restauration laws, agriculture and forest sector specific plans/roadmaps and land tenure legal frameworks. New legal levers such as “rights of nature” are being developed and spread around the world (Global Observatory of Climate Action, 2022) as a new instrument. However, the first rights granted to natural entities in Colombia and other countries (New Zealand, Tanzania) have yet to prove their effectiveness. These instruments provide certainty and longer-term stability that can enable more costly investments and longer-term visions for addressing direct and indirect drivers of land use change such as deforestation (Kissinger et al. 2012). Long term or more stable financial instruments area also critical to provide directionality and certainty if sustained finance mix of mechanisms and stable funding for shifting systems of practices (i.e. up-front public finance, subsidies, low interest loans, etc) are in place. It is also emerging in this context the consideration of species protection issues in climate finance and climate-change impacts in biodiversity finance (Nabuurs et al. 2022). Financial instruments such as, collective payments for environmental services combined with external enforcement they maintain strong effects even with lower sanctioning probabilities (Naime et al 2022).

On technology and innovation, the Research Development and Demonstration (RD&D) policies through funding of basic research, pilot demonstrators, supporting innovation in MRV systems and business models throughout AFOLU value chains while promoting of collaboration and knowledge

exchange across stakeholders on farming innovation (digitalization, inputs, pest and diseases control) can enable action transforming agricultural system of practices towards lower emissions in agriculture and forestry. Action can be accelerated by policies that establish direct subsidies and technical support to introduce high-impact, quickly implementable technical options (i.e. new breeds and varieties) that can be easily accessed and do not require completely new management practices or inputs. Emission reductions can be accelerated by voluntary instruments of sustainable forest management (Kissinger et al. 2012) and education and training programs for practitioners (farmers and foresters). The regulation of global markets to promote deforestation free supply chains (i.e. industry standards for supply chains, taxes to products with embedded deforestation) and CO2 price signalling in results base payments programs and market mechanisms represent promising innovative ways to reduce deforestation when combine with more directional investments indicated above. Food systems transformation regulations and circularity measures, including subsidies and fiscal incentives for consumer behavioural changes combined with other financial incentives to farmers and forest owners for low GHG emissions agriculture and sustainable forest products are identified as promising policy mixes. To demonstrate and further incentivise the progressive implementation of the mitigation measures, carbon footprint tracing systems for free-deforestation commodities and/or GHG emissions food print certifications certification of goods.

On policy coherency and integration, it is important to acknowledge that rural and agricultural development policies mostly intervene in the same spatial area, requiring coherence and co-ordination between them as well as with the other economy-wide policies, and across different levels of government (OCED 2020) and they often can conflict other land use policies (i.e. forest, nature protection). More land use policies integration and regulatory alignment across subsectors (agriculture, Forestry and other land uses) can allow optimizing land uses for different mitigation option measures. For example, regulations aiming to directly limit the use of land for agricultural purposes, such as regulations on livestock stocking densities, livestock exclusion and limiting land clearing for agricultural coupled to adequate monitoring and enforcement, showed to be effective. Input standards, technology standards, performance (output) standards also showed to be an effective instruments to reduce emissions in agriculture (ie.e fertilizer use standards). Hybrid instruments, such as subsidised crop insurance subject to cross compliance requirements has strengthened conservation incentives (DeBoe et al. 2020). Success in reducing emissions form land use change also requires structural policies such as welfare and increase the involvement of indigenous and local communities in environmental policy in the interests of sustainable land use or transitional assistance policies for displaced communities, simplification of regulatory environment and promotion of alternatives to wood fuel (energy sector). By promoting sustainable land use and resource extraction as part of the bio and circular economies demand of products that are drivers of GHG emissions can be reduced (OCDE 2020).

On public capacity and knowledge to enable the transition and reduce the risk and potential social and environmental impacts, enhancing institutional capacity to understand challenges of transformation in government bodies from local to national scale will facilitate transitions. Rural skills to accelerate changes in practices can be strengthened by improving collaboration between public authorities, local businesses and not-for-profit organisations, to ensure local education and training matches the current and future needs of rural producers. For example, maintaining and strengthening the agriculture extension services and supporting effective productivity farms by improving the local and regional business environment and facilitating training for entrepreneurs and SMEs (OCDE 2020) and the engagement of other stakeholders. Information systems and for farmers such as early warning

systems for disturbances (fires, droughts, etc) can support more efficient and intensive productions reducing losses, less area for same production. The development of systems for monitoring and evaluation, projects registries, national forest monitoring systems, GHG inventories, safeguards information systems and verification of timber legality allow to track effectiveness of climate change mitigation regulations and their enforcement.

Table 4 below summarises policy functions clustered by topics and illustrated by a list of policy instruments, that it does not pretend to be exhaustive given the complexity and interlinkages of nature protection, land use and agriculture policy landscape.

Table 4: Policy functions and instruments to enable the transformation of AFOLU sector.

Topic	Policy Function	Potential Policy Options & Instruments
Directionality	**Clarity and guidance**	○ Mitigation targets, laws defining overall policy direction/ambition ○ Plans/strategies outlining overall decarbonisation visions and sectoral interdependencies. ○ Biodiversity protection laws ○ Detailed Agriculture, Forest sector specific plans/roadmaps ○ Land use and restauration laws and policies (i.e. reforestation and afforestation) ○ Land use laws and regulations, including land use conversion moratoria (i.e. forest conversion) ○ Land tenure legal frameworks
	Sustained finance	○ Sustained finance mix of mechanisms to enable investments ○ Stable funding for shifting systems of practices (i.e. up-front public finance, subsidies, low interest loans, etc) ○ Mutual consideration of species protection issues in climate finance and climate-change impacts in biodiversity finance, payments for ecosystem services (PES) ○ Payments for environmentally sustainable practices, public investment in structural adjustment towards “greener” agricultural systems
Innovation	**Enhance public Research Development and Demonstration (RD&D)**	○ Public RD&D policies, incl. funding of basic research, pilot demonstrators ○ Support for innovation in MRV systems and business models throughout AFOLU value chains ○ Promoting of collaboration and knowledge exchange across stakeholders ○ Farming innovation (rethinking transport, digitalization, inputs, pest and diseases control)
	Accelerate early changes	○ Direct subsidies and technical support to introduce high-impact, quickly implementable technical options (i.e. new breeds and varieties) that can be easily accessed and do not require completely new management practices or inputs ○ Voluntary instruments of sustainable forest management ○ Education and training programs for practitioners (farmers and foresters)
	Reshaping of existing markets	○ Regulating global markets for relevant primary goods and creating incentives for deforestation free supply chains (i.e. industry standards for supply chains) ○ CO2 price in emissions trading schemes, tradeable offset schemes ○ Food systems transformation regulations and circularity strategies and plans ○ Subsidies and tax incentives for consumer behavioural changes ○ Other financial incentives low GHG emissions agriculture and forest products ○ Disincentives, i.e. taxes to products with embedded deforestation
	Transparency and information	○ Carbon footprint tracing systems ○ Free-deforestation tracing and/or certification of goods ○ GHG emissions food print certifications

Topic	Policy Function	Potential Policy Options & Instruments
Policy coherence & integration	**Reducing demand**	○ Circular economy measures across the food system ○ Health policies towards healthy diets to reduce animal proteins consumption
	International coherence	○ International agreements on coordination and orchestration of multiple actors ○ Alignments with agreed multilateral frameworks (i.e. Warsaw Framework for REDD+) ○ Common standards and rules for carbon markets
	Socio-economic implications	○ Just transition policies, incl. transitional assistance policies for displace communities ○ Structural policies such as welfare and increase the involvement of indigenous and local communities in environmental policy in the interests of sustainable land use
	Regulatory environment	○ Regulatory alignment across subsectors (agriculture, Forestry and other land uses) ○ Simplification of regulatory environment ○ Integrated land use policies ○ Input standards, technology standards, performance (output) standards ○ Subsidised crop insurance subject to cross compliance requirements has strengthened conservation incentives ○ Promotion of alternatives to wood fuel (energy sector)
Knowledge & Capacity	**Public capacity**	○ Institutional capacity to understand challenges of transformation in government bodies from local to national scale ○ Information systems for farmers, including early warning systems for disturbances (fires, droughts, etc) ○ Facilitating stakeholder engagements ○ Public training and capacity building, i.e. extension services
	Monitoring and evaluation	○ Systems for monitoring and evaluation, and projects registries ○ National forest monitoring systems, GHG inventories, Safeguards information systems, verification of timber legality
Adaptation linkages		○ Impacts of climate change and needs for adaptation are considered explicitly in mitigations instruments
Main sources of information: Kissinger et al. (2012), Nabuurs et al. (2022), DeBoe et al. (2020), OCED (2020), and policy data bases indicated in the reference section.		

6.2 Analysis of national AFOLU policy frameworks

To analyse if national policy frameworks are fit-for purpose to trigger the needed sectoral transformations we mapped at existing policies for all 10 countries, as March 2023. We then assessed the extent the above introduced policy functions are exploited by existing policies (yes, no, partially). Table 5 summarises these findings. The analysis is still very preliminary given the complexities of land use and agriculture polices and their historical context to which climate-oriented policies are built upon or add to.

The analysis shows that all 10 countries have policies in place that aim to incentivise or trigger mitigation efforts in one or more subsectors of the AFOLU sector. The analysis reveals strong differences across policy frameworks in terms income-level, country-specific context and policy functions, which are explored below. It also shows that while studied have relevant agriculture, nature protection and land use climate change-oriented policies in place, these generally remain disconnected and are not triggering the transformational changes needed in the sector. Most countries have long-term mitigation targets in place and have developed or are developing for some of the subsectors, which indicates political interest in accelerating transformations in the sector including the emissions reductions and the increase in sequestration as part of the land polices in general, and more concretely most of them specifically on forestry and agriculture. However specific activities to be incentivised that can lead to limited progress in the sector as a whole and sometimes are conflicting. Therefore, the existing policy framework for the AFOLU sector remain lacking the sufficiently integration and consistency to trigger the overall sectoral transformations needed to ensure the contribution to the Paris Agreement compatible pathways as expected in all 10 countries. Although with different degrees across countries. We observe strong differences across existing AFOLU climate policies across the 10 countries.

High-income country studied (EU and Australia) with economy wide climate targets have stronger directionality and sustainable finance policy instruments. Illustrated by stable land use and nature protection policy frameworks, exploiting the different policy functions to the larger extent and although not completely mainstreamed with overall land use and agriculture policies. Yet there are differences in prioritising instruments, while the Australia focuses primarily on economic instruments for the sector (i.e. Carbon farming outreach and extension; nature repair market), including beyond terrestrial systems (Blue carbon conservation, restauration and accounting program), the EU has a more comprehensive although still not fully coherent regulatory approach, such as the increase of policy instruments under their Climate Law and Green Deal for domestic implementation (i.e. LULUCF regulation, farm to fork strategy, land restauration law, biodiversity strategy, new 2030 forest strategy and many of its environmental regulations to reduce pollution impacts such as the nitrates directive) and affecting other countries (Regulation on deforestation-free products). Monitoring and evaluation policy instruments are well stabilised and transparent in high-income countries studied (GHG inventories robustness for the AFOLU sector is increasing rapidly and regular monitoring networks and technologies and deployed or under deployment to cover all lands). They show weak or non-consideration of the linkages with adaptation, although extreme climate events in Australia (large fires) and EU (extreme droughts in 2022 and 2023 across all EU) are hampering primary production and existing carbon stocks. Demand side policies are strongly emerging in the EU as climate change mitigation instruments (i.e. Farm to fork strategy, new circular economy action plan).

Middle-income countries have stronger differences in the landscape of land and agriculture policies and different status of development of their associated climate change-oriented policies. Russia states

in their latest update of their wide economy target the important role of protecting and improving the quality of natural sinks. While climate change mitigation instruments for apiculture and forestry are none explicit but rather partially addressed in broader regulation and instruments (i.e. National security strategy, federal Law on limiting greenhouse gas emissions, strategy for the socio-economic development of the Russian Federation with low greenhouse gas emissions until 2050). Innovation policies are oriented to productivity and intensification in all AFOLU sector. More explicitly Russia has regulations on guidance for monitoring GHG inventories on the sector and progressed on the transparency and robustness of its reporting. The rest of the studied middle-income countries (Mexico, Brazil and Colombia) relay extensively on the potential of reducing deforestation as they host large areas of tropical forest with high or relative high share of emissions. All phase challenges in relation to land tenure rights up to some extent. To this end, Brazil is probably the most advanced, with an economy wide target, has a zero illegal deforestation target for the Amazonia by 2030 and its efforts focused primarily in reducing deforestation regulation and enforcement from the mid-90s to the late 20s, this included constrain of area for cattle ranging and intensification of agriculture production though RD&D programs. The federal government of Brazil has strong capacities for forest cover change monitoring and early detection (PRODES and DETER programs are among the best worldwide) that showed to be effective in the context of enforcement of policies reduce deforestation. Brazil had access to finance for result base payments for reducing deforestation related efforts through the Amazon Fund and the Green Climate Fund. Mexico, although it has not specific target for the AFOLU in their NDC, stablished overarching policy instruments since more than a decade ago, including more forest oriented forest policy instruments that addressed mitigation such as the National Forestry Programme (PRONAFOR) and the National Strategy for the Reduction of Emissions due to Deforestation and Degradation (ENAREDD+), committed on a soft announce to implement natural base solutions that include the “Sembrando Vida Porgrame” and the creation of new protected areas and blue carbon strategy. Colombia also have overarching policy instruments, including more forest-oriented forest policy instruments that addressed mitigation and received financial support from international initiatives, such early movers and the Green Climate Fund. Monitoring public capacities are progressing and it has a good early warning system for detecting changes. But, despite exiting programs is evidence of a strong need to strengthen technical capacities in Colombia.

Low-income countries studied (Ecuador, Indonesia and Viet Nam) are the ones that present more differences among themselves. Ecuador, Indonesia and Viet Nam have large areas of tropical forest with primary drivers of deforestation dominated by illegal logging or forest conversion to crops. Indonesia has put in place policy instruments that provide clear signals of the prominent role of land use and in particular reducing deforestation and peatland restoration in their mitigation efforts. Several policies have contributed to the decline of deforestation, with strengthened law enforcement to prevent forest fires and land clearing arguably being the most efficient in Indonesia. While Morocco´s economy relay a lot on corps production and exports with little forest areas a number of specific measures and larger focus on adaptation policies while mitigation policies are focused on modernization for agricultural development, tree planting specific target, protecting biodiversity and combating desertification.

All the developing countries studied shoved signalled the direction in forest related mitigation by joining international initiatives such as the Bonn Challenge, New York Declaration on Forest or the Glasgow Leaders’ Declaration on Forests and Land Use

Table 5: Preliminary summary of the analysis of national policy frameworks against the policy functions

Topic	Policy Function	High income		Upper-middle income				Lower-middle income			
		EU	AU	RU	MX	BZ(2)	CO	EC	IN	MO	VI
Directionality	Clarity & guidance	+	+	±	±	+	+	+	+	±	±
	Sustained finance	+	+	-	-	±	-	-	-	-	-
Innovation	Enhance public RD&D	+	+	n.a.	n.a.	+	±	-	±	-	-
	Accelerate early changes	-(1)	±	n.a.	n.a.	±	±	±	±	-	-
	Market instruments	±	±	-	-	-	±	-	±	-	-
	Transparency and information	+	+	±	±	+	±	±	±	-	-
Policy coherence & integration	Reducing demand	+	n.a.	-	n.a.	-	-	-	-	-	-
	International coherence	±	±	-	±	±	±	±	±	-	-
	Socio-economic implications	-(1)	±	n.a.	±	-	-	±	±	-	±
	Regulatory environment	+	+	±	±	±	±	±	±	-	-
Knowledge & Capacity	Public capacity	+	+	±	+	+	+	±	-	-	-
	Monitoring and evaluation	+	+	+	±	+	±	±	±	±	±
Adaptation linkages		-	-	-	-	-	-	-	-	-	-

Countries: European Union (EU); Australia (AU); Russia (RU); Mexico (MX); Brazil (BZ); Colombia (CO); Ecuador (EC); Indonesia (IN); Morocco (MO); Viet Nam (VI).

Explanation of assessment scale:

The existence of policies and instruments for each policy function by existing national policies and measures (as of March 2023) was assessed on a non-existing (-), partially existing (±), covered (+) scale. n.a.: no information available, exploitation of function could therefore not be assessed.

The analysis is based on the case studies sheets, available in the supplementary material.

(1) Difficult to asses in the EU context across member states but it seems to be not addressed as in other sectors.
(2) For forest sector less for other sub sectors of AFOLU.

7 Conclusion

Our analysis and findings provide a systematic analyses of national implementation barriers and challenges. This information can be valuable in designing policies and measures to advance national sectoral mitigation. Additionally, it allowed for general conclusions on what is hampering and driving the overall mitigation realistic potential and ambition.

The analysis reveals that the AFOLU sector faces several significant challenges. Economic barriers include insufficient transformative investments, an excessive emphasis on result-based payments, underestimation of the actual costs involved, and complexities in the distribution of benefits. The sector also grapples with fragmented policy frameworks and a lack of international coordination or orchestration for all countries analysed, although at different extent. As a result, these factors hinder the sector's ability to achieve its land mitigation potential and impede the necessary sectoral transformations. Thus, while policies are increasingly appearing in all countries to address land, agriculture and climate change, existing policy frameworks alone are unlikely to trigger the transformations at the required speed. Large differences across countries and income levels remain.

The compilation of national land and agriculture climate change related policies allows to take stock of which policies have been already implemented across countries. Comparing existing policy frameworks allows us to assess whether they are in place to realize the mitigation potential of the sector. Although the complexity of the sector makes difficult to fully assess if they are fit for the purpose of enhancing mitigation ambition in the sector.

To achieve the sectoral transformations that are required for the 1.5°C objective of the Paris Agreement, enhance coherency and more cross-cutting policies are needed across the AFOLU subsectors, as well as increasing the linkages to other sectors. High-income countries increasingly rely on sinks to achieve their targets towards achieving net-zero targets. On the other hand, middle-income countries face challenges related to limited economic and governance capacity to implement and enforce more ambitious policies. This situation, combined with the reliance in high income countries on emission reductions and increased sinks as compensation for emissions in other sectors puts the overall collective ambition at risk. This highlights the need to further strengthen international cooperation to foster a more collective vision for the sector based on realistic potentials in different countries and regions, suitability of land for afforestation and restauration activities, and competing land uses such as for ensuring food and another goods provision. Since national context matters for the perception of both deforestation threats and effective policies, suggesting that there is no one-size-fits-all solution to improve forest policy at a global scale. Despite these differences, actors across scales agree about the most important drivers (i.e. agriculture) and about the most effective policy instruments (i.e. reforestation) in the coming decade, unexpected consensus that confirms the existence of common entry points for collaboration between institutions operating at different spatial levels, which is a precondition for effective policy design and implementation.

More detailed for the different regions and the interconnections between them through trade, and in-depth analysis of potential social and environmental consequences of the implementation of existing and emerging policy instruments will be needed.

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